

STEEL STRUCTURES

INTRODUCTION

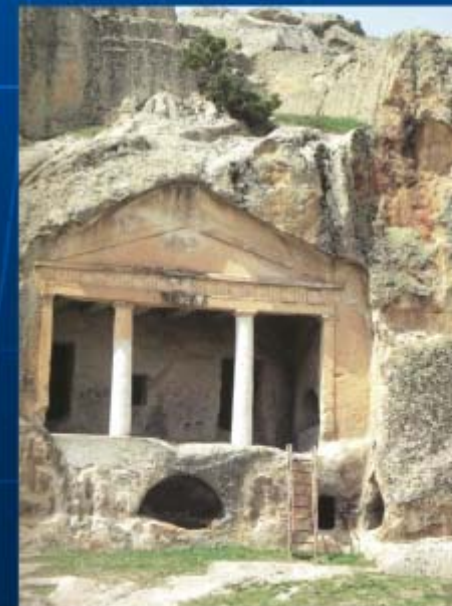
Prof. Dr. Nesrin YARDIMCI TIRYAKIOĞLU

1. HISTORICAL BACKGROUND

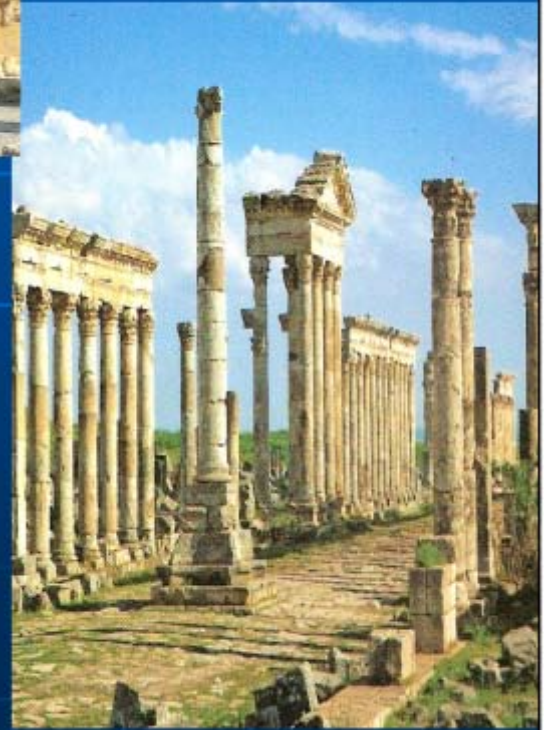
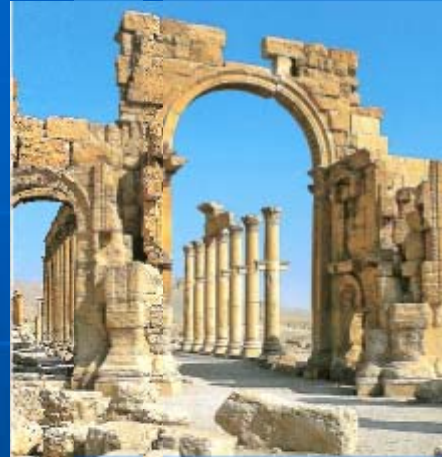
➤ Early humans built primarily for shelter, using simple methods.

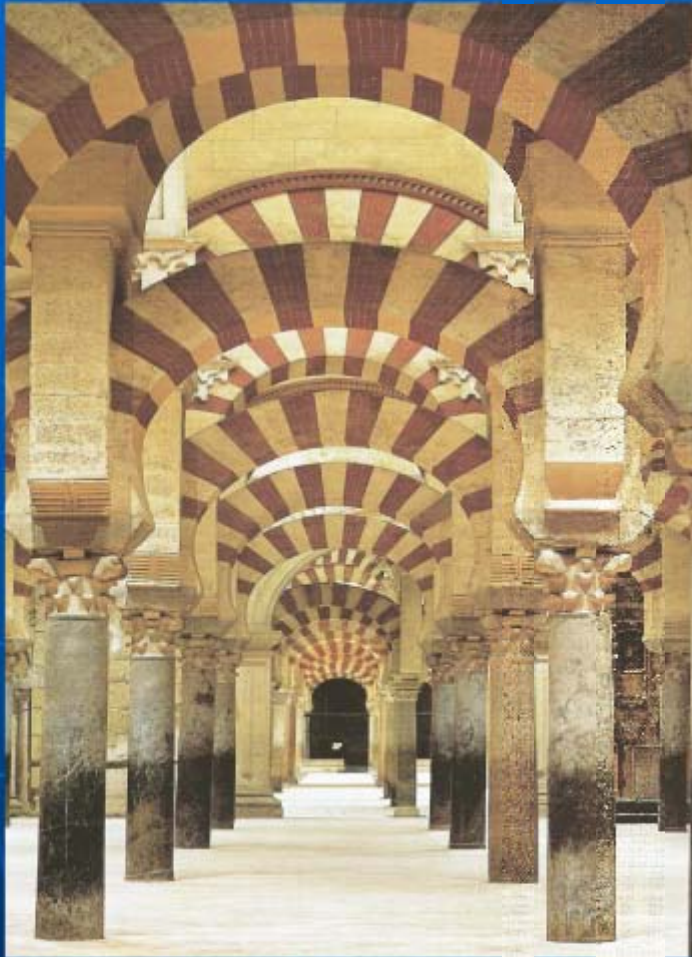
Building materials came from the land, and fabrication was dictated by the limits of the materials and the builder's hands and structures, like beams and arches could be also observed in nature.

➤ Building design was all about repeating what was already known.



➤ Until about 1850, structural design was largely an art.





➤ Usage of iron material in buildings was a new era in structural building.

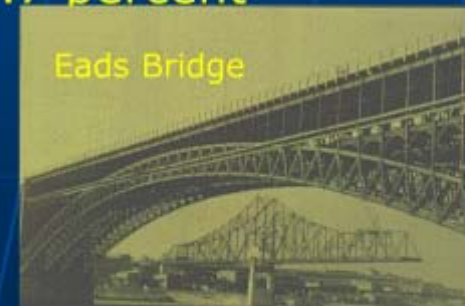
- Iron (tools, weapon)
- Cast iron-very high carbon content >2 percent (18.century-bridges- 1779 Coalbrookdale Bridge)
- Wrought iron-very low carbon content <0.15 percent (second half of 18.century- 1850 Britannia Bridge)
- Steel- carbon content from 0.15 percent to 1.7 percent (second half of 19.century- Bridge and high rise building- 1874 Eads Bridge, St. Louis Missouri)



Coalbrookdale



Eiffel Tower



Eads Bridge

Cast iron bridges



The Coalbrookdale Bridge (1779)

Span : 30m

Still used.

This bridge was a turning point in engineering history because it changed the course of the Industrial Revolution by introducing iron as a structural material.





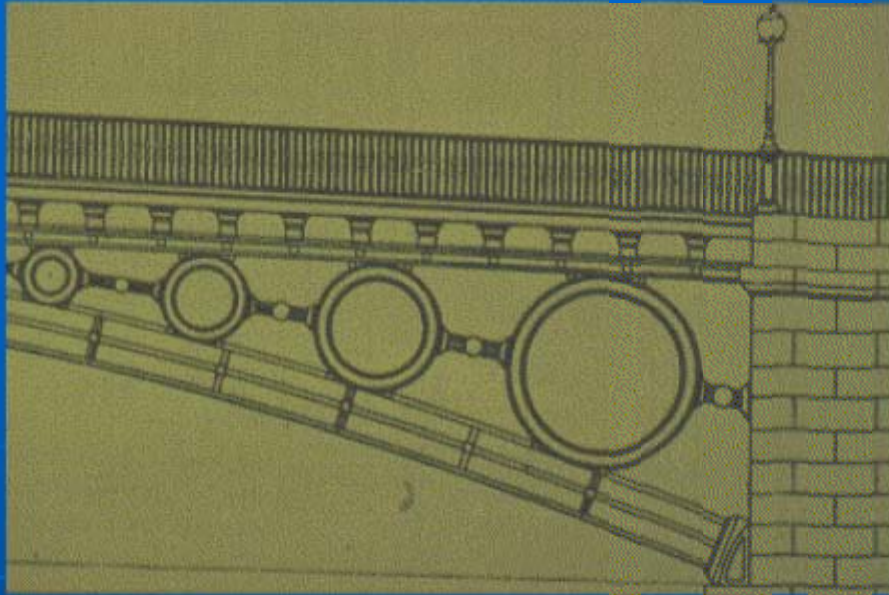
Telford's Mythe Bridge



Thomas Wilson's Wear Bridge



Southwark Bridge-London
(1819)
Span 73 m.
The longest cast iron bridge.



Pont du Carrousel Bridge-Paris
(1839)

Span : 3x48 m

Her biri 48m olan üç açıklıktan

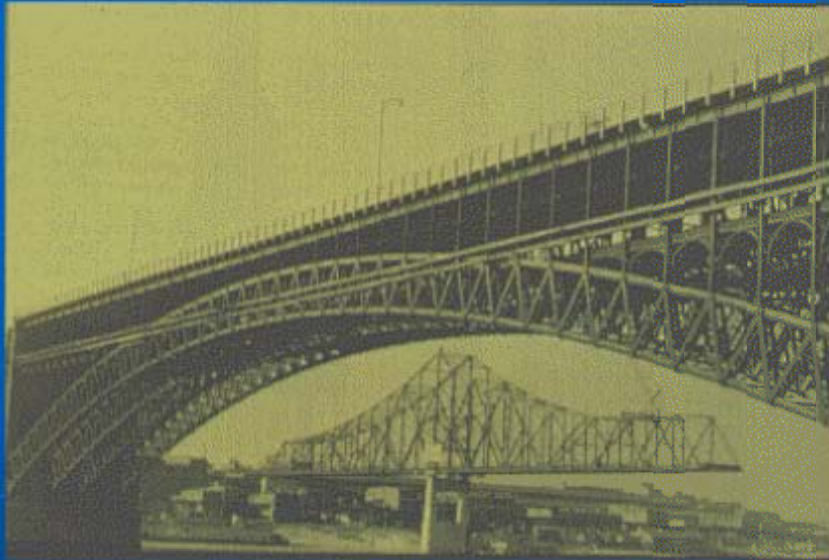
Grandfey Viaduct-Fribourg
(1862)

Span : 7x 49m

Wrough iron



Steel bridges



Eads Bridge- St. Louis, Missouri

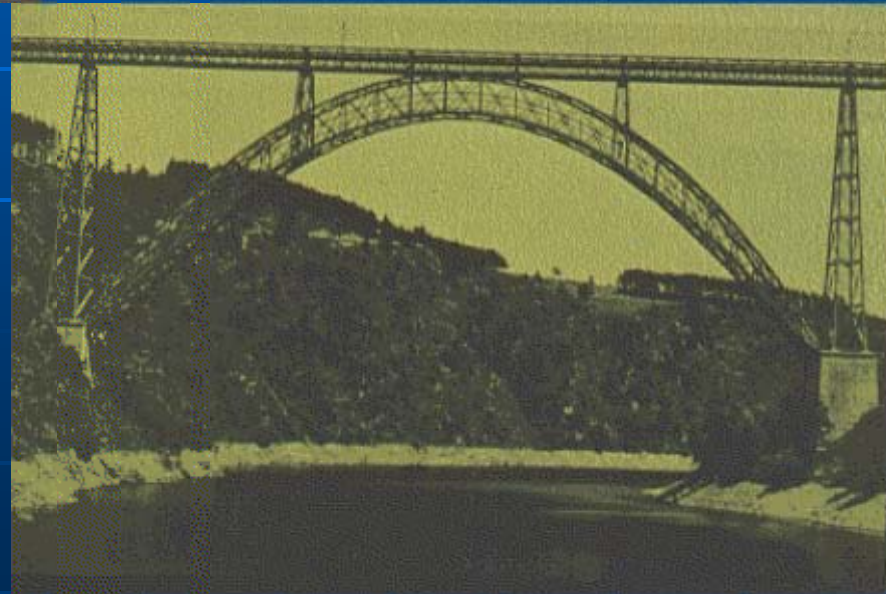
(1874)

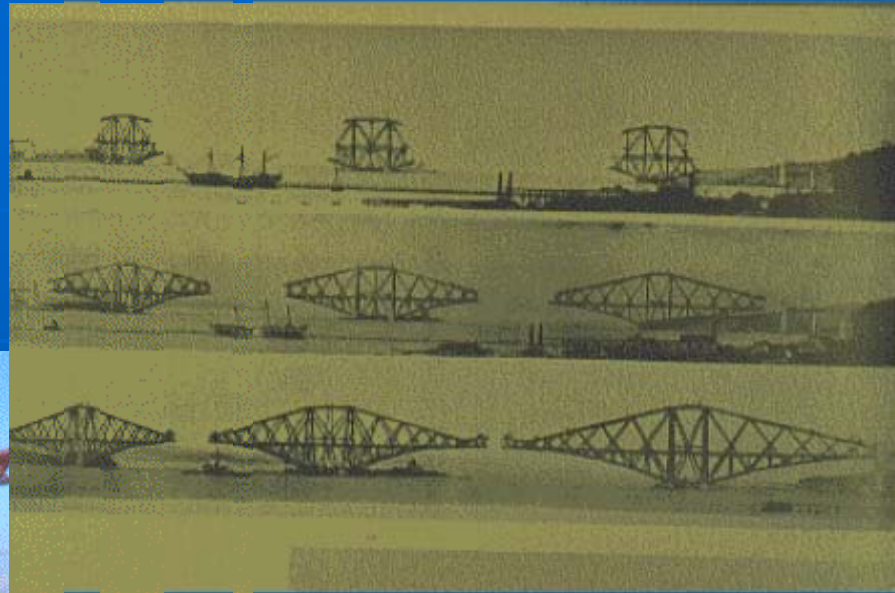
Span : 159 m

Garabit Viaduct-South of France

(1884)

Span : 165 m





During the construction
42000 ton steel and 4600 workers is used.

Firth of Forth Bridge-Scotland

(1883 – 1890)

Maximum Span : 521 m



Bayonne Bridge- New Jersey

(1931)

Span : 504 m

Sydney Harbour Bridge

(1932)

Span : 503 m

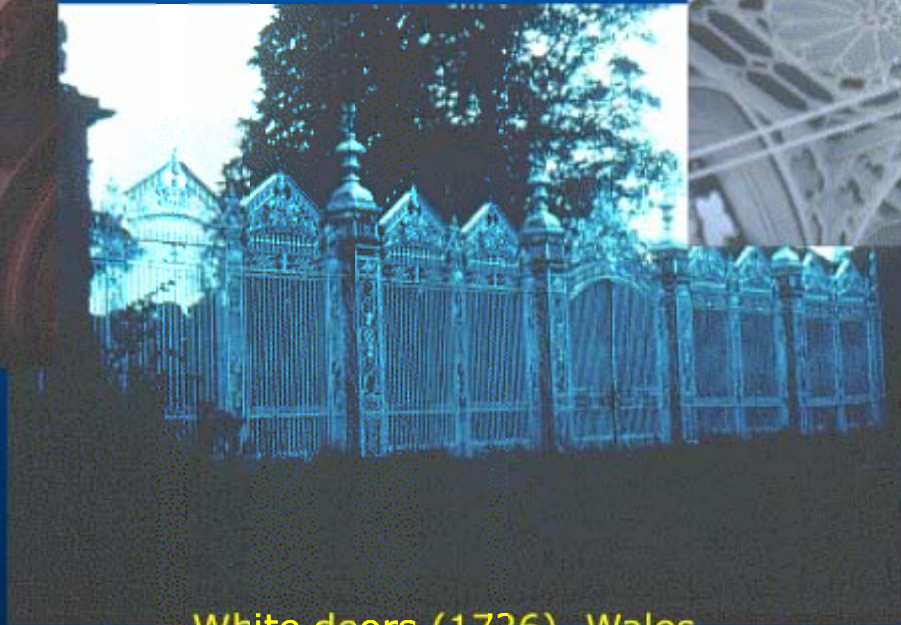


The first cast iron and steel buildings



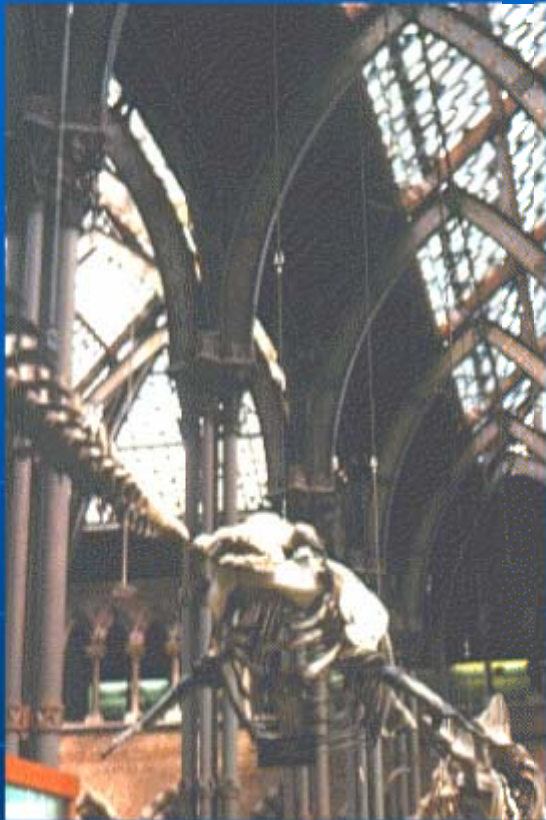
Bibliotheque Nationale
(1858-68)

St George's Church,
Everton, UK (1812-14)

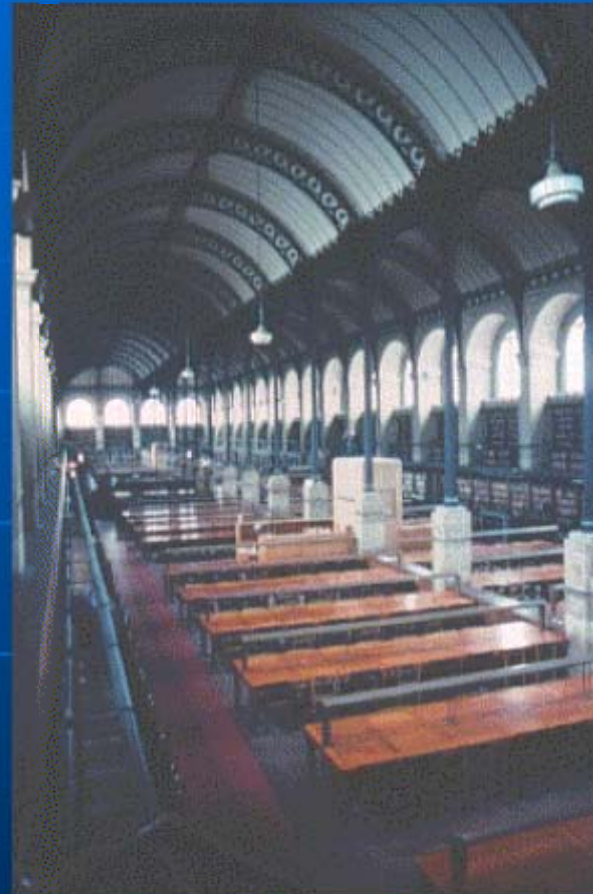


White doors (1726), Wales

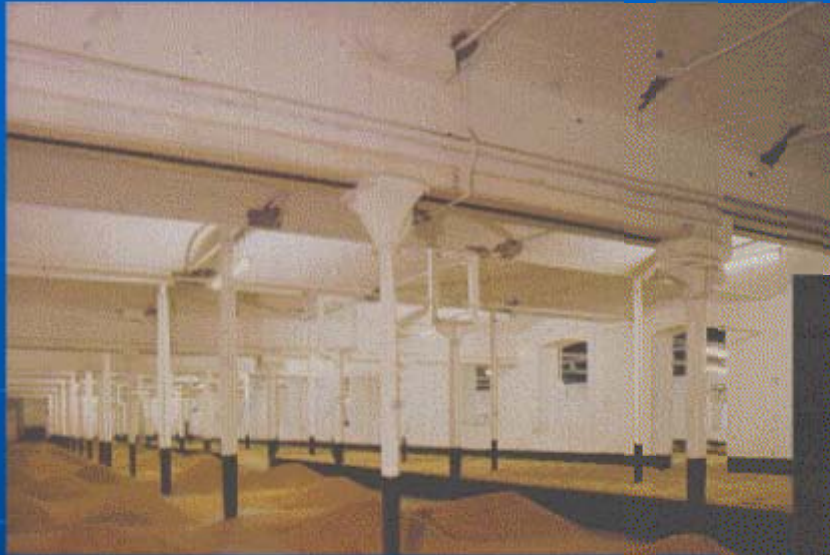
Oxford Museum (1860)



Bibliothèque Sainte Geneviève
(1843-50)



The first cast iron and steel industrial buildings



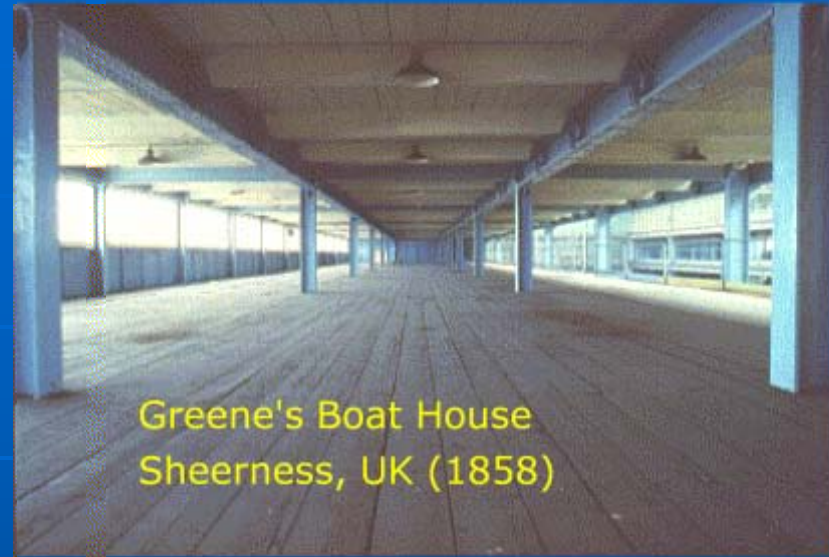
Charles Bage's Flax Mill,
Shrewsbury, (1796)

Albert Dock Buildings, Liverpool,
(1845)





Gardener's store-a-furniture, Glasgow
(1856)

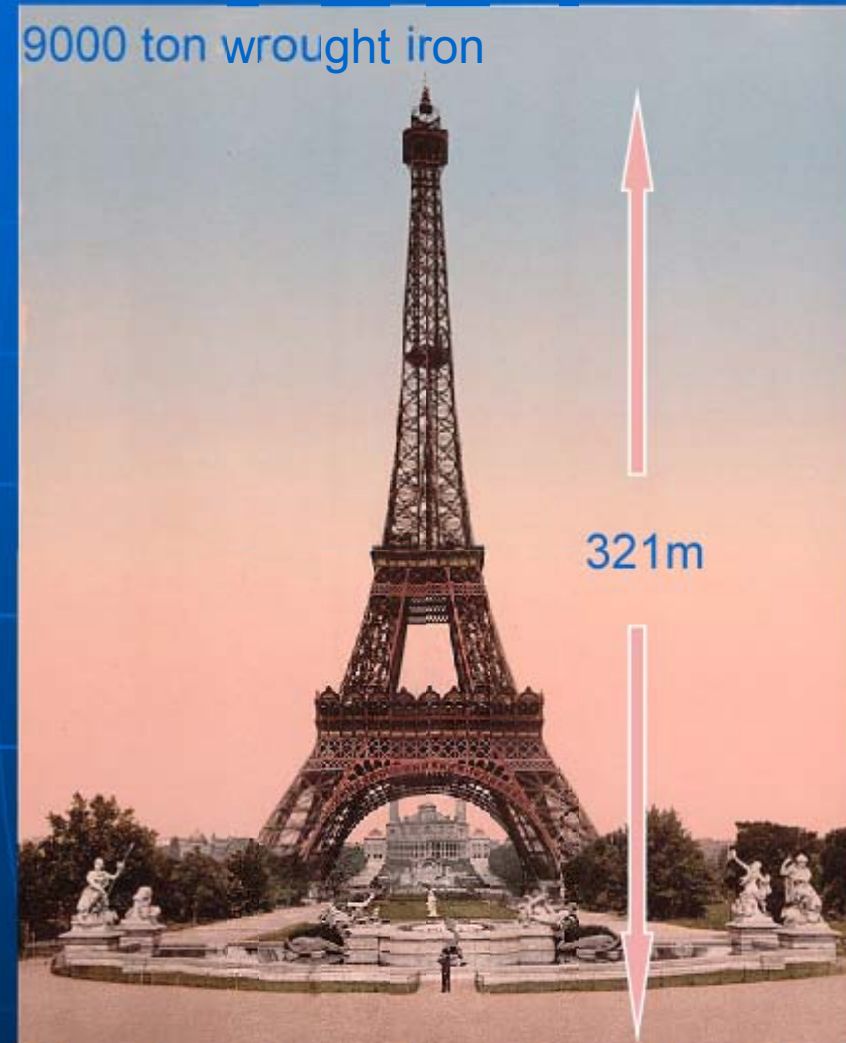


Greene's Boat House
Sheerness, UK (1858)



Menier Chocolate Factory
Noisiel-sur-Marne, (1872)

Eiffel Tower (Gustave Eiffel, Paris, France, 1887 ~ 1889)



The second step in the development of steel construction is the use of welded joints in the beginning of 20th century (Rivet-Bolt-Weld).

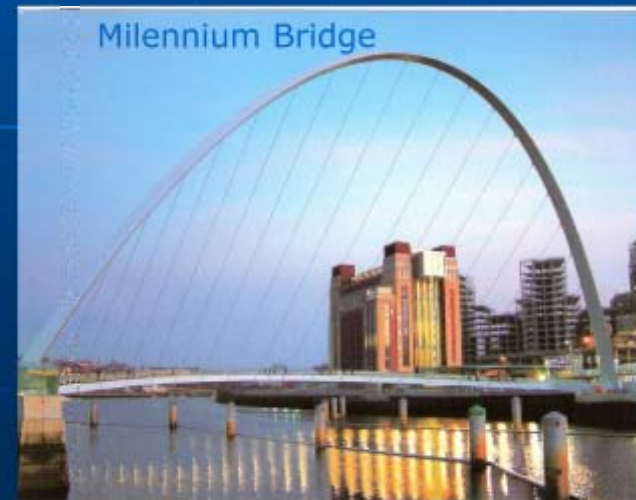
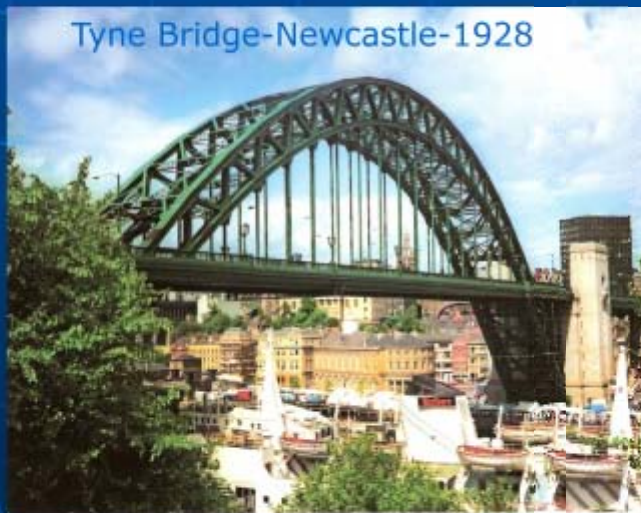
Advancement in the methods of analysis turned design from art into science.

Since those beginnings, steel has been vastly improved in both material and in methods and types of applications. The largest boom for steel building construction began during World War II when airplane hangars were produced utilizing an all steel construction for military use. Many structures were produced and required only the use of a small labour force and hand tools to assemble and, if necessary, could later just easily be disassembled and moved to another location.

Cost of labour and materials started to increase in the following years and being economic become as important as safety.

The necessity to be sensitive in preserving environment and using natural sources is a point that has to be taken into consideration.

(Safety, economy, aesthetics, environment and sustainability)





2. STRUCTURAL DESIGN

(Safety, economy, aesthetics, environment and sustainability)

Structural design may be defined as a mixture of **art and science**, combining the experienced **engineer's intuitive feeling** for the behaviour of a structure with a sound knowledge of principles of **statics, dynamics, mechanics of materials and structural analysis**, produce a safe economical structure which will serve its intended purpose. At the same time it is necessary to be sensitive to preserve environment and natural materials in structural design. **So structural design should be safe, economic, aesthetic and sustainable.**

2.1 Responsibilities of the structural designer

Safety

Structures must have enough strength, rigidity and toughness while they are used and at the same time they should have enough safety to overcome extra possible loads or loss of elements resistance. Provisions must be made for **overload** or **understrength**.

In general, the expression for structural safety requirement may be written as,

$$\Phi R_n \geq \sum \gamma_i Q_i$$

Left side represents the *design resistance* or *strength* and right side represents the *factored loads*.

Φ : Resistance factor < 1

γ : Load factor > 1

- The study what constitutes the proper formulation of structural safety has been continuing during nearly the past 30 years. (Failure occurring in a member, connection or system.)
- **Limit states** are the conditions of a structure at which it ceases to fulfill its intended function. These are
 - Strength (safety):** Behavioral phenomena as achieving maximum strength, buckling, fatigue, fracture, overturning and sliding.
 - Serviceability:** Concerned with occupancy of building (deflection, vibration, permanent deformation and cracking).

Failure of structures

- Insufficient attention to the details of connections, erection problems, and foundation problems.
- To neglect some of the forces acting on the connection.
- Insufficient bearing or anchorage.
- Foundation settlements cause a large number of structural failures like cracks.
- Inadequate attention to deflection or vibration.
- For steel structures some structural failures occur because inadequate attention is given to , fatigue of members, bracing against swaying, stability of members or system, buckling of compression members, lateral buckling of beams. When structure is completed, it should be sufficiently braced with floors, walls, connections, and special bracing. During erection some special temporary bracing may be required.

Economy

All the factors affecting the total cost of the structure have to be taken into consideration. And the designer needs to keep in mind the factors that can lower cost without sacrifice of strength. (The use of standard size members, simple connections and details, and members and materials that will not require an unreasonable amount of maintenance through the years.)

Aesthetics

The structure should be aesthetic and in harmony with the environment. Appearance may often be the major factor in selecting the type of structure.

Environment

- The construction and use of buildings, roads and bridges have an effect on the environment.
- “Natural resources are used to a minimum, energy is used economically and pollution is reduced.”
- The choice of materials by contractors; architects and engineers has ecological importance.
- It is essential to respect the environment, raw materials and natural resources.
- The extraction and transport of raw materials; the production and manufacture of construction materials; transport to the site; construction and its maintenance; and ability to recycle materials must be analyzed.

Sustainability

- Sustainability is “respond to the needs of the present without compromising the capacity of future generations to respond to theirs”.
- Human activities must become ecologically sustainable.
- The success of the project has to be measured on ecological, economic and social sustainability.
- For sustainability, cost of whole life cycle of the building should be calculated and evaluated with economy and environmental effects.
- Sustainable development means optimising the utilisation of raw materials and energy during their entire life cycle, and reducing to a minimum any adverse effects on the environment.

Constructability

It needs four processes to make a complete steel structure.

Production, Detailing, Fabrication, Erection

Production & Recycling

Generally, high quality steel can be produced from steel scraps within 3 hours. These scraps are collected with a crane and they are put in a furnace having at 75MW current (electricity) for 60 minutes with carbon electrodes. Then, the molten metal is poured into the container of required shape.

The properties of steel are varied by its carbon content because it is the major composition of steel with iron. As per the requirements, Mn, Ni and Cr also are added to make changes the properties of steel. Finally, the chemical composition and physical properties are checked. The unshaped steel pieces are in the form of flats, billets, ingots and near net shapes before getting required structural member.

Detailing

It is the process to create drawings and giving so precise and accurate dimensions to them which help much for complete fabrication and erection of steel structures. Nowadays, the drawing files are created as NC files also to give the direct input to CNC machines and the fabrication time also is reduced.

Fabrication

This is to be done in workshop with the help of detailed shop drawings. Generally, the required holes in a steel member are drilled at one go. Most of the cuttings are performed with flame cutting. The other processes like welding, punching and bending, etc. also are done in workshop. Finally, the parts are assembled according to the assembly drawings and they are marked with separate assembly number.

Erection

After fabrication, the marked assemblies are taken to working site by transport. It is a difficult process compared to detailing and fabrication. The detailed drawings should be more comfortable to erection labours working and safety wise. So while detailing, the safety standards should be considered and included.

Structures can be fabricated and erected without great problems arising. Designers need to understand fabrication methods and field erection (transportation of the materials to the job site, labor conditions, equipment available for erection) of steel. So reasonable, practical and economical designs can be produced.

2.2 Design procedure

➤ **Functional design** (adequate working areas, ventilation, air conditioning, transportation facilities, lighting, aesthetics)

➤ **Structural framework design**

- **Conceptual design** (Establishment of functions, general shape, layout of spaces, types of supports, accurate dimensions)

- **Preliminary structural configuration** (Arrangement of elements)

- **Establishment of the loads**

- **Preliminary design** (Member selection, approximate sizes, rough details)

- **Analysis**

- **Evaluation**

- **Redesign**

- **Final design** (Working drawings, shop drawings, project documents)

❖ ***It is important architect and engineers work together***

2.3 Material choice

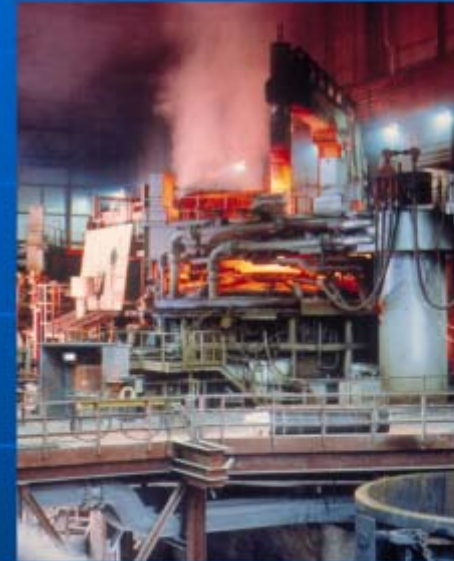
Major factors that may affect material choice are,

- Function of the structure,
- Soil conditions,
- Geographical location,
- Whether it is going to be permanent or temporary,
- Time period it is going to be in function,
- Determined date of operation,
- Funds dedicated to construction,
- Operational expenses,
- Changes in the costs of materials,
- Experience, local customs and habits.

3. STRUCTURAL STEEL

3.1 Mechanical properties

- Homogenous and isotropic
- High strength
- High Young Modulus
- Equal tension and compression strength
- Ductile
- Tough



- **Homogenous and isotropic**

The properties of steel do not change with time, and is same in every part of the cross-section.

- **High strength**

The high strength of steel per unit of weight means that the weight of the structures will be small. Safety coefficients used in the calculations are smaller than the other materials.

- **High Young Modulus**

Steel behaves closer to design assumptions than most materials because it follows Hook's law up to fairly high stresses. The moments of inertia of steel structure can be accurately calculated.

- **Equal tension and compression strength**

No other structural material has this property and this makes steel preferable in buildings that differ in their architectural design.

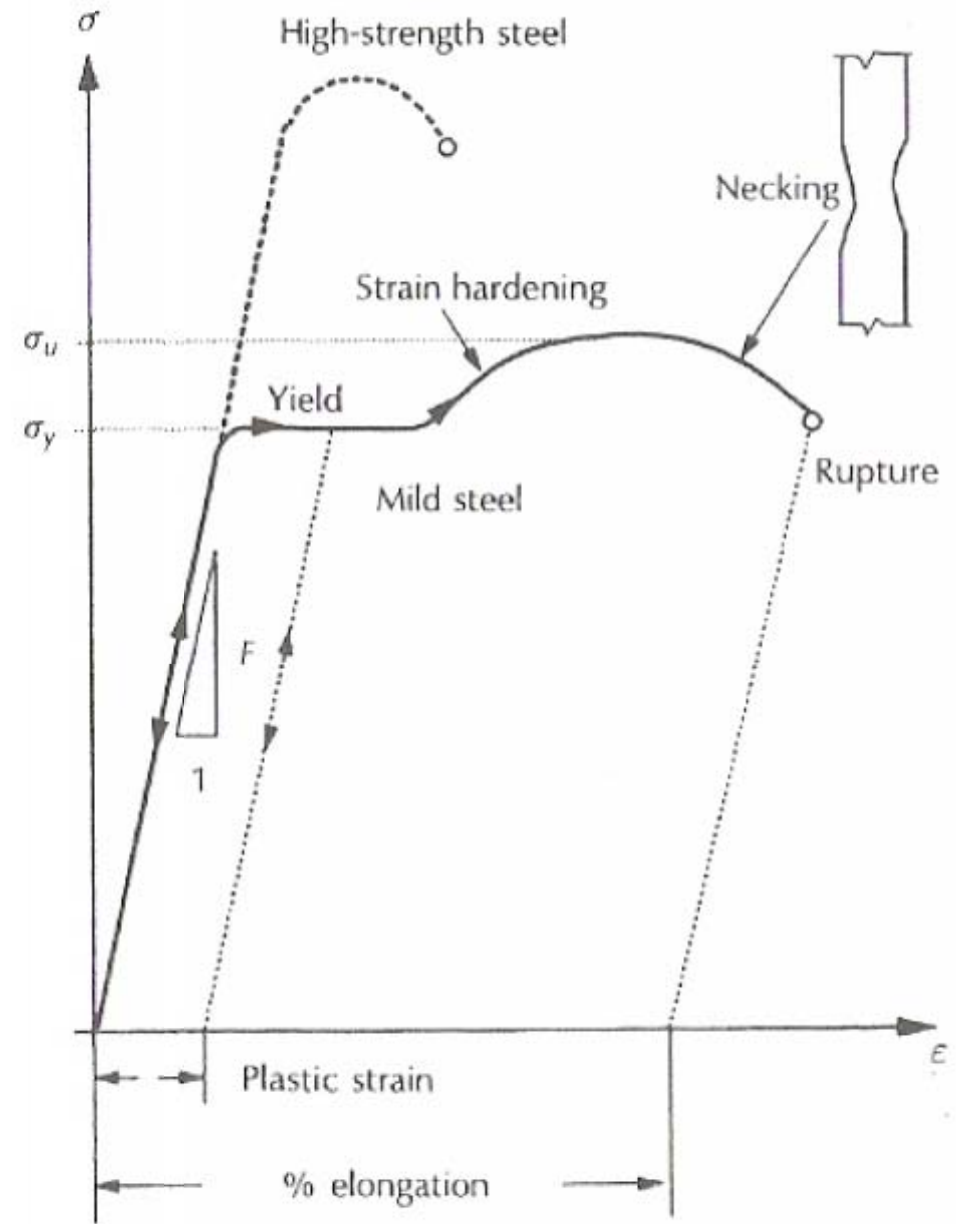
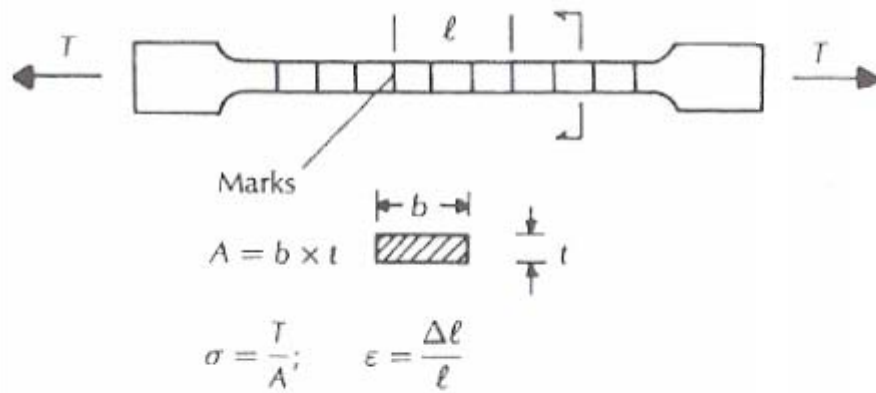
- **Ductility**

The property of a material by which it can withstand extensive deformation without failure under high tensile stresses is ductility. When a mild or low-carbon structural steel member is being tested in tension, a considerable reduction in cross section and a large amount of elongation will occur at the point of failure before the actual fracture occurs. A material that does not have this property generally unacceptable and is probably hard and brittle, and might break if subjected to sudden shock.

- **Toughness**

Structural steels are tough-that is they have both strength and ductility. A steel member loaded until it has large deformations will still be able withstand large forces. This is a very important characteristics, because it means that steel members can be subjected to large deformations during fabrication and erection without fracture-thus allowing them to be bent, hammered, and sheared, and to have holes punched in them without visible damage. The ability of a material to absorb energy in large amounts is called toughness.

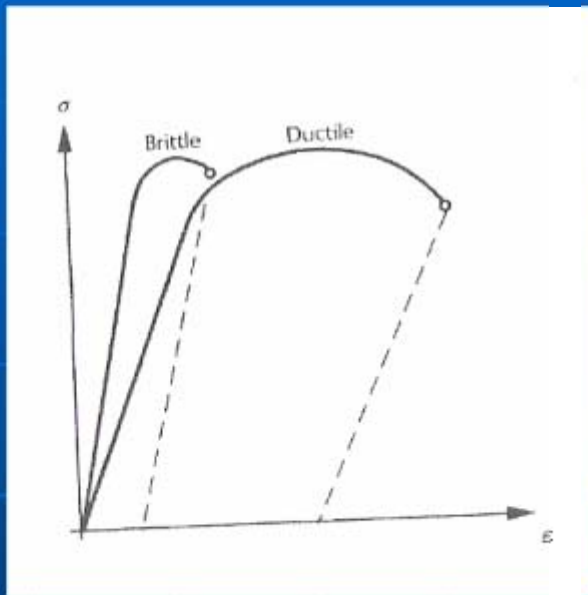
Stress-strain diagram



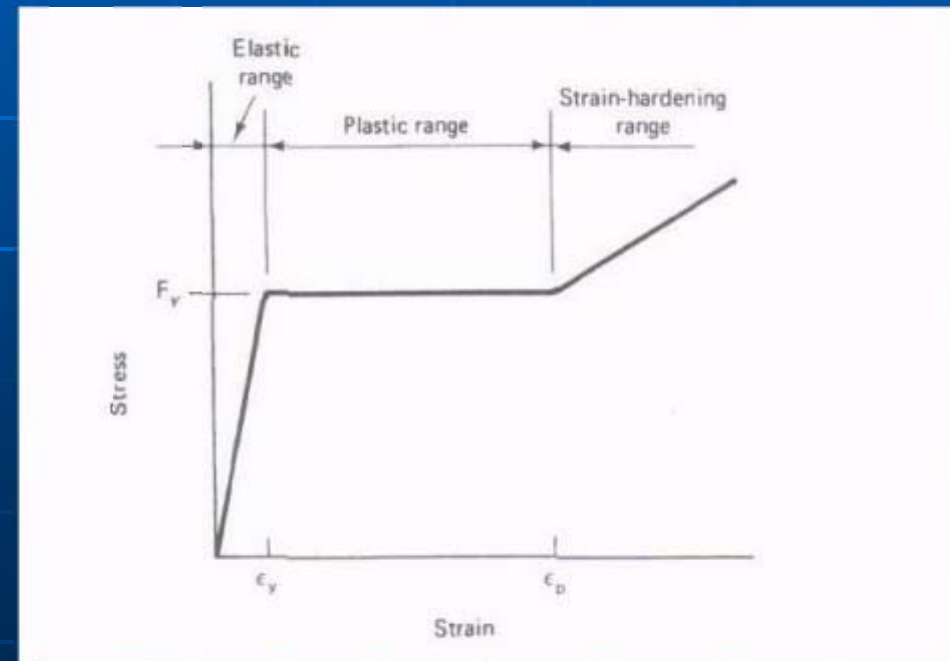
Stress-strain curve for steel

- If a piece of ductile structural steel is subjected to tensile force it will begin elongate.
- The amount of elongation will increase linearly within certain limits.
- When tensile stress reaches roughly equal to three-fourths of the ultimate strength the elongation will begin to increase at a greater rate without a corresponding increase in the stress.
- **Proportional limit:** The highest point of the linear portion (Hook's law applies)
- **Elastic limit:** The largest stress that material can withstand without being permanently deformed
- **Yield stress:** A significant increase in the elongation, or strain, without a corresponding increase in stress (The most important property for design)
- **Elastic strain:** The strain occurs before the yield stress
- **Plastic strain :** The strain occurs after the yield stress (with no increase in stress)

A steel structure has a reserve plastic strain that enables it to resist overloads and sudden shocks (ductility). If it did not have this ability it might suddenly fracture, like glass.



➤ ***Strain hardening:*** Following the plastic strain, the range additional stress is necessary to produce additional strain



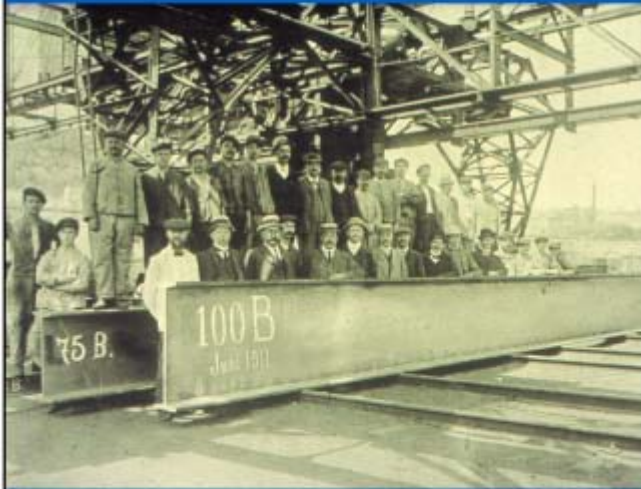
Tablo 3.1. Çelikler ve Mekanik Özellikleri

SATIR No.	1		2	3	4	5	6	7
	Çelik Cinsi ¹⁾		Kalınlık t mm	Akma gerilmesi σ_a kN/cm ² (t/cm ²)	Kopma mukavemeti σ_B kN/cm ² (t/cm ²)	Elastisite modülü E kN/cm ² (t/cm ²)	Kayma modülü G kN/cm ² (t/cm ²)	Lineer ısı genleşme katsayısı α_r
1	Yapısal Çelikler	St 37-2	t ≤ 40	24,0 (2,40)	36,0 (3,60)	21 000 (2100)	8 100 (810)	12 x 10 ⁻⁶
2		U St 37-2						
3		R St 37-2						
4		St 37-3	40 < t ≤ 80	21,5 (2,15)	(3,60)			
5		St 52-3	t ≤ 40	36,0 (3,60)	51,0			
6			40 < t ≤ 80	32,5 (3,25)	(5,10)			
7		St 44	t ≤ 16	27,5 (2,75)	42,0 - 55,0 (4,2 - 5,5)			
8			16 < t ≤ 40	26,5 (2,65)				
9			40 < t ≤ 65	25,5 (2,55)				
10	İnce Taneli Yapısal Çelikler	St E 355	40 < t ≤ 80	36,0 (3,60)	51,0 (5,10)			
11		W St E 355						
12		T St E 355						
13		E St E 355						
14	Döküm Çelikleri	GS-52		26,0 (2,60)	52,0 (5,20)			
15		GS-20 Mn 5	t ≤ 100	26,0 (2,60)	50,0 (5,00)			
16	Isıl İşlem Çeliği	C 35 N	t ≤ 16	30,0 (3,00)	48,0			
17			16 < t ≤ 80	27,0 (2,70)	(4,80)			

3.2 Structural steel production

- Steel is defined as a combination of iron and a small amount of carbon (Less than 1 percent) and also small percentages of some other elements.
- The first steel were accidentally present when iron was heated in contact with charcoal.
- Kelly and Bessemer added some needed elements to restore the impurities of molten iron.
- Today most of the structural steel shapes and plates are made by melting scrap steel. The molten steel is poured into molds that have approximately the final shapes of the member.
- The shapes may be further proceed by cold rolling, by applying various coatings, and by process of annealing (heated to an intermediate temperature range, held that temperature for several hours, and allow to slowly cool to room temperature-less hardness, greater ductility).
- Steel falls in between cast iron (≥ 2 percent carbon) and rough iron (≤ 0.15 percent carbon) and has carbon contents in the range of 0.15 and 1.7 percent.

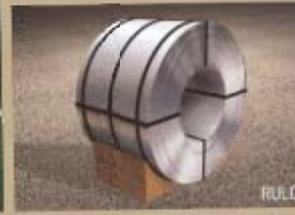
3.3 Sections



LEVHA



PAKET SAC



RULÖ



L-PROFIL



H-PROFIL



KÖŞEBENT



İNŞAAT DEMİRİ

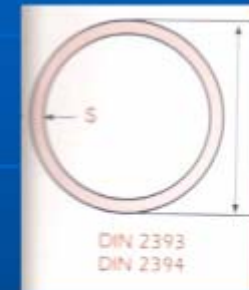
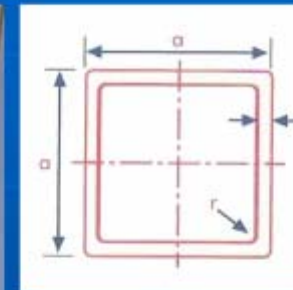
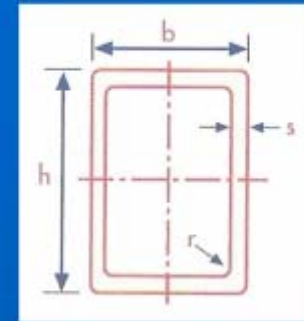
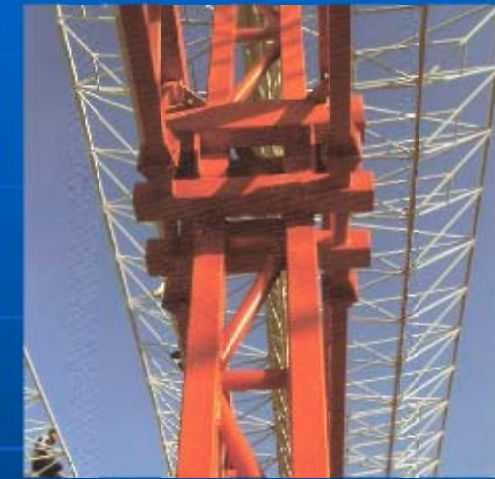


- **W – Shape (Wide Flange Beam):** Most commonly used for its good strength and easy availability. W-shapes have large moments of inertia around their principal axes, making them ideal for flexure with parallel inner and outer flange surfaces that are of constant thickness. This flange design provides greater strength than that of S shape.
- **S – Shape (American Standard I- Beam):** S-shape was the first beam section rolled in America but no longer widely used in building construction. It is a rolled section with two parallel, narrow flanges whose inner surfaces are sloped approximately 17 degrees connected by a web. It is used in monorails and crane runways.
- **HP – Shape:** This is similar to W-shape. But it is having width of web and flange equal but thicker than that of W-shape. Due to its higher strength, it is used only for withstanding the high impacts of a pile hammer.

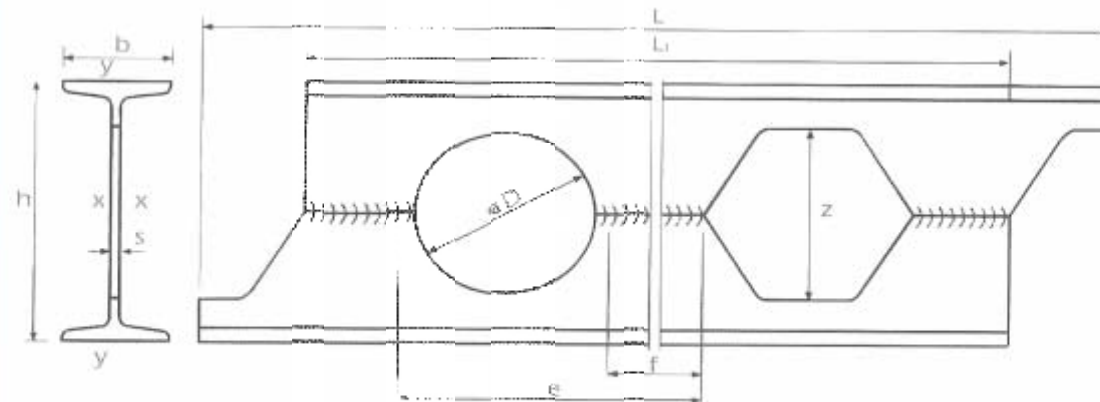
- **C – Channel:** Similar to S-shape, C shape has two narrow, tapering, parallel flanges except that it extends only on one side of the web. It is not effective as a beam or column. However, it is best to use for framing floor openings, stringers for steel stairs and stairwells. Efficient built-up members can be constructed out of channel assembled together with other structural shapes and connected by bolts or welds. The profiles of C-shapes available from different manufacturers are essentially the same.
- **M – Shape:** M-shapes are similar to W-shapes in cross sectional profile. These shapes are lightweight and cannot be classified as W, S, or HP shapes.
- **MC – Channel:** It is very similar to channel but differs with the width and slope of its flange. MC-shapes are special purpose channel other than the standard C-shapes. The availability of these shapes is limited and should be checked prior to specifying their use.

- **L – Angle:** It's legs may be equal or unequal and it is used for bracings, connections and trusses.
- **WT – Shape:** These shapes are manufactured directly from W, M, and S-shapes split longitudinally at mid-depth. However, these can also be produced by off-centre splitting as specified on order to the manufacturer. Structural tees are often used as top and bottom chords of pre-fabricated trusses and sometimes as lintels.
- **Pipe:** Steel pipe is also used as a structural member, specifically as column, in building construction. It has three classifications- the standard weight, extra strong, and double-extra strong. Its high strength-to-weight ratios give it excellent load bearing capabilities. It has also uniform wall thickness and exceptional concentricity simplifying fabrication and reducing material costs. It is used for handrails, columns and bollards.

- **HSS (Hollow Structural Shape)**: Earlier, it was referred as tubular section. Hollow Structural Section is high strength welded steel tubing used as structural elements in buildings and other structures and a variety of manufactured products. It is produced in round, square and rectangular shapes and a broad range of sizes. Benefits include aesthetic appeal, high strength to-weight ratios, uniform strength, cost effectiveness and recycling.
- **PL and FL Bars**: They are having a thickness greater than $1/8''$. They are used as base plate, cap plate, shear plate and end plate connections.
- **Sheet Metal**: Thickness less than $1/8''$ and is mostly not under the scope of a steel fabricator. It is referred as gage material.
- **Metal Deck**: Steel deck is made by cold forming structural grade sheet steel into a repeating pattern of parallel ribs. Standard deck width varies with the product used but full sheets are usually 12", 18", 24", 30" or 36". Deck is typically attached to the building frame with arc puddle welds, self drilling screws or powder or pneumatically driven pins. Sheet to sheet fastening is done with screws, button punching (crimping), or welds.



CASTELLATED BEAMS



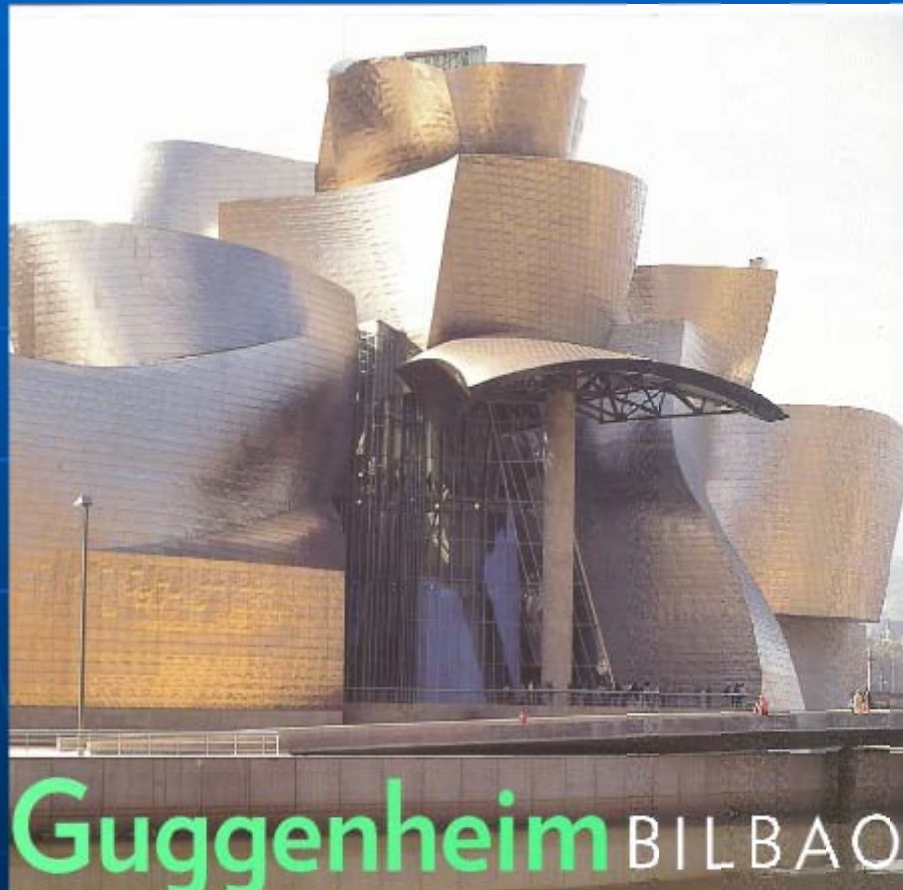
4. PROPERTIES OF STEEL BUILDINGS

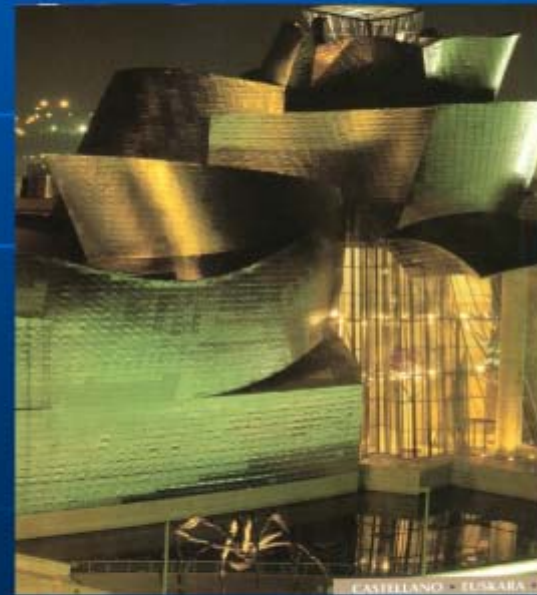
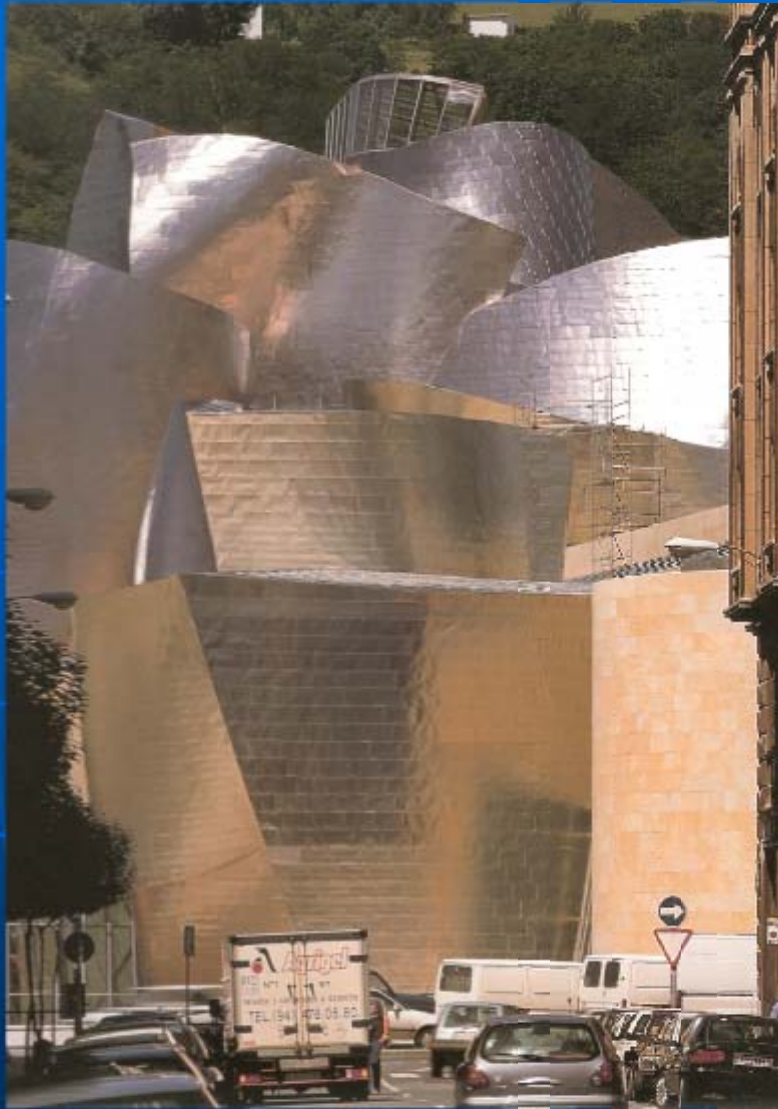
- Rapid construction in all weathers
- Ease of fabrication and speed of erection
- Easy field repair
- Design flexibility
- Renewable
- Components can be re-used
- Dimensional stability
- Repairing and strengthening
- Restoration and renovation
- Reduced form and scaffold
- Structure can start to function right after its completion
- Quality and comfort

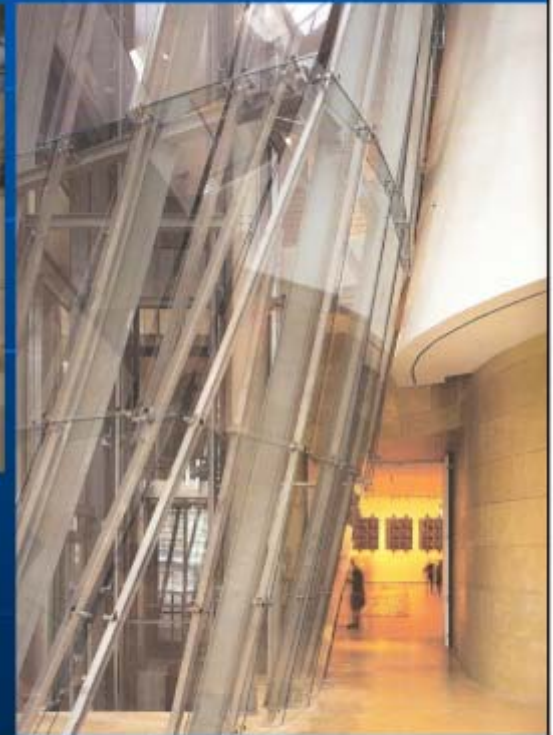
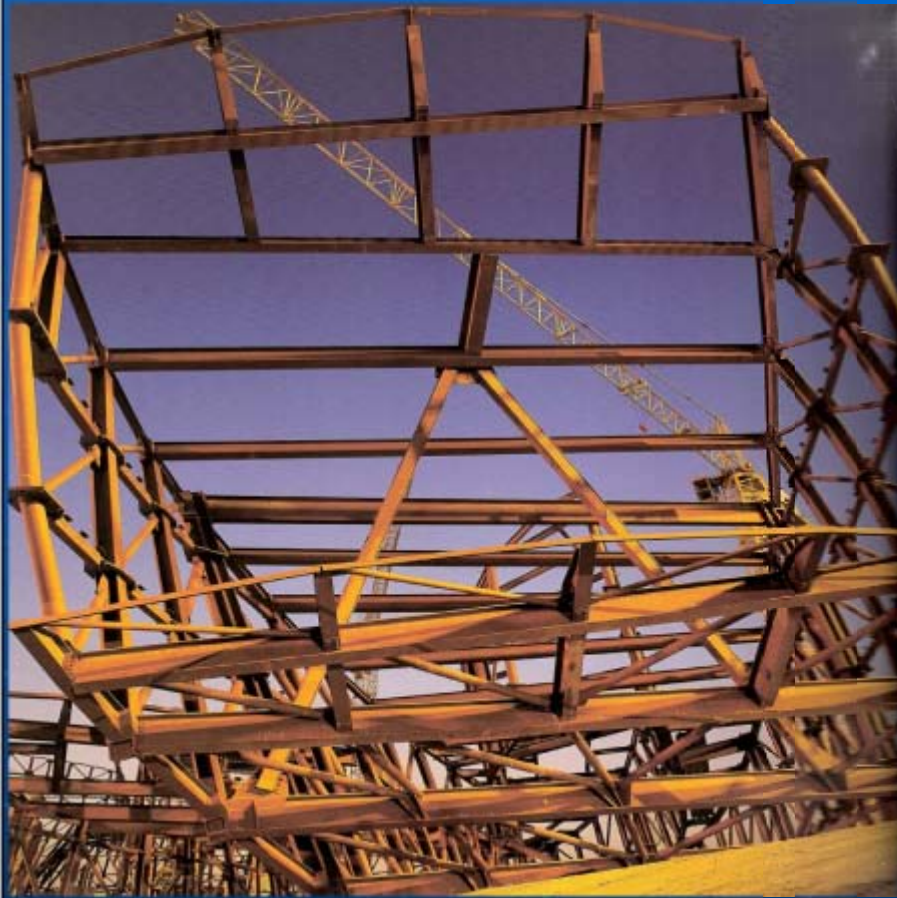


4.1 Architectural

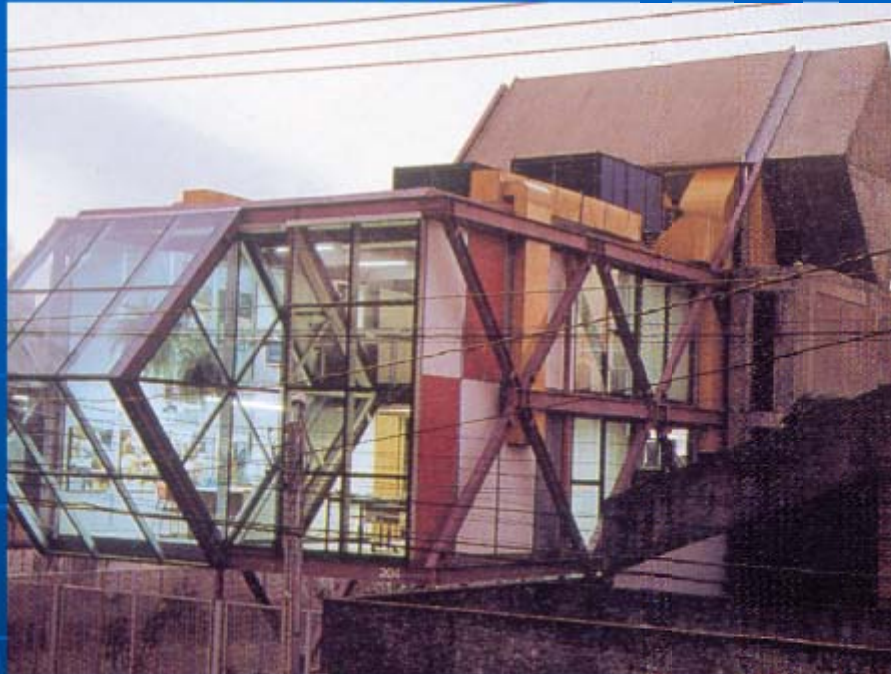
Steel creates architectural creativity and diversity.







Residences



Small offices



Altunizade residences



Borusan Showroom-İstanbul



Eczacıbaşı-Kanyon, İstanbul





- Reduced number of columns.
- Smaller beam and column sections.
- Thin slabs.



Column cross-sections

1000 kN, 3.6 m buckling length, 25 mm fire proof



B 45



140x140
235 MPa



120x120
235 MPa

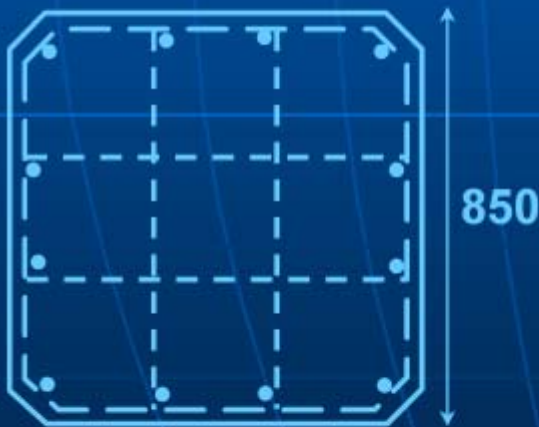


HEB180
235 MPa



HEA180
355 MPa

10 000 kN, 3.6 m buckling length, 25 mm fire proof



B 45



350x350
355 MPa



250x250
355 MPa

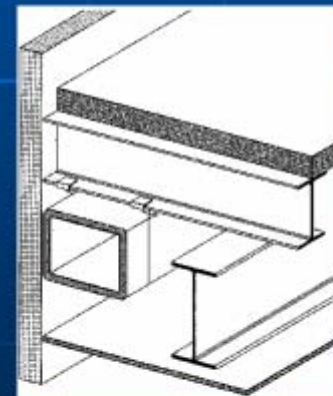
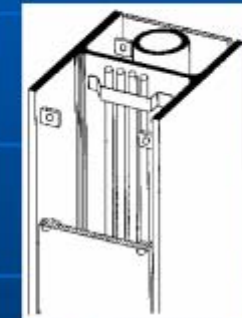
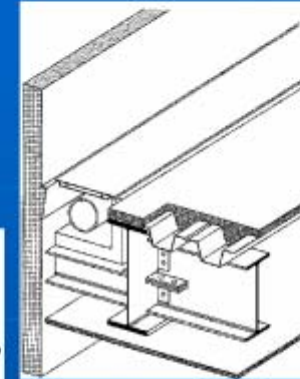
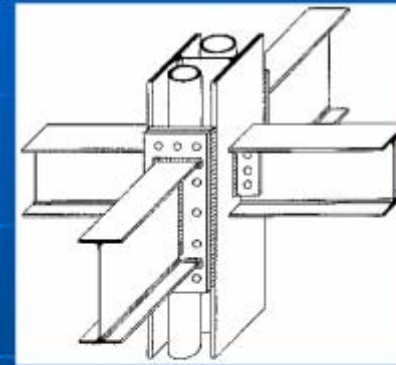


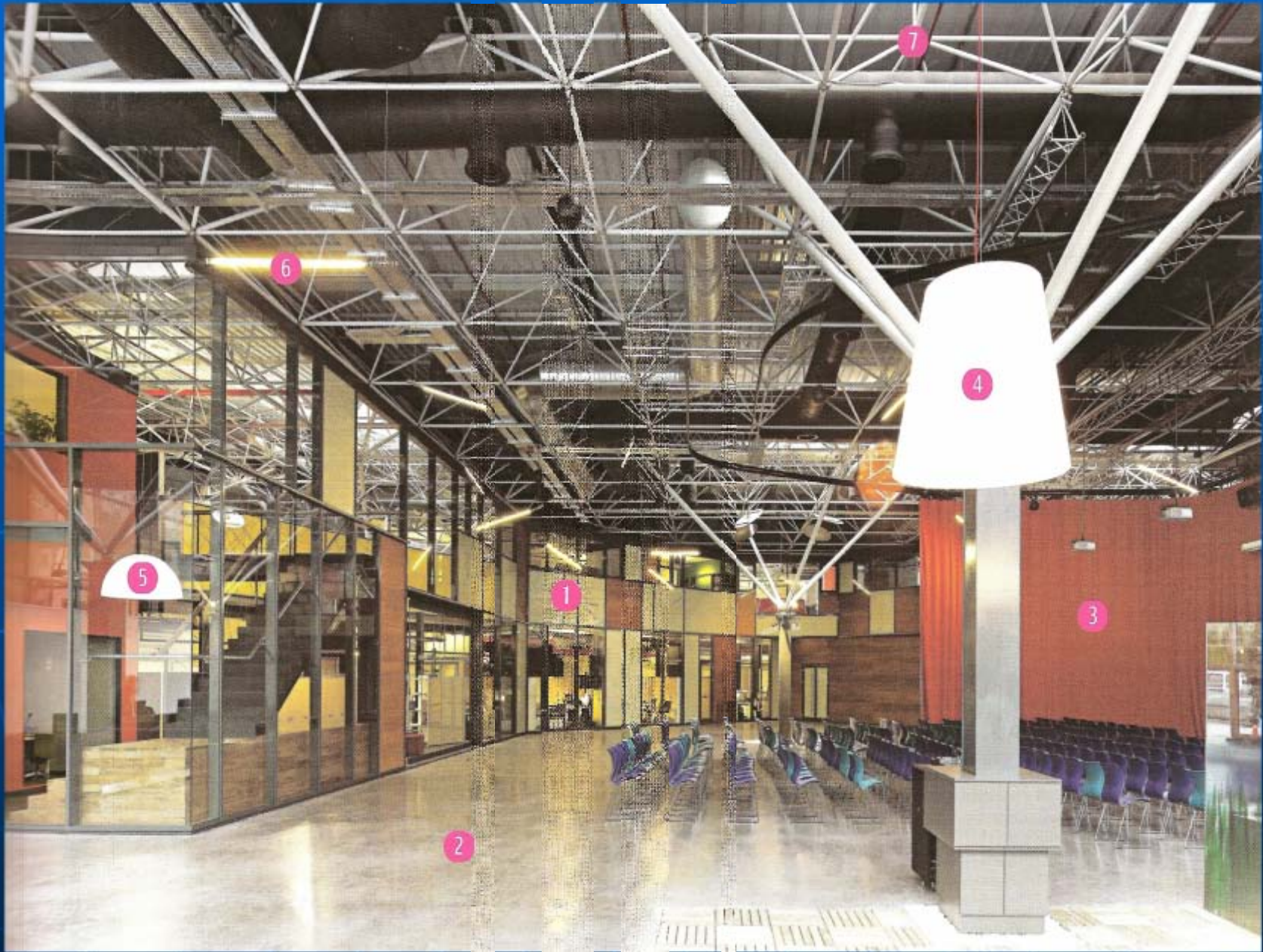
HD400x382
355 MPa



HD400x287
460 MPa

Space for installation.



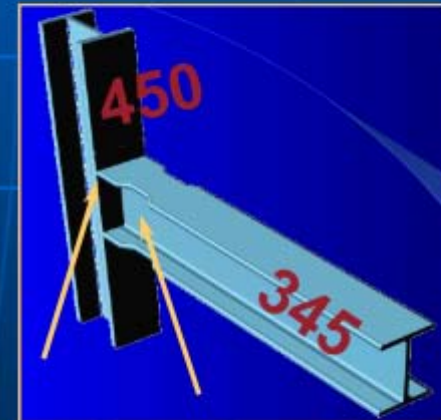


- **Space** : Clear spans achieved by using steel reduced number of supports, thereby increasing useable space, leading to increase flexibility of use of the enclosed space
- **Comfort**: The use of insulating materials improves acoustic, thermal and vibration comfort to acceptable or better levels, making the internal environment more peaceful and pleasant, bathing it in natural light coming through wide openings from outside.
- **Aesthetics**: Slender, elegant steel structures fit harmoniously into every kind of rural and urban environment. Steel structures are often used to renovate old buildings and can be adopted to both classical and contemporary styles.
- **Flexibility**: Steel solutions such as those used in office space with spans 18 meters, make it possible to rearrange the space to suit changes in use and thus support changing lifestyles and accommodate the any changes that lie ahead.
- **Freedom**: Opening up spaces, steel gives free rein to creativity. Because of its mechanical properties steel can accommodate any architectural design. It offers virtually infinite opportunities with respect to shape, colour and appearance.
- **Creativity**: Steel encourages architectural creativity and diversity. Though its ability to meet the highest technical standards while imposing few constrains with respect to shape, steel has given rise to an explosion in inventiveness.
- **Quality and comfort**: Because its structures have optimum weight/strength ratio steel opens up optimum, luminous space. Premises can be modified or enlarged to adapt to new uses or lifestyles and to improve the quality of life and comfort. The small amount of work required on site improves safety and convenience during the project.

4.2 Earthquake

Steel structural systems are advantageous in earthquake areas.

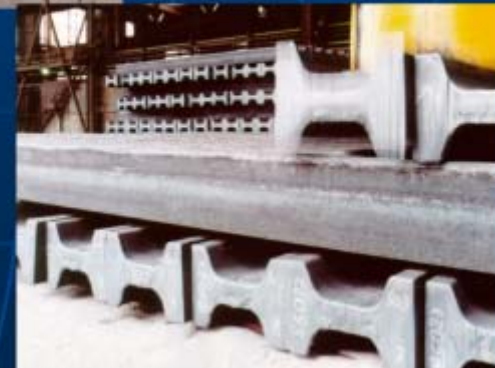
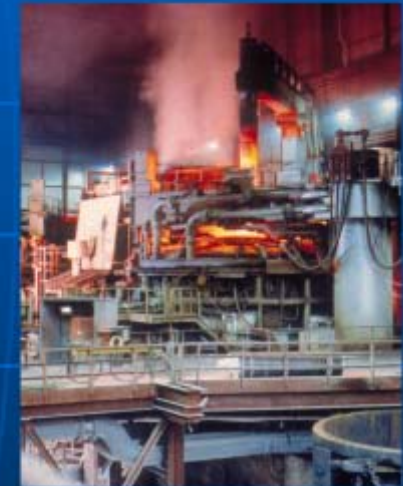
- Steel systems have low self-weight. So earthquake load is less than the other systems ($F=m*a$).
- The ability to absorb energy is in large amounts.
- Plastic hinges may occur and this gives more safety in design.



4.3 Recycling

Steel is 100% recyclable.

- 100% of the steel used in construction (all products) are recyclable. More over 80% of these steel have now themselves been produced from recycled steel. They conserve the planet's natural sources during construction by limiting the need for such materials as water and aggregates. Additionally, steel structures can be partly or completely dismantled and reused.



4.4 Quality

Structural steel is an industrial product.

- All parts of the structural system are built in a factory environment, according to standards and regulations and they have industrial quality guarantee. All structural steel materials can be seen and control, during the construction of the building and after it is built and used. This means transparency in every state of production and construction.



4.5 Environment

To built in steel is to respect the environment.

- Steel construction may be recycled indefinitely.
- Sections are produced exclusively from steel scrap.
- Use natural recourses and energy in a rational way.
- It is possible to construct buildings in very small construction sites. Work site is clean and does not generate dust and waste.
- The amount of work on site is limited and requires less transport
- Does not harm the environment in any stage of the construction. (Dry methods.)



4.6 Sustainability

- Less weight
- Small cross-sections
- Transparent facades
- Flexibility in design
- Easily modification or enlarging
- Re-use
- Recycling



A **sustainable building**, or **green building** is an outcome of a design philosophy which focuses on:

- ***increasing the efficiency of resource use***
– energy, water, and materials –
- ***reducing building impacts on human health and the environment***

during the building's lifecycle, through better siting, design, construction, operation, maintenance, and removal.

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

Effective green building can lead to:

- *reduced operating costs* by increasing productivity and using less energy and water,
- *improved public and occupant health* due to improved indoor air quality, and
- *reduced environmental impacts* by, for example, lessening storm water runoff and the heat island effect.

Practices

- Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off.

Material

- Building materials typically considered to be 'green' include rapidly renewable plant materials like bamboo
- The EPA (Environmental Protection Agency) also suggests using recycled industrial goods.

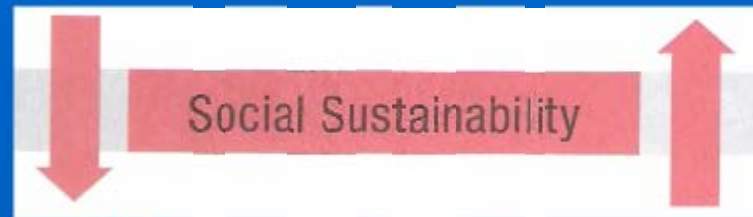
Reduced energy use

- To increase the efficiency of the building envelope, (the barrier between conditioned and unconditioned space), they may use high-efficiency windows and insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy homes.
- Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building.

Reduced waste

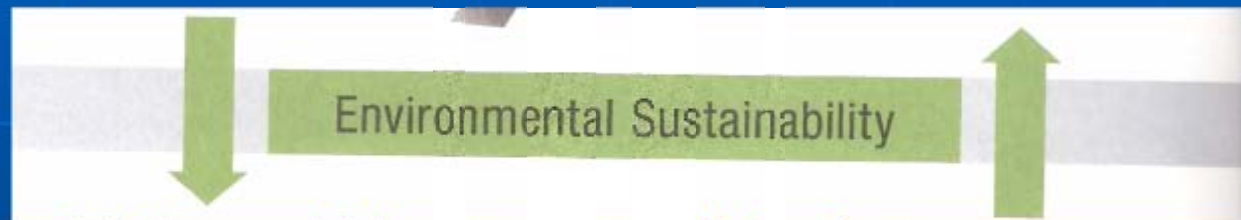
- During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills.
- Wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes.

The steel industry is an integral part of sustainable society.



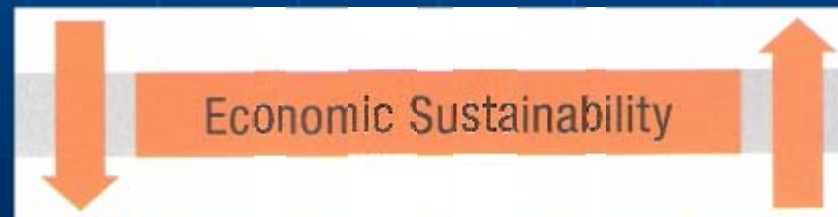
- Safe working environment
- Employee training and education
- Community healthcare and schools

- Talented employees
- License to operate



- Eco-efficient: %100 recyclable
- Synergies with other industries
- Responsible use of natural resources

- Natural resources
- Recycled steel
- Environmental laws and regulations



- Quality steel products
- Taxes and shareholders dividends
- Employees wages and benefits

- Capital
- Demand for steel products



4.7 Reconstruction without destruction

When steel buildings no longer have a reason for existence at the place in which they are located, they can be dismantled and rebuilt elsewhere. This solution has proved itself for buildings and car parks intended as temporary remedies to problems posed by current requirements.

So steel is reused in an optimum manner, and the costs of dismantling and reconstruction are generally less than those of a new construction.

4.8 Cost

All the factors affecting total cost has to be taken into consideration.

- Steel saves time. Prefabrication cuts construction time and allows accurate sequencing of the various building trades.
- Faster construction means reduced financing costs and leads to earlier rent income.
- The mechanical properties of steel make it both sturdy and lightweight, so smaller foundations are needed and structures can be built on soils with limited bearing capacity.
- Longer spans and large volumes can be achieved.
- Structural system elements are small this means more space to use.
- Re-use, recycling.

Economical design of steel members

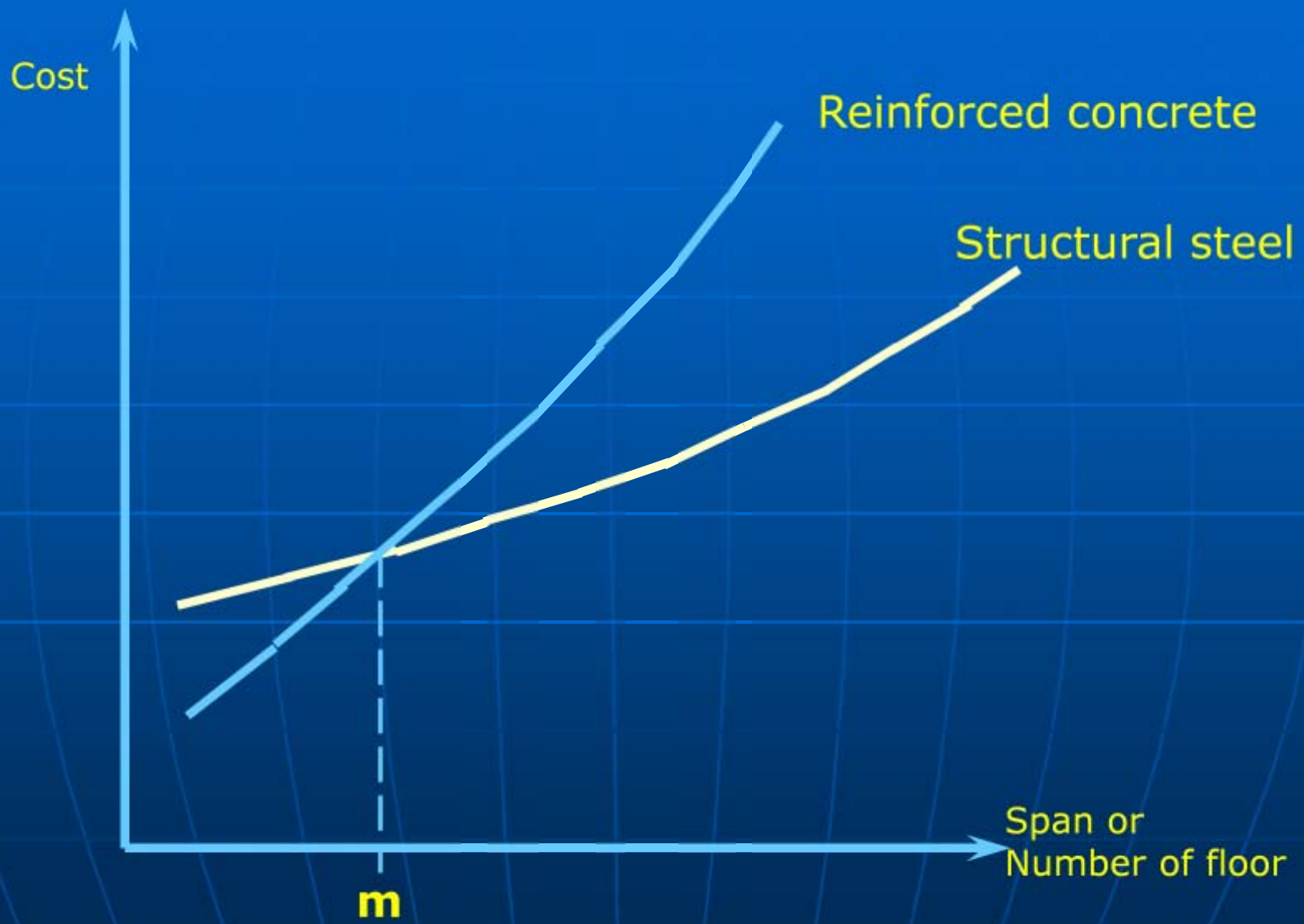
The labor cost of structural steel run close to 60 percent and material cost close to 25 percent of total cost.

Economical steel structures are the following:

- Open communications between all involved in a particular project.
- Information from the steel companies and steel warehouse about the sizes and lengths of sections available.
- To smooth out the sizes by selecting many members of the same sizes although some of them may be slightly oversized.
- The cost of erection and fabrication are approximately the same for light and heavy members (beams should be spaced as far apart as possible).
- Should be painted only if so required by the applicable specification.

- Repeating the same section will reduce the detailing, fabrication and erection costs.
- For larger sections (particularly the built-up ones) the designer needs to have information about transportation problems.
- Sections should be selected that are reasonably easy to erect and which have no conditions that will make them difficult to maintain (bridge members may be periodically painted).
- Every effort should be made to select steel members that will fit in with the requirements of filling (pipes, ducts, conduits) of the building.

Economy can be realized when fabrication is minimized.



4.9 With other materials

Visible or invisible, steel is paired with many other materials in construction.

It facilitates suitable combinations to enable both materials to be used to best effect.

- **Steel and concrete**

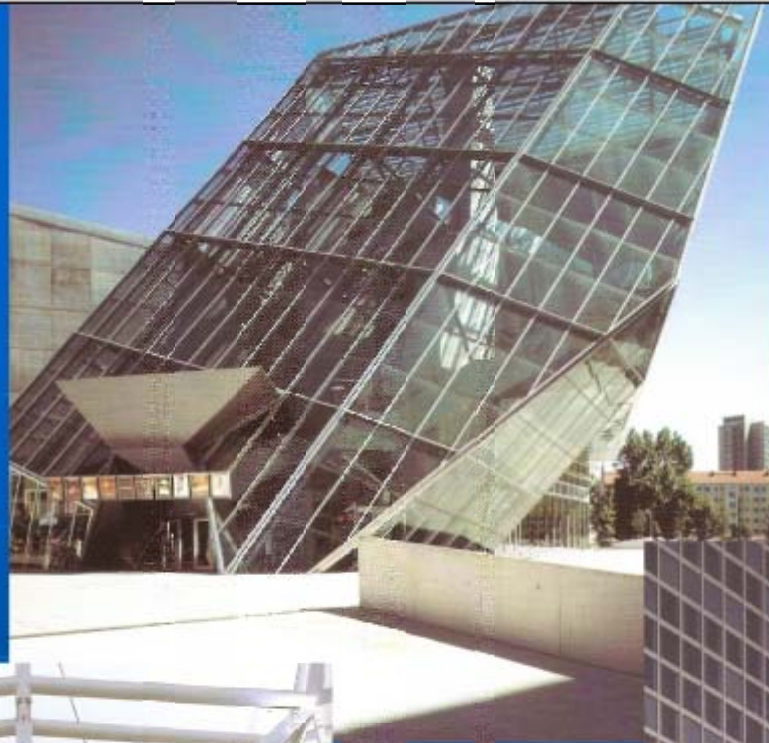
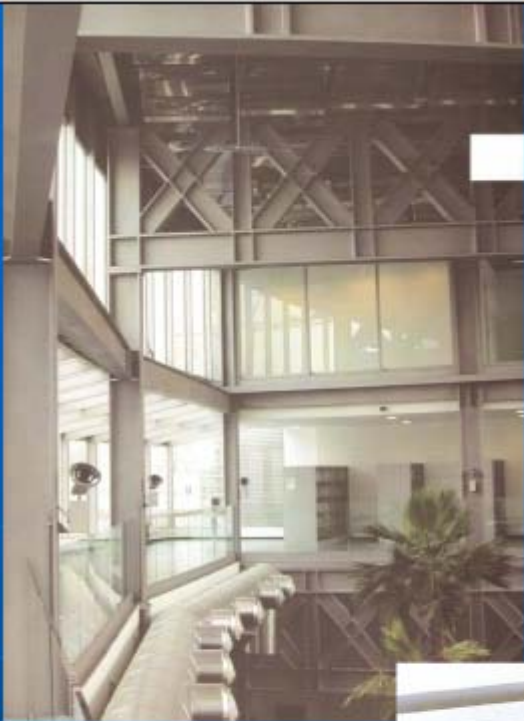
Composite construction makes the most of characteristics and advantages of both materials (floors, bridges and engineering structures). Composite construction achieves the best trade-off between mechanical performance, weight saving, aesthetics and cost.

- **Steel and glass**

In conjunction with glass, steel is light and transparent. Spectacular state-of-the-art solutions are possible (skylights, atriums, glass facades). Glass allows natural lighting so the combination saves energy.

- **Steel and wood**

Within the dry construction sector, steel is a natural partner for wood in all assembly functions (structure, facades, interior finishing, etc.), with warm, aesthetic and comfortable results.



4.10 Fireproofing

Although structural members are incombustible, their strength is tremendously reduced at temperatures commonly reached in fires. Furthermore steel is an excellent heat conductor non-fireproofed steel members may transmit enough heat from burning section or compartment of a building to ignite materials with which they are in contact in adjoining sections of the building. When steel is used in combination with other acceptable materials such as concrete and plaster, building code fire resistance requirements can be met or exceeded. And the building may have to include a sprinkler system.

Fire safety analysis.



➤ Fire safety

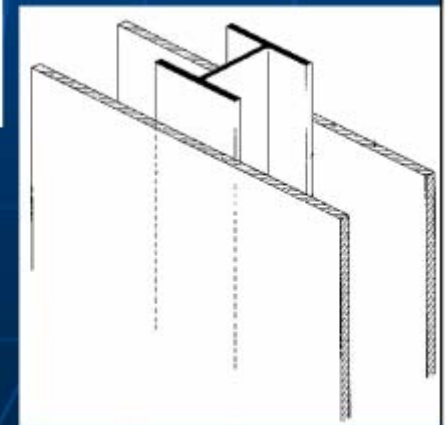
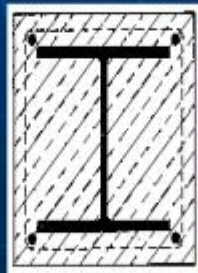
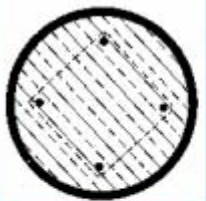
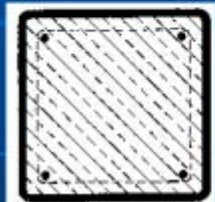
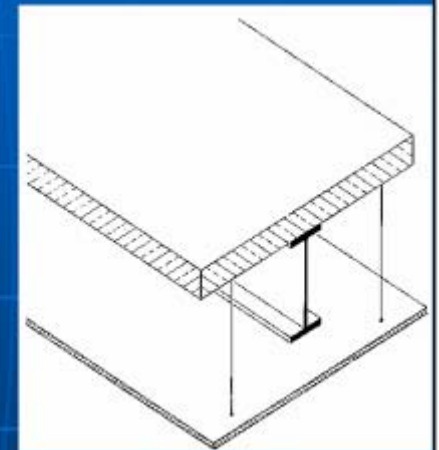
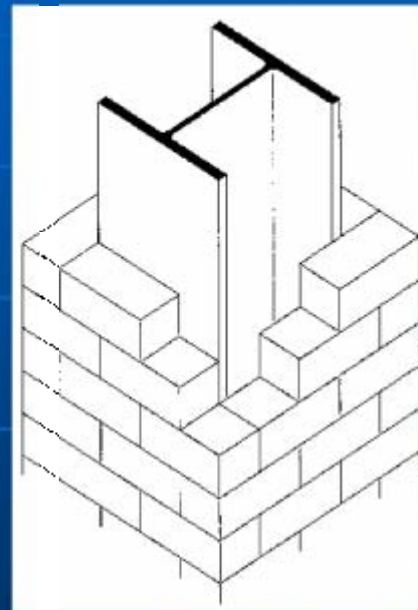
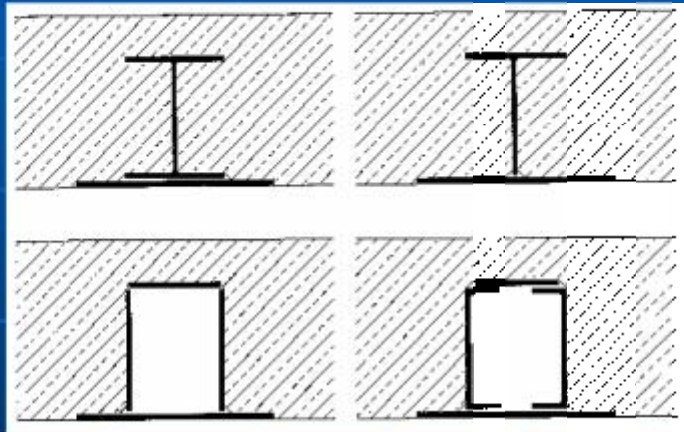
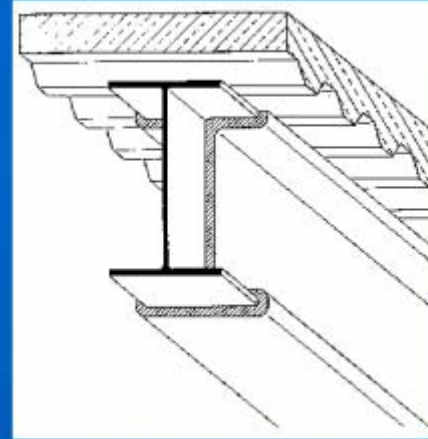
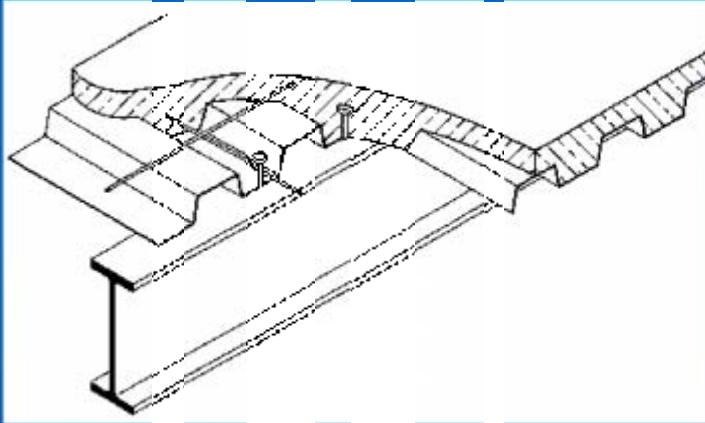
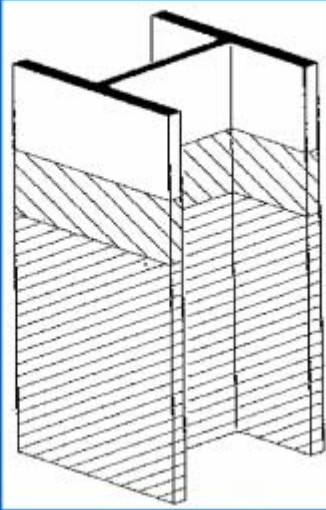
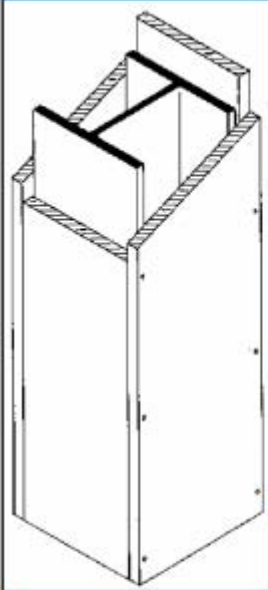
Active systems (fire detection systems, sprinkler systems)

Passive systems (To design the structure in such a way that it will achieve to resist in case of fire; some partitioning; special doors)

➤ Fire resistance: A period of time.

➤ Fire protection:

Unprotected Steel
Board Fire Protection
Sprayed Fire Protection
Intumescent Coatings
Composite Floors
Slim Floor Systems
Composite H Members
Concrete filled tubular columns
Shielded Members
Water filled structures



4.11 Corrosion

- Most steels are susceptible to corrosion when freely exposed to air and water, and therefore must be painted periodically.



4.12 Susceptibility to buckling

As the length and slenderness of a compression member is increased, its danger of buckling increases.

4.13 Fatigue

If steel is subjected to a large number of stress reversals or even to a large number of variations of tensile stress its strength may be reduced.

4.14 Brittle fracture

Under certain conditions steel may lose its ductility and brittle fracture may occur at places of stress concentrations. (Fatigue type of loadings; very low temperatures; three axial stress conditions.)

5. STEEL STRUCTURAL SYSTEMS

Structures may be divided into three general categories

➤ **Framed structures**

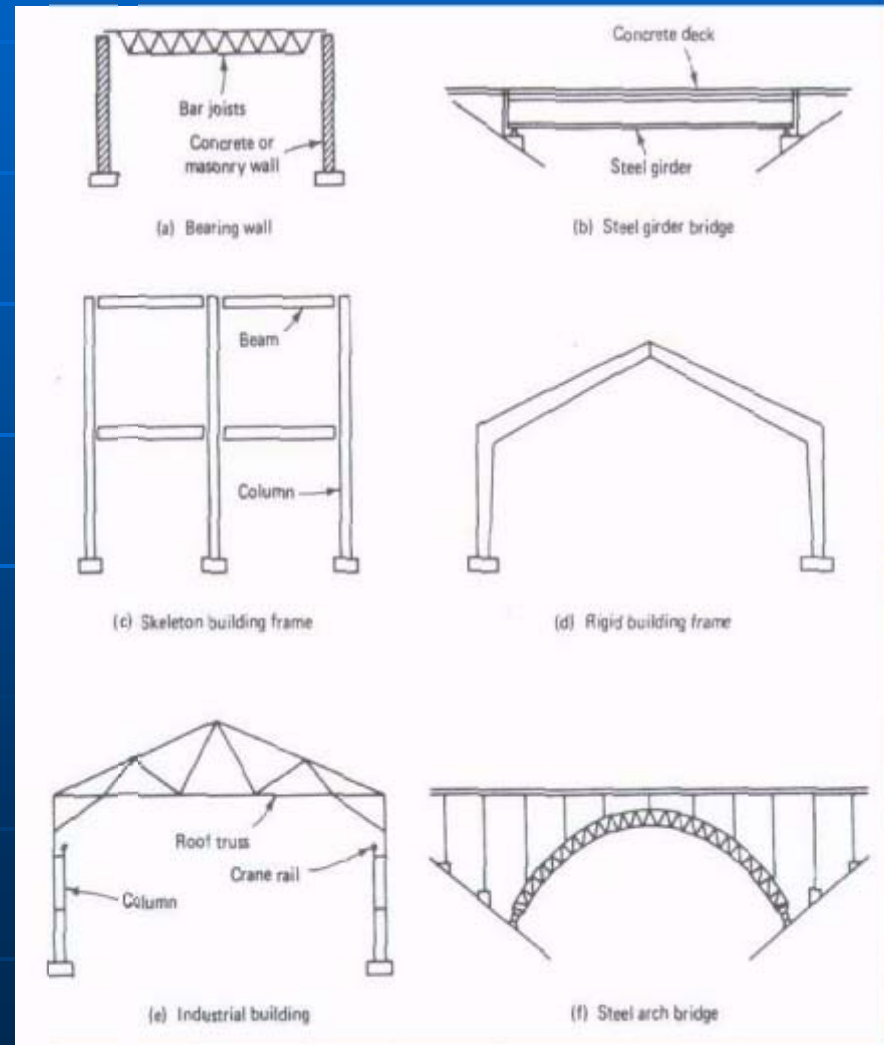
Most typical buildings

➤ **Shell Type Structures**

Tanks

➤ **Suspension Type Structures**

Bridges, roofs





It is advantageous to use steel structural systems in the following type of buildings

- Buildings on poor soil conditions
- Buildings in earthquake regions
- Multi storey and high rise buildings
- Industrial buildings
- Bridges
- Car parks
- Temporary buildings
- Rapid constructions
- Restoration and renovation constructions
- Repair and retrofitting

High rise buildings



Bridges



wowTUR

Fatih Sultan Mehmet Köprüsü



Industrial buildings



Car parks



Train station





Stadium

Swimming pool





Hospital

School



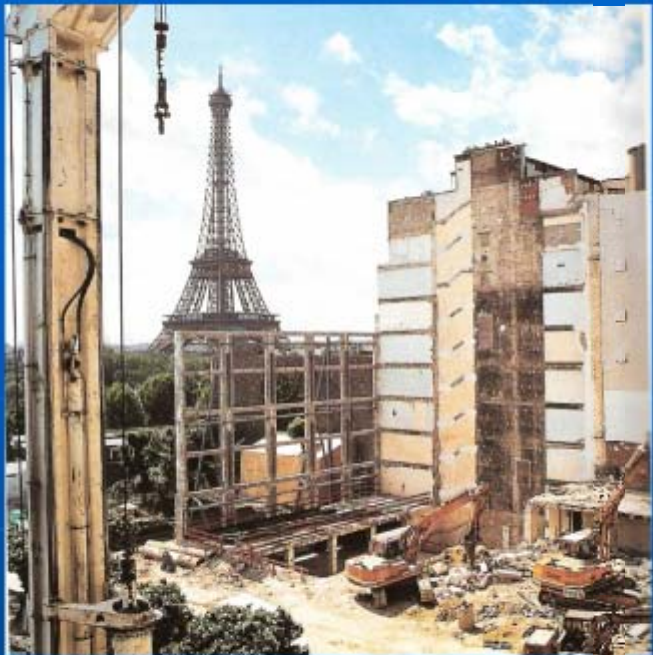


Leisure center

Shopping center



Restoration







Repairing



6. SPECIFICATIONS AND LOADS

- The design of most structures is controlled by building codes and specifications.
- Governments establish building codes which are actually laws or ordinances and vary from country to country. Codes specify design loads, design stresses, construction type, material quality and other factors.

IBC: International Building Code; EC: Euro Codes;
EN: Euro Norms; BS: British Standards;
DIN: German Norms

- Organizations publish recommended practices for regional or national use and their specifications are not legally enforceable.

AISI: American Iron and Steel Institute

AISC: American Institute of Steel Construction

AASHTO: American Association of State Highway and
Transportation Officials

Turkish Specifications and Building Codes for Steel Structures

TS 498 : Design Loads for Buildings

TS 648 : Building Code for Steel Structures

TS 3357 : Building Code for the Design and Execution of
Welded Connections in Steel Structures

Turkish Earthquake Code-2007

6.1 Loads

Loads are classified according to their character and duration of application. (Dead Loads, Live Loads, Environmental Loads.)

Dead Loads: Loads of constant magnitude that remain in one position (Structural frames own weight and other loads that are permanently attached to the frame).

Live Loads: Loads that may be change in position and magnitude. Floor loads, Traffic loads for bridges, Impact loads, Longitudinal loads, Soil pressure, Hydrostatic pressure, Thermal force, Centrifugal force.

Environmental Loads: Snow load, Rain load, Wind load, Earthquake load.

- These loads are referred to as service or working loads.
- Various combinations of these loads that feasibly occur at the same time are grouped together.

6.2 Loads and Loading Cases due to (TS 498)

1. First Group loads

For Buildings: Weights, snow load, crane load, dead loads (loads permanently attached to the structure).

For Bridges: Weights, traffic loads.

2. Second Group loads

For Buildings: Wind load, earthquake load, temperature effects, mounting loads.

For Bridges: Wind load, earthquake load, temperature effects, snow load, support friction load, mounting loads.

Loading Case I (LC I) : First Group loads

**Loading Case II (LC II): First Group loads +
Second Group loads**

7. METHODS OF DESIGN

AISC Specification provides two acceptable methods:

- **Allowable Stress Design (ASD):** $R_n/\Omega \geq R_a$
(Nominal strength of member)/(Safety factor) \geq Largest computed force
- **Load and Resistance Factor Design (LRFD):** $\Phi R_n \geq R_u$
(Resistance factor)x(Nominal strength of member) \geq Computed factor force

Nominal strength: Calculated theoretical strength with no safety factors or resistance factors.

Safety factor (Ω) is a number greater than 1.0

Resistance factor (Φ) is a number less than 1.0

In general $\Omega = \Phi / 1.5$

Load factors and safety factors are subject to so many uncertainties:

- Material strength may vary from their assumed values (creep, corrosion, fatigue).
- The method of analysis are often subject to errors.
- Hurricanes, earthquake etc. cause conditions difficult to predict.
- The stresses produced during fabrication and erection are often severe. They may exceed the stresses occur after the structure is completed.
- There are technological changes that affect the magnitude of live loads. (Dead loads can usually be estimated quite closely.)
- Presence of residual stresses and stress concentrations, variation of dimensions of the member cross section and so on.

“The European Steel Design Awards”

given by

**European Convention for
Constructional Steelwork
(ECCS)**

Winner Turkish Projects since 1997

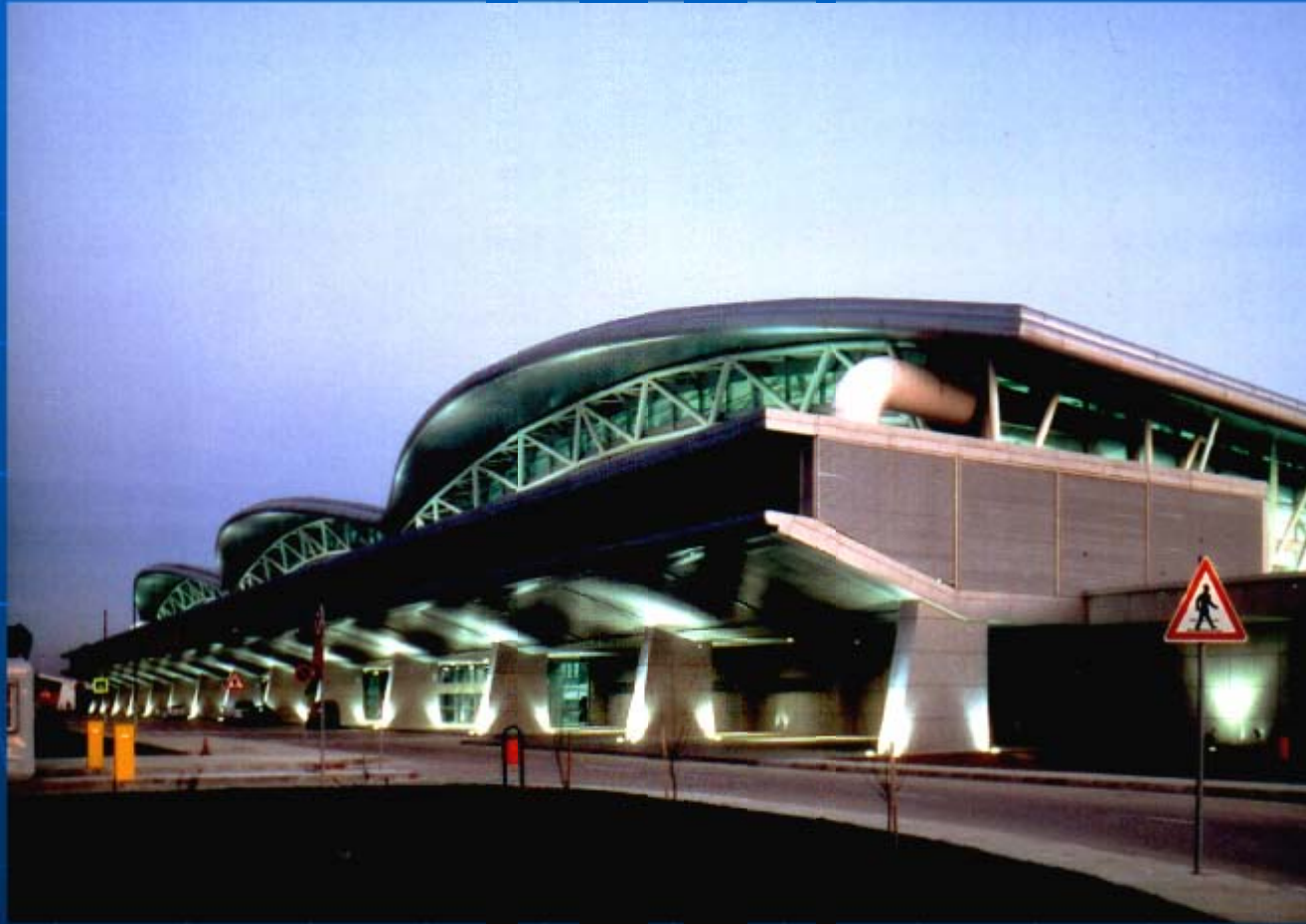
Tatilya-İstanbul 1997 ECCS Design Award



Glass Pyramid -Antalya 1999 ECCS Design Award



Sabiha Gökçen Airport-İstanbul 2001 ECCS Design Award



Bahar Car Park-İstanbul 2003 ECCS Design Award



Bilgi University Campus-İstanbul 2005 ECCS Design Award

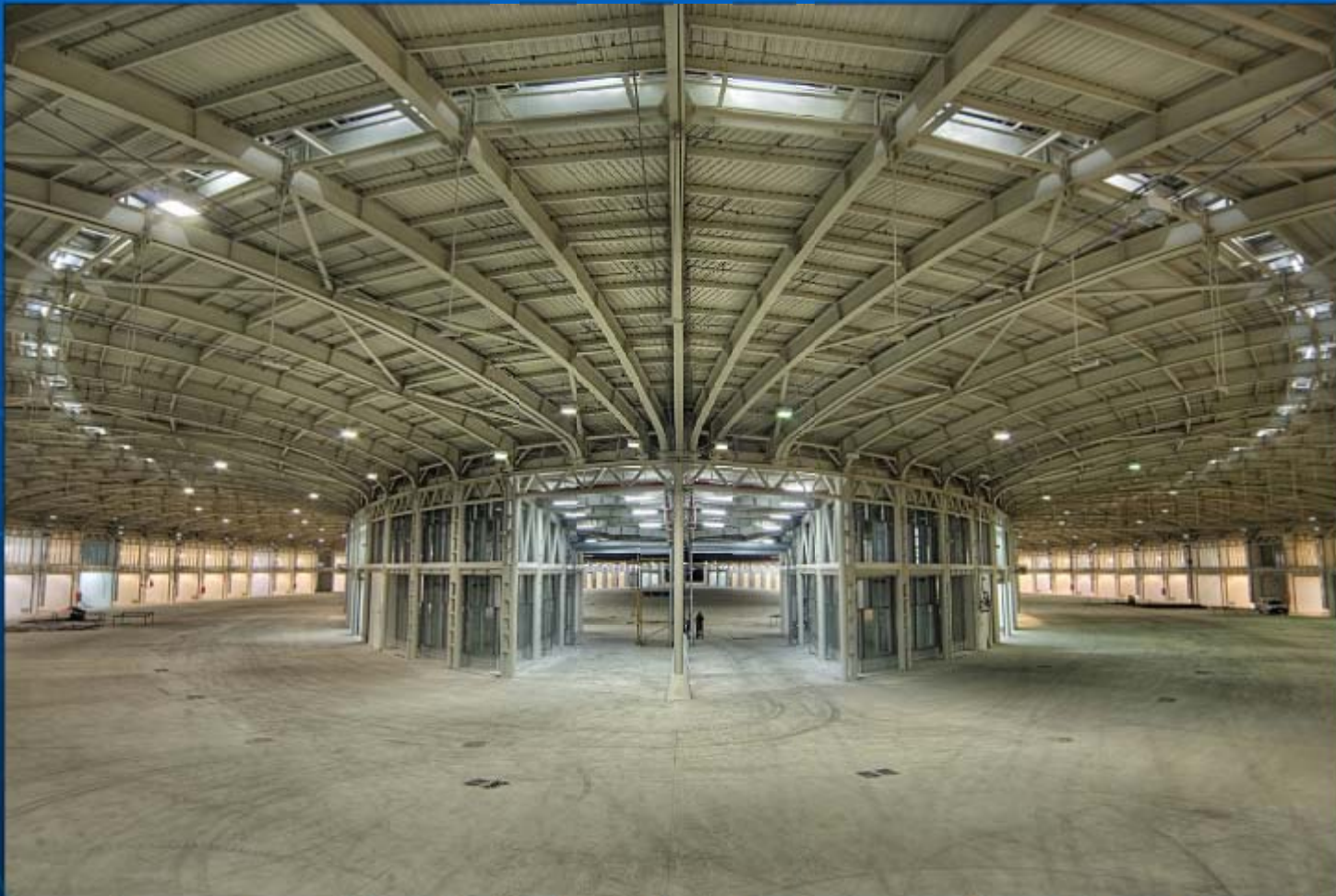


Adnan Menderes Airport-İzmir 2007 ECCS Design Award



Greengrocers & Fishmongers Market – Bursa

2009 ECCS Design Award



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