

6.0 `STEEL TECHNOLOGY

Introduction

Steel, an [alloy](#) of iron and carbon by far the most widely used material for [building](#) the world's [infrastructure](#) and industries, it is used to fabricate everything from sewing needles to [oil](#) tankers. Steel displays a number of properties not found in other materials; for example, high tensile and compressive strength, the ability to deform plastically without damage, rapid surface oxidation in the atmosphere; good heat and electrical conduction properties.

The main reasons for the popularity of steel are the relatively low cost of making, forming, and processing it, the abundance of its two raw materials (iron [ore](#) and scrap), and its unparalleled range of mechanical properties.

Steel products used in construction can be classified as follows:

1. structural steel for use in plates, bars, pipes, structural shapes, etc. Fig 1
2. fastening products used for structural connections, including bolts, nuts and washers
3. reinforcing steel (rebars) for use in concrete reinforcement Fig. 2
4. miscellaneous products for use in such applications as forms and pans



Truss made of structural steel for the structural support of a building.



Steel rebars used to reinforce portland cement concrete wall.

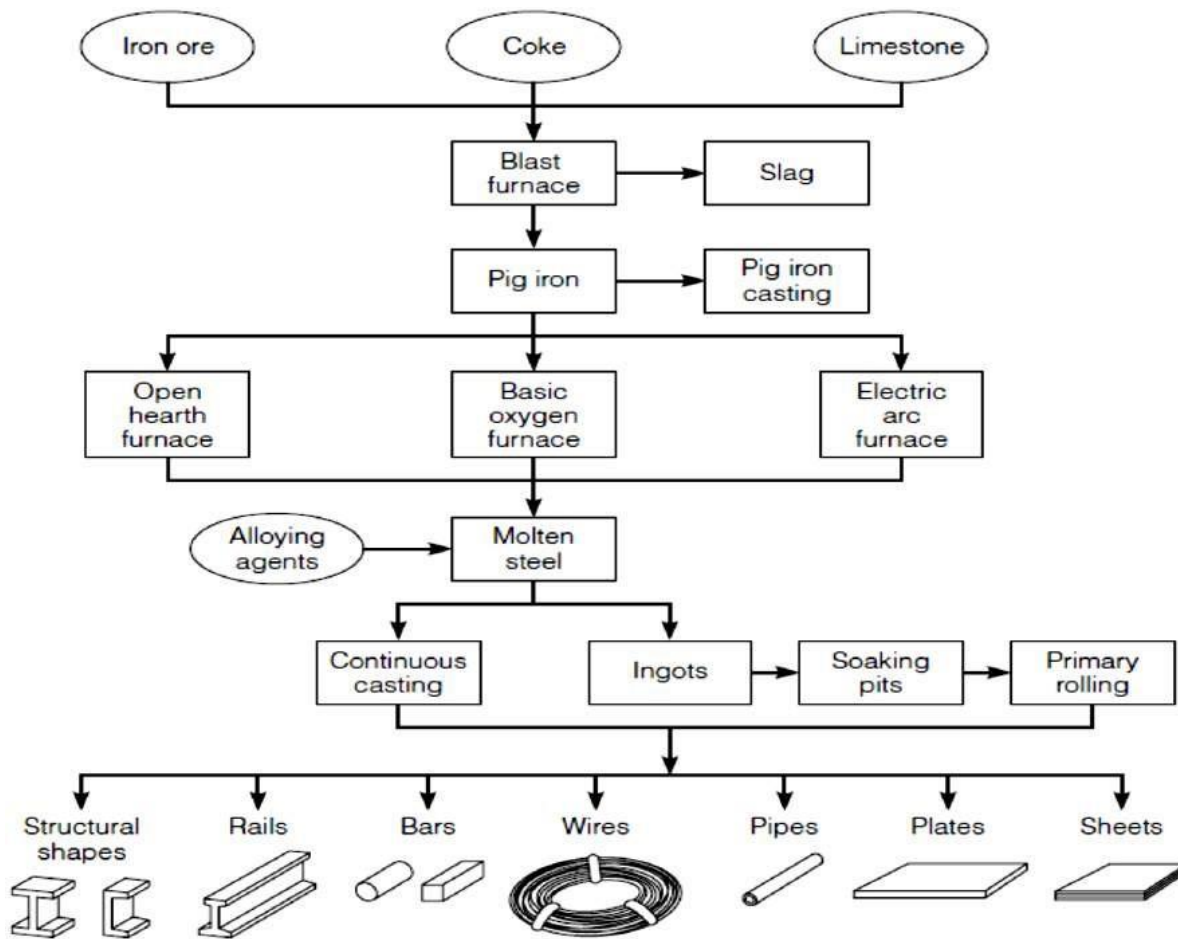
Civil and construction engineers rarely have the opportunity to formulate steel with specific properties. Rather, they must select existing products from suppliers. Even the shapes for structural elements are generally restricted to those readily available from manufacturers. While specific shapes can be made to order, the cost to fabricate low-volume members is generally prohibitive. Therefore, the majority of civil engineering projects are designed using standard steel types and structural shapes.

Even though civil and construction engineers are not responsible for formulating steel products, they still must understand how steel is manufactured and treated and how it responds to loads and environmental conditions.

Steel Production

The overall process of steel production is shown in Fig. 3. This process consists of the following three phases:

1. reducing iron ore to pig iron
2. refining pig iron to steel
3. forming the steel into products



Conversion of raw material into different steel shapes.

The materials used to produce pig iron are coal, limestone, and iron ore. The coal, after transformation to coke, supplies carbon used to reduce iron oxides in the ore. Limestone is used to help remove impurities. Prior to reduction, the concentration of iron in the ore is increased by crushing and soaking the ore. The iron is magnetically extracted from the waste, and the extracted material is formed into pellets and fired. The processed ore contains about 65% iron.

Reduction of the ore to pig iron is accomplished in a blast furnace. The ore is heated in the presence of carbon. Oxygen in the ore reacts with carbon to form gases. A flux is used to help remove impurities. The molten iron, with an excess of carbon in solution, collects at the bottom of the furnace. The impurities, slag, float on top of the molten pig iron.

The excess carbon, along with other impurities, must be removed to produce high-quality steel. Using the same refining process, scrap steel can be recycled.

Three types of furnaces are used for refining pig iron to steel:

1. open hearth
2. basic oxygen
3. electric arc

The open hearth and basic oxygen furnaces remove excess carbon by reacting the carbon with oxygen to form gases. Lances circulate oxygen through the molten material. The process is continued until all impurities are removed and the desired carbon content is achieved. Open hearth furnaces have been used since the early 1900s. Now, due to greater efficiency and productivity, basic oxygen furnaces are the industry standard for high-production mills.

A basic oxygen furnace can refine 280,000 kg (300 tons) of steel in 25 minutes, compared with the eight hours it takes to refine the same quantity of steel in an open-hearth furnace.

Electric furnaces use an electric arc between carbon electrodes to melt and refine the steel. These plants require a tremendous amount of energy and are primarily used to recycle scrap steel. Electric furnaces are frequently used in minimills, which produce a limited range of products. In this process, molten steel is transferred to the ladle. Alloying elements and additional agents can be added either in the furnace or the ladle.

During the steel production process, oxygen may become dissolved in the liquid metal. As the steel solidifies, the oxygen can combine with carbon to form carbon monoxide bubbles that are trapped in the steel and can act as initiation points for failure. Deoxidizing agents, such as aluminum, ferrosilicon and manganese, can eliminate the formation of the carbon monoxide bubbles.

Completely deoxidized steels are known as killed steels. Steels that are generally killed include

- Those with a carbon content greater than 0.25%
- All forging grades of steels
- Structural steels with carbon content between 0.15 and 0.25 percent
- Some special steel in the lower carbon ranges

Regardless of the refining process, the molten steel, with the desired chemical composition, is then either cast into ingots (large blocks of steel) or cast continuously into a desired shape. Continuous casting is becoming the standard production method, since it is more energy efficient than casting ingots, as the ingots must be reheated prior to shaping the steel into the final product.

Steel Reinforcement

Steel reinforcing bars are produced from molten steel, by forming it into large rectangular billets and then running it through a series of dies, which shape the steel into reinforcing bars. During the forming

process, deformations are formed in the surface of the bars that are used to help in transferring loads between the concrete and the reinforcing steel.

Steel reinforcement are steel bars that are provided in combination with plain cement concrete to make it reinforced concrete. Hence these structures form steel reinforced cement concrete structure (R.C.C). Steel reinforcement is commonly called as 'rebars'.

Need for Steel Reinforcement

Steel reinforcement bars or rebars are used to improve the tensile strength of the concrete, since concrete is very weak in tension, but is strong in compression. Steel is only used as rebar because elongation of steel due to high temperatures (thermal expansion coefficient) nearly equals to that of concrete.

The tensile property provided by the steel reinforcement will prevent and minimize concrete cracks under tension loads. The coefficient of thermal expansion of steel reinforcement and concrete are similar in that they undergo similar expansions during temperature changes. This property will ensure that the concrete is subjected to minimal stress during temperature variations. The surface of the steel reinforcement bars is patterned to have a proper bond with the surrounding concrete material.

The two main factors that provide strength to the concrete structures are steel and concrete. The design engineer will combine both the elements and design the structural element such a way that the steel resists the induced tensile and shear force, while the concrete takes up the compressive forces.

Types of Steel Reinforcement

The steel reinforcement used in concrete construction is mainly of 4 types. They are:

1. Hot Rolled Deformed Steel Bars
2. Cold Worked Steel Bars
3. Mild Steel Plain Bars
4. Prestressing Steel Bars

- 1. Hot Rolled Deformed Bars:** Hot rolled deformed bars are most commonly used steel reinforcement for R.C.C structures. As the name says, the hot rolling of the reinforcement is undergone leaving certain deformations on its surface in the form of ribs. These ribs help to form a bond with the concrete. The typical yield strength of hot-rolled deformed bars is 60000psi.



Hot Rolled Steel Bars

2. **Cold Worked Steel Bars:** A cold worked reinforcement bar is obtained by letting the hot rolled steel bars to undergo cold working. In the cold working process, the bars will undergo twisting and drawing. The process is performed at room temperature. The cold worked steel bars do not undergo a plastic yield thus have less ductility when compared with hot rolled bars.
3. **Mild Steel Plain Bars:** The mild steel plain reinforcement bars do not have ribs on their surface. They have a plain surface. These bars are used for small projects where the major concern is the economy. The tensile yield strength of these bars has a value of 40000psi.

3. **Mild Steel Plain Bars:** The mild steel plain reinforcement bars do not have ribs on their surface. They have a plain surface. These bars are used for small projects where the major concern is the economy. The tensile yield strength of these bars has a value of 40000psi.



Mild Steel Bar

4. **Prestressing Steel Bars:** The prestressing steel reinforcement are steel bars used in the form of strands or tendons. Multiple strands are employed in concrete in order to perform the prestressing action. The strands are made of multiple wires either 2 or 3 or 7 wire strands. The wires used here are cold

formed and have a high tensile strength ranging from 250000 – 270000 psi. This high strength helps to effectively prestress the concrete.

Advantages of Steel Reinforcement

Steel reinforcement is a reinforcing choice compared to other reinforcing materials due to its unique advantages. They are:

1. **Compatibility with Concrete:** The fresh concrete is placed on the formwork mold already prepared with reinforcement. The steel reinforcement won't float in concrete during the concrete placing procedure. Hence, steel reinforcement does not demand special tying up with formworks.
2. **Robustness of Steel Reinforcement:** The steel bars are robust in nature that they have the ability to withstand the rigors, the wear and tear during the construction activities.
3. **Bent Property of Steel Reinforcement:** The steel bars once manufactured to standard size, it can be bent to the required specifications. Hence fabricated steel bars are delivered easily at the site.
4. **Recycling Property:** The steel reinforced left over after the service life of a structure is recycled again and used for new construction.
5. **Easily Available:** Every region of a country will have a steel supplier or manufacturer. Hence steel reinforcement is easily available.

Disadvantages of Steel Reinforcement

The main disadvantages of steel reinforcement are mentioned below:

1. **Reactive Nature of Steel Reinforcement:** In concrete structures where the cover is small and subjected to external moisture and salt action, the reinforcement undergoes reaction and starts to corrode. These can lessen the strength of concrete and finally to failure.
2. **Expensive:** The cost of steel reinforcement is high. This will increase the cost of construction
3. **Melts at high temperature:** At higher temperatures, the steel reinforcement may melt. This is the reason why the steel reinforcement is tied up and not welded.

Properties of Rebars

Steel is ideal for reinforced concrete due to some unique factors:

- **Elastic properties** – The modulus of all steel reinforcement is 29,000,000 psi and this value may be used in design. This uniform modulus for all grades and bar sizes simplifies the design process. Materials with lower moduli may require additional bars to provide the same serviceability and

structures designed with these materials may experience increased deflections and additional cracking. Steel has similar elastic properties under both tensile and compression loads.

- **Elongation under load** – Steel reinforcement has significant elongation under load providing for well-defined cracks in the structure during overload conditions. Such cracking provides suitable warning for occupants regarding the loading of a structure. Materials that do not exhibit non-elastic behavior under load may not provide sufficient ductility to warn of impending failure.
- **Uniform properties in 3D** – Steel reinforcement generally has uniform properties in all directions and the shear strength is similar to the longitudinal yield strength.
- **Fatigue** – The fatigue properties of steel reinforced concrete structures are well understood.
- **Bond development** – The development strength of reinforcing steel in both straight and bent conditions is well researched and understood.
- **Yield** – At loads less than yield, steel exhibits elastic properties that enable a structure to rebound upon reloading. Steel reinforcement is available with yield strengths from 40 to 100 ksi. The yield strength of steel is not dependent on the bar diameter and substitution of different combinations of bars with the same bar area may be readily provided. This provides flexibility in the methods of obtaining the same properties in a concrete structure.
- **Thermal properties** – The modulus of thermal expansion of steel reinforcement is very similar to that of concrete. Due to the similarity of concrete and steel thermal properties additional stresses or deflections are not introduced upon heating the concrete structure.
- **Strength retention** – Under heating from fire, steel is able to withstand high temperatures before strength and ductility properties change. Many concrete structures that have been subjected to fire can be rehabilitated using the existing reinforcing steel.
- **Joining** – Steel reinforcement can be joined using welding or couplers that have strengths similar to that of the reinforcing steel.
- **Code Acceptance** – Steel reinforcement is accepted by all concrete design codes worldwide.

Corrosion, Definition and Prevention

Corrosion is when a refined metal is naturally converted to a more stable form such as its oxide, hydroxide or sulphide state this leads to deterioration of the material.

Corrosion of steel is an electrochemical reaction that requires the presence of water (H_2O), oxygen (O_2) and ions such as chloride ions (Cl^-), all of which exist in the atmosphere. Atmospheric chloride ions are in greatest abundance anywhere near the coastline. This electrochemical reaction starts when atmospheric oxygen oxidizes iron in the presence of water.

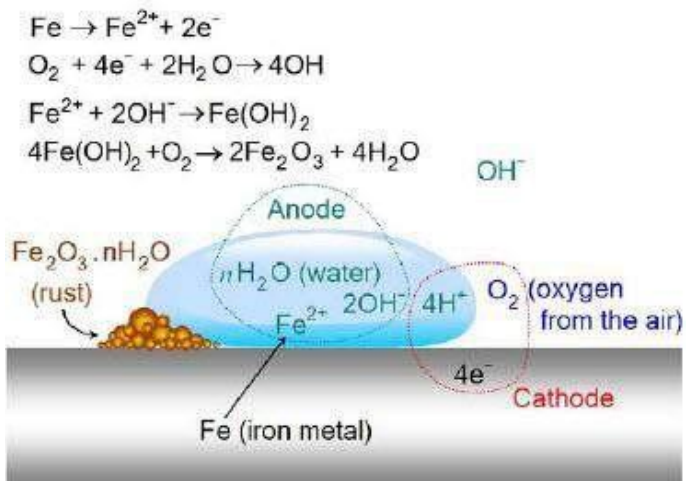
Causes of Corrosion

Metal corrodes when it reacts with another substance such as oxygen, hydrogen, an electrical current or even dirt and bacteria. Corrosion can also happen when metals like steel are placed under too much stress causing the material to crack.

When two metals having different potentials are coupled together and are contained in a conductive electrolyte, current will flow and corrosion will commence. Current will flow from the metal with the greater negative potential through the electrolyte to a metal that is more positive. Corrosion will occur at the point where the current leaves the metal surface.

In addition, the atmosphere also carries emissions from human activity, such as carbon dioxide (CO₂), carbon monoxide (CO), sulphur dioxide (SO₂), nitrous oxide (NO₂) and many other chemicals, which can also be significant in the corrosion process.

Also, if any two dissimilar metals are in contact with each other, the more reactive metal will corrode in preference to the less reactive metal.



Schematically exhibits of corrosion process

Main method of Preventing Steel from Corroding

There are three methods that may be used to protect steel from corrosion.

1. Passive Barrier Protection

Passive barrier protection works by coating the steel with a protective coating system that forms a tight barrier to prevent exposure to oxygen, water and salt (ions). The lower the permeability of the coating system to water, the better the protection provided. Two-pack epoxy coatings and chlorinated rubbers

applied at sufficiently high film builds offer the most successful corrosion protection through passive barrier protection.

2. Active Protection

Active corrosion protection occurs when a primer containing a reactive chemical compound is applied directly to the steel. The reactive compound disrupts the normal formation of anodes on the surface of the steel in some way. For example, inorganic zinc inhibitive pigments, such as zinc phosphate, offer active anti-corrosive protection to the steel substrate (Zinc phosphate ($\text{Zn}_3(\text{PO}_4)_2$) is only slightly soluble in water). It hydrolyses in water to produce zinc ions (Zn^{2+}) and phosphate ions (PO_4^{3-}). The phosphate ions act as anodic inhibitors by phosphating the steel and rendering it passive. The zinc ions act as cathodic inhibitors.

3. Sacrificial Protection (Cathodic Protection or Galvanic Protection)

The above-mentioned reaction between dissimilar metals can be used to protect steel against corrosion. The most widely used metal for the protection of steel is zinc. Zinc metal in direct contact with the steel substrate offers protection through the preferential oxidation of zinc metal. Zinc is a great choice in protecting steel, as not only does it corrode in preference to the steel, the rate of corrosion is generally slower. This rate, however, is accelerated in the presence of ions such as chlorides in coastal locations.

How to Prevent Corrosion

There are several cost-effective ways to prevent corrosion including:

- Use non-corrosive metals, such as stainless steel or aluminium
- Make sure the metal surface stays clean and dry
- Use drying agents
- Use a coating or barrier product such as grease, oil, paint or carbon fibre coating
- Lay a layer of backfill, for example limestone, with underground piping
- Use a sacrificial anode to provide a cathodic protection system

These effective corrosion inhibitors can help extend the lifetime of your assets.

Types of Corrosion

1. **Uniform Corrosion:** This is the most common form of corrosion which usually takes place evenly over large areas of a material's surface.

2. **Pitting Corrosion:** One of the most aggressive forms of corrosion, pitting can be hard to predict, detect or characterise. This localised type of corrosion happens when a local anodic or cathodic point forms a corrosion cell with the surrounding surface. This pitting can create a hole or cavity which typically penetrates the material in a vertical direction down from the surface. Pitting corrosion can be caused by damage or a break in the oxide film or a protective coating and can also be caused through non-uniformities in the structure of the metal. This dangerous form of corrosion can cause a structure to fail despite a relatively low loss of metal.
3. **Crevice Corrosion:** This form of corrosion occurs in areas where oxygen is restricted such as under washers or bolt heads. This localised corrosion usually results from a difference in the ion concentration between two areas of metal. The stagnant microenvironment prevents circulation of oxygen, which stops re-passivation and causes a build-up of stagnant solution moving the pH balance away from neutral. The imbalance between the crevice and the rest of the material contributes to the high rates of corrosion. Crevice corrosion can take place at lower temperatures than pitting corrosion, but can be minimised by proper joint design.
4. **Intergranular Corrosion:** Intergranular corrosion occurs when impurities are present at the grain boundaries which form during solidification of an alloy. It can also be caused by the enrichment or depletion of an alloying element at the grain boundaries. This type of corrosion occurs along or adjacent to the grains, affecting the mechanical properties of the metal despite the bulk of the material being unaffected.
5. **Stress Corrosion Cracking (SCC):** Stress corrosion cracking refers to the growth of cracks due to a corrosive environment which can lead to the failure of ductile metals when subjected to tensile stress, particularly at high temperatures. This type of corrosion is more common among alloys than with pure metals and is dependant on the specific chemical environment whereby only small concentrations of active chemicals are required for catastrophic cracking.
6. **Galvanic Corrosion:** This form of corrosion occurs when two different metals with physical or electrical contact are immersed in a common electrolyte (such as salt water) or when a metal is exposed to different concentrations of electrolyte. Where two metals are immersed together, known as a galvanic couple the more active metal (the anode) corrodes faster than the more noble metal (the cathode). The galvanic series determines which metals corrode faster, which is useful when using a sacrificial anode to protect a structure from corrosion.

Effects of Corrosion

The annual worldwide cost of metallic corrosion is estimated to be over \$2 trillion, yet experts believe 25 - 30% could be prevented with proper corrosion protection. Poorly planned construction projects can lead to a corroded structure needing to be replaced, which is a waste of natural resources and contradictory to global concerns over sustainability. In addition, corrosion can lead to safety concerns, loss of life, additional indirect costs and damage to reputation.

7.0 WOOD (TIMBER) TYPES AND THEIR USES

Wood is a renewable and natural product obtained from trees. Based on the type of growth, trees are classified as endogenous and exogenous. Endogenous trees are not applicable for engineering applications, but the wood from exogenous trees are used for engineering applications.

The two main types of wood are:

- Softwood,
- Hardwood, But also, we have;
- Engineered wood.

Each of these different wood types can be used in a number of different ways.

Softwoods

Softwoods are the wood and lumber which are milled from conifer trees. Scientifically known as Gymnosperms, Conifer trees are any trees which have needles and produce cones.

Uses of softwoods

- Home woodworking projects
- Flooring,
- Roofing Structural framing
- Furniture and cabinets
- Paneling and cladding

Hardwoods

Hardwoods come from any trees which do not produce needles or cones. These trees are most commonly are known as deciduous trees, more scientifically known as Angiosperms. Hardwoods are trees which produces leaves and seeds.

Uses of hardwoods

- Making boats and ships
- For tanning leather
- Furniture making

- Flooring Fencing,
- gates for timber frames of buildings

Are Softwoods Softer Than Hardwoods?

Contrary to popular belief, softwoods are not named softwoods because they are “soft”. While it is true that some varieties of hardwoods are very hard and therefore more challenging to work with, the distinction between hardwood and softwood has little to do with the actual softness or whether one wood is harder to work with. There are many hardwoods which are softer than softwoods.

The main difference between hardwood and softwood is that hardwood trees are typically slower growers and are considered angiosperm, deciduous trees (shed their leaves annually), which leads to a denser wood, whereas softwood trees are gymnosperms, meaning they are evergreen trees (do not shed their leaves)

Engineered Wood: Manufactured Wood Products

The third type of wood you may encounter are engineered woods. Engineered wood does not occur naturally in the environment but instead are manufactured.

Engineered wood is often treated through chemical or a heat process to produce a wood product which can meet certain sizes that would be difficult to achieve from nature.

Popular examples of engineered woods include;

- Plywood,
- Oriented Strand Board,
- Medium Density Fiber Board, and
- Composite Board.

Moisture properties of wood

Wood is a hygroscopic, meaning it is a material that absorbs water. Moisture exists in wood as either bound or free water. Bound water is held within the cell wall by adsorption forces, whereas free water exists as either condensed water or water vapor in the cell cavities. In green wood, the cell walls are saturated. However, the cell cavities may or may not contain free water. The level of saturation at which the cell walls are completely saturated, but no free water exists in the cell cavities, is called the fiber saturation point (FSP). FSP varies from species to species, but is typically in the range of 21% to 32%. The FSP is of great practical significance, because the addition or removal of moisture below the FSP

has a large effect on practically all physical (density, specific gravity, shrinkage) and mechanical properties of wood, whereas above the FSP, the properties are independent of moisture content.

Anisotropic Nature of Wood

Wood is an anisotropic material in that it has different and unique properties in each direction. The three axis orientations in wood are longitudinal or parallel to the grain, radial or cross the growth rings, and tangential or tangent to the growth rings, as illustrated in the Figure. The anisotropic nature of wood affects physical and mechanical properties such as shrinkage, stiffness, and strength.

The anisotropic behavior of wood is the result of the tubular geometry of the wood cells. The wood cells have a rectangular cross section.

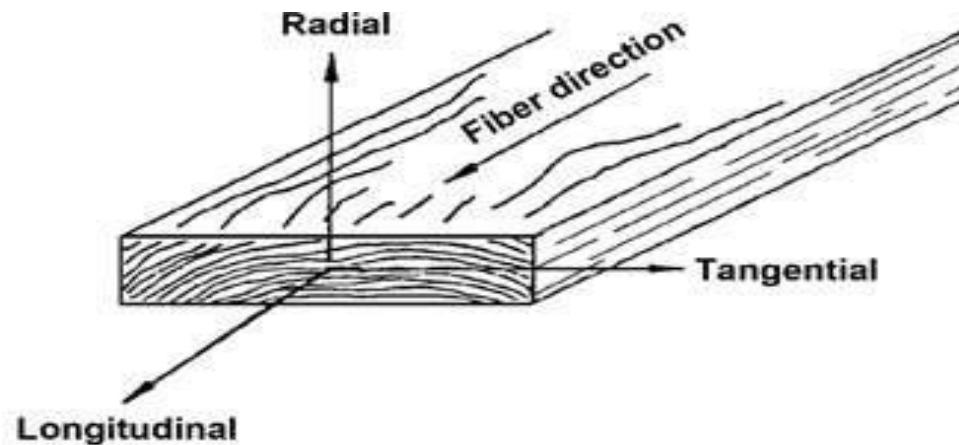


Figure: Main structural features of a typical tree

Wood chemical composition

Wood is composed of cellulose (a polymer glucosan), hemicellulose (a polysaccharide producing wood sugars), lignin (a multi-ring organic compound), extractives, and ash producing minerals.

Cellulose is a glucon polymer consisting of linear chains of glucopyranose units. The exact percent is species dependent. The main building block of cellulose is sugar glucose. Its average molecular weight is 100,000. Cellulose component normally constitutes 45-50% of the dry wood.

Hemicellulose is a mixture of polysaccharides mainly composed of glucose, mannose, galactose, xylose, arabinose, methylglucuronic acid and galacturonic acid residues. Generally, it is of much lower molecular weight than cellulose and is amorphous in structure unlike cellulose. Hemicellulose is different

from cellulose in that it has several sugars tied up in its cellular structure. Hardwood contains 20% to 30% hemicellulose and softwood averages 15% to 20%.

Lignin accounts for 23% to 33% of softwood and 16% to 25% of hardwood by weight. Lignin is mostly an intercellular material. Chemically, lignin is an intractable, insoluble, material that is loosely bonded to the cellulose. Among the wood chemical composition, lignin being the one that shows the most significant mechanical property changes at the lowest temperatures.

The extractives compose 5% to 30% of the wood substance. Included in this group are tannins and other polyphenolics, coloring matters, essential oils, fats, resins, waxes, gums, starches, and simple metabolic intermediates.

The ash-forming materials account for 0.1% – 3.0% of the wood material and include calcium, potassium, phosphate, and silica.

Wood varieties from sawmills

Wood is cut at sawmills into a variety of products, with different sizes and shapes for engineering applications. These products are;

- **Dimensional lumber** is wood from 50 mm to 125 mm (2 in. to 5 in.) thick, sawn on all four sides. Common shapes include 2 x 4, 2 x 6, 2 x 8, 2 x 10, 2 x 12, and 4 x 4.
- **Heavy timber** is wood sawn on all four sides; common shapes include 4 x 6, 6 x 6, 8 x 8, and larger.
- **Round stock** consists of posts and poles used for building poles, marine piling, and utility poles.
- **Engineered wood** consists of products manufactured by bonding together wood strands, veneers, lumber, and other forms of wood fiber to produce a larger and integral composite unit.

8.0 BITUMINOUS MATERIALS

Bituminous materials are classified as asphalts and tars. Asphalt is one of the oldest materials used in construction. Asphalt is used mostly in pavement construction, but is also used as sealing and waterproofing agents. Asphalt came from natural pools found in various locations throughout the world, such as the Trinidad Lake asphalt, which is still mined. However, with the discovery and refining of petroleum in Pennsylvania, use of asphalt cement became widespread. By 1907, more asphalt cement came from refineries than came from natural deposits. Today, practically all asphalt cement is from refined petroleum.

Tars are produced by the destructive distillation of bituminous coal or by cracking petroleum vapors. Tar is used primarily for waterproofing membranes, such as roofs. Tar may also be used for pavement treatments, particularly where fuel spills may dissolve asphalt cement, such as on parking lots and airport aprons.

Uses of Asphalt

The main use of asphalt is in pavement construction and maintenance. In addition, asphalt is used in sealing and waterproofing various structural components, such as roofs and underground foundations. The selection of the type and grade of asphalt depends on the type of construction and the climate of the area. Asphalt cements, also called asphalt binders, are used typically to make hot-mix asphalt concrete for the surface layer of asphalt pavements. Asphalt concrete is also used in patching and repairing both asphalt and portland cement concrete pavements. Liquid asphalts (emulsions and cutbacks) are used for pavement maintenance applications, such as fog seals, chip seals, slurry seals, and microsurfacing. Liquid asphalts may also be used to seal the cracks in pavements.

Types of Asphalt Products

Asphalt used in pavements is produced in three forms:

1. *asphalt cement*,
2. *asphalt cutback*,
3. *asphalt emulsion*.

Asphalt cement

Asphalt cement is a blend of hydrocarbons of different molecular weights. The characteristics of the asphalt depend on the chemical composition and the distribution of the molecular weight hydrocarbons. As the distribution shifts toward heavier molecular weights, the asphalt becomes harder and more

viscous. At room temperatures, asphalt cement is a semisolid material that cannot be applied readily as a binder without being heated.

Asphalt cement has excellent adhesive characteristics, which make it a superior binder for pavement applications. In fact, it is the most common binder material used in pavements.

Liquid asphalt

Liquid asphalt products, cutbacks and emulsions, have been developed and can be used without heating. Although the liquid asphalts are convenient, they cannot produce a quality of asphalt concrete comparable to what can be produced by heating neat asphalt cement and mixing it with carefully selected aggregates.

A cutback is produced by dissolving asphalt cement in a lighter molecular weight hydrocarbon solvent. When the cutback is sprayed on a pavement or mixed with aggregates, the solvent evaporates, leaving the asphalt residue as the binder. In the past, cutbacks were widely used for highway construction. They were effective and could be applied easily in the field. However, three disadvantages have severely limited the use of cutbacks.

1. As petroleum costs have escalated, the use of these expensive solvents as a carrying agent for the asphalt cement is no longer cost effective.
2. Cutbacks are hazardous materials due to the volatility of the solvents.
3. Application of the cutback releases environmentally unacceptable hydrocarbons into the atmosphere.

An alternative to dissolving the asphalt in a solvent is dispersing the asphalt in water as emulsion. In this process the asphalt cement is physically broken down into micron-sized globules that are mixed into water containing an emulsifying agent. Emulsified asphalts typically consist of about 60% to 70% asphalt residue, 30% to 40% water, and a fraction of a percent of emulsifying agent.

Chemical Properties of Asphalt

Asphalt is a mixture of a wide variety of hydrocarbons primarily consisting of and carbon atoms, with minor components such as sulfur, nitrogen, and oxygen (heteroatoms), and trace metals. The percentages of the chemical components, as well as the molecular structure of asphalt, vary depending on the crude oil source.

Asphalt, Bitumen and Tar are hydrocarbons, termed as bituminous materials. Asphalt and bitumen are petroleum products, whereas tar is a dark coloured product collected from destructive distillation of organic substances like coal, wood or bituminous rocks

Concrete and asphalt are both mixtures of sand and crushed stone called aggregate. The difference is what binds the aggregate together. In concrete, cement binds the mixture and gives it a light gray appearance. Asphalt is bound with a black, viscous petroleum-based substance.

Main difference between Tar and Asphalt and their chemical compositions

Asphalt is a sticky, black and highly viscous liquid or semi-solid form of petroleum. The main use of asphalt is in pavement construction and maintenance. In addition, asphalt is used in sealing and waterproofing various structural components, such as roofs and underground foundations Asphalt cement is used mostly in pavement construction, but is also used as sealing and waterproofing agents.

Asphalt chemical compositions consist of compounds of hydrogen and carbon with minor proportions of nitrogen, sulfur, and oxygen.

Tar can be produced from coal, wood, petroleum, or peat. Tar is used primarily for waterproofing membranes, such as roofs. Tar may also be used for pavement treatments, particularly where fuel spills may dissolve asphalt cement, such as on parking lots and airport aprons.

Tar is a complex mixture of a larger number of aromatic hydrocarbons (benzene, naphthalene, anthracene, phenanthrene and their homologues), aromatic acids and nitrogen-containing compounds.