# R.N.G.P.I.T, Bardoli
# Electrical Engineering Department


Subject: EMMI


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# CH: Electrical Engineering Material

- This Lecture contain

➢ Special purpose materials

## Galvanization Materials :

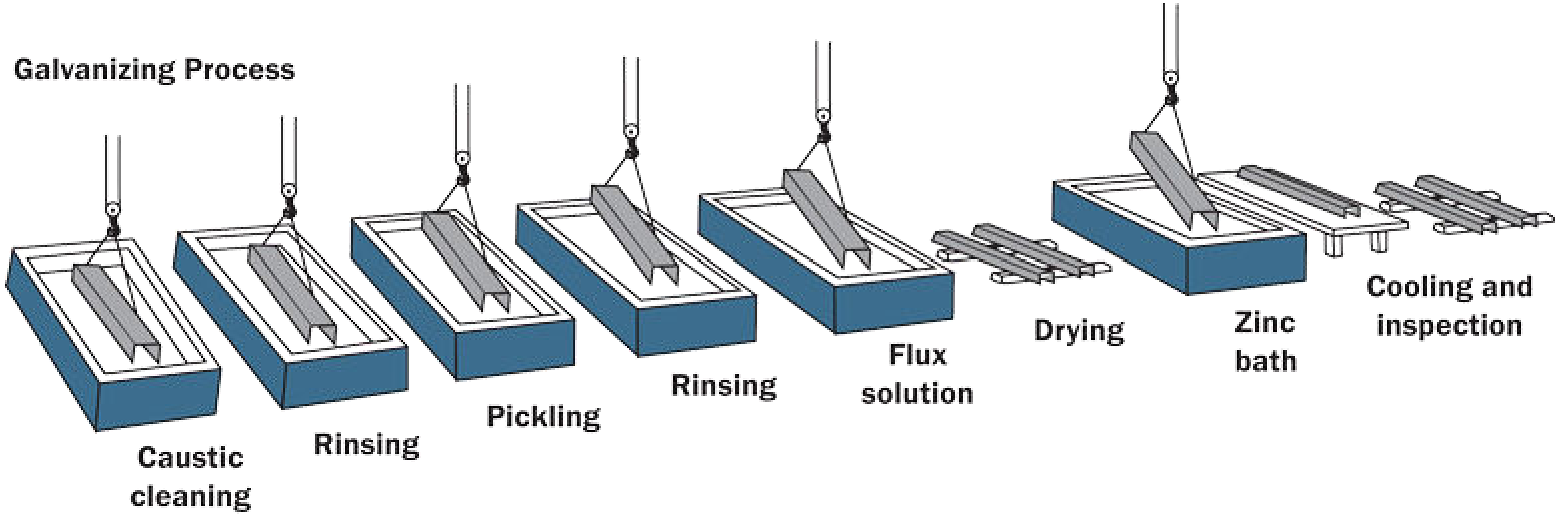
Galvanizing is one of the most widely used to methods for protecting metal from corrosion. It involves applying a thin coating of zinc to a thicker base metal, helping to shield it from the surrounding environment. A number of methods can be employed for galvanizing of zinc to the metal substrate. Some of important techniques are described below.

### 1) Hot Dip Galvanizing :

- The first step of this process is cleaning of the work piece that involves its degreasing by acid rinsing followed by water cleaning. The second step is its annealing and cooling in an oxide free atmosphere. During cooling when temperature of work piece reaches near to the temperature of molten zinc bath temperature. The work piece is dipped in to the bath. Very thin and uniform coating layer can be maintained by passing the sheets through rollers just after the coating.
- This method is not recommended for galvanizing of very delicate and complex shaped parts having complex interior designs.

## 2)Flow Galvanizing :

- It is also a type of crude way of galvanizing. In this process, hot zinc bath is made to flow over the surface of the sheet metal to be galvanized. Molten zinc is spread over the whole areas (surface) of the sheet metal. Excess zinc flowing down the surface is collected back for its recycling. This process is suitable for galvanization of flat sheet metals only. The thickness of coating by this process can be maintained to a uniform value. This process was later modified on the base of metal spraying process.
- This modified process uses a metal spraying gun. The gun is equipped with a device to produce oxygen flame, through which a zinc wire is fed and melted. Air pressure is used to spray this molten zinc on to the surface of sheet metal. The limitation of dipping very large work piece in hot dip galvanizing is overcome. It also maintains a thin and uniform thickness layer of coating.

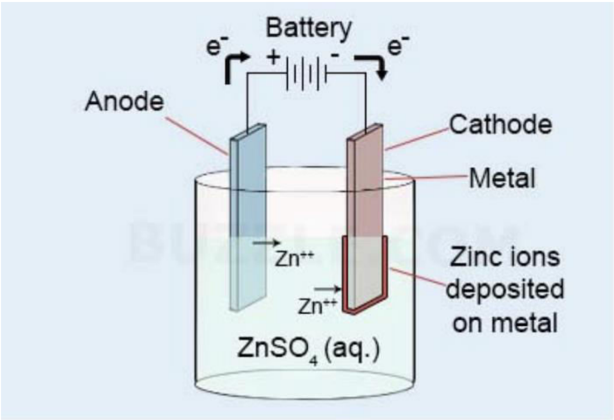


## 2)Sherardizing :

- This process is used for galvanizing of those small parts having intricate shapes. In this process there is a box or container having filled with fine zinc powder. The parts are placed in this box, surrounded with the powder. The box is then heated in an oxygen. Zinc powder vaporizes. Zinc vapor comes in contact with the surface of work piece and zinc is deposited on the work piece. The work piece is then taken out of over and it is allowed to cool down to room temperature. In this way galvanizing of work piece can be completed.

## 3) Electroplating Galvanizing :

- In case of electroplating galvanizing, zinc is deposited on to the work piece by making it cathode. It is just like a electroplating process. This process is time consuming so it is not recommended for mass production. Thickness of coating layer is very thin so it is not capable to provide corrosion resistant property to the work piece.



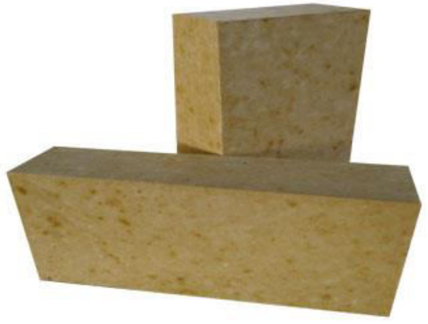
## 4) Cold Dip Galvanizing :

- This process involves cleaning, buffing, degreasing of the work surface before galvanizing. Cold bath is used in this process. No heating of flow of current through electrolyte solution is required. The cold bath is prepared by dissolving shafts, like zinc chloride, tin chloride, ammonium chloride and potassium bitartrate, etc. in water and it is filled in a tank. The tank used in this process is a metallic tank, carrying a thick lining of rubber or PVC sheet on its internal surface. During the preparation proportion of tin chloride should always be less than half of the quantity of zinc chloride.
- The parts to be galvanized are suspended immersed in the bath. How long these should be kept immersed depends on the thickness of the coating required. Dipping time varies from 3 to 12 hours. For thicker coating dipping time should be large

## Refractory Materials :

A refractory material or refractory is a material that is resistant to decomposition by heat, pressure, or chemical attack, and retains strength and form at high temperatures. Refractories are polycrystalline, polyphase, inorganic, nonmetallic, porous, and heterogeneous.

## High Alumina Bricks :



- High alumina bricks refer to refractory materials with an AL3 content of more than 48%, mainly composed of corundum, mullite, and glass.
- It is mainly used in the metallurgy industry to build the plug and nozzle of a blast furnace, hot air furnace, electric furnace roof, steel drum, and pouring system, etc.

## Silicon Bricks :

- The $SiO_2$ content of silicon brick is more than 93%, which is mainly composed of phosphor quartz, cristobalite, residual quartz, and glass.
- Silicon bricks are mainly used to build the partition walls of the coking oven carbonization and combustion chambers, open-hearth heat storage chambers, high-temperature bearing parts of hot blast stoves, and vaults of other high-temperature kilns.

## Magnesium Bricks :

- Magnesium bricks are alkaline refractory materials made from sintered magnesia or fused magnesia as raw materials, which are press-molded and sintered.
- Magnesium bricks are mainly used in open-hearth furnaces, electric furnaces, and mixed iron furnaces.

## Corundum Bricks :

- Corundum brick refers to refractory with alumina content ≥90% and corundum as the main phase.
- Corundum bricks are mainly used in blast furnaces, hot blast stoves, refining outside the furnace, and sliding nozzles.

## Ramming Material :

- The ramming material refers to a bulk material formed by a strong ramming method, which is composed of a certain size of refractory material, a binder, and an additive.
- The ramming material is mainly used for the overall lining of various industrial furnaces, such as open-hearth furnace bottom, electric furnace bottom, induction furnace lining, ladle lining, tapping trough, etc.

## Plastic Refractory :

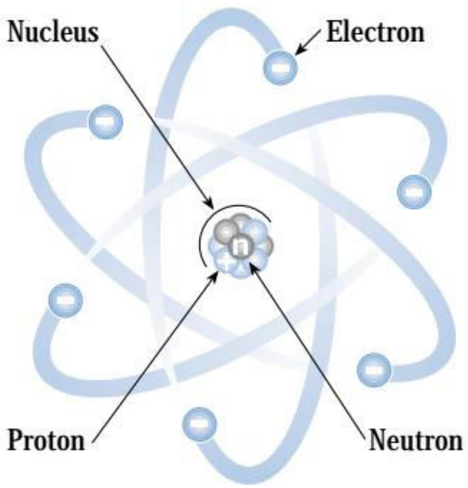
- Plastic refractories are amorphous refractory materials that have good plasticity over a long period of time. It is composed of a certain grade of refractory, binder, plasticizer, water and admixture.
- It can be used in various heating furnaces, soaking furnaces, annealing furnaces, and sintering furnaces.

## Casting Material :

- The casting material is a kind of refractory with good fluidity, suitable for pouring molding. It is a mixture of aggregate, powder, cement, admixture and so on.
- The casting material is mostly used in various industrial furnaces. It is the most widely used monolithic refractory material.

## Radioactive Material :

- Radioactivity is a part of nature. Every thing is made of atoms. Radioactive atoms are unstable; that is, they have too much energy. When radioactive atoms spontaneously release their extra energy, they are said to decay. All radioactive atoms decay eventually, though they do not all decay at the same rate. After releasing all their excess energy, the atoms become stable and are no longer radioactive. The time required for decay depends upon the type of atom.




- Most of the 92 naturally occurring elements on earth are unstable and can change into other forms. Radiation begins in the center of the nucleus of these elements, where energetic particles or waves of energy are released as the atom decay to stable forms.
- More than 80% of the radiation we are exposed to comes from "background" radiation natural sources like sunlight, soil and rocks. Most remaining exposure come from manmade sources, such as x-rays and common household appliances like smoke detectors and color televisions.

Table 1.1 shows the average annual dose from natural background radiation. Table 1.2 shows the average annual dose from manmade sources.

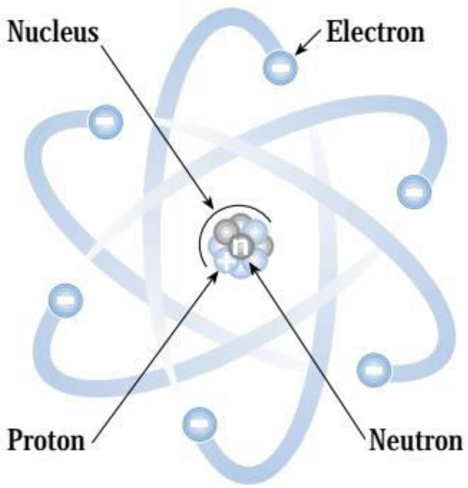
**TABLE 1.1**

| SOURCE | MREM/YR |
|---|---|
| Cosmic rays (radiation from the sun and outer space) | 28 |
| Terrestrial (radiation from rocks and soil) | 26 |
| Radon (in certain geographic areas) | 200 |
| The human body | 25 |
| Building materials | 4 |

**TABLE 1.2**

| SOURCE | MREM/YR |
|---|---|
| Medical (primarily from diagnostic x-rays) | 90 |
| Fallout form atomic weapons (WWII and testing) | 5 |
| Consumer products (color television, computers, smoke detectors) | 1 |
| Nuclear power | 0.3 |

## Radioactive Material Uses:




- Radioactive materials are used in producing many of the products we use every day: plastic wrap, radial tires, coffee filters, and smoke detectors.
- Many medical facilities contain radioactive hazards (medical isotopes are use for diagnosis and treatment of many diseases).
- Radioactive materials are used for diagnostic radiology, radiation medicine, and radiopharmaceuticals. Radiation hazards also exist wherever radioactive materials are stored or radioactive waste products are discarded.
- Fires involving radioactive materials can result in widespread contamination. Radioactive particles can be carried easily by smoke plumes, ventilation systems, and contaminated water runoff. While radiation exposure outside of medical and research facilities is not common, you should be alert to its presence in labs, hospitals, and other treatment facilities

Table 1.3 lists some commonly used radioisotopes, examples of their uses, the forms in which they are transported, and the most common mode of transportation.

**Table 1.3 Radioisotopes Used in Medicine and Industry**

| Radioisotope | Examples Of Uses | Form for Shipping | Mode Of Transport |
|---|---|---|---|
| Americium 241 | Used in industry to:<br>• Determine drilling locations for oil wells<br>• Manufacture home smoke detectors<br>• Measure lead in dried paint<br>• Ensure uniformity in steel and paper production | Powder (enclosed in capsule) | Highway<br>Rail<br>Air |
| Californium 252 | Used in medicine to:<br>• Research and treat cancer (especially cervical, ovarian and brain cancers)<br>Used in industry to:<br>• Detect explosives in luggage at airports<br>• Measure moisture in soil and silos<br>Start up nuclear reactors. | Solid | Highway<br>Air |
| Cobalt 60 | Used in medicine to:<br>• Treat cancer<br>• Suppress immune reaction in transplants<br>• Sterilize surgical instruments<br>Used in industry to:<br>• Test welds and castings<br>• Check for internal structural flaws<br>• Locate buried utility lines<br>Used in agriculture to:<br>• Preserve poultry, fruits and spices | Solid | Highway<br>Rail<br>Air |
| Iodine 131 | Used in medicine to:<br>• Diagnose and treat medical disorders<br>• Trace medical observations | Solid | Highway<br>Rail<br>Air |
| Iridium 131 | Used in medicine to:<br>• Treat prostate cancer<br>Used in industry to:<br>• Check the integrity of pipeline welds, boilers and aircraft parts. | Solid | Highway<br>Air |
| Plutonium 238 | Used in medicine to:<br>• Power pacemakers | Solid | Highway<br>Air |
| Hydrogen 3 (Tritium) | Used in industry to:<br>• Illuminate paint, exit signs and aircraft<br>• Trace the flow of water<br>• Identify molecules in scientific studies. | Solid | Highway<br>Rail |

## Structural Material:

### Iron:

- Wrought Iron: Wrought iron is the simplest form of iron, and is almost pure iron (typically less than 0.15% carbon). It usually contains some slag. Its uses are almost entirely obsolete, and it is no longer commercially produced.

- Wrought iron is very poor in fires. It is ductile, malleable and tough. It does not corrode as easily as steel.

- Cast Iron: Cast iron is a brittle form of iron which is weaker in tension than in compression. It has a relatively low melting point, good fluidity, castability, excellent machinability and wear resistance. Though almost entirely replaced by steel in building structures, cast irons have become an engineering material with a wide range of applications, including pipes, machine and car parts.

- Cast iron retains high strength in fires, despite its low melting point. It is usually around 95% iron, with between 2.1% and 4% carbon and between 1% and 3% silicon. It does not corrode as easily as steel.

## Structural Material:

### Iron:

- Steel: Steel is an iron alloy with controlled level of carbon (between 0.0 and 1.7% carbon).

- Steel is used extremely widely in all types of structures, due to its relatively low cost, high strength-to-weight ratio and speed of construction.

- Steel is a ductile material, which will behave elastically until it reaches yield (point 2 on the stress-strain curve), when it becomes plastic and will fail in a ductile manner (large strains, or extensions, before fracture at point 3 on the curve). Steel is equally strong in tension and compression.

- Steel is weak in fires, and must be protected in most buildings. Despite its high strength to weight ratio, steel buildings have as much thermal mass as similar concrete buildings.

- The elastic modulus of steel is approximately 205 GPa.

# Structural Material:

## Iron:

- Stainless steel: Stainless steel is an iron-carbon alloy with a minimum of 10.5% chromium content. There are different types of stainless steel, containing different proportions of iron, carbon, molybdenum, nickel. It has similar structural properties to steel, although its strength varies significantly.

- It is rarely used for primary structure, and more for architectural finishes and building cladding.

- It is highly resistant to corrosion and staining.

## Structural Material:

### Concrete:

- Concrete is used extremely widely in building and civil engineering structures, due to its low cost, flexibility, durability, and high strength. It also has high resistance to fire.
- Concrete is a non-linear, non-elastic and brittle material. It is strong in compression and very weak in tension. It behaves non-linearly at all times. Because it has essentially zero strength in tension, it is almost always used as reinforced concrete, a composite material. It is a mixture of sand, aggregate, cement and water. It is placed in a mould, or form, as a liquid, and then it sets (goes off), due to a chemical reaction between the water and cement. The hardening of the concrete is called hydration. The reaction is exothermic (gives off heat).
- The elastic modulus of concrete can vary widely and depends on the concrete mix, age, and quality, as well as on the type and duration of loading applied to it. It is usually taken as approximately 25 GPa for long-term loads once it has attained its full strength (usually considered to be at 28 days after casting). It is taken as approximately 38 GPa for very short-term loading, such as footfalls.
- Concrete has very favourable properties in fire – it is not adversely affected by fire until it reaches very high temperatures. It also has very high mass, so it is good for providing sound insulation and heat retention (leading to lower energy requirements for the heating of concrete buildings). This is offset by the fact that producing and transporting concrete is very energy intensive. To study the material behavior plenty of numerical models were developed, e.g. the microplane model for constitutive laws of materials.

## Structural Material:

### Reinforced concrete:

- Reinforced concrete is concrete in which steel reinforcement bars ("rebars"), plates or fibers have been incorporated to strengthen a material that would otherwise be brittle. In industrialised countries, nearly all concrete used in construction is reinforced concrete. Due to its weakness in tension capacity, concrete will fail suddenly and in brittle manner under flexural (bending) or tensile force unless adequately reinforced with steel.

- **Prestressed concrete:**
- Prestressed concrete is a method for overcoming the concrete's natural weakness in tension. It can be used to produce beams, floors or bridges with a longer span than is practical with ordinary reinforced concrete. Prestressing tendons (generally of high tensile steel cable or rods) are used to provide a clamping load which produces a compressive stress that offsets the tensile stress that the concrete compression member would otherwise experience due to a bending load.

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## Structural Material:

## Aluminium:

- Aluminium is a soft, lightweight, malleable metal. The yield strength of pure aluminium is 7–11 MPa, while aluminium alloys have yield strengths ranging from 200 MPa to 600 MPa. Aluminium has about one-third the density and stiffness of steel. It is ductile, and easily machined, cast, and extruded.
- Corrosion resistance is excellent due to a thin surface layer of aluminium oxide that forms when the metal is exposed to air, effectively preventing further oxidation. The strongest aluminium alloys are less corrosion resistant due to galvanic reactions with alloyed copper.
- Aluminium is used in some building structures (mainly in facades) and very widely in aircraft engineering because of its good strength to weight ratio. It is a relatively expensive material.

- In aircraft it is gradually being replaced by carbon composite materials.

## Structural Material:

### Composites:

- Composite materials are used increasingly in vehicles and aircraft structures, and to some extent in other structures. They are increasingly used in bridges, especially for conservation of old structures such as Coalport cast iron bridge built in 1818. Composites are often anisotropic (they have different material properties in different directions) as they can be laminar materials. They most often behave non-linearly and will fail in a brittle manner when overloaded.
- They provide extremely good strength to weight ratios, but are also very expensive. The manufacturing processes, which are often extrusion, do not currently provide the economical flexibility that concrete or steel provide. The most commonly used in structural applications are glass-reinforced plastics.

## Structural Material:

### Masonry:

- Masonry has been used in structures for thousands of years, and can take the form of stone, brick or blockwork. Masonry is very strong in compression but cannot carry tension (because the mortar between bricks or blocks is unable to carry tension). Because it cannot carry structural tension, it also cannot carry bending, so masonry walls become unstable at relatively small heights. High masonry structures require stabilisation against lateral loads from buttresses (as with the flying buttresses seen in many European medieval churches) or from windposts.
- Since the widespread use of concrete, stone is rarely used as a primary structural material, often only appearing as a cladding, because of its cost and the high skills needed to produce it. Brick and concrete blockwork have taken its place.
- Masonry, like concrete, has good sound insulation properties and high thermal mass, but is generally less energy intensive to produce. It is just as energy intensive as concrete to transport.

Brick masonry

## Structural Material:

### Timber:

- Timber is the oldest of structural materials, and though mainly supplanted by steel, masonry and concrete, it is still used in a significant number of buildings. The properties of timber are non-linear and very variable, depending on the quality, treatment of wood, and type of wood supplied. The design of wooden structures is based strongly on empirical evidence.
- Wood is strong in tension and compression but can be weak in bending due to its fibrous structure. Wood is relatively good in a fire as it chars, which provides the wood in the centre of the element with some protection and allows the structure to retain some strength for a reasonable length of time.