# Adhesives and Glues

# Definition

- An adhesive is a compound that adheres or bonds two items together.
- The use of the terms adhesive and glue is confused.
  - Historically natural compounds used as an adhesive were called glues
    - ❖ Historically, glue only referred to protein colloids prepared from animal tissues.
  - Synthetic compounds were called adhesives.
- Today the meaning of the term “adhesive” has been extended to any type of glue-like substances that is used to attach one material to another.

# History of Adhesives

- The first adhesives were gums and other plant resins.
  - Vegetable gums:
    - Guar gum
    - Gum Arabic
- Archaeologists have found 6000-year-old ceramic vessels that had broken and been repaired using plant resin.
- Most early adhesives were animal glues made by rendering animal products.
  - Native Americans use of buffalo hooves
  - Hide glue
  - Bone glue
  - Fish glue
  - Rabbit skin glue

# History--cont.

- Native Americans in what is now the eastern United States used a mixture of spruce gum and fat as adhesives and as caulk to waterproof seams in their birch bark canoes.
- During the times of Babylonia, tar-like glue was used for gluing statues.
- Egypt was one of the most prominent users of adhesives.
  - The Egyptians used animal glues to adhere tombs, furniture, ivory, and papyrus.
- Mongols used adhesives to make their short bows.
- In Europe in the Middle Ages, egg whites were used to decorate parchments with gold leaves.
- In the 1700s, the first glue factory was founded in Holland, which manufactured hide glue.
- In the 1750s, the British introduced fish glue.
- As the modernization continued, new patents were issued by using rubber, bones, starch, fish, and casein.

# Adhesive/Glue Terms

- Pot time
  - The amount of time that can elapse between when the adhesive is exposed/mixed until the reaction develops to the point that the adhesive will not produce a good joint.
  - Movement of the joint during this time should not reduce the strength of the joint.
  - Varies with the type of adhesive and the environment.
- Set time
  - Starts with the assembly of the joint.
  - Any stress applied to the joint during this time will reduce the strength of the joint.
  - For some adhesives it is the amount of time pressure should be held on the joint.
- Cure time
  - The amount of time before the adhesive reaches maximum strength.
  - Varies with the type of adhesive an the environment

# Advantages and Disadvantages of Adhesive Bonding

| Advantages |
| --- |
| No stress concentrations due to piercing of the adherend |
| Improved fatigue resistance |
| Lighter weight structures |
| Ability to join and seal simultaneously |
| Ability to join shock-sensitive substrates |
| Can be less expensive than mechanical fasteners |
| Process can be easily automated |

| Disadvantages |
| --- |
| Strength is dependent upon the condition of the adherend surface |
| Limited non destructive quality control methods |
| Can be more expensive |
| Bond quality is dependent upon many variables |
| No single universal adhesive for all applications |
| Limited disassembly and repair |
| |

# Categories of Adhesives

- Structural
  - Natural
  - Synthetic adhesives
  - Thermoplastic adhesives
  - Thermosetting
- Pressure sensitive

Structural adhesives harden by one of four (4) methods:

1. Evaporation of a solvent or water (white glue),
2. Reaction with radiation (dental adhesives),
3. Chemical reaction (two part epoxy)
4. Cooling (hot melt)

- Pressure sensitive adhesives (PSA's) form a bond simply by the application of light pressure to marry the adhesive with the adherend.
- Pressure sensitive adhesives are designed with a balance between flow and resistance to flow.
- PSA's are designed for either permanent or removable applications

# Natural Adhesives

Generally set by solvent evaporation.

They are generally of low strength and are susceptible to moisture and mold.

Their use is restricted to the joining of low strength materials.

| Type | Notes |
|---|---|
| Fish | Improved temperature resistance, resistance to water compared to above |
| Animal | Made from collagen, (Skin/bone) with sugar and glycerol added for flexibility.<br>Supplied as powder/bead which is dissolved in water |
| Casein | Made from milk precipitated with acid. Supplied a powder for mixing with water. Improved properties compared to all above glues |
| Vegetable | Based on starch, dextrine.<br>Supplied as a powder for mixing with water.<br>Low strength.<br>Low resistance to water/high temps |

http://www.roymech.co.uk/Useful_Tables/Adhesives/Nat_Adhesives.html

# Synthetic Adhesives
# Elastomers

Based on natural and synthetic rubbers set by solvent evaporation or heat curing.

They have relatively low shear strength and suffer from creep and are therefore used for unstressed joints.

They are useful for flexible bonds with plastics and rubbers.

| | |
|---|---|
| Natural Rubber | Rubber solution with bonding be evaporation of solvent.<br>Not suitable for loaded structures or adverse environments.<br>Good for water but low resistance to oils and solvents |
| Polychloroprene | (Neoprene) |
| Polyurethene | Two component adhesives which can be formulated for applications.<br>Resistant to acids, oils some solvents and alkalis.<br>Susceptible to moisture.<br>Load bearing duties viable.<br>Flexible bonds suitable for shock and vibratory loading.<br>High strength joints |
| Silicone Rubber | Set at room temperatures.<br>Has a high temperature service temperature of up to 300° C.<br>Low shear strength. Very good sealing /space filling adhesive - widely used for glazing |

http://www.roymech.co.uk/Useful_Tables/Adhesives/Adhesives.html#Types

# Thermoplastic Adhesives

- Fusible
- Soluble
- Poor heat and creep resistant.
- They are normally used for low/medium loads.
- They have good resistance to oils but poor resistance to water.

| | |
|---|---|
| Polyvinyl Acetate (PVA) | Supplied as an emulsion in water, for porous materials, especially wood<br>Shear strength is good<br>Resistant to oil<br>Poor resistance to water<br>Low heat tolerance ( White glue) |
| Cyanoacrylates | Harden quickly in seconds based on catalytic action of surface moisture.<br>Good for rubber.<br>Care needed when used with metals in moist warm conditions.<br>"Superglue" |

# Thermo Setting Adhesives

Set as a result of the build up of molecular chains to produce a rigid cross linked structure.

| Type | Info |
|---|---|
| Resorcinol resins | Good water resistance.<br>Used for exterior plywood. |
| Polyesters (unsaturated) | Usually made to harden by chemical action rather than by the evaporation of solvents and thus cure with little shrinkage. |
| Polyamides | High performance adhesives requiring higher curing temperatures and bonding pressures (up to 0.7 MPa ).<br>High cost adhesive. |
| Epoxy resins | Epoxy (mostly 2-part) adhesives have good strength and chemical resistance, do not produce volatiles during curing, and have low shrinkage.<br>Form extremely strong and durable bonds with most materials in well-designed joints.<br>Single part adhesives require heat for setting or long setting times. |

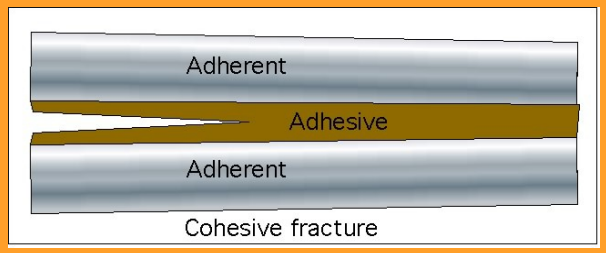
# Using Adhesives

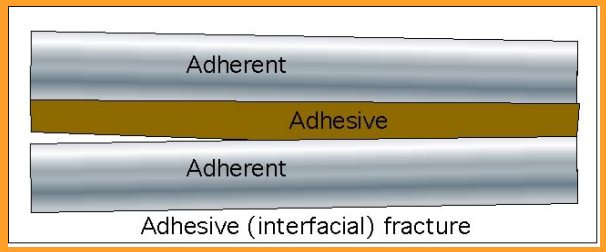
- Select the best adhesive for the materials being used and the environment.
  - Follow manufacturers instructions.
- Prepare joint
  - Clean
  - Close fitting
  - Dampen
- Apply adhesive
  - Uniform layer
  - Some suggest using a notched applicator.
  - Insure joint has sufficient adhesive to form a squeeze line when the joint is clamped.
    - ❖ No squeeze line = insufficient adhesive (starved joint)
    - ❖ Excessive adhesive squeezing out = wasted adhesive

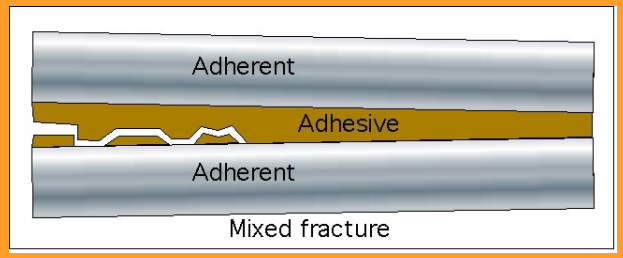
# Using Adhesives--cont.

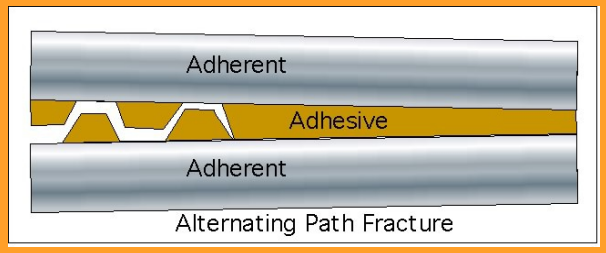
- Force surfaces together
  - Use correct amount of pressure
    - Insufficient pressure will result in a poor joint
    - Excessive pressure may reduce joint strength
  - Clamps
  - Nails or other fasteners

# Adhesive Failure




- Adhesives can fail at several different points.
- Common failures are:
  - Cohesive
  - Adhesive (Interfacial)
  - Mixed fracture
  - Alternating crack path

Questions