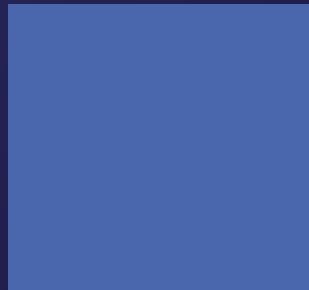




ADHESIVE PROJECT

MICROTON Marketing



TOPICS



- WHAT IS ADHESIVE
- HOW MANY TYPE OF ADHESIVE and TYPE OF ADHESIVE BOND
- COMPARISION OF ADHESIVE
- APPLICATION METHOD OF ADHESIVE
- TESTING STANDARED OF ADHESIVE
- REFERANCE ARTICLES

WHAT IS ADHESIVE ?



- An adhesive is a compound that adheres or bonds two items together
- ADHESIVE IS A SUBSTANCE WHICH CAPABLE OF HOLDING MATERIALS BY SURFACE ACTION
- ADHESIVE MAY COME FROM EITHER NATURAL OR SYNTHETIC SOURCES.
- AND THIS PROCESS OF JOINING TWO OR MORE SURFACER IS KNOWN AS ADHESION

HISTORY



- The first adhesives were natural gums and other plant resins. 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 such as the Native American use of buffalo hooves. 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 birchbark canoes. During the times of Babylonia, tar-like glue was used for gluing statues. Also, Egypt was one of the most prominent users of adhesives. The Egyptians used animal glues to adhere tombs, furniture, ivory, and papyrus. Also, the 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. Later, in the 1750s, the British introduced fish glue. As the modernization continued, new patents were issued by using rubber, bones, starch, fish, and casein. Modern adhesives have improved flexibility, toughness, curing rate, temperature and chemical resistance.

MECHANISMS OF ADHESION



- The strength of attachment, or adhesion, between an adhesive and its substrate depends on many factors, including the means by which this occurs. Adhesion may occur either by mechanical means, in which the adhesive works its way into small pores of the substrate, or by one of several chemical mechanisms.
- In some cases an actual chemical bond occurs between adhesive and substrate. In others electrostatic forces, as in static electricity, hold the substances together. A third mechanism involves the van der Waals forces that develop between molecules. A fourth means involves the moisture-aided diffusion of the glue into the substrate, followed by hardening.

STRESS AND BENEFIT Of ADHESIVE



- One of the primary benefit of adhesive is that it holds something together resisting the STRESS trying to pull it apart.
- SOME TYPE OF STRESS ARE -
 - TENSILE STRESS is exerted equally over the entire joint straight and away from the adhesive bond.
 - SHEAR STRESS is across the adhesive bond, the bonded materials are being forced to slide over each other.
 - CLEAVAGE STRESS is concentrated along at the one edge and exerts a prying force on the bond.
 - PEEL STRESS is concentrated along a thin line at the bond edge, one surface is flexible

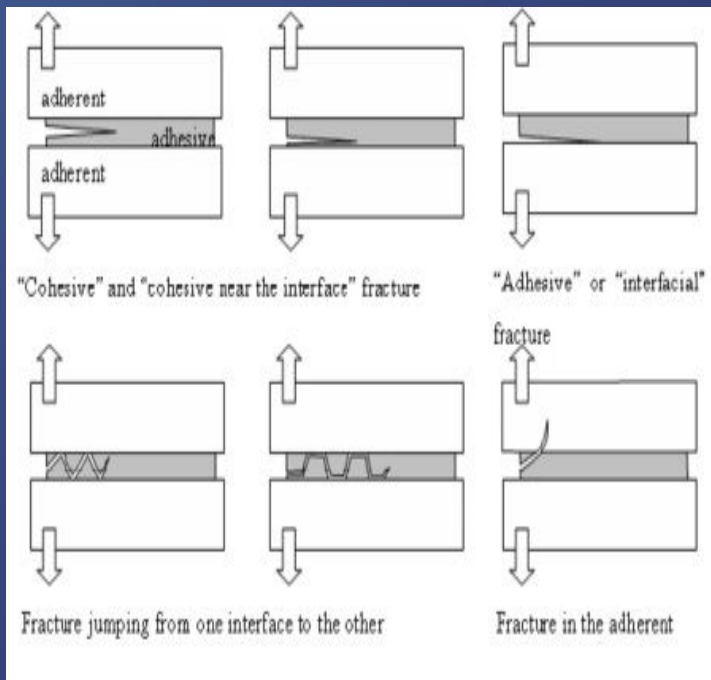
ADVANTAGE OF ADHESIVE



The following are the six points of adhesive for stress resistance.

- Uniform distribution can eliminate stress concentration.
- Bonding can produce combination superior in strength and performance.
- Elastomeric flexibility improves resistance to vibration fatigue.
- Holes are eliminated maintaining the integrity of bonded materials.
- Continuous contact between mating surface can effectively bond and seal against environment.
- Costs can be lowered by reducing materials requirements and weight.

FAILURE



- Failure of the adhesive joint

- When subjected to loading, debonding may occur at different locations in the adhesive joint. The major fracture types are the following

- Cohesive fracture

- "Cohesive" fracture" is obtained if a crack propagates in the bulk polymer which constitutes the adhesive. In this case the surfaces of both adherents after debonding will be covered by fractured adhesive. The crack may propagate in the centre of the layer or near an interface. For this last case, the "cohesive" fracture can be said to be "cohesive near the interface". Most quality control standards consider that a "good" adhesive bonding must be "cohesive".

- Interfacial fracture

- The fracture is "adhesive" or "interfacial" when debonding occurs between the adhesive and the adherent. In most cases, the occurrence of "interfacial" fracture for a given adhesive goes along with a smaller fracture toughness. The "interfacial" character of a fracture surface is usually detected by visual inspection, but advanced surface characterisation techniques such as spectrophotometry allows to identify the precise location of the crack path in the interphase. Failure of the adhesive joint can occur in different locations

TYPES OF ADHESIVE & ADHESIVE BOND



- Adhesive is classified on the basis of two points
 - physical classification
 - chemical classification
 - thermoplastic adhesive
 - thermosetting adhesive
 - rubber resin blends
- Structurally adhesive are of two type
 - structural adhesive
 - non structural adhesive
- Adhesive is divided groups only on the basis of application method of respected of adhesive.

CATEGORIES OF ADHESIVES



- Natural adhesives : Adhesives, from inorganic mineral sources, or biological sources such as vegetable matter, starch (dextrin), natural resins, animal skin, and bioadhesives
- Synthetic adhesives: Adhesives based on elastomers, thermoplastic, and thermosetting adhesives.
- Drying adhesives: These adhesives are a mixture of ingredients (typically polymers) dissolved in a solvent. Glues such as white glue, and rubber cements are members of the drying adhesive family. As the solvent evaporates, the adhesive hardens. Depending on the chemical composition of the adhesive, they will adhere to different materials to greater or lesser degrees. These adhesives are typically weak and are used for household applications. Some intended for use by small children are now made non-toxic.
- Contact adhesives: Contact adhesive is one which must be applied to both surfaces and allowed some time to dry before the two surfaces are pushed together. Some contact adhesives require as long as 24 hours to dry before the surfaces are to be held together[1]. Once the surfaces are pushed together the bond forms very quickly[2], hence it is usually not necessary to apply pressure for a long time. This means that there is no need to use clamps, which is convenient.
- Natural rubber and polychloroprene (Neoprene) are commonly used contact adhesives. Both of these elastomers undergo strain crystallization. When an adhesive bond containing either of these materials is pulled apart, the elastomer is strained, develops crystallites, and actually becomes stronger than in the original, unstressed, state.
- Contact adhesives find use in laminates, such as bonding Formica to a wooden counter, and in footwear, for example attachment of an outsole to an upper

HOT MELT ADHESIVE



- A glue gun, an example of a hot adhesive Hot Glue
 - Also known as "hot melt" adhesives, these adhesives are thermoplastics; they are applied hot and simply allowed to harden as they cool. These adhesives have become popular for crafts because of their ease of use and the wide range of common materials to which they can adhere. A glue gun, pictured right, is one method of applying a hot adhesive. The glue gun melts the solid adhesive and then allows the liquid to pass through the "barrel" of the gun onto the material where it solidifies.
 - Paul E. Cope [deceased, 2003] is reputed to have invented thermoplastic glue [circa 1940] while working for Procter & Gamble as a chemical and packaging engineer. His invention solved a problem with water based adhesives that were commonly used in packaging at that time. Water based adhesives often released in humid climates which caused packages to open and become damaged. Mr. Cope was a graduate of the University of Cincinnati College of Engineering. He advanced at Procter & Gamble to become Associate Director, Head of Packaging Engineering. After spending 40 years with P&G, he retired in 1973. Patents issued to Paul Cope include the laminated toothpaste tube and this for In Package Sterilization
- Reactive adhesives
 - A reactive adhesive works by chemical bonding with the surface material. They are applied in thin films. Reactive adhesives are less effective when there is a secondary goal of filling gaps between the surfaces. These include two-part epoxy, peroxide, silane, metallic cross-links, or isocyanate.
 - Such adhesives are frequently used to prevent loosening of bolts and screws in rapidly moving assemblies, such as automobile engines. They are largely responsible for the quieter running modern car engines.
- UV and Light Curing Adhesives
 - Typically, these adhesives fully cure in seconds upon exposure to UV or visible light of the proper wavelengths, intensity, and duration. Some formulations are "fixtured" with UV light, but require additional time or curing mechanisms to achieve full cure. UV curing adhesives can be formulated with a wide variety of properties (low to high viscosity, flexible to rigid, clear to colored, adhesion to glass/plastics/metals/ceramics, depth of cure to >1/2").

POLYURETHANE-BASED ADHESIVES-



- On the way to a new and better glue for bookbinders, a new adhesive system was introduced in 1985. The base for this system is polyether or polyester, with polyurethane (PUR) being used as prepolymer. Its special features are coagulation at room temperature and reaction to moisture.

PRESSURE SENSITIVE ADHESIVES



- Pressure sensitive adhesives (PSAs) form a bond by the application of light pressure to marry the adhesive with the adherend. They are designed with a balance between flow and resistance . The bond forms because the adhesive is soft enough to flow, or wet, the adherend. The bond has strength because the adhesive is hard enough to resist flow when stress is applied to the bond. Once the adhesive and the adherend are in close proximity, molecular interactions, such as van der Waals' forces, become involved in the bond, contributing significantly to its ultimate strength.
- Pressure sensitive adhesives (PSAs) are designed for either permanent or removable applications. Examples of permanent applications include safety labels for power equipment, foil tape for HVAC duct work, automotive interior trim assembly, and sound/vibration damping films. Some high performance permanent PSAs exhibit high adhesion values and can support kilograms of weight per square centimeter of contact area, even at elevated temperature. Permanent PSAs may be initially removable and build adhesion to a permanent bond after several hours .
- Removable adhesives are designed to form a temporary bond, and ideally can be removed after months or years without leaving residue on the adherend. Removable adhesives are used in applications such as surface protection films, masking tapes, bookmark and note papers, price marking labels, promotional graphics materials, and for skin contact (wound care dressings, EKG electrodes, athletic tape, analgesic and transdermal drug patches, etc.).
- Pressure sensitive adhesives are manufactured with either a liquid carrier or in 100% solid form. Articles are made from liquid PSAs by coating the adhesive and drying off the solvent or water carrier. They may be further heated to initiate a crosslinking reaction and increase molecular weight. 100% solid PSAs may be low viscosity polymers that are coated and then reacted with radiation to increase molecular weight and form the adhesive; or they may be high viscosity materials that are heated to reduce viscosity enough to allow coating, and then cooled to their final form.

GENERAL ADHESIVE GROUPS IN USE

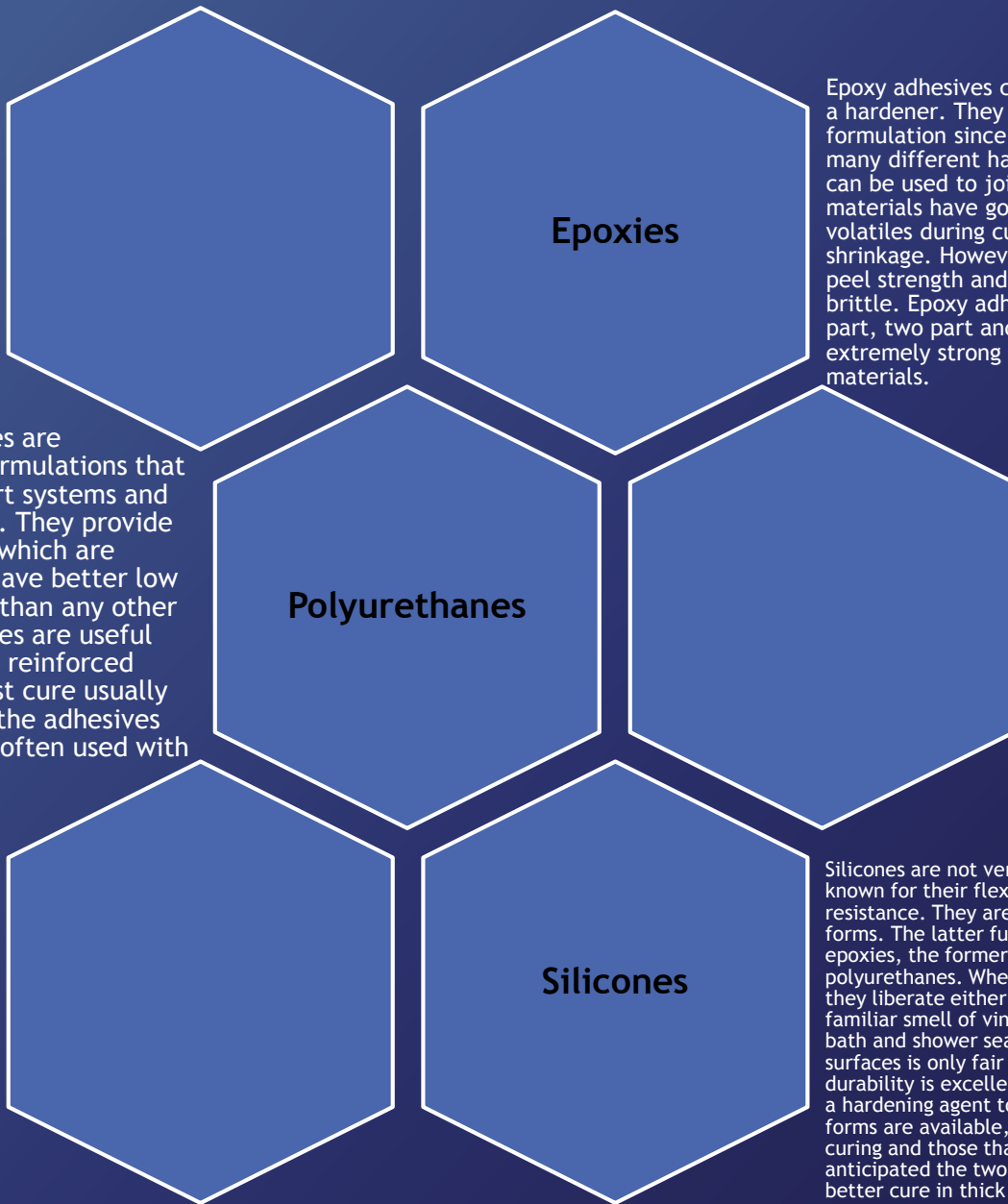
Group
Textile adhesive
"School glue" (for paper)
Glue sticks (for paper)
Plastic adhesives
Vinyl adhesives
Wood adhesives
Adhesives for general purposes
Contact adhesives
Two-component adhesives
Adhesive gun (Hot-Melt adhesive)
Super glue
Adhesive sprays
Adhesives for special purposes

MODERN ADHESIVE IN USE



- A bewildering variety of adhesives are available from a range of adhesive manufacturers. However, it is possible to simplify the choice by classifying the adhesive, and this can be done either by the way they are used or by their chemical type. The strongest adhesives solidify by a chemical reaction, Weaker varieties harden by some physical change. The major classifications are described in the following sections.
- Anaerobics: Anaerobic adhesives cure when in contact with metal, and the air is excluded, e.g. when a bolt is home in a thread. They are often known as "locking compounds", being used to secure, seal and retain turned, threaded, or similarly close fitting parts. They are based on synthetic acrylic resins.
- Cyanoacrylates: Cyanoacrylate adhesives cure through reaction with moisture held on the surface to be bonded. They need close fitting joints and usually solidify in seconds. Cyanoacrylates are suited to small plastic parts and to rubber. They are a special type of acrylic resin.
- Toughened Acrylics: Toughened acrylics are fast curing and offer high strength and toughness. Both one and two part systems are available. In two part systems, no mixing is required because the adhesive is applied to one substrate, the activator to the second substrate, and the substrates joined. They tolerate minimal surface preparation and bond well to a wide range of materials.





Polyurethane adhesives are chemically reactive formulations that may be one or two part systems and are usually fast curing. They provide strong resilient joints which are impact resistant and have better low temperature strength than any other adhesive. Polyurethanes are useful for bonding glass fibre reinforced plastics (GRP). The fast cure usually necessitates applying the adhesives by machine. They are often used with primers.

Epoxy adhesives consist of an epoxy resin plus a hardener. They allow great versatility in formulation since there are many resins and many different hardeners. Epoxy adhesives can be used to join most materials. These materials have good strength, do not produce volatiles during curing, and have low shrinkage. However, epoxies can have low peel strength and flexibility and can be brittle. Epoxy adhesives are available in one part, two part and film form and produce extremely strong durable bonds with most materials.

Silicones are not very strong adhesives, but are known for their flexibility and high temperature resistance. They are available in single or two part forms. The latter function like the two part epoxies, the former like the single part polyurethanes. When the single part adhesives cure they liberate either alcohol or acetic acid (the familiar smell of vinegar). They are often used as bath and shower sealants. Their adhesion to surfaces is only fair but like their flexibility, their durability is excellent. The two part versions need a hardening agent to be mixed into the resin. Two forms are available, those which liberate acid on curing and those that do not. As might be anticipated the two part adhesive systems give a better cure in thick sections than do the single part types.



- Phenolics were the first adhesives for metals and have a long history of successful use for joining metal to metal and metal to wood. They require heat and pressure for the curing process.

Phenolics

- Polyimide adhesives are based on synthetic organic chains. They are available as liquids or films, but are expensive and difficult to handle. Polyimides are superior to most other adhesive types with regard to long term strength retention at elevated temperatures.
- The following adhesives undergo a physical change and are less effective at forming the adhesive bond.

Polyimides

- Hot melts are based on modern thermoplastics and are used for fast assembly of structures designed to be only lightly loaded.

Hot Melts

- Plastisols are modified PVC dispersions that require heat to harden. The resultant joints are often resilient and tough.
- Rubber Adhesives: Rubber adhesives are based on solutions or latexes and solidify through the loss of the medium. They are not suitable for sustained loadings.

Plastisols

- Vinyl acetate is the principal constituent of the PVA emulsion adhesive. They are suited to the bonding of porous materials, such as paper or wood, and to general packaging work.

Polyvinyl Acetate (PVA's)

- Pressure sensitive adhesives are suited for use as tapes and labels and although they do not solidify they are often able to withstand adverse environments. This type of adhesive is not suitable for sustained loadings.

Pressure-Sensitive Adhesives

TYPES OF ADHESIVE BONDING



- Adhesive bonding may originate in a variety of ways. It may be the result of mechanical interlocking of the adhesive with the bonded surface, covalent bonding between bonded surfaces, or secondary electronic interactions between the bonded materials.
- In mechanical adhesion, the adhesive flows around the substrate surface roughness so that interlocking of the two materials takes place. The adhesive may penetrate the substrate surface. Surface interpenetration often involves polymer diffusion; this type of bonding depends on the ability of the polymer adhesive to diffuse into the bonded surface.
- Secondary electronic bonding may result from hydrogen bonds between the adhesive and substrate, from the interactions of overlapping polymer chains, or from such nonspecific forces as Van der Waals interactions.
- In the case of covalent bonding, actual primary chemical bonds are formed between the bonded materials. For example, graft or block copolymers may bond different phases of a multicomponent polymeric material together
- Adhesive - Types Of Adhesive Bonding, Bonding Metals, Bonding Plastics, Bonding Wood - Bonding applications, Fabric and paper bonding

COMPARISON AND FORMULATION

MANUFACTURING PROCESS:

Several manufacturing processes are used to manufacture pressure sensitive adhesives. They include solvent-based, hot-melt, and emulsion processes.

Solvent:

In solvent-based processes, **adhesive** ingredients are dissolved in solvent solution and applied to a web of material. After coating, the solvent dries out, leaving the **adhesive**.

Hot Melt:

In hot-melt processes, thermoplastic rubbers are formulated with tackifying resins, oils, and antioxidants. The **adhesive** is coated onto a web of material at temperatures exceeding 300F.

Emulsion:

In emulsion techniques **adhesive** ingredients are emulsified in water, applied to a web, and then dried.

ADHESIVE COMPARISON CHART



FEATURE	ACRYLIC	MODIFIED ACRYLIC	RUBBER BASED
Adhesion	Medium to High	High	Medium to High
Cost	Medium to High	Medium to High	Lowest
HSE Plastics*	Excellent	Excellent	Excellent
LSE Plastics*	Poor	Moderate	Excellent
Plasticizer Resistance	Good	Moderate	Poor
Shear	Medium to High	Low	Medium to High
Solvent Resistance	Medium to High	Low to Moderate	Poor
Tack	Low to Moderate	High	Medium to High
Temperature Resistance	Medium to High	Low to Moderate	Low
UV Resistance	Good	Poor	Poor

*HSE: High Surface Energy Plastics: HDPE, PET, PETE, Vinyl, Polypropylene

*LSE: Low Surface Energy Plastics: LDPE, Polystyrene, Teflon, Rubber (latex)

FORMULATION



ADHESIVE FORMULATIONS:

Adhesives are derived from rubber-based, acrylic, modified acrylic, and silicone formulations. Each formulation displays distinct performance characteristics.

Rubber-Based Adhesives:

These adhesives are synthetic, non-latex rubbers formulated with tackified resins, oils, and antioxidants. They provide good to excellent initial tack and adhesion particularly to low-surface-energy materials such as plastics. They do not demonstrate good temperature resistance (typically <math><150^{\circ}\text{F}</math>) or resistance to solvents, sterilization, chemicals, or ultraviolet rays. Some rubber-based adhesives are specially formulated to achieve exceptional adhesion in high-moisture applications.

Acrylic Adhesives:

Based on acrylic polymers, acrylic adhesives provide resistance to solvents, UV light, elevated temperatures, plasticizers, and chemical reagents. They tend to be more costly than rubber-based varieties, but provide better long-term aging and environmental resistance. They have low to moderate initial tack and adhesion, and generally do not adhere well to low-surface-energy substrates.

Modified Acrylic Adhesives:

Formulated from acrylic polymers but incorporating additional components found in rubber-based systems, modified acrylics offer improved initial tack and adhesion to low-surface-energy materials compared with non-tackified acrylic formulations. The modifiers decrease resistance to solvents, plasticizers, and UV light. Shear properties and temperature resistance are also reduced. While modified acrylics gain tack and adhesion, the trade-off is a loss of internal strength and environmental stability.

GENERAL APPLICATION PROCEDURE OF ADHESIVE



- APPROPRIATE ADHESIVES
 - EXAMPLE· Mapei KeraQuick + Lateks Plus
 - Henkel CM 17 (one component), CM 111+Ceresit CC 83 (mixture proportion: 25 kg CM 111, 2 liter CC 83, 4,5 liter water)
- Checking and Fixing the Substrate
 - Tiling substrate must be smooth, cured and free of moisture.
 - It must be flat, stable, solid and free of cracks.
 - It must be absolutely clean of any substances that might hinder proper adhesion, such as dust, paint, oil and gypsum.
 - The substrate must be level. If not, it must be smoothed prior to tiling by using either leveling screed or repair mortar.
- Preparation of the Adhesive Mixture
 - In preparation of the mixture, instructions of the producer must be observed.
 - In order to obtain homogeneity, the mixture must be stirred well with a mixer.
 - During tiling, the temperature of the environment must be between +5 °C and +30 °C and the substrate moisture less than 3%

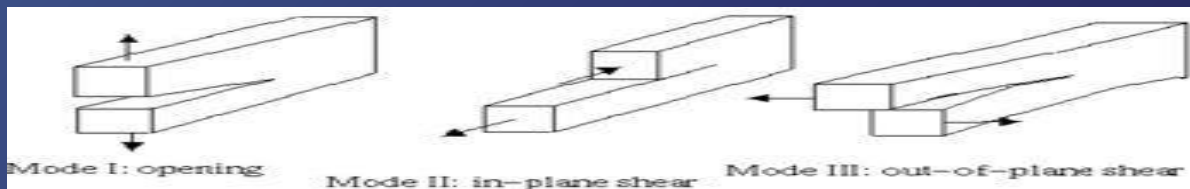
TILING



- Lay a thin layer of prepared mixture, enough to cover a tiling area at a time, on the substrate with the smooth side of the trowel.
- Add a sufficient amount of this adhesive mixture and spread it evenly on the area with the notched side of the trowel.
- Also spread a thin layer of the adhesive mixture on the backside of the Dekostone products with the smooth side of the trowel.
- Place the Dekostone and tap into place with a rubber mallet for a better adhesion and perfect leveling.
- Continue laying while inserting joint crosses in the joints around the tiles.
- Make sure that the thickness of the adhesive is 0.5-1.0 cm or as recommended by the producer.
- Check the adhesiveness of the mixture, spread on the substrate, by hand. If the adhesive smears onto fingers, continue laying. If not, cleanse off the substrate and spread a new layer onto it once more.
- Immediately remove any trace of adhesive on the tiled Dekostone products by the help of a wet sponge.
- Once the tiling is finished, cover the tiles with damp cloths or a nylon for a minimum of 24 hours to provide protection.

TESTING AND DESIGN OF ADHESIVE JOINTS

- DESIGN OF ADHESIVE JOINTS
- A general design rule is a relation of the type: "Material Properties > Function (geometry, loads)". The engineering work will consist in having a good model to evaluate the "Function". For most adhesive joints, this can be achieved using [fracture mechanics](#). Concepts such as the stress concentration factor K and the energy release rate G can be used to predict failure. In such models, the behavior of the adhesive layer itself is neglected and only the adherents are considered. Failure will also very much depend on the opening "mode" of the joint.



Modes of failure

- **Mode I** is an opening or tensile mode where the loadings are normal to the crack.
- **Mode II** is a sliding or in-plane shear mode where the crack surfaces slide over one another in direction perpendicular to the leading edge of the crack. This is typically the mode for which the adhesive exhibits the higher resistance to fracture.
- **Mode III** is a tearing or antiplane shear mode.

As the loads are usually fixed, an acceptable design will result from combination of a material selection procedure and geometry modifications, if possible. In adhesively bonded structures, the global geometry and loads are fixed by structural considerations and the design procedure focuses on the "material properties" of the adhesive (i.e. select a "good" adhesive) and on local changes on the geometry. Increasing the joint resistance is usually obtained by designing its geometry so that:

- The bonded zone is large
- It is mainly loaded in mode II

Stable crack propagation will follow the appearance of a local failure

TESTING OF ADHESIVE JOINTS



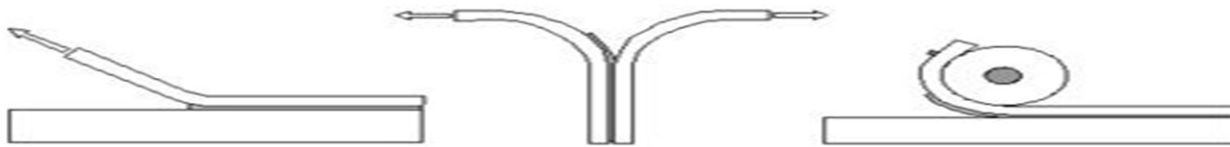
- Testing the resistance of the adhesive
- A wide range of testing devices have been imagined to evaluate the fracture resistance of bonded structures in pure mode I, pure mode II or in mixed mode. Most of these devices are beam type specimens. We will very shortly review the most popular:
- Double Cantilever Beam tests (DCB) measure the mode I fracture resistance of adhesives in a fracture mechanics framework. These tests consist in opening an assembly of two beams by applying a force at the ends of the two beams. The test is unstable (i.e. the crack propagates along the entire specimen once a critical load is attained) and a modified version of this test characterised by a non constant inertia was proposed called the Tapered double cantilever beam specimen (TDCB).



Double cantilever Beam (DCB) and Tapered Double Cantilever Beam (TDCB) tests



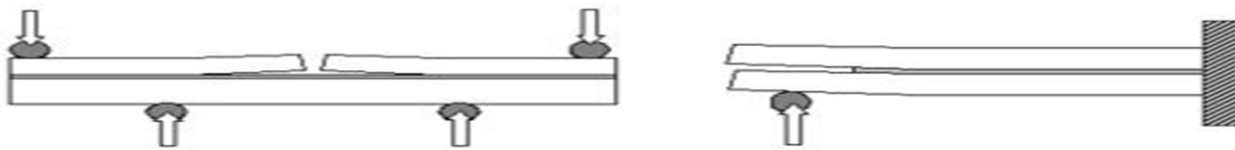
Peel tests



Wedge tests



MMDB and End Notch Flexure (ENF) tests



Symmetrical and Dissymmetrical Crack Lap Shear tests (CLS and DLS)



TESTING DEVICES



- Peel tests measure the fracture resistance of a thin layer bonded on a thick substrate or of two layers bonded together. They consist in measuring the force needed for tearing an adherent layer from a substrate or for tearing two adherent layers one from another. Whereas the structure is not symmetrical, various mode mixities can be introduced in these tests.
- Wedge tests measure the mode I dominated fracture resistance of adhesives used to bond thin plates. These tests consist in inserting a wedge in between two bonded plates. A critical energy release rate can be derived from the crack length during testing. This test is a mode I test but some mode II component can be introduced by bonding plates of different thicknesses.
- Mixed-Mode Delaminating Beam (MMDB) tests consist in a bonded bilayer with two starting cracks loaded on four points. The test presents roughly the same amount of mode I and mode II with a slight dependence on the ratio of the two layer thicknesses.
- End Notch Flexure tests consist in two bonded beams built-in on one side and loaded by a force on the other. As no normal opening is allowed, this device allows testing in essentially mode II condition.
- Crack Lap Shear (CLS) tests are application-oriented fracture resistance tests. They consist in two plates bonded on a limited length and loaded in tension on both ends. The test can be either symmetrical or dis-symmetrical. In the first case two cracks can be initiated and in the second only one crack can propagate.

TESTING OF ADHESIVE (physical and chemical method)

Analysis methods

Determination of the content of dry matter

FTIR analysis

X-ray analysis

Gas chromatography at mass spectrometric detection

Analysis results and comments

Infrared spectroscopic analysis (FTIR)

Analysis for the content of dry matter

GC/MS analyses

Analysis results for phthalates

Analyses for a content of formaldehyde and acetaldehyde

Analysis for Isocyanates

REFERANCE ARTICLES



- GREEN ROBERT E,
- MACHINERY'S HANDBOOK
- PETRIE EDWARDS M, HANDBOOK OF ADHESIVE AND SEALANTS
- POCIUS, A.V. ADHESION AND ADHESIVE TECHNOLOGY



Thank you...



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