Paint is a liquid surface coating that forms a protective film upon evaporation. It often contains pigments and various additives for visual effect. Cave paintings are the earliest applications of paint, some dating 40 to 50 thousand years ago. The application of paint with the specific intention to visually enhance a space came from the ancient Egyptians, known to be brilliant paint manufacturers and artists. Some of their wall applications still possess their brilliancy today. Ready-mixed, or prepared paint, became widely available towards the end of the 19th century, enabled by the industrial revolution, transforming the look of interiors as well as products. Today, paint is the most inexpensive method to protect and visually enhance a surface.

Paint is a mixture of 4 fundamental components: ❶ pigments to give color to the coating, ❷ additives to enhance the performance, ❸ binders to hold the particles together, ❹ solvent to enable transfer and spread to a surface. The
amount, balance, and quality of each one of these will affect the quality of the paint job. Lower-grade content would be cheap but the result won’t be satisfactory. Higher-grade content may be easier to work with and suitable for DIY situations but might not be justified in all scenarios due to budget limitations. Trained professionals can achieve good results with relatively lesser quality paint, that is why contractor-grade paint is cheaper than retail-grade paint.

**Pigments** are powdered chemical compounds, such as copper phthalocyanine or titanium dioxide, that introduce color and brightness qualities to the mixture. There are two types of pigments; prime pigments that introduce the color, and extender pigments that enhance coloring properties. Higher pigment concentration, or pigment load, provides a coating with better saturation, coverage, and hiding power, however, it is relatively expensive. On the other hand, lower pigment concentration looks more desaturated, less brilliant and intense; appearing somewhat dull and transparent. Depending on the resin content, paint can appear relatively glossier. Too much pigment in a paint mixture can be detrimental to the application, causing gaps to form between particles. The application surface becomes textured, matte, permeable, and less resistant to abrasion. It is the overall balance and appropriateness for the purpose that determines the performance of the paint.

**Extender pigments** are colorless and inert chemicals such as calcium carbonate, calcium sulfate, silica, clay, talc, etc. These are added to adjust or improve the paint’s properties such as glossiness, uniformity of the application, and enhance durability and abrasion resistance. Extender pigments are typically low cost compared to prime pigments; they give the paint body and bulk. Typically, higher quality paint has a higher prime-to-extender pigment ratio. Even though it functions similar to extender pigments, **titanium dioxide**, TiO$_2$, is an important prime pigment that has a bright white color and it is
Titanium Dioxide ($\text{TiO}_2$) is a pure white pigment with highly useful properties. Widely used to introduce brightness, opacity, and hiding power to paint. It is relatively expensive. Recently $\text{TiO}_2$ has been classified as a suspected carcinogen by the International Agency for Research on Cancer (IARC). It is much less toxic than lead, but it might ultimately share a similar fate.

**Additives** are special-purpose ingredients that improve or fine-tune the performance of the coating. There’s a large selection of additives available such as thickeners that improve the consistency of the paint; dispersing additives that are used to eliminate flocculation, which is forming of small loose aggregations within the mixture; wetting agents that improve the liquid absorption capabilities of the powdered paint components; antisettling agents that increase the viscosity of the mixture delaying the drying and settling processes both during application and storage; defoamers that eliminate foaming which causes coating defects during application; coalescents that facilitate continuous film formation during application; UV stabilizers that prevent UV degradation; biocides that inhibit mold and mildew growth; fire-retardants that establish fire resistance, achieving up to ASTM E-84 Class A rating depending on the amount of additive mixed in. It is also possible to add various additives to introduce texture, such as sand texture, smooth texture, or coarse texture additives.

Designers should be careful as paint additives, even though they are highly useful, can significantly impact toxicity levels and VOC emissions.

**Binders** hold the contents of the paint together and enable the film coating to adhere to the application surface. Gum Arabic is a type of natural binder exuded by some types of acacia, first used in 4000BCE by the Chinese and Japanese. Binder directly determines paint’s performance in terms of abrasion resistance, scrubbability, color and gloss retention, etc. Typically, binders have very high density and limited flow, they need to be mixed with a solvent to make paint application possible. Common binders include alkyd, resin, latex, and urethane; binder type needs to match solvent type.
The ratio of the binder determines the sheen level of a paint application. **Lower sheen levels feature lower binder ratios**, they are harder to maintain, however, they also hide imperfections, easy to touch up, and produce no glare. On the other end of the spectrum, **high gloss finishes feature higher binder ratios**. They are easier to clean and maintain, however, they highlight imperfections and require extensive substrate preparation. The lowest sheen levels are best for ceilings where substrate prep is more expensive and almost no traffic will be received, and the highest sheen levels are appropriate for conditions where ensuring hygiene or maximizing daylighting is an important factor. Typically, manufacturers designate a name for each sheen level based on the percentage of reflectivity; some common ones are flat (up to 10% reflectance), eggshell (10% to 20%), satin (20% to 35%), semi-gloss (35% to 65%), and high-gloss (65% and up).

**Solvents**, or thinners, facilitate carrying the other ingredients of paint to the application surface, sometimes referred to as “vehicle”. They increase flow, enable a uniform spread, and allow the penetration of the application surface. Solvents are not part of the cured application; they evaporate leaving a consistent film coating.
of the other three of the components of the paint. The amount of solvent negatively affects coverage and hiding power of paint, cheaper paints feature proportionally more solvent. Spraying applications might necessitate higher solvent content to increase flow and minimize clogging. One gallon of paint typically covers 300 to 400 square feet of wall surface. However, the number of coatings ultimately impacts how much paint is needed. For repainting over the same color, one or two coats would be sufficient, for darker, deeper, or lively and saturated colors multiple coats would be needed. Absorbeny of the substrate might affect the number of coats, if not primed properly gypsum board or plaster can soak a significant amount of paint. The complete curing of paint can take up to 2 months and some manufacturers suggest refraining from wiping or washing the application for around two weeks.

There are two main categories of paint based on the solvent utilized: water-based and oil-based. Water-based paints feature water as the solvent, which are commonly referred to as latex paint, acrylic paint, or acrylic latex. Some advantages include fast curing times and significantly low VOC emissions, convenient cleanability with soap and water. Latex paints feature better elasticity, they are resistant to cracking and retain color well. They are breathable, allow moisture through, rather than causing it to build up in the substrate, which may end up resulting in mold and mildew growth.

The latex paints currently available in the market can match oil-based paint performance and some even exceed it. There are extremely durable water-based paints in the market, up to 25000 scrubs in accordance with ASTM D2486.

Also referred to as alkyd-based, oil-based paints feature alcohol or mineral spirits (paint thinners) or alkyd resin as the solvent. Oil-based paints are resistant to heavy wear and impact, appropriate for use in trims, woodwork, cabinetry where abrasion is expected, especially on movable or sliding parts. They provide higher washability and scrubbability, do not allow moisture penetration, hence commonly found in wet spaces. They also have higher coverage, a smoother look, more forgiving to substrate imperfections; they have longer drying times but that also means brushwork is much less visible. Despite their advantages, oil-based paints have some significant disadvantages. They are comparatively more expensive; require chemical solvents for cleanup; odor-intensive when drying, release an abundant amount of VOCs, to an extent that some municipalities have restricted use. Water-based paint cannot be painted over with oil-based paint.

The VOC emission levels for architectural paint are regulated by EPA under the Clean Air Act (CAA), however, designers should consider that this act mainly targets ambient air quality and does not guarantee low toxicity in indoor environments. In many states the amount of VOC (pounds per gallon) is restricted.

In addition to water-based and oil-based paint, there are many other types of paint that feature
different formulations. **Clear coatings**, such as varnishes and urethane coating, has no pigment content and primarily applied to provide additional protection to a surface. **Stains** have a high concentration of solvent and low concentration of pigment and binder, intended to penetrate the application surface and provide a transparent tint. Paint can also have very specific functionality. **Intumescent paint** is a fire-resistant film coating that foams and expands when exposed to heat above around 400°F creating an insulating barrier, mainly used on steel or wood structural elements. The number of coatings gives 30- to 120-minute fire protection; though an excessive number of coats might result in sagging. It is possible to apply a compatible topcoat in any color.

**GYPSUM & PLASTER**

Gypsum and plaster are the two most common substrates for paint as well as wallcovering applications, therefore a fundamental understanding of general properties and construction is imperative.

**Gypsum board**, also known as drywall or gyp-board, is a very common wall and ceiling substrate. Gypsum is the name given to a naturally occurring and highly common mineral, calcium sulfate dihydrate (CaSO₄·2H₂O). It is a non-hazardous, non-toxic chemical, though in powder form, that is commonly encountered on construction sites, can irritate eyes, skin, and respiratory system. The mineral is first heated into an intermediary product known as calcined plaster, which is later mixed with water and sandwiched between paper facers. Evolved from a product called plasterboard, the first gypsum boards manufactured in 1916 featured paper-felt facers, in the next two decades the construction of the board improved and transformed into the version with paper facers widely in use today. It has been a consistently popular construction material since the 1940s.

Aside from the high energy cost of the baking process, **gypsum requires quarrying** which results in deforestation and habitat loss. However, gypsum is also fully and infinitely recyclable. The paper facers on both sides are removed along with screws and nails, which are also fully recyclable. The downside is, the amount of contamination reduces the quality of recycled material. Therefore older boards from demolition waste require extra processing, and only so much recycled gypsum is allowed in newly manufactured boards. But, ground gypsum has many uses other than being recycled into gypsum.
boards, it can be used to amend the soil, as an additive for other construction materials such as plaster, for water treatment, etc. However, if gypsum ends up in landfills, untreated, there’s a possibility of producing toxic gases due to bacterial activity.

There is a wide selection of gypsum board types, aside from the regular product. Gypsum is inherently fire-resistive, but it starts to crumble after 30-minutes of exposure. Fire resistive gypsum boards are called **type-X boards**, these feature glass fibers as well as other core additives to achieve 1-hour fire resistance per each 5/8” thick board and 45 minutes for 1/2” thick board. Multiple boards can be layered to meet exact building code requirements. There is a type-C version available with improved performance.

*If some form of impact, piercing, or sustained application of force is expected, abuse-resistant or impact-resistant gypsum panels may be a good option.* These panels uniquely feature a fiberglass mesh between the core and the backing. A **glass-reinforced gypsum board** is a lightweight and high-strength alternative to the regular gypsum board. It is somewhat water and mold-resistant.

**Moisture-resistant gypsum board**, or green board, features a green-colored moisture-resistant backing. It provides resistance against humidity, however, it is not completely water-resistant. There’s a higher performance **foil-backed version**, where the moisture-resistant backing is substituted with a vapor retarder aluminum foil. For both types, the rest of the gypsum board is standard. Gypsum, when allowed to get wet, it can sag and facilitate mold and mildew growth. There’s a **sag-resistant gypsum board** available; these are used as ceiling boards. The core is strengthened with additives or reinforced with glass fibers; they are lighter weight than regular drywall boards.

The standard 1/2” drywall can be bent at a radius of 10ft and 1/4” drywall can be bent at a 5ft radius. A **flexible gypsum board** is a 1/4” thick board that can be curved around a 1ft radius without warps, bows, crumbling, or cracking. No wetting facers or scoring/kerfing for very tight curves is needed.

**Prefinished gypsum boards** save installing costs and time, eliminating dust and debris. There are benefits such as high washability, low maintenance, and fire resistance. They can feature vinyl or textile surfaces with various colors or textures.

*In the standard GA-214, the Gypsum Association defines 6 levels of gypsum board finish, that are commonly referenced in modern construction projects. Each level of finish outlines criteria to achieve incrementally higher finish quality and smoothness, based on how much visual exposure and scrutiny the surface will be subject to. The lowest level, Level 0 is appropriate for temporary construction, is a completely unfinished application featuring no taping, sanding, patching of any kind. Level 1 is
appropriate for areas where the surface will be concealed and away from public view, features seams treated with taping and joint compound, tool marks, and ridges are tolerable. On top of Level 1 recommendations, Level 2 features covered and coated fasteners as well as a thin coating of joint compound on all seams; it is appropriate for use as a tile substrate, or in areas with low aesthetic priority such as storage rooms or garages. Level 3 features an additional coat of joint compound on fastener heads and accessories, all joint compound is expected to be smooth and free of any tool marks or ridges; appropriate as a substrate for textured wallcovering or paint applications. Level 4 is appropriate for smooth paint and thick profile backed wallcovering applications, and level 5 recommended for high sheen smooth paints, especially if side lighting or grazing lighting is expected, and thin profile wallcovering applications. Both levels feature a smooth surface, level 5 featuring an extra thin skim coat of joint compound. The standard ASTM C840 can also be referenced for this process. It defines a stricter specification for the application and finishing of gypsum boards. 

Plaster is a thick viscous material, a mixture of gypsum, water, and sand that hardens as it dries and becomes rigid and brittle. The mixture can be referred to as mud. Gypsum plaster, also known as plaster of Paris, uses gypsum as a binder; it is comparatively more common. This type of plaster is targeted towards interior applications. Too much moisture exposure can cause mold and mildew. It is commonly reinforced with glass fiber for enhanced performance. Joint compound is a specific mixture of gypsum plaster. Gypsum can be substituted with cement or lime to achieve different types of plaster. Cement plaster, also referred to as stucco, uses Portland cement as a binder. It is relatively more durable, can be used on exterior walls. It is possible to mix in glass fiber and vermiculite for added strength. Lime plaster is permeable and inhibits mold and mildew growth. It is less brittle than gypsum and cement plaster and less prone to cracking.

Around the 1940s, before gypsum wallboard became a widely used material, wood lath and plaster was the dominant wall construction method. The application was expensive and
time-consuming. There are lath and plaster walls and ceilings still present in houses built before the 1940s. They can be harder to repair than drywalls, and might require relatively costly replacement.

Compared to gypsum board, plaster is a slightly more durable application and it provides a relatively tighter seal and good acoustic separation. Vermiculite can be introduced to the mixture for improved fire resistance. **Plaster is brittle after it is completely dried, building movement may introduce cracks to the material, therefore it needs routine maintenance.** Drying times are shorter than drywall skim coating and application is relatively quick, however, it requires skill to install, therefore it is costly.

Contemporary applications feature one of the many types of metal or fiberglass lath. Lathes are typically slightly furred, meaning spaced from the attached substrate, providing support for the plaster. Diamond wire lath is a simple wire mesh. Paperback wire lath is attached to a backing paper for easier installation. **Expanded metal lath** features some inherent depth to hold onto multiple layers of plaster application. Ribbed lath features even deeper ribs for more robust plastering, much more dimensionally stable than other options, and suitable for ceiling applications. Exterior applications require an exterior grade galvanized metal lath, as plaster tends to soak up moisture and can cause corrosion.

Typically, plaster is applied in three coats – **scratch coat** is applied first to create a combed surface for the second coat, commonly referred to as **brown coat** to attach. This layer is left rough and open for the application of the smooth **finish coat**, third and last. Each coat is applied after the previous coat has dried. A two-coat or thick single coat application is possible but they provide less durability and protection.

Plaster, has excellent moldability and retains intricate detail. Glass fiber reinforced plaster is highly appropriate and widely used for molded decorative applications, such as crown moldings, cove moldings, chair rails, or wainscoting.

**PAINT APPLICATION**

For any common paint application, surface preparation is the most important procedure to ensure a well-performing and aesthetically pleasing finish. Since paint is essentially a very thin film, often 3 to 5 mils, any irregularity or imperfection on the substrate is directly telegraphed to the surface. A **mil** is a thousandth of an inch, equals
to 25.4 microns. Newly constructed substrates are much more predictable, on the other hand, older substrates are full of surprises. They can feature corrosion, decay, soaked chemicals, moisture build-up, or even feature hidden fungal growth; all of which can possibly bleed into the finish coat, causing adherence problems, deformation, and staining.

After confirming that the substrate is healthy, **Surface preparation** typically involves removing previous application residues and mending defects, such as patching cracks, dents, and other surface irregularities. For drywall preparation, all seams are taped, nail and screw holes are set and filled. Typically, **joint compound** is used for patching and filling, spackle is a different product and used for small patching jobs. **Skim coating** is a way to create a consistently flat and smooth foundation for paint application. It is achieved by applying a layer of joint compound and smoothening with a skimming blade. If the substrate features an undesired texture, substantial flaws, or it belongs to a wall that is expected to receive grazing lighting, skim coating is a necessity. After the filling compounds are cured, the surface should be sanded with increasingly finer grit abraders to achieve a smooth application surface. For some applications, the surface is expected to be coarser for the paint to adhere, for others, maximum smoothness is expected to achieve the best finish with a thin coat. For **wood surface preparation**, moisture content must be balanced with the target environment, knots should be sealed to prevent resin bleed, cracks and holes should be filled with wood putty. Wood should never be sanded across the grain, this might create highly visible scratches. For **metal surface preparation**, the first step is cleaning rust and residue from the previous application. Sandblasting is an alternative to manual sanding.

The typical paint application features three layers: primer or basecoat, undercoat, and topcoat or finish coat. **Primer** is the foundation for the subsequent coats, the first layer applied after substrate preparation is complete. There are self-priming finish coats available that negate a primer, but most professional applications would require one. White primer is usually fine with pale-colored finishes but if a very dark or bright colors will be used, primer should be tinted.

Fresh drywall soaks in liquid and moisture and **primers** minimize substrate absorption, enabling efficient use of paint. It creates a surface for better paint adhesion ensuring consistency of color and sheen. Specialty primers can retard moisture, inhibit rust, or block stains. Oil-based based primers are better at blocking the chemical bleeding from the substrate, which can be a problem for old construction. Primer should always match the paint solvent type. An **undercoat** can prevent moisture and stain seepage from the substrate, may provide extra protection for denting, and creates a tinted foundation for darker colors.
Paint can be applied via brush, roller, or spray. **Brushing** gives better control, results in a consistent, uniform finish, however, application process is relatively slow. **Rollers** can quickly cover large areas, though the details have to be sorted with a brush. It is easier to reach higher areas. The required skill ceiling is relatively low. **Spraying** is another tool to cover large areas, however, skill and experience are a requirement to achieve a consistent application. Spraying does not leave any brush marks, however, coats might be thinner due to the lighter consistency required for spraying, more coats therefore more paint is needed. An inconsistent application might cause drips and globs to occur. In all applications, **masking** wall details is mandatory to prevent brush slip-ups or overspraying. **Novelty and faux finishes** are used to create an illusion of texture on a surface by employing sponges, special rollers, rags, etc. Such applications require tools, skill, experience, but also a keen sense of composition, rhythm, and visual balance. Considering the time commitment required, novelty and faux finishes can be fairly costly to implement.

**Paint is classified as household hazardous waste** and the transportation, removal, and disposal are regulated at the government level as outlined by EPA. Planning is required when ordering paint. How much paint is required should be carefully calculated and leftovers should be expected. It is possible to donate paint leftovers in its original container with labels left intact. You can also seek paint recyclers for disposal. **Never pour leftover paint directly into the sinks or toilets.** It is also important that painting tools such as rollers, brushes, etc. should only be washed into the blackwater stream, that is connected to the public sewer system. For water-based paint, let it dry in the container then dispose of after it is hardened. For solvent-based paint, contact local or state environmental control agencies for guidance.
Lead was a hugely popular paint additive from 1900 to 1960. In 1978 it was banned from use after the negative health impact was better understood. **Lead-based paint** was present in three-quarters of U.S. homes built before 1978, and even today many of these houses **might feature lead paint**. The reason behind lead use was to stabilize the paint, increase durability, and resist moisture. Lead paint crackles over time, flakes, and dust are released to the environment, which can be ingested or inhaled. Lead is a known carcinogen, a poisonous neurotoxin, and an endocrine disruptor. It is extremely harmful especially during child development.

**It is critical that lead paint is identified and removed by experts**, or sealed in an approved manner. Any demolition process, or even sanding down a substrate can disturb the present lead and release lead dust, so utmost care and attention is required.

**WALLCOVERINGS**

**Wallcoverings** are continuous sheet materials that are intended to be cut into strips, aligned, and adhered to wall surfaces. **Wallpaper** refers to a single type of wallcovering product; the two terms are **not interchangeable**. In the olden days, the material was just paper whereas today’s wallcoverings can be cotton, vinyl, cork veneer, wood veneer, or grasscloth. Chinese rice paper examples on walls were dated to as early as 200BCE. The oldest fragment of possibly the first European wallpaper application is from the year 1509, was found in Christ’s College, Cambridge England. The repetitive matching of today’s wallpapers is credited to the late 17th century French printmaker Jean Papillon. After the industrial revolution, wallpaper became available to people of more moderate means, William Morris’s paisley pattern designs stimulated public interest. Also popular in this period, **flocked paper** designs were printed with an adhesive and heavily sprinkled with finely

---

**Fig.05/18** Flocked wallpaper is often associated with the Victorian era patterns and aesthetic.

**Fig.05/19** Paisley designs were popularized by William Morris, from the Arts & Crafts movement.
Most commonly used international wallcovering symbols.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Resistant</td>
<td>Free Match</td>
</tr>
<tr>
<td>Washable</td>
<td>Straight-Across Match</td>
</tr>
<tr>
<td>Extra Washable</td>
<td>Drop/Offset Match</td>
</tr>
<tr>
<td>Scrubbable</td>
<td>20-10 Pattern Repeat Offset</td>
</tr>
<tr>
<td>Paste the Wall</td>
<td>Direction of Hanging</td>
</tr>
<tr>
<td>Paste the Paper</td>
<td>Reverse Alternate Length</td>
</tr>
<tr>
<td>Pre-pasted</td>
<td>Peelable</td>
</tr>
<tr>
<td>Moderate Light Fastness</td>
<td>Strippable</td>
</tr>
<tr>
<td>Good Light Fastness</td>
<td>Duplex</td>
</tr>
<tr>
<td>Excellent Light Fastness</td>
<td>Coordinated Fabric Available</td>
</tr>
</tbody>
</table>

Fig.05/20 Most commonly used international wallcovering symbols.

chopped bits of silk and wool, imitating damask or velvet.

Accurate specification of wallcovering products requires an understanding of characteristic properties, which are as follows: **washability** determines the resistance against sponging with listed cleaning solutions; **scrubbability**, is measured in cycles, determines the resistance against brushing with listed cleaning solutions; **abrasion resistance**, is also measured in cycles, determines the wallcoverings ability to withstand scuffing, scratching, scrubbing, and scraping; **stain resistance** determines the material’s ability to endure staining from a variety of reagents; **colorfastness** determines the ability to maintain color and resist fading against chemical and mechanical abrasion as well as UV exposure; **blocking resistance** is the material’s ability to avoid unwanted adhesion; **strippability** refers to the ability of the wallcovering to be separated from the substrate as a single piece, without leaving any residue; slightly different, **peelability** refers to a feature where when separated from the substrate, the wallcovering leaves a liner layer behind to be used for new application or can be cleaned with warm water.

The **breathability**, or permeability of a wallcovering is an important concern that determines the possibility of fungal growth on the substrate. Similar to oil-alkyd paints, the trapped moisture might facilitate hidden mold and mildew growth behind the wallcovering. This is especially problematic on the interior surface of exterior walls that are not well insulated. Cold spots due to thermal bridges eventuate condensation points that are much more susceptible to growth. **Microventing** enables breathability for otherwise impermeable non-woven products. It is normally invisible, visible only when held up to a light source. Woven or breathable wallcoverings are **susceptible to bleed**, where moisture, stains, or adhesives from the backside can bleed towards the front facing of the product. A sealer on the substrate, as well as a backcoating is required to prevent this phenomenon. Applying wallcovering without cleaning up the previous layers of paint or wallcovering might impede breathability and create problems, even when the new wallcovering is breathable.

A typical wallcovering product features three layers: decorative layer, intermediary layer, and backing layer. **The decorative layer** features the pattern and relief determining the visual quality; it can feature a transparent wear layer

The designer should consider that **organic fibers** are food source for micro-organisms and insects. Moreover, they might not be able to sustain dimensional stability with moisture changes. Polymer-based or fiberglass wallcoverings are less susceptible to this problem.
for improved abrasion resistance. Various materials can be used as decorative layers such as paper, grasscloth, string, wood veneer and cork veneer, foil and Mylar®, flocking, cloth, leather, and vinyl. There are several printing methods for applying patterns and textures on wallcoverings – *screen printing* involves several screens with different colors and patterns assigned to them, which are sequentially pressed for a combined impression. *Block printing* is a more traditional technique that involves pressing paint via carved blocks onto the wallcovering. *Rotogravure*, or cylinder printing, involves the wallcovering running through engraved cylinders fed with colored ink. Digital printing provides flexibility, enables previously highly expensive murals at a reasonable price, or custom patterns in short-runs. *The intermediary layer* supports the decorative layer both structurally and visually.

Lastly, *the backing layer* that is adhered to the wall surface determining the mechanical performance of the product. The backing layer can belong to one of the three categories: *Paper backing* is more appropriate for light traffic applications. *Woven backing*, often involves a cotton polyester blend for better performance and increased flexibility. Woven scrim backing is lightweight, and Osnaburg backing is medium-weight. Drill refers to a heavy-duty backing used for high traffic situations. *Nonwoven backing* allows higher dimensional stability, can be fused with the decorative layer.

**Acoustic wallcovering** solutions are available with a noise reduction coefficient (NRC) between 0.2 to 0.8. Lacking physical depth, wallcoverings are very ineffective in attenuating lower frequencies and they are not intended as standalone acoustical solutions by themselves. They are more likely to complement the acoustics.

According to the standard *ASTM F793*, wallcoverings are classified into 6 categories based primarily on use characteristics, with increasingly higher performance requirements. *Category I* is decorative applications only. *Category II* covers decorative and medium serviceability applications; some colorfastness, washability, and flame resistance requirements are present. *Category III* covers decorative and high serviceability applications; with some scrubbability requirements, good crocking resistance, and stain resistance against a variety of reagents. *Category IV*, also referred to as Type I, is for commercial serviceability, with higher scrub, abrasion, and tear resistance requirements. *Category V* or Type II is also for commercial serviceability, involves higher performance requirements and significantly higher blocking resistance and stain resistance. *Category VI* or Type III is for commercial serviceability as well, with significantly higher performance requirements. For instance, 1000 cycles abrasion resistance vs. 300 for Category V or 500 cycles scrubbability resistance vs. 300 for Category V.
Between multiple manufacturers, wallcoverings feature a massive selection of patterns. Wallcoverings can also feature relief patterns, embossment, sheen, etc. Murals are large-scale, non-repeat applications split and printed on a series of panels. They can be scenic, floral, architectural, or graphic in nature. For instance, Chinoiserie murals feature patterns that reflect the heavy interest developed towards eastern artwork in the 18th century Europe. Almost every wallcovering manufacturer has a custom pattern service with detailed submission requirements. Custom projects can be costly with increased lead times. Besides a litany of colors and patterns, wallcoverings also provide functionality such as magnetic, dry erase, or whiteboard surfaces.

Pattern matching is a very important concept in wallcovering applications. The major types of pattern matching are straight-across match, random match, and drop match. In straight-across match, all adjoining strips must be lined up so the pattern is aligned on a single line, typically the ceiling, and matches exactly on both sides of the strip. In random match, the pattern of strips will match regardless of adjoining strip positions. However, achieving a good sense of randomness and balance requires experience and skill on the wallpaper hanger’s part. Alternative strips can be reversed to reduce the negative effects of color and shading variations.

In drop-match, the pattern aligns only when one strip is dropped per pattern repetition. Typically the length of the pattern repeat is 18” or 36”. Instead of the horizontal axis, a diagonal axis is emphasized. Drop-match results in the most wastage, each vertical strip needs to be continuous. There are two types available: half-drop match and multiple-drop match. Half-drop match involves dropping every other strip by half of the pattern length; so for a 36” pattern repeat the drop is 18”. Multiple-drop match is more complex, involving at least 4 drops before the strip aligns with the first strip. This means for a 36” pattern height stretching 4 strips, each strip should be dropped 9” before the pattern repeats itself on the horizontal axis. Wallcovering should be carefully cut, laid down, and numbered before adhesive application. Dye-lot number indicates if a series of wallcovering rolls are printed in sequence or not. This is important to make sure that the colors will exactly match between strips from different rolls, minimizing visual inconsistency.

Wallcovering rolls are priced as a single unit but sold as continuous double units (double roll),
which minimizes wastage. Triple rolls are also available. There are two width alternatives, the narrower type is called European rolls are 20.5” wide with 33’ double roll length, covering approximately 55 square feet. And the alternative is the American roll that is 27” wide with 27’ double roll length, covering approximately 60 square feet.

**WALLCOVERING APPLICATION**

Wallcovering application is a fairly straightforward and relatively less messy application, one of the last jobs on site. Similar to paint application, the **minor imperfections on the substrate would be amplified on the wallcovering surface.** This, however, is also tied to the backing type used. Wallcoverings with thicker backing are slightly more forgiving. The substrate needs to be fully sealed before the application, and the seal needs to be fully cured before moving forward. Especially for gypsum board applications, a sealer application underneath the wallcovering is beneficial in the sense that when torn down, wallcovering can **damage the paper facer of gypsum.** The sealer improves strippability of the wallcovering. Wallcovering primer works with the same principles as paint primer, though the formulations are different. Smoothing out the wall, increases the adherence to difficult surfaces, hides the previous colors and stains, makes removing the wallcovering easy.

**Wall liner,** also known as paper liner or liner paper, is a useful barrier for hiding flaws and imperfections on the substrate while providing a smooth surface. It comes in various thicknesses, thinner wall liners are not able to hide flaws. Wall liners, as well as wallcoverings, can be **pre-pasted,** meaning the backing is treated with adhesive during manufacturing which is typically activated by the application of water. Liners are applied horizontal to the wall, underneath the vertical wallcovering strips. Wall liners can also provide a surface to paint on, it is possible to omit the wallcovering layer altogether. Sizing a wall means applying wall size on plaster or over primer. **Sizer application creates a somewhat slippery layer, helps with sliding and adjusting the wallcovering during installation, also helps with grip and peelability.** Before hanging the wallcovering, the stock should be carefully examined for defects such as color bleeding, shading errors, off-register prints, ink spots, delamination, etc. The overall job should run on grain, and pattern should not be clashing architectural details, rather enforce them. There should be no adhesive drips or smears on the wallcovering facing. There shouldn’t be any bubbles or crush marks visible.

![Adhesive is being applied on cut strips of wallcovering.](image)