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Whiter than White

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Whiter than White

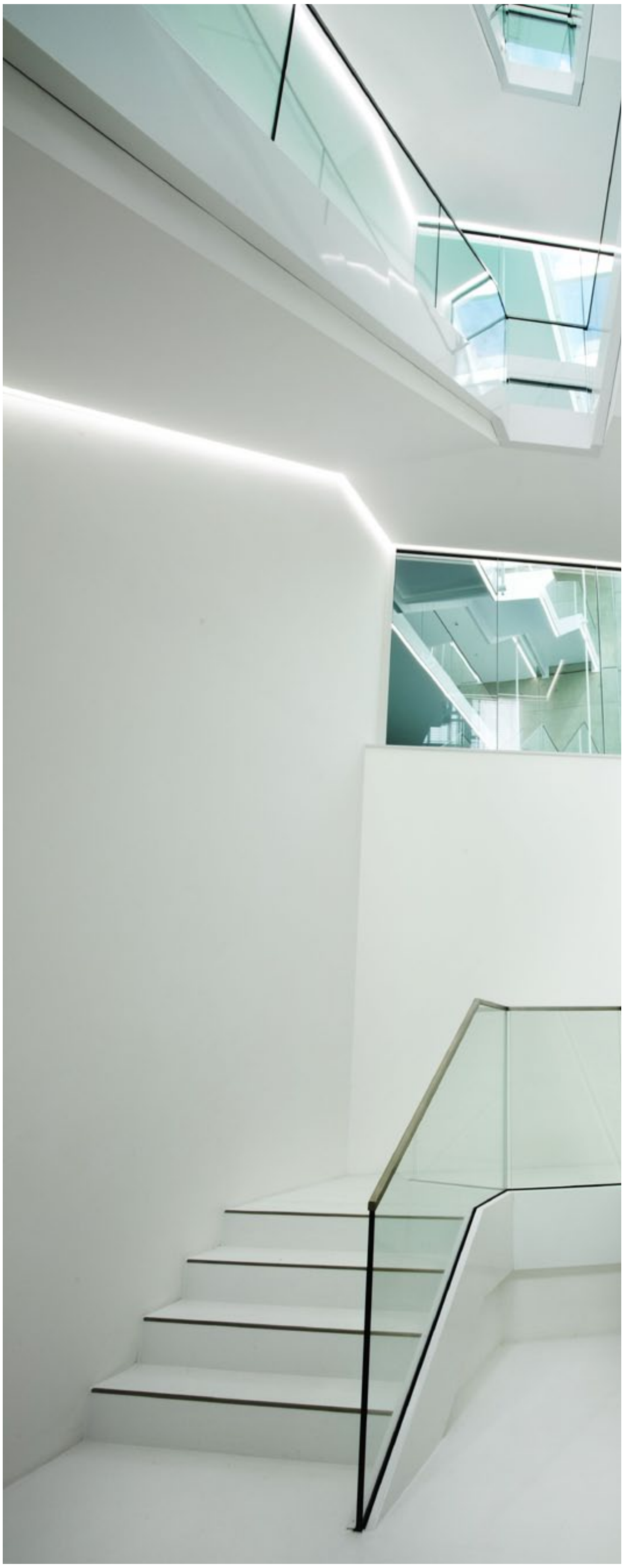
White, the defining icon of modernism.

Immortalised by Le Corbusier's 'Law of Ripolin', his decree to white-wash all walls and surfaces, white was venerated by modernism as a universal purifier for modern habitation and a pure expression of rationalism. But while a strict modernist aesthetic today is increasingly hard to find, a modernist design tradition of material and construction honesty still prevails among many designers and architects.

Le Corbusier declared: "Trash is always abundantly decorated; the luxury object is well-made, neat, pure and healthy, and its bareness reveals the quality of its manufacture. It is to industry that we owe the reversal in this state of affairs: a cast-iron stove overflowing with decoration costs less than a plain one; amidst the surging leaf patterns flaws in the casting can not be seen."

Among the bold inferences here that modernist aesthetic and philosophy are superior in both culture and integrity, is the clear assertion that in the pure and un-ornamented world of whiteness and modernism lies the highest level of design and skill, unable to hide flaws and defects beneath superfluous decoration.

It is in this sense that an ever present whiteness continues to prevail throughout modern architecture. Not as architectural or philosophical ideology but as the most explicit demonstration of the highest quality design and construction.



Hank + Hirth Free Architekten - Photo: Oliver Stark

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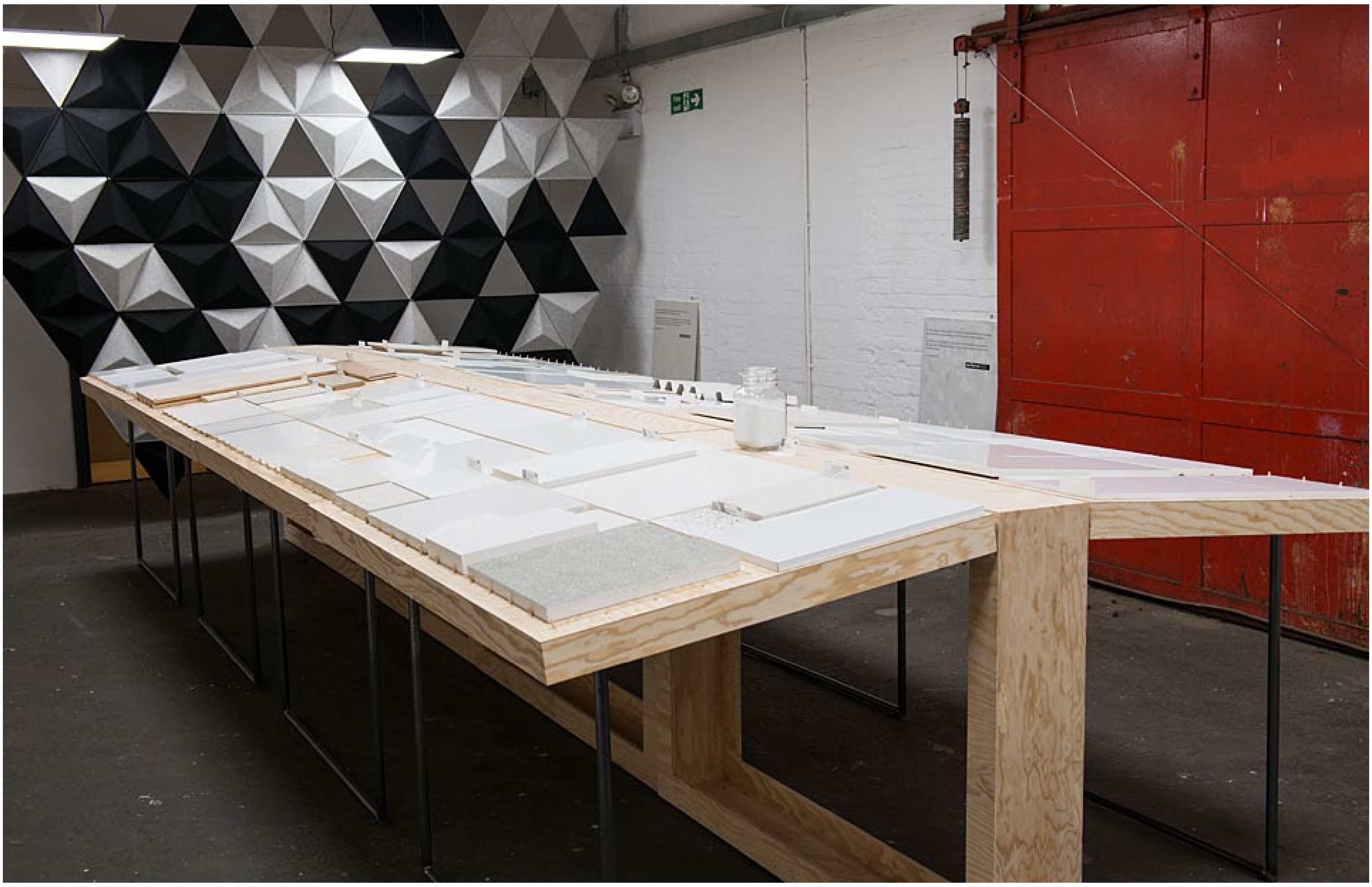
The exhibition

Whiter than White is an exploration of the pursuit of 'whiteness' in the built environment, showcasing a highly-curated selection of architectural materials and finishes.

What makes a material white and what concessions must be made by designers in the face of practical, economic and environmental constraints?

Whiter than White demonstrates that achieving an iconic 'whiteness' is not as simple as it first appears.



Practical design implications of white materials in architecture

White surfaces are not just an aesthetic choice or architectural ideology, they also have many practical design implications that can be employed by effective design strategies to improve the performance of a building.

However, if not properly implemented or controlled these same phenomenon can also pose design challenges when using white materials.

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Albedo

Albedo is the term used to describe the total solar radiation reflectance of a material or surface. The higher the albedo of a material the more solar energy is reflected from its surface.

A higher albedo is beneficial in mitigating thermal build up in materials. This phenomenon is a key design strategy in improving the energy efficiency of buildings and alleviating the urban heat island effect.

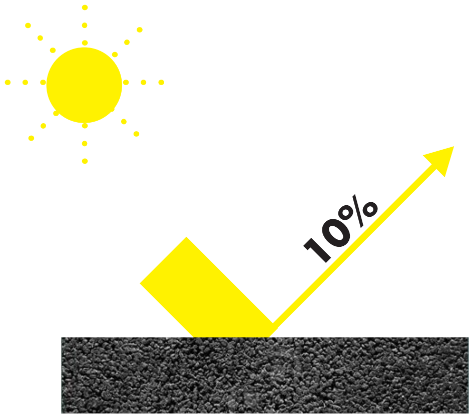
Dark external surfaces with a lower albedo are problematic through a number of mechanisms:

- greater thermal transfer into buildings requiring more energy for cooling
- uncomfortable outdoor spaces, with experienced temperatures above ambient temperatures
- decreased lifespan of materials as a result of fluctuating temperature cycles
- greater contribution to the greenhouse effect as more long wave infrared energy (heat) is emitted and trapped by the Earth's atmosphere
- decreased air quality of surroundings

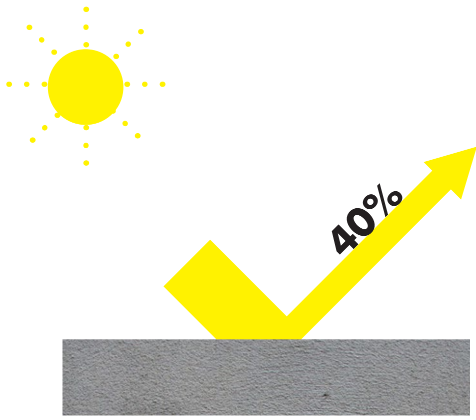
Lighter surfaces typically have a higher albedo than darker surfaces, with polished metals and white surfaces exhibiting the highest values.

Despite highly polished metals having a higher albedo compared to white surfaces, it is the white surfaces that are the most effective in mitigating thermal build up and the heat island effect. This is due to polished metals' low emissivity, the rate at which heat is radiated from a material.

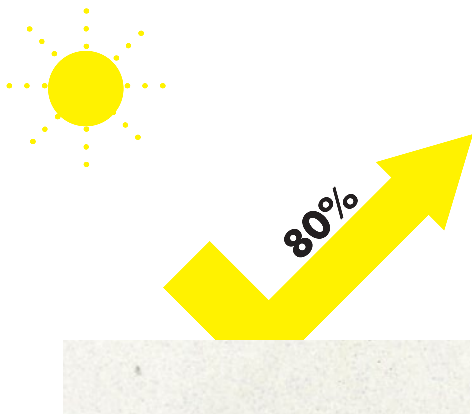
Typical albedo values of paving materials



Asphalt:
Albedo 0.1



Concrete:
Albedo 0.4



White Concrete:
Albedo 0.8

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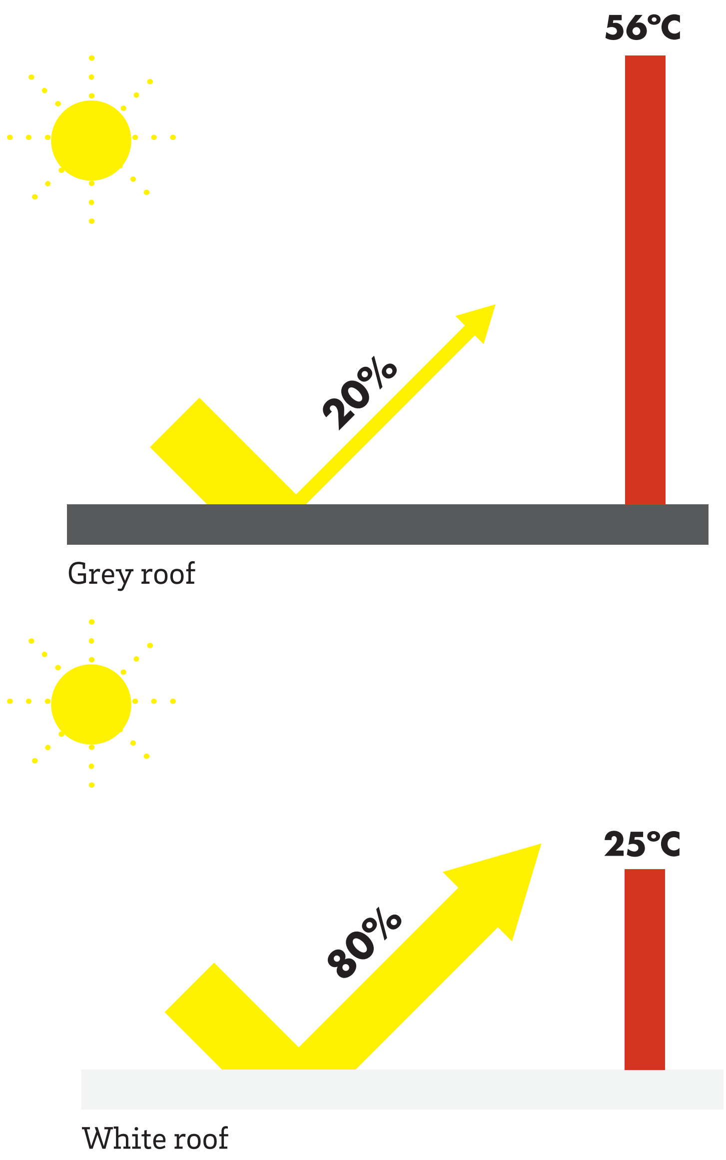
Albedo in action

On a typical summer afternoon, a clean white roof that reflects 80% of sunlight will stay approximately 31°C cooler than a gray roof that reflects 20% of sunlight



Calculated under the standard summer afternoon weather specified in ASTM Standard E1980-11, using the medium wind speed condition.
Berkeley Laboratories – Heat Island Group (http://heatisland.lbl.gov/)

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Increased Light Reflectance Value

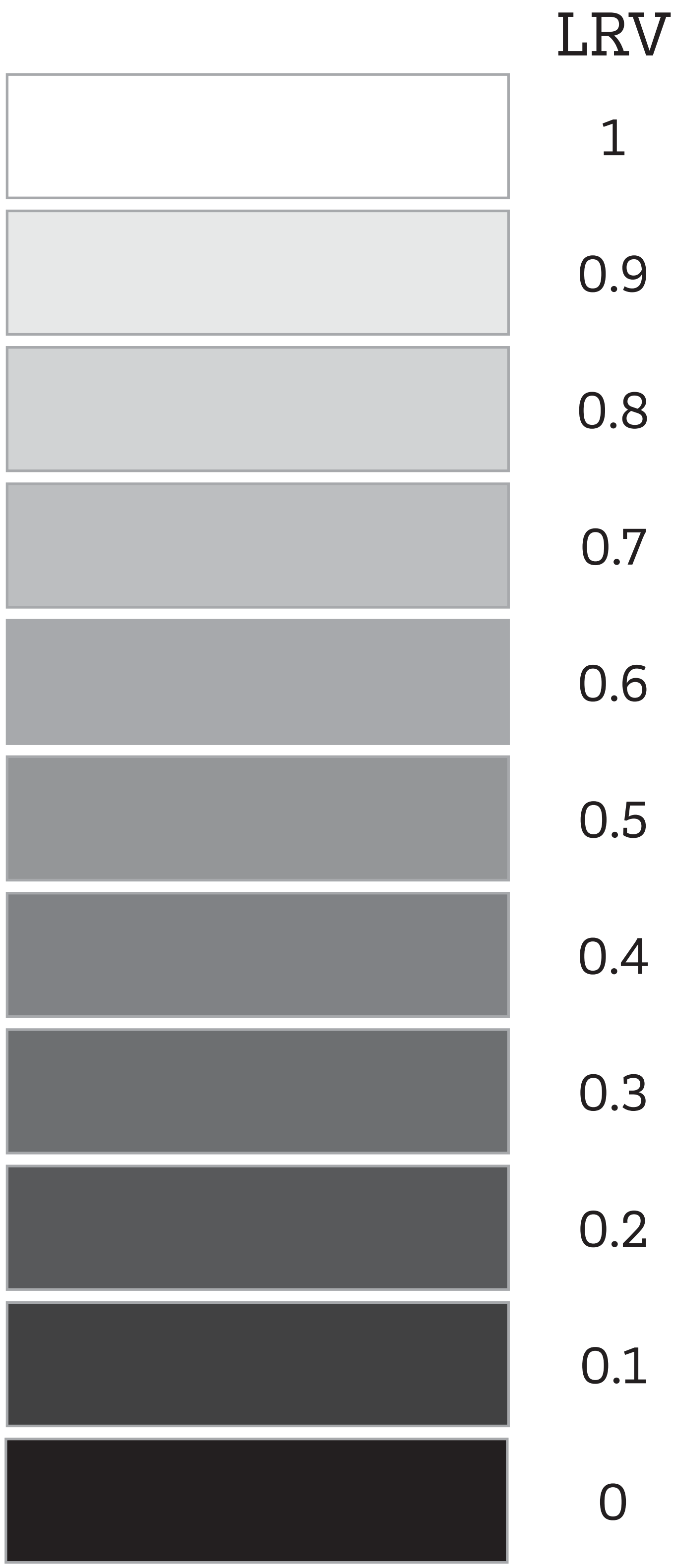
The Light Reflectance Value (LRV) of a material is the percentage of light in the visible part of the spectrum that is reflected from its surface.

LRV values are between 1 and 0, with a theoretical perfect white achieving a value of 1, reflecting 100% of visible light, and a theoretical perfect black achieving a value of 0, absorbing 100%. In practice LRVs will not reach the theoretical limits with white surfaces achieving values up to 0.85.

Increasing the LRV of surfaces within a space increases the brightness of that space. In practical terms this means that natural daylight is maximised, windows can be made smaller and the demand for artificial light is reduced, decreasing the number or power of fixtures required and ultimately lowering a building's energy consumption.

LRV is similar to albedo, however it only indicate the reflectivity in the visible part of the spectrum. Albedo refers to the total solar energy reflectivity including UV and infra red radiation.

Indicative Light Reflectance Values



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Colour neutrality and light source

Reflecting all colours in the visible light spectrum, white surfaces reflect light in its most natural form. As all visible colour wavelengths are present in the reflected light, the colours of objects appear their most authentic, a reason galleries in particular are typically blank white spaces.

This phenomenon is of course dependent on the quality of light incident in a space.

The sun is considered to be the reference for light sources emitting the fullest spectrum of visible light, with incandescent sources and their halogen derivatives performing most similar. However, high quality low-energy light sources such as LEDs and fluorescent bulbs now also perform admirably, demonstrating high Colour Rendering Index (CRI) values - the measure of the ability of a light source to faithfully reproduce the colour of an object in comparison to a reference light source.

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Maintenance

White materials and surfaces require a higher frequency of cleaning and maintenance than their darker coloured counterparts. This increased visibility of dirt and debris is part of the rationale behind the association of hygiene and white surfaces.

Maintenance issues are especially problematic in absorbent and porous materials such as unsealed natural stone or textiles.

When selecting white materials, maintenance schedules and the perceived aging of a building must be considered. High-traffic areas or use in areas with high levels of airborne contaminants (pollution) are least suitable for white environments.

However, white surfaces employed externally can have an extended life span compared to their darker counter parts due to the reduced detrimental effect of thermal cycles.

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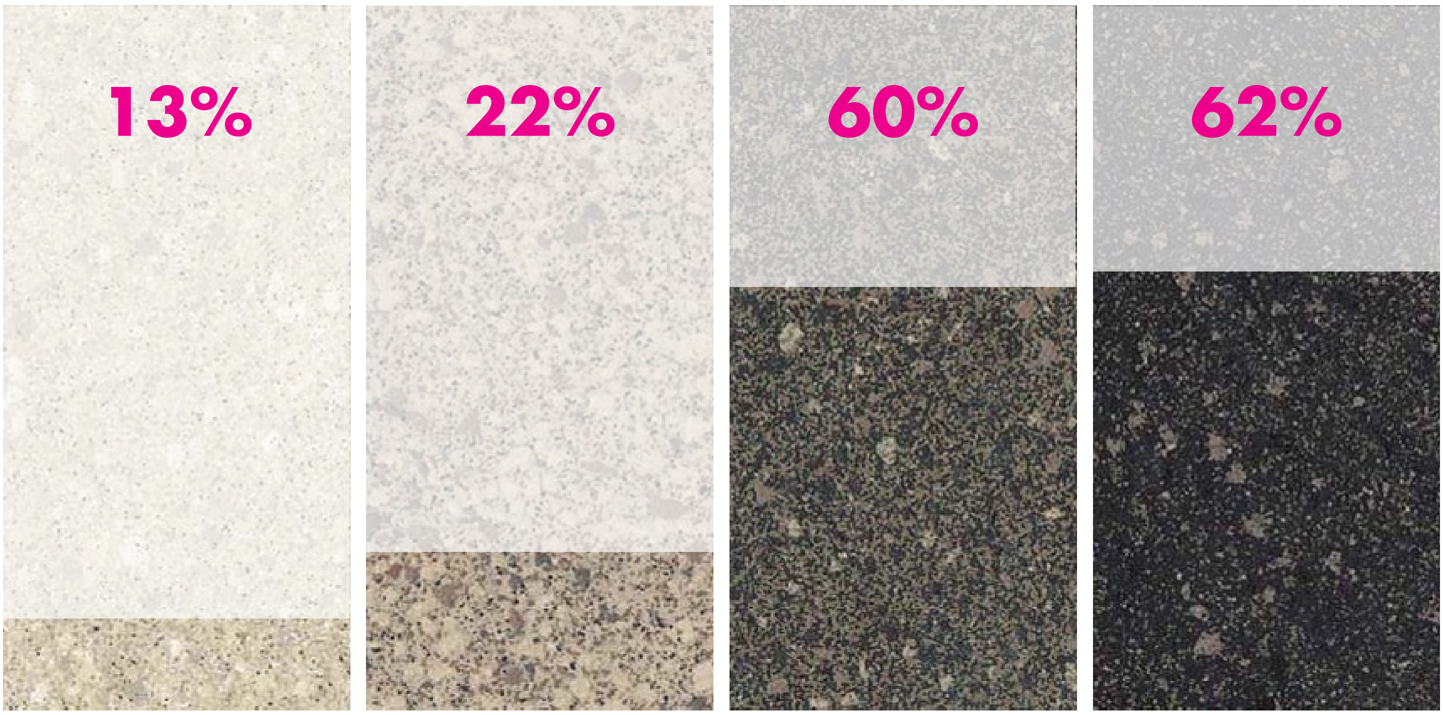
Recycled content

Challenges in waste separation and the sourcing of high quality recycled raw materials leads to lighter coloured materials generally having a lower recycled content than their darker coloured counterparts. This is particularly problematic with post-consumer recycled content.

As can be seen below in the example of a porcelain tile range, the tone of the tile becomes darker as the amount of post-consumer recycled content increases.

Proportion of recycled content in a porcelain tile



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Material groups

The various material typologies available to us - glass, stone, metals, timber, polymers - are derived from many different raw materials and go through a wide range of processes to make a final usable product.

By examining each stage of a material's production we can understand how the choices we make and the design constraints placed upon us influence its appearance, cost and performance.

Understanding these influences allows us to make better and more informed material selection and specification.

Glass

Hard and dense, nonporous, weather and chemical resistant, glass is a material that can be used in an array of architectural applications. Its inherent brittleness can be overcome by thermal and chemical treatments, or through lamination with a flexible polymer interlayer. Glass products can be found internally or externally, used for floors, walls, ceilings and even entire building envelopes.

Glass is manufactured from readily available, abundant raw materials and can be endlessly recycled. It is nontoxic and long lasting, giving it an impressive environmental story.

Its most enduring quality, transparency, is used extensively in windows and curtain wall constructions, bringing natural light into buildings and allowing views to the outside. These optical qualities, however, can make glass an environmentally problematic material when considering a building's operational performance.

When employed to achieve a white surface the transparency and durability of glass is used to protect less robust coatings or layers, giving this almost colourless material its white appearance. Although less common, through-bodied white glass products, where the colouring is present throughout the body of the glass, are also available.

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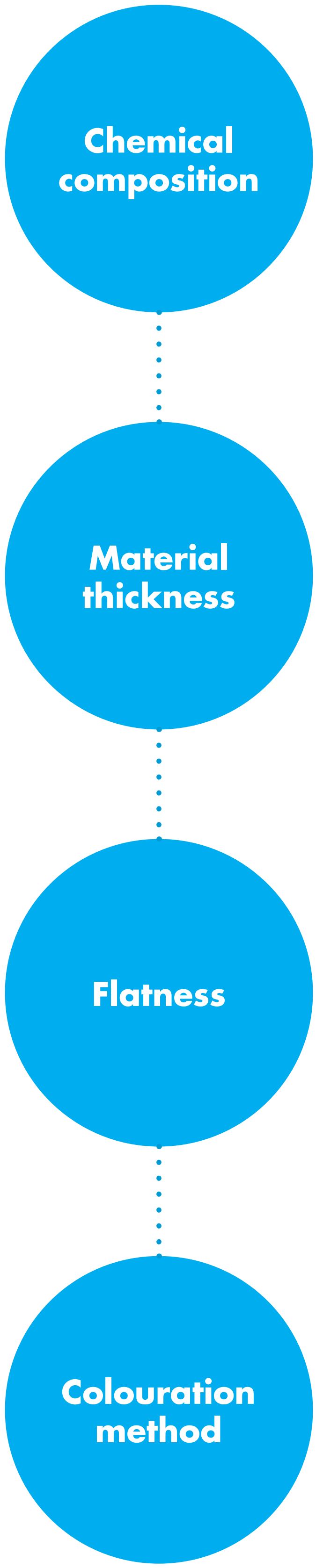
What makes glass white?



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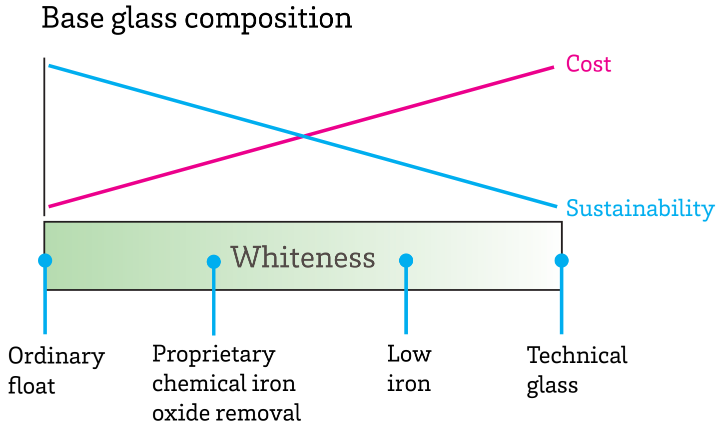
Glass

What makes glass white?

Chemical composition

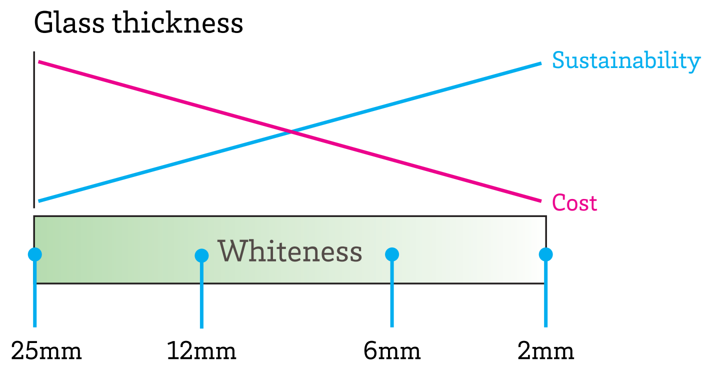
Glass is primarily composed of silicon dioxide (SiO^2) but its visual properties are also effected by chemical impurities in its makeup, commonly metal oxides.

The instantly recognisable green tint is the result of iron oxide (Fe^2O^3) impurities. By reducing the iron oxide content in glass the green tint can be reduced, improving its optical clarity. However, low iron glass is inherently more costly to produce and embodies a higher environmental burden.



Glass thickness

With increasing thickness any visible colour tint in the glass will become more apparent. By minimising the glass thickness weight and cost can be decreased, however strength and durability are compromised and the thermal insulation performance of the glass is also reduced.



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Flatness

Flatness plays an important role in ensuring a homogenous colour tone across a glass sheet. Any undulations in the surface of glass will be visible as shadowing or distorted reflection.

Toughening processes used to create safety glass causes a ripple on the face of glass sheets, known as 'rollerwave', leading to distorted reflections and a reduced consistency of colour due to shadowing.

Colouration method

Glass can be given a coloured appearance through a number of production methods:

• a coloured ceramic or polymer coating applied to the rear of a pane, known as **back-painted glass**
• a polymer interlayer laminated between glass sheets, known as **interlayered glass**
• etching the surface with acid or sand blasting to create a milky appearance that diffuses light, known as **etched glass**
• pigmentation added in the production of the glass to produce colour throughout the sheet, known as **body-coloured glass**

Back painted glass products, if toughenable, can be used for external applications.

The double faced nature of interlayered glasses makes it suitable for applications where both faces are exposed, such as partitions and balustrades.

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Stone

A relatively unprocessed material extracted directly from the earth, a natural stone's physical properties are a consequence of the environmental conditions that led to its formation. The wide variation of matter and circumstances that have created the natural stones means their aesthetic qualities and performance properties are equally diverse.

Dimensional stones suitable for use in architecture are typically hard, dense and long lasting. Weight can often be an issue as relatively large thicknesses of material are required to ensure an appropriate level of strength and a long service life.

In environmental terms, the longevity of suitable natural stones, their inertness and the minimal required processing are big strengths. However, the quarrying of natural stones can generate large quantities of waste material (called 'overburden') and has a severe detrimental impact on the ecosystem it occurs in. Transportation, necessitated by quarry locations, of such heavy elements can also lead to large quantities of greenhouse gas emissions.

Pursuing a white appearance in stone can be challenging. Naturally occurring mineral impurities in the body of natural stones cause aesthetic variations and reduce their colour consistency. There are also limited quantities of particular stones accessible to be quarried.

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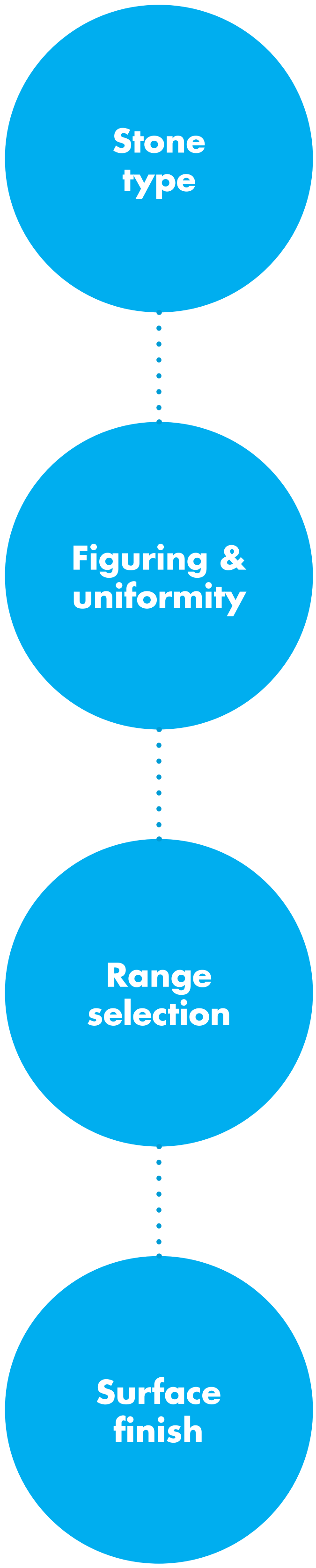
What makes stone white?



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Stone

What makes natural stone white?

Stone type

The appearance of a natural stone is determined by its chemical make-up and the process by which it was formed. Stones formed of large percentages of calcium carbonates or quartz crystals are typically the whitest.

The condition the stone was formed under determines the (crystal) grain size, with finer crystals leading to a more homogenous and therefore whiter appearance.

Figuring and uniformity

Veins, features and movement in natural stone are a consequence of mineral differences within the body of the stone. The colour and uniform distribution of these characteristics play a large role in achieving a desired level of consistent whiteness.

It is advisable to select a stone that is known to be consistent in colour and form from the outset as controlling the appearance of a more lively product through selection and surface finishing can be a costly and involved process.

Grain size effecting uniformity

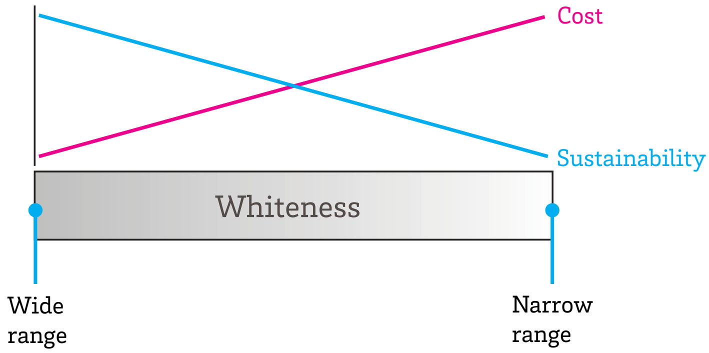
Two stones Naxos (left) and Thassos (right), chemically very similar, however differences in crystal size produce a distinct difference in homogeneity.

Range selection

Agreeing an acceptable 'range' of the visual quality of the desired stone, the amount of figuring and uniformity, in advance with the stone supplier is crucial in achieving a consistent white appearance.

A narrow range, allowing for little variation in the stone's appearance, can be a very costly and lead to high levels of wastage. This strategy is realistically only applicable when the required quantities of natural stone are relatively small.

Range selection



Surface finish

Natural variation and features within a stone can be emphasised or subdued depending on the finish applied to the surface of the stone.

A polished surface produces more vibrant colours accentuating any features within the stone, whereas more textured surface finishes, such as sandblasted or hammered, can be used to attenuate colour and create a more homogenous tone across the surface of the material.

Smooth surface finishes, such as honed or polished, are unsuitable for flooring applications due to their extremely low slip values. Textured finishes, such as flamed, sand blasted or hammered, improve the slip rating of stone surfaces enabling their use as extremely hard wearing flooring.

Reconstituted stone

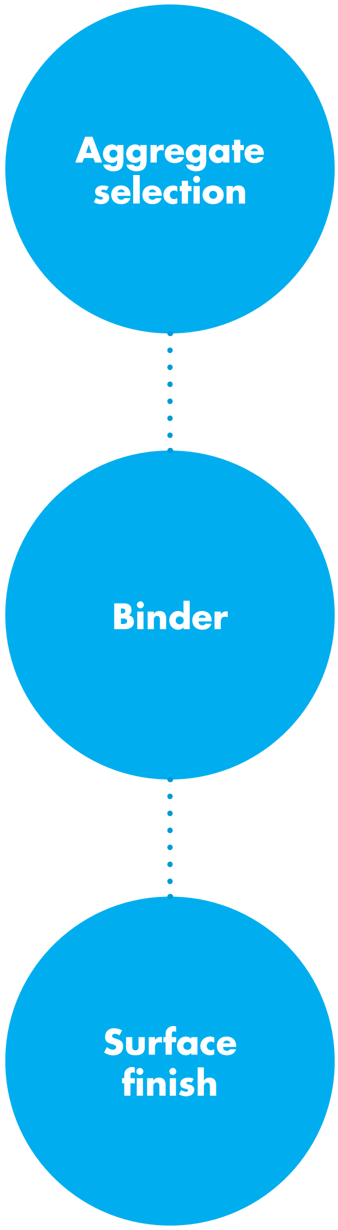
A combination of mineral aggregate and resin binders, reconstituted (recon) stone blends the aesthetic qualities of natural stone with the performance and predictability of a synthetic material.

Hard, dense, nonporous, chemical and weather resistant, recon is a highly durable material suitable for a range of demanding applications. It is most frequently used for internal flooring and work surfaces.

Recon can easily be manufactured using by-products of stone quarrying or recycled materials. There are some concerns over the use of petrochemical based binders, however advances are being made in reducing their environmental impacts, with some manufacturers using bioresins as a binding matrix. Recon stone is a long lasting material, but its end of life reprocessing options are currently limited to downcycling.

As a man made product recon stone can be readily supplied in large consistent slabs or panel sizes with uniform visual qualities throughout the body of the material. Aggregate and binding material can be selected to control the product's colour tone with reasonable precision, making it an excellent option when searching for white materials.

What makes recon white?



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Reconstituted Stone

What makes reconstituted stone white?

Aggregate selection

Recon stone is manufactured from small, high quality chippings of natural stone, called aggregate, held together with a binder. The stone selected for use as the aggregate has a significant impact on the recon's appearance. When aiming for a white recon, a white consistent natural stone must be selected for aggregate.

The size of the selected aggregate, its grading, is also important. Finer and consistently sized aggregate will produce a more uniform appearance in the final product, whereas larger aggregates give a more similar appearance to natural stone.

Reconstituted stone can readily incorporate waste material from the quarrying of dimensional stone. However, as quality demands increase, the virgin material required can also increase. This is unfortunately the case for the whitest materials.

Aggregate size affecting uniformity

Binder

The binding resin that holds together the stone aggregate makes up between 5 - 15% of the body of a reconstituted stone. Being a synthetic additive it allows more accurate control of colour and tonality.

An issue to be aware of is that resins are not completely UV stable and can 'yellow' over time with exposure to UV light. This can be especially prominent with light-coloured stones.

Recon stones that use a natural binder, primarily cement, are called Terrazzo. They are typified by medium to large grades of high quality aggregate.

Surface finish

Reconstituted stones are most commonly available in honed or polished finishes, which have limited impact on the colour consistency of the material surface, however a polished surface can be used to provide an enhancing sheen to an already brilliant white surface.

Again, the poor slip performance of smooth surface finishes, such as honed or polished, are unsuitable for flooring applications. Textured finishes, such as flamed, sandblasted or hammered, improve the slip rating of recon tiles enabling their use as extremely hard wearing flooring.

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Concrete

Liquid stone, concrete is ubiquitous within the built environment. Made using varying proportions of cement, sand, aggregate, water and an abundance of admixtures and reinforcement materials, concrete's performance can be manipulated to fit a wide range of potential applications.

Abrasion resistant, high strength, low cost, available in large sizes, precast or cast in-situ, all qualities which have made concrete the most widely used material in construction projects. Weight is the major draw back when considering concrete, with large volumes needed to achieve appropriate strength and technical performances.

Environmentally, concrete is the largest cause of greenhouse gas emissions of all architectural materials. This is predominantly due to the energy intensive process of cement manufacture but, importantly, also due to the vast quantities of concrete consumed. It is hard-wearing, long-living and has excellent thermal performance properties making concrete a strong option when considered in the context of a building's life cycle and operational performance. The concrete industry is also making significant steps to reduce the environmental impact of cement production.

Concrete, often considered as a rough construction material, can be produced to have an excellent standard of finish rivalling the aesthetic qualities of any white surface.

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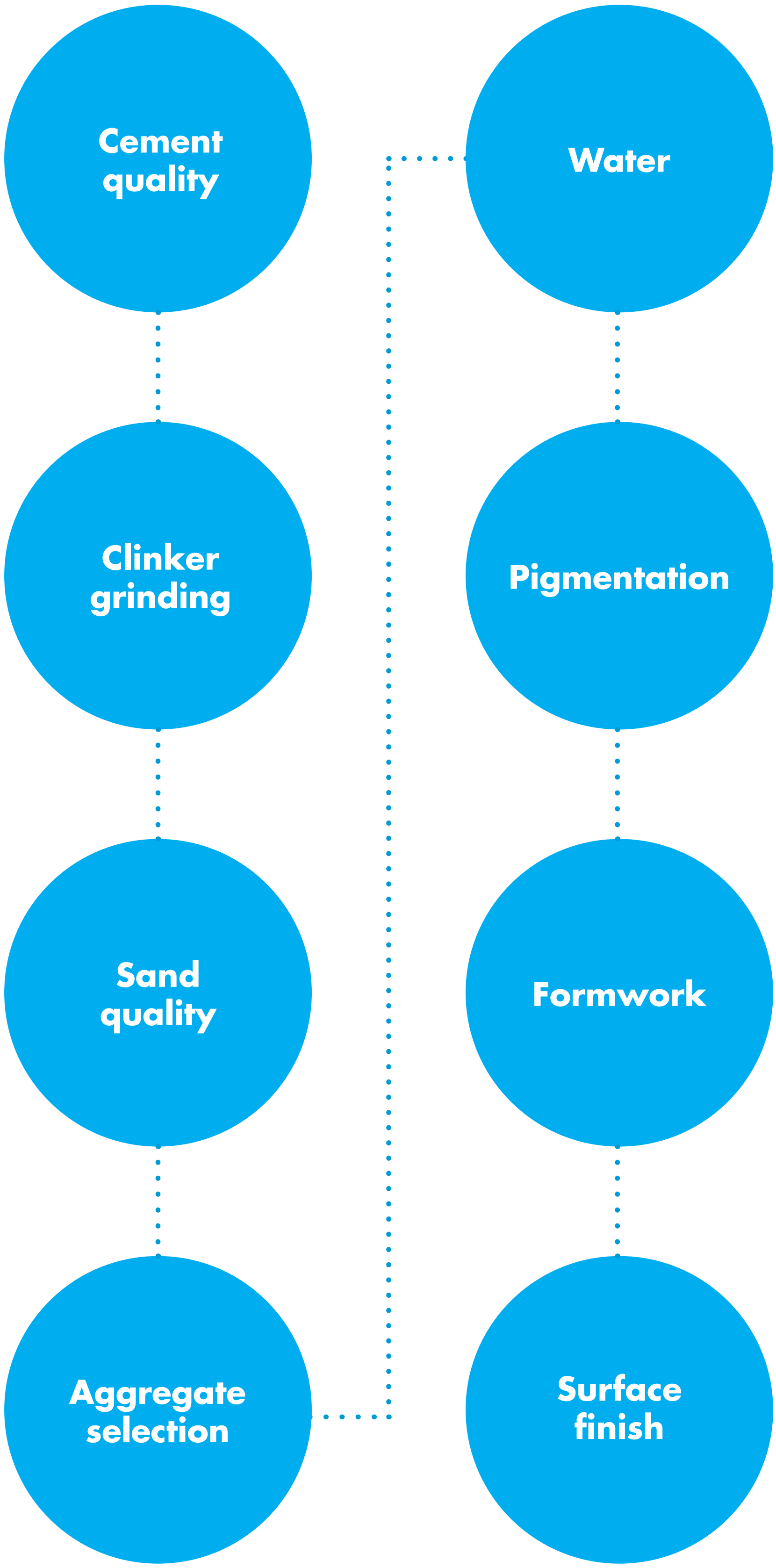
What makes concrete white?



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Concrete

What makes concrete white?

Cement quality

By controlling the mineral impurities usually present in grey Portland cement a whiter, more consistent cement can be achieved, essential for the production of white concrete.

Again, iron oxide (Fe^2O^3) is a key impurity to control in achieving a brilliant white.

The colour of the cement component of concrete is most important in smooth, fair-faced concrete finishes and decreases in importance as more aggregate is revealed through further surface finishing processes.

It has been shown that cement plays a dominant role in the albedo value of concrete mixes and so the use of a white cement can improve the building performance of concrete elements and surfaces.

GGBS (ground granulated blast furnace slag), recovered from the production of steel, is a light-coloured cement replacement with environmental benefits. Although it will not result in the most brilliant white concrete it has a strong environmental story. Another cement replacement is PFA (pulverised fly ash), though this is less white still.

White cement is inherently more costly than ordinary Portland cement. A concrete with white cement can cost twice as much.

Ordinary Portland cement

Ultra-white cement

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Clinker grinding

Clinker is the large aggregate chips derived from limestone. These chips are then ground down to produce the cement used in concrete.

By grinding the clinker for longer, a finer more consistent cement is produced, improving the whiteness of the resultant concrete. But this additional grinding also increases the material processing time and, therefore, its cost.

Sand quality

The colour and purity of the sand used in a concrete mix will greatly effect its colour. A crisp white low-iron sand is preferred for a white concrete mix, however sand of this clarity and quality is less common and must be transported from particular locations, further increasing costs.

Aggregate selection

To achieve a consistent white concrete with a smooth fair-faced or polished finish, careful selection of very finely ground aggregate is important.

A fine aggregate will effect the body colour of light-coloured concretes, therefore light-coloured natural stones such as dolomites or quartz are preferred as the source of aggregate for white concrete mixes.

For concretes with exposed aggregate finishes, the coarse aggregate selection becomes more influential on the appearance of the finished material. In this case, white stone chips with minimum colour variation is desired.

Pigmentation

The addition of a pure white pigment, most commonly titanium dioxide, which can constitute up to 10% of the concrete, increases the whiteness of the body of the concrete.

This addition can mitigate potential discolouration of the concrete where quality control is not especially stringent.

Water

The use of clean water, free from impurities, in the mix is also important in the production of truly white concrete.

Formwork

The formwork used to give precast concrete its shape is important for imparting smooth finishes, such as fair-faced or polished, to the surface of a concrete.

The formwork should be clean, flat and free from contamination. Its design should promote even curing of the concrete to ensure there is no discolouration from uneven moisture retention. Even drying leads to an even colour.

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Surface finish

A variety of finishing techniques can be applied to the surface of concrete to enhance a white finish or attempt to remedy any colour variation that has appeared during the production process.

Polishing the concrete surface produces the most vivid colours, however care must be taken in the selection of a fine, high-quality, neutral aggregate as it will be most accentuated by the application of a polishing process.

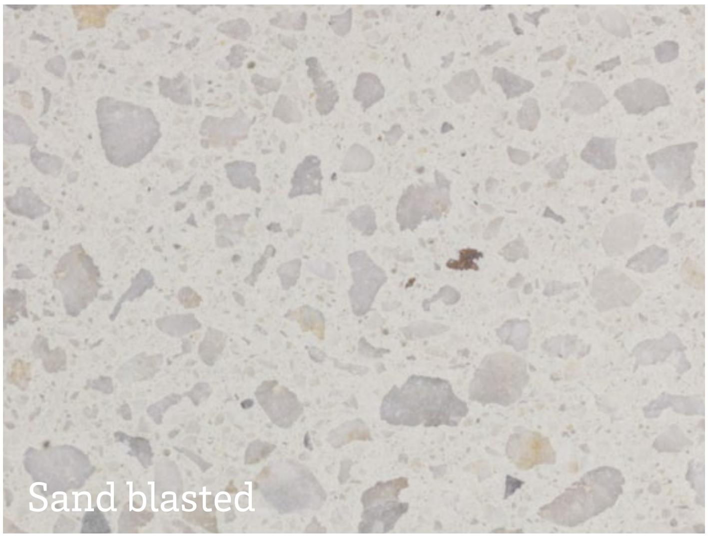
Sandblasting is an effective process used to improve the uniformity of tone across the surface of a concrete, though it does create a rough surface and exposes aggregate.

Acid etching produces an effect somewhere in the middle, homogenising the tone, while also exposing some finer aggregates.

Surface finish effect on identical concrete mix


Polished


Acid etched


Sand blasted

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Polymers

Plastics, the first truly synthetic materials, allow a level of control in physical performance, aesthetic qualities and manufacturing flexibility unprecedented before its relatively recent invention.

Polymers are available with an astounding array of physical properties: hard or soft, heavy or light, strong or weak, expensive or low cost and so on. Being a fully synthetic material, the chemistry and microscopic structure of the material can be manipulated to achieve the desired properties. This flexibility allows polymers to be used in practically every application.

Polymers are manufactured from petrochemicals and can suffer all the negative environmental aspects related to crude oil production and processing, including greenhouse gas emissions, bio-accumulation and slow degradation. Some polymers contain toxic admixtures necessary for certain performance properties, linking some plastics to a host of human health issues. Positively it is possible for polymers to be endlessly recycled. The polymer industry is constantly developing new products to reduce their deleterious impact, including the promising emergence of biopolymers produced from renewable resources.

The synthetic nature of polymers allows a high level of control over the appearance of the material, with brilliant whites available in the plastics most commonly used in architectural applications.

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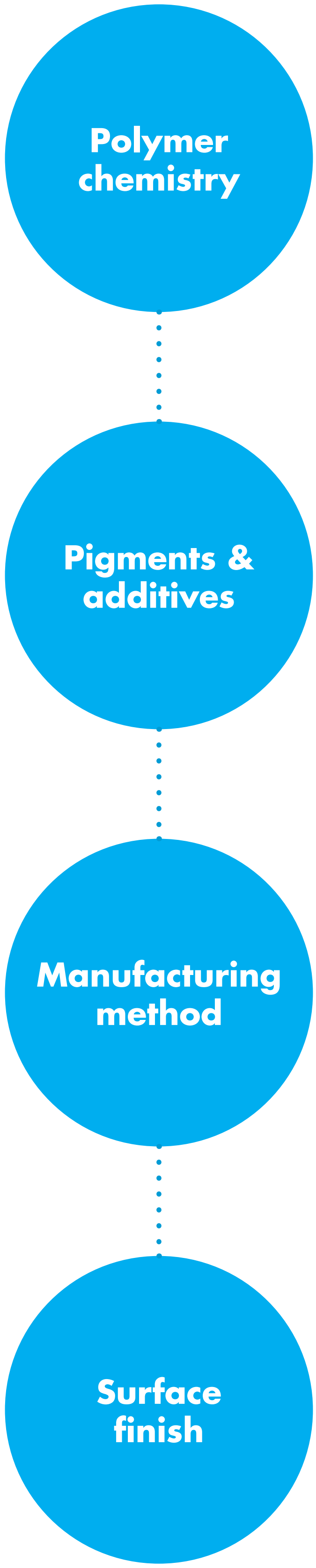
What makes polymers white?



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Polymers

What makes polymers white?

Polymer chemistry

Colourless or milky, base resins are the starting point for plastic products, requiring additives to achieve the desired appearance and performance. Different base resins require specific, carefully measured proportions of pigments and dyes in a suitable carrier resin to achieve a brilliant white.

Pigments & additives

As mentioned above, colour is imparted on a polymer through pigments and dyes. For white plastics, titanium dioxide is the most commonly used pigment. To achieve a brilliant opaque white the correct 'dosage' (quantity) of pigment must be added to the mix, any change in the dosage will affect the nuance of white.

Another important factor is the uniformity of colour dispersion throughout the polymer. This is controlled by ensuring the pigments granules are appropriately sized and added to the polymer mix in a suitable form. Often pigments are added as part of a 'masterbatch', a premixed compound of pigments and performance enhancing additives.

Opaque white can be challenging to achieve at small wall thicknesses. In the case of acrylic a small quantity of carbon black must be included to achieve an opaque material, however this leads to a less brilliant white.

Manufacturing method

Process and quality control, ensuring the correct quantities and no contamination in production are important factors in brilliant white plastics. Precise production controls such as consistent temperatures, pressures and flow speeds in manufacturing are a prerequisite for uniform colouring in individual items and from batch-to-batch in mass production.

Low tolerances and high production control require modern machinery, skilled operators and a regular maintenance program, which understandably comes at an increased cost.

Surface finish

Although the body colour of a polymer maybe identical, the surface finish on a material will effect the perception of whiteness and uniformity. A lightly textured 'satin' finished surface reflects light diffusely producing a more homogenous appearance. Surface blemishes and scuffs are also less visible when compared to high gloss finishes.

Timber

Low density, renewable, easy to work and spread over a third of our planet, wood, a natural composite, is one of the oldest and most familiar construction materials.

Available in hundreds of species, timber can be used for a wide variety of applications. Its most common use in architecture are flooring and structure, though cladding and carpentry is also common. Modern timber products overcome many of timber's inherent shortcomings such as resistance to moisture, dimensional stability, fire performance and relatively low strength.

Timber, a renewable resource, locks in CO2 as it grows, biodegrades at the end of its life and, if properly cared for, can have an extremely long service life. However, care must be taken to specify sustainably harvested timbers as the destruction of forests reduces the planets ability to absorb CO2, an essential part of the carbon cycle. Use of deleterious preservatives can also be an issue when improving the performance of timber, leading to poor indoor air quality within buildings.

As with all natural materials, timber exhibits a rich variation in colour and features making it challenging to achieve a white finish while maintaining its characteristic appearance.

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What makes timber white?

Timber species

Timber cut

Timber grading

Surface finish

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Timber

What makes timbers white?

Timber species

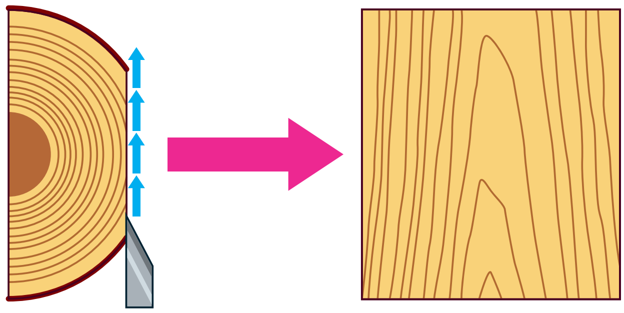
To achieve a white timber finish that maintains the natural characteristics of wood it is critical to select a species which is naturally pale and has a minimal contrast in grain tone.

Nontropical species are usually preferred for this. Ash, Maple and Beech are good examples of commonly available, lightly-coloured timbers.

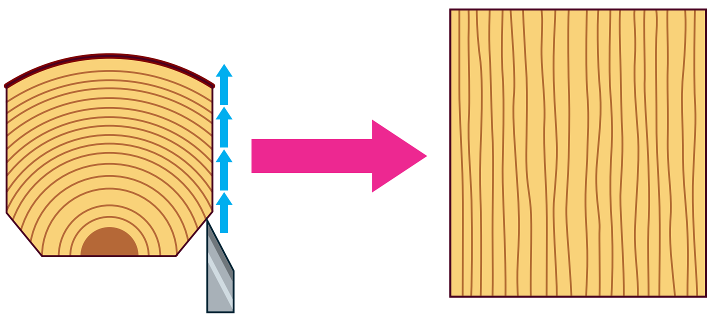
Timber cut

The type and direction of cuts used to convert logs into usable planks or veneers defines the visual characteristics of the grain on finished products. Crown cut timber displays greater grain patterning while the quarter cut technique creates a relatively straight and consistently distributed grain structure.

Crown cut



Quarter cut



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Timber grading

Timber grading provides the opportunity to discuss with the manufacturer an acceptable level of natural features within timber.

Grading allows control over such features as grain consistency, knots, pips and sugar marks. Although stringent grading selection will lead to a more homogenous, repeatable appearance, there is also an increase in cost proportionate to the strictness of the tolerance.

A narrower permissible range can also have a detrimental effect on the environmental aspects of the material as it can lead to increased levels of wastage.

Surface finish

A number of surface finishes are available to produce a more homogenous appearance, or to alter the inherent tone of a timber.

Mechanical finishing techniques can be used to reduce the visual impact of defects and create a variety of appearances.

Applied finishes are highly effective in creating whiter timber surfaces: oils, soaps, pigments, stains and bleaches can all be used to brighten the body colour of the material. Again, cost, environmental and maintenance issues must be considered in the selection of a finish.

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Ceramics

Produced from the high temperature firing and pressing of minerals - primarily quartz, fledspar and kaolin - ceramics are dense, nonporous, chemical resistant and very hard wearing materials.

In architecture ceramics are commonly used in tiles for internal floor and wall applications, their low porosity making them particularly suited to wet areas. There is also a growing move to use ceramics for external applications, both flooring and cladding. Ceramics are available in a range of standard formats, with the maximum standard size continually increasing.

Ceramics are being produced increasingly with recycled materials, and the ability to reprocess ceramic products at the end of their life is also improving. The inertness and longevity of ceramics makes them a strong product when assessed in the context of a building life cycle. The high firing temperatures make ceramics a reasonably energy intensive product to manufacture, however, reductions in tile thicknesses and improvements in production efficiencies is reducing this issue.

Ceramics can comfortably be manufactured to a brilliant white when glazed. Full bodied products and those with recycled content are more challenging to produce, however.

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What makes ceramics white?

Mineral composition

Recycled content

Manufacturing technique

Surface finish

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Ceramics

What makes ceramics white?

Mineral makeup

The raw materials used to manufacture ceramics are primarily responsible for the final appearance of a ceramic product. Accurate control of the 'recipe' for a product ensures the colour consistency of individual tiles and across batches.

The cost and availability of white pigments suitable for ceramics makes it challenging to achieve a brilliant white in full-bodied procelains. A zirconium pigment is used for a brilliant white, where as the more common, and cost effective, titanium dioxide pigment creates an off-white tone.

Inclusion of modern photocatalytic and other 'smart' compounds enhance the long term whiteness of a product through self cleaning or anti-bacterial mechanisms.

Recycled content

Ceramic tiles are increasingly available with a high recycled content; some products are now made with 100% recycled materials.

However, due to the mixed colour of waste materials available for reprocessing, white coloured products are not able to include as large a volume of recycled content as their darker counterparts.

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Manufacturing process

Different manufacturing processes present distinct challenges when producing white ceramics.

In glazed ceramics, the control of the uniformity of the base material has an impact on the homogeneity of the surface appearance of the final product.

Full bodied porcelains offer a through colour product, ensuring colour consistency in the event of damage to a tile surface but to achieve a consistent colour a high degree of control must be maintained during the whole manufacturing process.

Surface finish

Appropriate selection of a surface finish can aid the longevity of a white surface; polishing a tile produces an easy clean surfaces with no 'dirt traps' present in more textured finishes.

Textured surface finishes help disguise any variation in colour tone within a product, however, as mentioned above, textured surfaces are more likely to accumulate dirt, requiring more involved maintenance.

Glazed porcelain

Beige porcelain biscuit with matt white glaze

Full-bodied porcelain

Full-bodied porcelain zirconium pigmented

Metals

The powerhouse of the industrial revolution, metals have been crucial in the forging of the modern built environment. High strength, good conductors, ductile and hard wearing, metals are excellent engineering materials. Weight is a major drawback, however, as metals have the highest density of construction materials. Steel, aluminium, zinc, copper, and its alloys, are the architectural metals of choice, with the use of titanium also increasing.

Metals are commonly used in most architectural applications: structure, cladding, ceilings and roofs. Flooring, although perfectly possible is not an application where metals are usually found.

High melting temperatures and difficult refining procedures make metals energy intensive to produce. However, their ability to be endlessly recycled combined with excellent durability reduces their environmental burden.

Despite the two major white pigments of recent history being metal oxides (lead and titanium) there are no inherently white metal products available to architects. When pursuing white in metals, products must be treated or coated.

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What makes metals white?

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Metals

What makes metals white?

Base metal

Predominantly steel or aluminium, the condition and tone of the base metal to be coated influences the final colour and consistency of applied coatings.

Metals will typically be pickled and descaled to produce a uniform base material. Primers may also be applied to improve adhesion, corrosion resistance and appearance.

Coating selection

The choice of coating material and process will determine the visual quality and whiteness of a metal product.

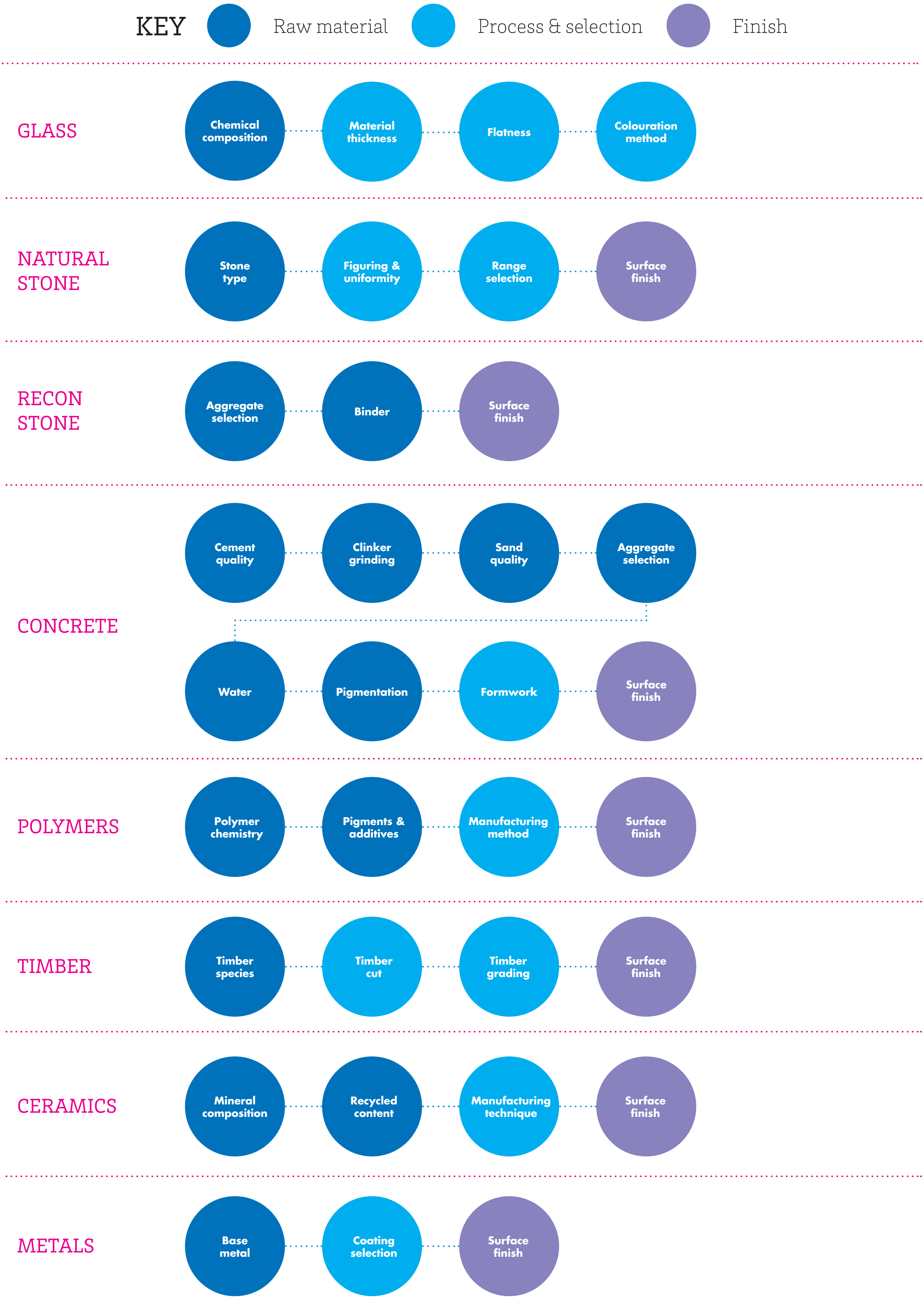
Polymers are the most common architectural coating for metals, with polyester, PVDF (polyvinylidene fluoride) and polyurethane being the favoured plastics. The particular polymer utilised makes little difference to the appearance of the coating, their selection is primarily dictated by the required performance of the finish.

More influential on the appearance of the product is the application technique employed. The three primary processes: powder coating, coil coating and die coating increase the resulting uniformity of the coating respectively.

Surface finish

Gloss and matt surfaces create differing visual effects and can be used to enhance a brilliant white aesthetic. Photocatalytic, easy-clean and self cleaning surfaces can be applied to reduce maintenance and preserve a white surface for longer.

Factors of whiteness overview



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