Cleaner Glass is Greener Glass

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Abstract

Architectural glass is a major part of the built or man-made environment and has huge effects, both directly and indirectly, on the natural environment and human well-being. These effects can be negative or positive, depending on the type of glass and its level of "green" performance.

Many countries are developing and implementing green building practices to minimise the negative impacts of buildings through improved efficiencies in the use of energy, water and other resources throughout the life cycle of a building. Architectural glass should be a key part of these green building practices because of its extensive use in the exterior and interior of residential and commercial buildings, frequently without green credentials.

Ordinary architectural glass cannot be considered as green because it is a high-maintenance material of construction that requires frequent and often difficult maintenance – generating higher energy consumption and increased carbon dioxide (CO2) emissions through increased use of cleaning chemicals, water, fuel and other resources. Even with frequent and sometimes intensive washing, ordinary glass becomes increasingly difficult to clean and keep clean. Its bare surface easily becomes stained and discoloured by contaminants that bond firmly and cannot be removed by conventional cleaning methods.

Bonded contaminants reduce light transmittance, which means the glass no longer meets original industry performance standards such as light transmittance (t-Value). Lower t-Value means higher costs for artificial lighting, reduced productivity of building occupants and poorer health conditions.

The potential savings in resources, benefits to the environment and improvements to human health and productivity are huge when architectural glass meets green performance requirements.

To be green in performance, glass must be proven in practice to retain its original clarity, visibility and cleanliness over extended periods of time while being much easier to clean and keep clean with significantly reduced frequency of maintenance. It must also be resistant to glass surface corrosion, staining and discolouration, and be eco-friendly.

Meeting these requirements is not possible unless the glass surface has durable protection against contamination by both organic and inorganic dirt. Dirty glass cannot meet typical standards for appearance, light transmittance and cleanability.

Cleaner glass is greener glass because of its Added Value based on:

- energy savings – by reducing requirements for power, water and other resources;
- environmental benefits – by reducing CO2 emissions or carbon footprints;
- better health and productivity – by maintaining or improving the transmittance of natural light, and by resisting the adhesion and growth of bacteria.

To achieve these valuable benefits architectural glass needs durable surface protection, like any other material of construction. Long-lasting glass surface protection is not a cost, it is an investment in ways of enhancing both man-made and natural environments.

Introduction – the Importance of Glass Cleanliness

The main purpose of architectural glass is to transmit light, natural and artificial. Generally speaking, anything that helps to maintain the original light transmittance of glass is positive and anything that interferes with light transmittance is negative. The importance of light transmittance emphasises the need for glass that is clean and easy to see through, particularly in architectural glazing where natural sunlight and connections with the outside world are important.

New glass promises visibility, clarity and cleanliness. Of these three promises, cleanliness is the most important because it directly affects the other two. Cleanliness also affects light transmittance.

Cleanliness may be next to godliness, but it depends on cleanability of the glass which depends on strong and durable resistance to surface corrosion caused by –

- the two biggest enemies of glass –
  - moisture, both liquid and vapour;
  - alkalinity.
- chemical and physical properties of glass itself
- the Dirt Factor - adhesion of all types of contaminants –
  - physically attached and chemically bonded;
  - organic and inorganic;
  - acidic, neutral and alkaline.

If glass does not have resistance to the causes of surface corrosion, it becomes increasingly difficult to clean and keep clean – making it high in maintenance. The causes of glass surface corrosion also make glass unhygienic – breeding grounds and transfer points for germs.

Cleanability becomes a real issue for glass without resistance to surface corrosion because cleanliness cannot be achieved easily without ever-increasing resources such as manpower, energy and cleaning materials. Glass without resistance to surface corrosion also causes risks to work environments through reductions in light transmittance and to the global environment through increases in carbon dioxide and other greenhouse gases generated by high energy requirements for cleaning and maintenance.

The easiest and most cost-effective solution is durable glass surface protection with "non-stick", easy-clean, low-maintenance, anti-bacterial performance. Technology exists as the 'prevention' or the 'cure' - helping glass keep its original promises of visibility, clarity and cleanliness through improved cleanability by resisting the causes of glass surface corrosion.

Background - the Need for Cleaner and Greener Glass in Buildings

Cleaner and greener glass is not just a label or certification, it is a state of mind that should apply to all residential and commercial buildings. The overall objective should be to keep glass looking and performing like new for longer – with its original visibility, clarity and cleanliness – in the most cost-effective, energy-saving and environmentally-friendly ways possible.

Surface corrosion makes ordinary, unprotected glass a high-maintenance material of construction that often appears dirty and increasingly difficult to see through – in spite of frequent and sometimes intensive washing. This causes dissatisfaction and complaints from building occupants and visitors.

Exterior glass is typically for seeing through, not only from inside a building but also from the outside, but too often the views are not clear because of surface contamination that cannot be removed by conventional cleaning methods.

The dirtier the glass, the higher the risks of losing much time, effort and money. Throughout the world, for example, dirty glass is the cause of costly call-backs, replacements, delays in project completion, increased use of cleaning materials and higher energy consumption.

Interior glass is not only high in maintenance, but is exposed to other types of surface contamination. Dirty glass has breeding grounds and transfer points for bacteria, creating risks to the health of building occupants and visitors.

Cleaner and greener glass is not a cost, it is an investment. The simplest and most cost-effective way of achieving cleaner, greener glass is strong and durable protection against the enemies of glass.

The Enemies of Glass Causing Surface Corrosion

Surface corrosion is the biggest enemy of glass because it causes the most degradation and makes ordinary, unprotected glass a high-maintenance material of construction. The causes of glass surface corrosion are similar to the causes of metal corrosion and "concrete cancer" - weathering, including natural abrasion, and chemical attack by the Dirt Factor as outlined in Figure 1.

Natural weathering degrades most building surfaces, and glass is no exception. Similar to unprotected metals and concrete, unprotected glass is susceptible to surface corrosion caused by chemical and physical attack. In combination, these enemies can easily stain/discolour and chemically etch the surface of glass within a relatively short period of time.

Even with frequent washing or polishing, unprotected glass surfaces become increasingly difficult, if not impossible, to clean and keep clean. They also become increasingly stained and discoloured.

Architectural Glass at High Risk of Surface Corrosion

Most architectural glass is at risk of damage by moisture, alkalinity and/or other causes of surface corrosion, but the greatest threats as shown in Figures 2, 3 and 4 are to:

- glass canopies, conservatory roofs and other sloped glazing – where moisture generally remains on the surface longer than on vertical glazing and the glass is exposed to building run-off from materials of construction such as concrete, stonework, brickwork or lead flashing;
- both sloped and vertical glazing - during construction when exposed to high humidity and cement dust or mortar – after construction by moisture and alkalinity;
- windows in seaside buildings – moisture, both liquid and vapour, from rainfall, sea water and sea spray – also alkalinity from limescale;
- skyscrapers or tower blocks - where moisture vapour and contamination from airborne contaminants can be severe, adding to already high cleaning costs and greatly reducing light transmission and visibility.

Glass surface corrosion can quickly and easily damage unprotected glass in any of the above installations - before, during and after installation. Some of the greatest threats are during construction, where the glass may be exposed to attack by moisture as well as alkalinity from contaminants such as concrete splatters and cement dust.

Interior glass installations such as shower enclosures are also subject to surface corrosion if unprotected.

The Two Main Causes of Glass Surface Corrosion - Moisture and Alkalinity

Moisture attack is one of the most common causes of glass surface corrosion and glass that remains wet, or even damp, is highly vulnerable. Alkalinity alone can attack the surface of glass and in concentrated form causes dissolution of the surface.

At even higher risk is unprotected glass exposed to a combination of moisture, especially in the vapour phase, and alkalinity – when surface corrosion can be quick and irreversible. This aggressive combination makes unprotected glass high in maintenance by creating an even rougher substrate and making it easier for contaminants to bond chemically which further increases the rate of surface corrosion.

The speed and severity of glass surface degradation, with the resulting drop in glass performance, depends largely on the levels of moisture - from rainfall and condensation - and alkalinity from materials of construction and cleaning products – before, during and after construction.

The "Dirt Factor" – Other Causes of Glass Surface Corrosion

The Dirt Factor outlined in Figure 1 describes 14 types of contaminants on the surface of glass in buildings, exterior or interior. The dirt is either physically or chemically bonded, organic or inorganic and acidic or alkaline. The most aggressive combination is chemically bonded, inorganic and alkaline.

The Physical and Chemical Properties of Glass – also Contributing to Glass Surface Corrosion

The susceptibility of unprotected glass to surface degradation is increased by the physical and chemical properties of glass itself. Ordinary, unprotected glass is:

- microscopically rough, not smooth – with more surface area making it easier for contaminants to adhere and, depending on the type of dirt, increases in the rate of surface corrosion.
- water-attracting – with a molecular layer of moisture on its surface which, in combination with humidity or rainfall, can cause chemical attack and surface corrosion.
- a good electrical insulator – helping it to hold static charges which increase the attraction and adhesion of dust, especially in combination with the molecular layer of moisture mentioned above.
- chemically reactive – as shown in Figure 1, both organic and inorganic contaminants react with glass and bond firmly, causing surface staining and chemically attacking or etching the surface.
- damaged more easily by alkalinity than acidity – because glass is resistant to most acids except hydrofluoric (HF), but is highly susceptible to chemical attack by alkalinity from cleaning products, seawater, hard tap water and mineral run-off from buildings which attack the silica of glass and the surface simply dissolves.
- an unhygienic surface – because bacteria love surfaces that are not clean and dry, especially glass with a "rougher" surface with lots of places for bacteria to hide and multiply – and also more difficult to clean and disinfect.

Cleaner, Greener Glass for More Efficient Use of Resources and Reduced Operating Costs

Green building design has become increasingly important theme in recent years, and glass is an important part of this theme because it plays a major role in functionality of any building.

- Energy requirements – less need for artificial lighting, reduced frequency of cleaning with less trips to job sites with lower consumption of fuel and other costs, reduced costs of operating and maintaining access equipment, reduced consumption of cleaning chemicals and other materials, less risks of delays in completion of projects.

- Energy efficiency – photovoltaic (PV) solar cells for electricity generation, solar panels for heating water and commercial greenhouses.
- Water required for glass washing or cleaning – especially where processing costs are high due to water desalination.
- Cleaner, Greener Glass for Improved Health, Well-Being and Productivity

Glass in buildings is a major factor in the good health, quality of life and comfort of building occupants. Glass brings natural light, solar heat and a view to the outside world.

As a result, building design requirements focus more and more on requirements of health & safety and the work environment. Human health and comfort have become important issues as follows:

- Visual properties of the glass – helping to maintain positive attitudes and general well-being of building occupants by resisting degradation of the visual properties of glass through staining, discolouration, pitting, surface erosion and other factors described in this paper.
- Daylighting – helping glass maintain performance against industry standards such as light transmittance (t-Value) and having positive effects on the health, productivity and comfort of building occupants by influencing the biological clock, mood, performance and welfare.
- Hygiene – resisting the adhesion and growth of bacteria, therefore reducing the risks of illnesses and contagious diseases.

Cleaner, Greener Glass for Reduced Environmental Impacts

- Carbon footprints – reduced emissions of carbon dioxide (CO_2) and other greenhouse gases caused by higher usage of transportation and access equipment for maintenance, call-backs and replacements as well as production and use of cleaning supplies and equipment.
- Hazardous cleaning chemicals and abrasive methods – normally not required for glass with durable surface protection and "non-stick", easy-clean, low-maintenance performance.
- Sustainability – reduced need for glass replacements due to unsightly appearance caused by surface corrosion.

Summary

Architectural glass plays a major role in the health, quality of life and productivity of building occupants. Sunlight is an essential part of our lives, which has made light transmittance or 'daylighting' a central theme in the design of modern buildings.

From the time that glass is produced, its appearance and performance are at risk of damage by its biggest enemy - surface corrosion. Moisture, both liquid and vapour, and alkalinity from inorganic sources are the biggest causes of surface corrosion, but there are many other contributors as described in this paper.

Of the three promises of new glass, cleanliness is most important because it directly affects the other two – visibility and clarity. Cleanliness is largely a result of surface cleanability which, in turn, depends on strong and durable resistance to the causes of glass surface corrosion.

Glass without durable surface protection risks the loss of much time, effort and money. Throughout the world, for example, unprotected glass is the cause of costly call-backs, replacements, delays in project completion, increased use of cleaning materials and higher energy consumption.

Glass without durable surface protection meets industry performance standards, such as light transmittance (t-value), at the time of supply but may not meet the standards afterwards. This creates risks to work and productivity, hygiene and global environments.

Why Glass Without Durable Surface Protection Suffers from Corrosion and is High in Maintenance

I. The 'Dirt Factor' - one or more of 14 types of contaminants commonly found on the surface of glass in the exterior and interior of buildings:

A. Physically Attached Dirt – can be washed away using conventional methods such as water, detergent and a cloth or sponge -

1. Organic - substances of biological origin

a) **Acidic or Neutral** – does not stain/discolour or attack/etch glass -

1) adhesive - oily or greasy substances that cling by their 'stickiness', such as body fats in a shower and cooking oil vapours in a kitchen;
2) attracted – dry, non-oily/greasy particles held by electrostatic force, such as hair, lint and fibers;
3) inert – non-sticky, uncharged particles such as sawdust and fine cinders.

B. Chemically Bonded Dirt – difficult, if not impossible, to wash away using conventional methods.

1. Organic – substances of biological origin

a) Acidic – causes surface staining, but normally does not attack or etch glass -

4) sulphates – from flue, gas, coal burning and vehicle emissions;
5) road film – oily/greasy mixtures of road tar and unburned hydrocarbons from the exhausts of motor vehicles;
6) tree sap and mist (sometimes alkaline, in which case it may attack or etch glass);
7) bird droppings and insect excretions (sometimes alkaline, in which case it may attack or etch glass);

2. Inorganic – substances from mineral or non-biological origins

a) Acidic – causes surface staining, but does not attack or etch glass -

8) iron oxide from railways, such as rail and brake pad dust
9) run-off from silicone sealants and silicone-lubricated gaskets (sometimes neutral)

b) Neutral – causes surface staining, also chemically attacks or etches glass

10) surface reactive salts (SRSs) formed by neutralisation reactions between acids and alkalis;

c) Alkaline – causes surface staining, also chemically attacks or etches glass

11) chlorides from industrial emissions, marine environments and road de-icing products;
12) limescale deposits from hard tap water and seawater
13) mineral deposits from run-off of buildings made of concrete, bricks, mortar and/or stonework;
14) highly alkaline solutions such as industrial cleaning products.

II. Physical Abrasion – increases the total surface area of glass, especially in combination with substances of the Dirt Factor that chemically attack and etch glass (categories I.B.2.b and I.B.2.c. above):

A. Man-made
- incorrect handling during transport, storage, installation and use
- use of abrasive cleaning products and methods.

B. Natural
- wind erosion
- windblown particles of dust, grit and sand.

Conclusions

New architectural glass is a marvellous material of construction but, if unprotected, becomes high in maintenance with exposure to chemical and physical attacks by one or more of its many enemies that cause surface corrosion either directly or indirectly.

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Referring to the 14 types of contaminants or dirt outlined in Figure 1, it is concluded that:

- only four (4) are physically attached and easily removed using conventional methods such as water, detergent and a cloth;
- ten (10) of the 14 are chemically bonding and therefore cannot be removed by conventional methods;

- the same 10 types of contaminants/ dirt also cause glass surface staining and discolouration;
- five (5) of these 10 types of contaminants/dirt also attack or etch glass chemically.

It is also concluded that:

- glass is not chemically attacked or etched by organic dirt which is acidic;
- glass is attacked or etched chemically by inorganic dirt because it is alkaline.

Technology exists for strong and durable glass surface protection that helps to maintain the appearance and performance of architectural glass by making it "non-stick", easy-clean and low-maintenance. This technology also helps to reduce risks to work, hygiene and global environments.

This innovative technology is the ClearShield System for glass renovation, protection and maintenance – the prevention or the cure for glass surface corrosion. For more details, please see www.ritec.co.uk.

Ritec International Limited is manufacturer of the 'ClearShield System' for Glass Renovation, Protection and Maintenance.