MAINTAINING STAINED GLASS WINDOWS

Ethical Conservation Practices in Australia

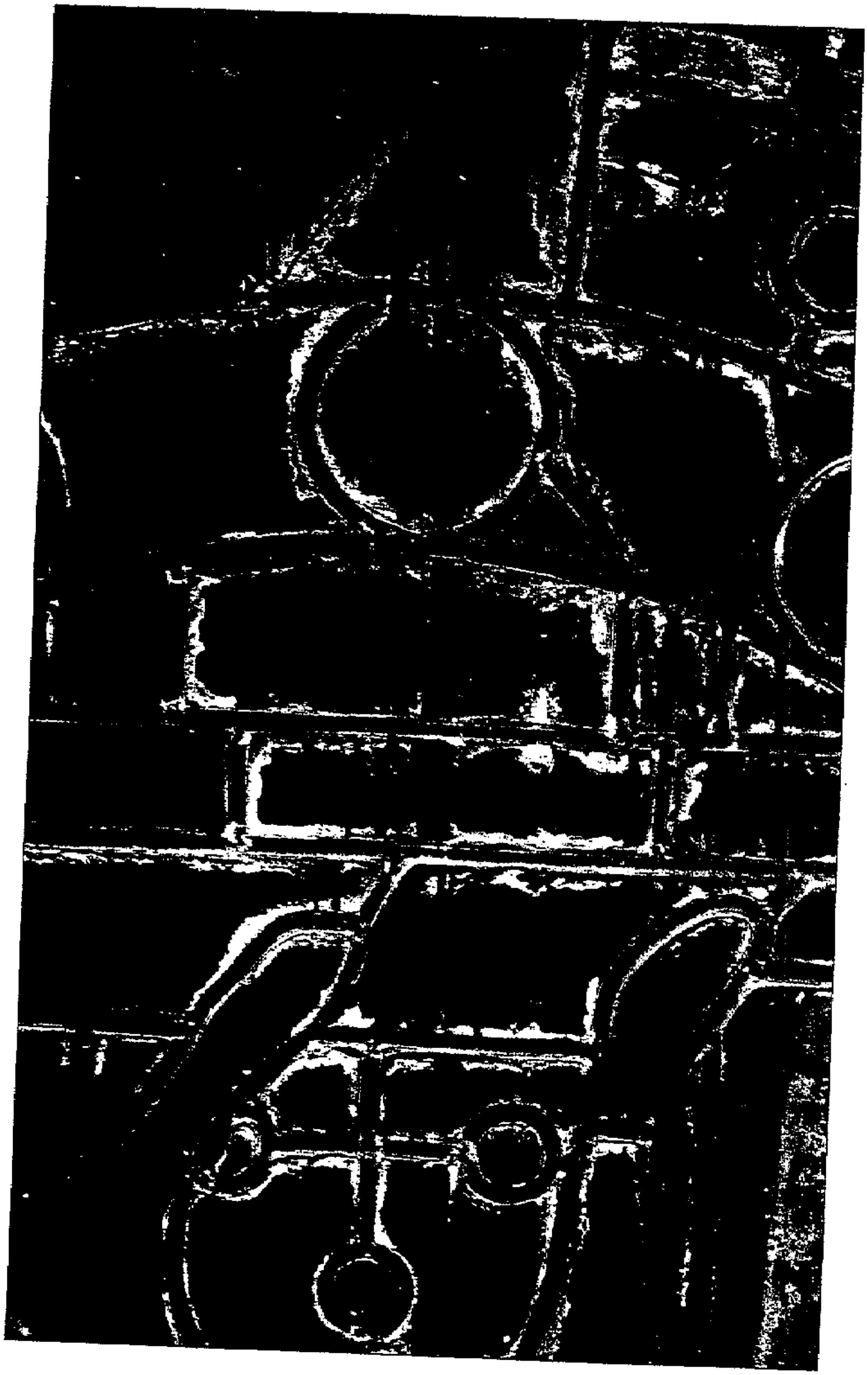
by Geoffrey Wallace

Introduction

Over the last year or so, the professional stained glass community has had access to two quality Internet discussion forums that are proving to be a great vehicle for an immediate exchange of ideas and information. Coming from the other side of the world and, until now, relatively isolated from US practice, I have enjoyed immensely the broad and extensive exchange of ideas, knowledge and experience. I have been impressed by the expertise and specific knowledge freely offered and instantly available.

As most of the forum contributors have been from the US, and thanks to the various postings and links to other web sites, I have been able to gain a general insight into your huge country's stained glass conservation policies. What has quite surprised and concerned me, though, has been the practice of what you call "restoration." This has led me to consider my own findings and practices in stained glass "conservation" and to offer up some articles on a different approach to maintaining stained glass windows.

Where I come from, the state of Victoria in Australia, is one of the world's great repositories of Victorian-era stained glass, due mostly to the immense wealth generated by the discovery of gold in 1851, at the beginning of the worldwide window boom. We have windows from most of the major and many minor English and European studios of the day, although the opalescent movement never really reached Australia. As in the US, many of our windows are now 100 to 150 years old, and, for the first time in history, it has become the responsibility of our generation to conserve the nation's stained glass heritage for the future.



The siphoned water is usually observed internally as a damp band around each piece of glass and, when dry, often leaves behind a deposit of white powder that was dissolved in the water as it penetrated the degraded cement.

A 115-year-old window undergoing in situ *conservation work and showing the before (bottom section) and after (top section) effects of the recementing process.*

This recementing procedure is done in situ *with no need for invasive excavation and the potential damage to the fabric of both the window and the building.*

One of the more-often-heard claims I hear from the US regarding the life expectancy of a new or newly restored window is the bold assertion that, "This wonderful window will now be fine for the next 100 years!" Why 100 years? Why not 300 years or 50 years? And how much of the original window is still remaining after "restoration," anyhow?

It seems this claim is based on the observation that, after a century, many windows are demonstrating structural problems and failed weather resistance. This generally takes the form of buckling or bulging of the lead matrix, water penetration and perhaps stretching or splitting of the window fabric due to movement in the building. Sometimes there will also be a few fatigue cracks in the lead came, usually near solder joints, and stretched or broken wire ties to the saddle bars. However, in these cases, the window has generally had ***no maintenance whatsoever*** throughout its life, apart from necessary "patch up" repairs after impact damage to the glass.

Every other part of a building demands regular maintenance to prevent failure, so why not a stained glass window? Are the constituent materials so resilient that they are impervious to deterioration until the magic 100-year mark? Of course not! There have been signs of deterioration much earlier than this, but nobody has intervened.

In this series, I will examine and discuss, from my own experience, the main components of a traditional (i.e., Anglo/ European construction) stained glass window, these being glass, lead matrix, cement matrix and architectural installation. I will look at how each deteriorates and how they can be ethically conserved. The need for a 25-year "cyclic" maintenance program for windows will be introduced and elucidated upon.

Hopefully, you will discover that the "tried and true" glazing system that is stained glass is smarter than you ever imagined. The longevity of this system and its regenerative and sometimes self-repairing qualities are fascinating. I must point out that my field of knowledge is limited to the traditional Anglo/ European/ Australian methods of stained glass construction, which is usually glazed directly into masonry frames. Not all of the procedures that I recommend will transfer directly to heavily plated American windows.

In the field of "restoration" practice, it appears that there are many widely accepted "facts" that started as uninformed opinions expressed by "experts" or teachers when pressed. They were then passed on by all and sundry as the truth of the matter and are now well-entrenched industrial myth. The term "restoration" itself is vague and open to misinterpretation, whereas the term "conservation" comes with its own set of principles and ethics of practice already attached. In whatever field conservation is practiced, whether it be conservation of stone, paper, gardens, cave paintings, fabric, aqueducts, wilderness, timber, ceramics, ships, oil paintings, archaeological sites, etc., it is accompanied by a set of common principles, the most basic of which are: "minimum intervention" and "maximum retention" [of fabric]. Wholesale releading of a window is definitely ***not*** conservation.

Many specific-interest conservation groups have formulated their own principles including the Corpus Vitrearum Medii Aevi (***http://www.cvma.ac.uk/content/about/***). In Australia, we have the "Burra Charter" on Conservation of Places of Cultural Significance (***http://www.icomos.org/australia/burra.html***). This document was first formulated in 1979 by ICOMOS Australia and has been expanded and refined regularly since. It serves practitioners, heritage professionals, state and federal government bodies and others involved in conservation as the basis and plan for any intervention, on whatever scale. It is our conservation bible.

A Charter of Principles is not a "how to" document, but it does provide answers and direction as to which procedure is most appropriate in a given circumstance. To solve a particular problem, an experienced glazier has many technical solutions at his/her disposal, but it is the principles and ethics of conservation that point to which one will be the most appropriate in that particular situation. A Charter of Principles can also be used to demonstrate, unequivocally, what is bad and unethical practice. Many of the techniques and procedures that I will propose are contrary to common practice and industrial myth in the US, but the principles behind the methods are sound. The Burra Charter has been my guiding document on ethical conservation throughout the development of many of my procedures and all of my practices.

I hope that these articles might encourage you all to question and test for yourself any "knowledge" that you have acquired regarding "restoration," including what I am proposing, and hopefully many myths and old wives' tales will be dispelled to the benefit of our stained glass heritage.

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Leadlight Cement: The Backbone of a Window

The importance of leadlight cement is one area in particular that has suffered from unfair misconceptions, ignorance and contempt, mainly because it is not one of the "sexy" areas of stained glass conservation. It requires the practitioner to get sweaty and dirty. The practice has more often than not been left in the hands of unskilled, minimum-wage and casual laborers and has, therefore, not received the attention it deserves.

The major structural component of a stained glass window is the humble leadlight cement from which it derives its inherent bonding strength, rigidity and waterproofing. Unlike any other glazing method where the bedding compound is plastic to cope with thermal expansion and contraction, traditional leadlight cement is relatively tough and rigid. This is because, in a stained glass window, the lead matrix is the flexible component, and it is this that copes with thermal expansion. The glass panes are basically cast in stiff leadlight cement contained by flexible lead channeling. This is so that as long as it is not exposed to lateral pressure, a panel will quite easily support its own vertical weight without the need for saddle bars.

Saddle bars are not there to support the weight of the window or to stop it buckling, but are put in place out of necessity as the panel is very weak laterally, due to the flexibility of the lead. Without saddle bars, a window would not survive the lateral pressure of wind and rain for long.

The rules that apply to conventional glass installations don't necessarily apply to leadlight structure and can't automatically be carried over into our field. What is true for a rigid frame like steel, timber or aluminum is not necessarily true for a malleable frame like lead. If you didn't use a soft, plastic bedding material for conventional glazing, the thermally-expanding glass would be crushed by the inertia of the rigid framing material. This is not true for a malleable frame like lead.

In its most basic form, traditional leadlight cement consists of two parts whiting and one part Plaster of Paris, combined with boiled linseed oil that has usually been thinned with mineral turpentine and colored with lamp black. There are many variations to this basic recipe, but, in most circumstances, no other additives are necessary or desired. What I will explain in this article is the importance of the plaster component in cement, an inclusion wrongly condemned by many in the field of stained glass "restoration."

Whiting is pulverized limestone ($CaCO_3$, Calcium Carbonate) and is a very stable, naturally occurring mineral. Plaster of Paris began its life as gypsum ($CaSO_4 \cdot 2H_2O$, Calcium Sulphate Dihydrate), another naturally occurring mineral, until it was burnt in a kiln to form Plaster of Paris ($CaSO_4 \cdot \frac{1}{2}H_2O$, Calcium Sulphate Hemi-hydrate). During the burning process one-and-a-half of the water molecules are driven off, and the burnt ore is then pulverized and sold as Plaster of Paris powder, a volatile substance. When this powder is added to water, crystal growth is activated, and, during this process, the missing water molecules are regained, and the mix cures to become solid gypsum once again. Natural gypsum crystals are porous or hygroscopic.

As water is not added to leadlight cement, the Plaster of Paris is never activated, so, after curing, it contains no gypsum but only immature Plaster of Paris powder and whiting, all held fast by congealed, waterproof linseed oil.

Linseed oil is a naturally occurring fatty acid that is extracted from the seeds of the flax plant.

Traditionally, boiled linseed oil was not actually boiled at all, as the required temperature is too high, 384C, by which time spontaneous combustion would have occurred. Instead, it was cooked at high temperatures for an extended period in order to oxygenate the oil and thus speed up oxidation during use. Today, "boiled" linseed oil has chemical catalysts added to activate oxidation. Raw linseed oil is not used in leadlight cement as it does not thoroughly oxidize into the coagulated gum that is the binding agent required for strong leadlight cement.

Linseed oil dries by oxidation; mineral turpentine dries by evaporation. By the time the cementing process is complete, nearly all of the mineral turpentine has evaporated into the atmosphere, and all that remains is linseed oil and stable aggregate. As the linseed oil dries, it congeals and hardens, and this process will continue forever or until oxidation is complete. The plaster component in the cement will not "set" as it has not been exposed to water and, at this stage, is only aggregate or "filler" in the compound, completely protected from contact with water by the coagulated linseed oil.

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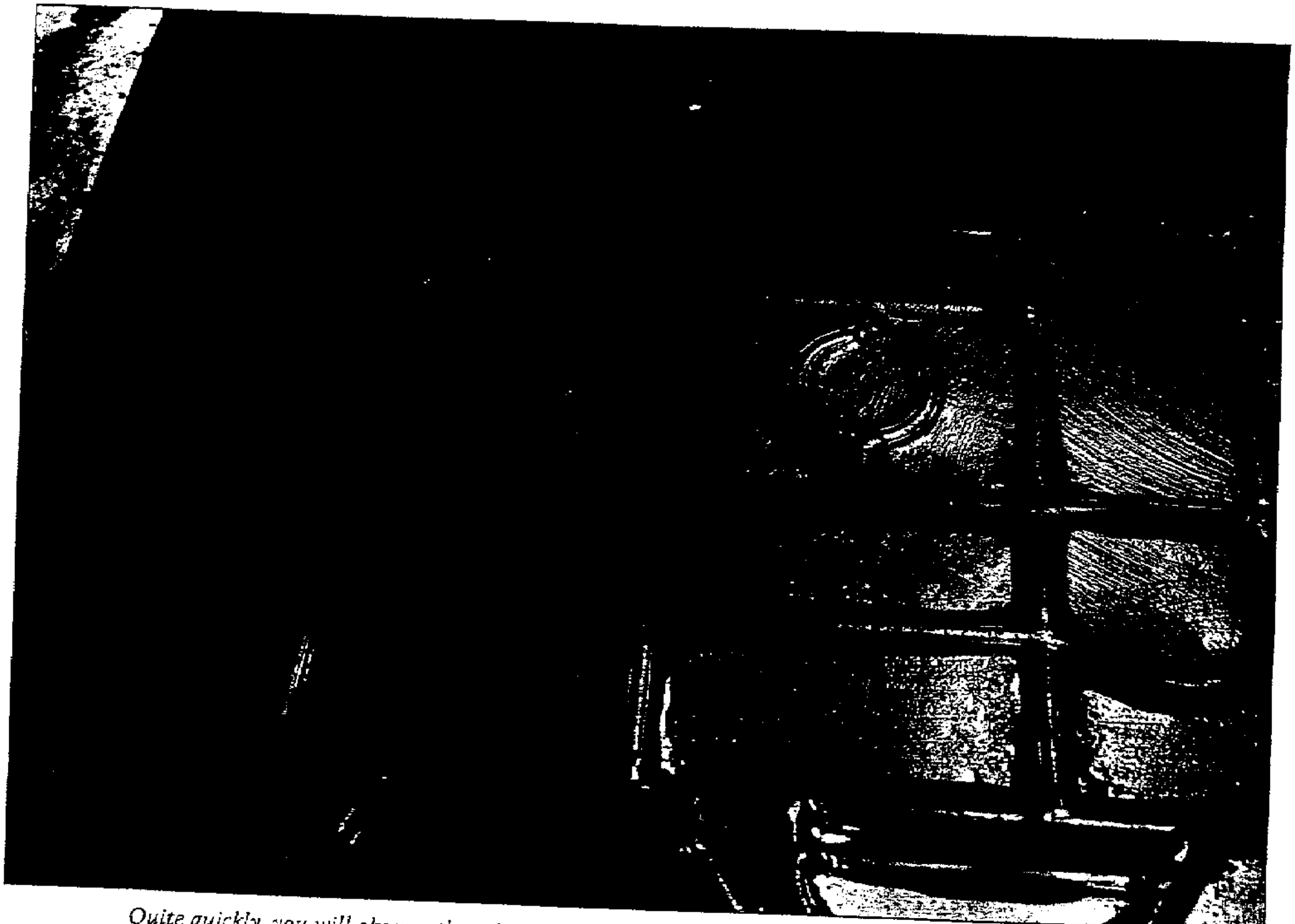
Degradation: Time takes its toll

Like all linseed oil-based glazing compounds and paints, the effective life of leadlight cement is usually somewhat less than 50 years. Have you ever seen a timber building that has not been repainted for fifty years or glazing putty left to the elements without overpainting? They are certainly not performing their original function. Leadlight cement is no different, except, unlike these other products, traditional leadlight cement is able to be regenerated.

Thanks to the congealed linseed oil, cured cement will have a consistency similar to that of hard boot-sole leather: it will flex a little but barely compress or expand. It will mostly remain in this state for another 30 to 40 years, depending on exposure to UV radiation. During this time, the glass component is literally cast in a very rigid cement matrix that contains a soft heart of lead to cope with thermal stress. Leadlight glazing is more akin to *dalle de verre* glazing than it is to steel, timber or aluminum glazed glass. The lights are literally cast in rigid leadlight cement that is contained by a soft, forgiving sheath and heart of lead.

As the leadlight cement ages, the linseed oil component continues to oxidize and becomes harder and harder until, being organic, it starts to decompose. This occurs on the outer or exposed surfaces of the cement first and never fully reaches the interior of the cement. Even though the old cement may be rattling in the cames and pieces are falling out, the interior of those pieces contains unexposed plaster and sound coagulated linseed gum. As the linseed oil decomposes, it becomes water soluble and is washed away during rain, exposing the immature Plaster of Paris as it does. The exposed plaster particles are now able to make contact with water and can finally change back to gypsum which, unlike the bulk of the cement, contains microscopic cavities in its crystal structure and is quite brittle. The oxidation process continues to progress until, usually by about 50 years, secondary problems arise as a result of this gradual decomposition of the linseed oil.

The first of these is ingress of water. This occurs because the degraded, now partly porous, leadlight cement begins actively sucking water, through capillary attraction, from the outside of the building to the interior. The effect is the same as dipping the corner of a dry sponge in liquid and



Quite quickly, you will observe the mixture dry out around the lead cames as the new linseed oil is sucked into the old cement through capillary action.

watching it rise up through the sponge in defiance of gravity. This action is what is meant by the term "hygroscopic" that pops up so often in condemnation of Plaster of Paris. The siphoned water is usually observed internally as a damp band around each piece of glass and, when dry, often leaves behind a white calcium deposit that had been dissolved in the water as it made its way through the now-degraded leadlight cement.

As the leadlight cement continues to lose its major bonding component, linseed oil, it becomes more brittle, and cracks appear in the cement, glass will often rattle in the cames, and small sections of cement begin to dislodge from under the flanges of the lead came. By this time, the fragile lead matrix is under extreme stress, as it is required to bear the whole weight of the window and absorb the various forces acting on it without the rigid, bonding strength once provided by the leadlight cement. As we all know, lead cames cannot carry even their own weight for very long, and, as a result, metal fatigue will occur at points of major stress, and the lead matrix will easily stretch and eventually buckle, bulge or sag, often with dire consequences for the *raison d'etre* of the window structure, the glass component.

Regeneration: New From Old

The most wonderful thing about traditional leadlight cement is that it can be regenerated. The results of its decay are also the means for the gentlest and most effective method of window conservation: recementing. The fact that gypsum is hygroscopic or porous means not only that it is able to draw in water but it can alternatively draw in new linseed oil and reseal itself, once again becoming structurally rigid and impervious to water. This

Transmitted light

Reflected light: notice the localized paint loss where water has been entering through a glass crack.

is the amazing thing about so many traditional materials: they are often regenerative in a way that no modern material ever will be. For instance, dry, oxidized timber, a traditional building material, can be fed with linseed oil that will regenerate it also, but not to the extent that leadlight cement does. You can't replace missing wood fiber but only regenerate that which has not decomposed. With leadlight cement, you can actually replace the decomposed organic matter that was linseed oil in the first place, and there is no fiber, only an aggregate of whiting and plaster that can also be replaced.

Thankfully for the windows, this procedure can be performed *in situ* with no need for invasive excavation and potential damage to the fabric of both window and building. Furthermore, the original lead cames can be preserved for several centuries if maintenance is carried out on a regular basis to prevent excessive stress and weight from being transferred to the fragile lead matrix alone.

Recementing is carried out using the traditional mixture, but it is now made up to a very thin, soupy consistency. After thorough cleaning of the window, the mixture is liberally applied to the exterior surface using a paint brush and left to be absorbed by the old cement. Quite quickly, you will observe the mixture dry out around the lead cames as the oil is sucked in.

At this point, more thin cement mixture is applied, and this is repeated two or more times until the old cement is thoroughly saturated with boiled linseed oil. The excess cement is then cleaned off the window and, during this process, the solids in the mix will fill any cracks or dislodged sections of the old cement.

Once the new mix has cured, usually sufficient for handling after about 48 hours, the window is just as solid and resilient as it was when new. A perfect bond between old and new cement has been achieved through saturation and capillary attraction or, as plasterers and stone masons have always called it, "suction."

The same principles of saturation and capillary attraction can be used to straighten bulged or buckled panels after they have been excavated. The affected panel is placed on a work bench, painted side down, and water-saturated towels are laid over the top. After a time, the old cement becomes saturated with water, and, at this time, a flat board can be placed on top of the panel and weighted accordingly. Depending on the age of the window, the water will either soften the old cement, or, at the very least, provide total lubrication for the straightening process. I usually leave the panel overnight, and in the morning it will be flat again. If the panel has no other problems it can be left to totally dry out and then be recemented to once again securely cast the glass and lead into a straight and strong stained glass window.

Benefits: Preserving our Heritage

The ingress of water is one of the major contributors to paint loss. Many English glass paints produced around the period 1850 to 1880 contained borax as a substitute for powdered glass flux. During extended periods of saturation, borax is water soluble, and, when this occurs, the bonding of the oxides in the glass paint is lost, and the oxides detach. This is most obvious on

Of course, a cyclic maintenance program includes much more than recementing.

trace lines or black-out paint, where the oxides are applied in a thick layer. On the same piece of glass, the matt may remain sound because the thinner layer of oxides was able to fuse directly with the glass surface. Regular recementing will help keep the interior painted surface dry.

Failure of the lead matrix is directly related to the degradation of the leadlight cement. When the cement bond between glass and lead is strong, any stress to the window structure is evenly distributed throughout the panel, which discourages localized lead fatigue. A healthy cement matrix physically supports the weight of the window, a task beyond the capability of lead came alone, and, so long as this is kept healthy, stress to the lead is minimized. A regular 25-year maintenance program that includes recementing will see the original lead matrix survive for several centuries.

The rewards of cyclic maintenance are many and benefit not only the windows but the parish and the studio as well. With a cyclic maintenance program, a parish is not burdened by having to raise a massive amount of funds for a total relead every 100 years; instead the cost is spread, in 25 year installments, over 200 ro 300 years — a much more manageable pace that can also be budgeted for well in advance. This means that more churches can afford to maintain their windows.

For the studio, there will be a wider spread of business and ongoing work for the next generation of glass conservators as well as return business. My greatest concern for the "100-year approach" is that when the time comes around again, it is likely there will be no studios left who know what to do. The glass and paint will be a lot more decayed than now, because they will have suffered a second hundred years of neglect.

Of course, a cyclic maintenance program includes much more than recementing, but this will be discussed in later articles.

Geoffrey Wallace is a master glazier and founding director of Geoffrey Wallace Stained Glass, in Melbourne, Australia. He is stained glass conservator for windows in the collections of the Melbourne Museum, the State Library of Victoria and the Ian Potter Museum of Art at Melbourne University. His studio specializes in the conservation of ecclesiastic and heritage stained glass windows and undertakes major conservation projects, which have included all the windows of St. Patrick's Catholic Cathedral, Melbourne, in 1993-94 and they are currently providing the same service for St. Paul's Anglican Cathedral. He is consultant and advisor to local, state and federal heritage bodies, numerous parish churches, basilicas, universities, colleges and hospitals and has conserved many of Australia's most important heritage windows.