Principles

2.3 Work in order
2.4 Work at right pace
2.5 Appropriate skills
4.1 Respect for (natural) aging process
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
6.2 Maximum retention
6.3 Patina preserved
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.3 Reversible repair
7.4 Cautious high-tech repair
7.5 Recipes tested before application

References

For general information on repairs to all types of roofing on small buildings, especially houses, see BOWY80, CUNN84, DAVE80/86, FINE86, HANS83, HUTC80, KAPL78/86, KIRK84, KITC83, LABI80, LITC82, LOND84, LYNC82, MELV73, POOR83, READ73, READ82 and STLOnda. For larger and more complex buildings see FEIL82 and STAH84.

For examples of appropriate materials and styles for early residences, see MACR63, MACR75 and MCAL84. See MACE98, RADF83 and POWY29 for early specifications and drawings of roof construction. The special problems of metal roofing are covered in GAYL80, INSA72, PETE76 and TIMM76. Of the small-building sources noted above, LABI80 and POOR83 have useful advice on repairs to slate roofing, while DAVE80/86 and LITC82 cover chimney repairs for old houses (see also WILL83).

Types and materials

The roof is the most exposed part of a building; it often dominates a building's visual character, but is also the single element most vulnerable to weathering and thus to periodic change. Even when well maintained (and inaccessibility makes maintenance difficult) roofing materials do not last as long as other parts of the exterior. Much deterioration throughout a building is caused by too much moisture in the wrong place over a period of time — and much of this moisture gets in through gaps or weaknesses in the roofing, especially at junctions or edges. At some points in a building's life an owner will face a crucial decision whether to continue repairs or to replace the roofing entirely. In these cases, where conservation may mean renewal rather than repair, the craft, durability and visual impact of the old must be recalled very carefully by the new.

Roofing materials in 19th-century Ontario included shingles in wood, slate, and metal, as well as continuous seamed sheets of metal. Metals for roofing included copper, tin-plated iron, terne-plated iron (terne is a lead/tin alloy), and (very rarely) lead. The early 20th century added asphalt shingles and clay and concrete tiles to the repertoire. With few exceptions, the general lightness of structures (compared to European precedents) was echoed in lightweight roofing materials — copper rather than lead, thin slates rather than heavy stone flags. Even lowly asphalt has had a long career on roofs, tested by the Royal Engineers as waterproof roofing in Kingston as early as 1840.

Roofing techniques distinguish between flat or very shallow roofs where water-*proofing* is needed to resist moisture penetration from standing or slowly evaporating water and snow, and more or less steep roofs which emphasize rapid water-*shedding*.

In Ontario, flat and shallow roofs are usually covered with continuous sealed membranes of tar or bitumen (usually laid with gravel to protect the membrane) on a built-up base of paper and felt over a wooden substructure of joists and roof boards. Much rarer for low-pitch roofs is sheet metal (copper or terne-plate) with interlocking flat seams — extremes of temperature make metal roofs especially vulnerable to creeping, curling and punctures.

A flat roof must retain its integrity despite accumulations of rain and snow as well as tremendous variations in temperature from day to day — even hour to hour. Many tar-and-gravel roofs on quite old buildings sit on top of worn-out metal. Few built-up roofs last long without leaking, though the effective life of a well-maintained flat roof range from 10 years to perhaps 30.

On sloping roofs, metal roll or sheet roofing provides a smooth, relatively impervious surface, but can fail at seams and joints as well as at punctures. Thermal expansion and contraction tax every part of a metal roof — most deterioration comes at folds or standing seams that cannot move enough to relieve strains. The use of standing seams or even wooden battens at seams gives metal roofs a characteristic vertical emphasis and also offers the metal considerable room to expand and contract.

Repairing metal roofing is expensive and requires experienced experts; poor short-term repairs will accelerate deterioration. Shingle roofing in any material is more vulnerable to leaks between units and at flashings, but it is more amenable to bit-by-bit repairs; a roof's overall life can be extended by those repairs, but only to a point. The flashing and drainage of all sloped roofs are critical, for any water build-up can back up underneath shingles or sheets by capillary action, as if the roof were sucking on a straw. Locating sources of leaks may not be so easy as looking for obvious dampness; much moisture may be coming via capillary action from the side or even from below.

- Carefully assess the remaining life expectancy of a roof before deciding to repair or replace part or all of its surface — especially slate roofs, where many slates may or may not be reusable (see "Replacement", below).
- Look and feel very carefully in attic spaces for subtle signs of damp or rot that may not be apparent from above. Inspect the roof in wet weather to see it at its worst.
- Ensure that the space beneath the roof is properly ventilated, so that any moisture can readily evaporate without damage to structure or materials and to dissipate summertime heat build-up.

DURABILITY

Ontario's climatic extremes take their toll on roofing. Slate and copper are the most durable of the historic materials, lasting up to 100 years without needing major repairs or replacement. Properly installed, wooden shingles may be good for 40 years or more; asphalt shingles may last 15 to 25 years. Each material has advantages and disadvantages. Slate is heavy and brittle, but durable. Metals are light, but prone to punctures and buckling. Wood is light, but vulnerable to rot unless treated, and even more vulnerable to fire. Asphalt shingles are light — and relatively cheap — but not so durable as more traditional coverings. Newfangled lightweight composition materials try to imitate the texture and colour of slate, with more durability than asphalt, but their lifespan is uncertain.

In extreme cases such as steeples, roofing repairs require special scaffolding and extra safety precautions.

- Make certain the roofing is properly anchored and that the anchors are not corroded or broken.
- Make vents, skylights and other new elements fit as discreetly as possible, both visually and materially. Flash and seal any openings fully and inspect them regularly. There are many traditional ways to conceal or incorporate such elements, as part of the roofing itself or in conjunction with gables, dormers or chimneys (see VISUAL HARMONY AND GOOD FIT).
- Make sure there is proper protection against damage by lightning, especially for high buildings in rural areas. Lightning rods on barns and churches may or may not be properly grounded; if not, they will be worse than nothing in the event of storms.

Repairs

- Arrest deterioration and repair problems in the roof *structure* before final repairs on the roof *surface*. Remove wood damaged by infestation or rot and replace with sound material. If replacing roof boards with plywood sheathing, provide sufficient ventilation between roofing and sheathing. Make sure that the roof has temporary covering while it is open for repairs.
- Be especially careful about safety on sloped roofs. Work in cool weather. Take special precautions when working on brittle slate roofs (soft-soled shoes, wooden planks or ladders to obviate walking on slates, and so on) — sloppy repair work may break more slates than it fixes.
- *Never* use bituminous (tar) patches on metal or shingle roofs. Such patches do not cure a leak; they only postpone its damage for a short while. They are almost completely irreversible and often cannot be fixed without complete replacement of the underlying material.
- Match the colour, dimensions, texture and material of surrounding roofing when replacing individual units or sheets. In the case of slates, maintain any polychrome patterns that may exist. Ensure that substitute units are fastened in a way and with materials that will not hasten deterioration around them. Do not artificially age the appearance of new sections of copper — in time, they will fit into the general appearance of the roof without assistance.
- Ensure chemical and physical compatibility between roofing, fastenings and flashings. Do not use copper with cedar shingles. Do not use different metals together — fasten copper with copper, terne-plate with lead-coated nails, and so on. Decorative iron cresting designed for slate roofing will not go with a copper replacement roof. Watch for signs of corrosion of metal flashings and drains from stone particles eroded from slate roofs and replace deteriorated troughs and downspouts.

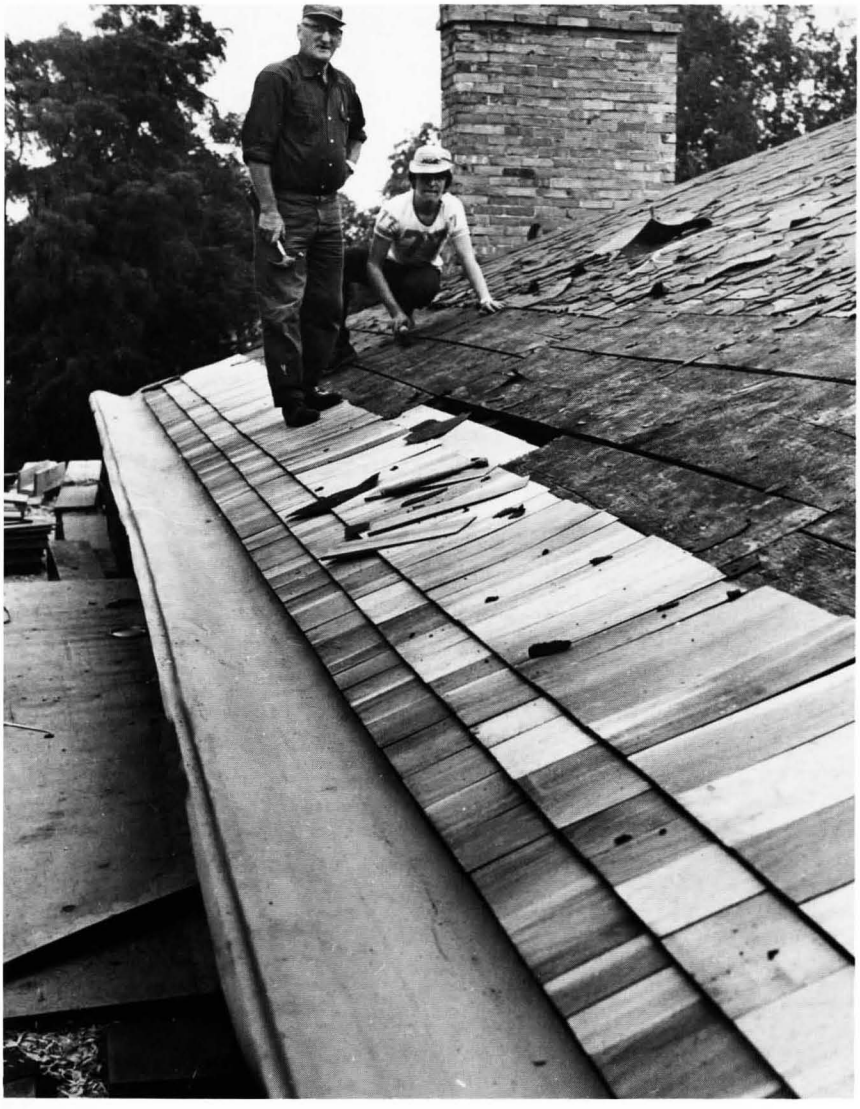
Replacement

- Wherever possible, replace worn-out roofing with the same materials. Where there is sufficient documentary or archaeological information, consider replacing modern short-life roofing with the more durable covering of the building's earlier years. Do not presume that the original material was necessarily wood shingles or copper sheeting. Consider a conjectural "period" substitution only when it proves impossible to determine the authentic materials and techniques used for the roofing (or when the historic technology is no longer available), and then only treatments commonly used in the region during the period of construction.
- Do not lay new roofing over top of existing roofing. Ensure that roofing can expand and contract without losing its integrity.
- Consider the choice between repair or replacement of slate roofing with the following in mind:
  - Soundness of the slates in general
  - Integrity and durability of existing flashing
  - Capacity of existing roof structure
  - Percentage of slates that can be re-used — thickness, brittleness, sound nail-holes, cracking
  - Estimated life of sound slates

- ❒ Sources for replacements; new or used; colour-matching
- ❒ Time and labour costs
- ❒ Estimated life of the renewed roof as a whole

- ❖ Interim short-lived roof coverings should be similar in colour and texture to what is replaced or to the early covering ("interim" may be a long period of time).
- ❖ Be especially cautious when replacing slates with lightweight simulations; in assessing relative costs, consider these as short-lived alternatives until their durability has been proved. Match as well as possible the texture, colour, and details of the specific building rather than accepting the standard offered by the supplier.

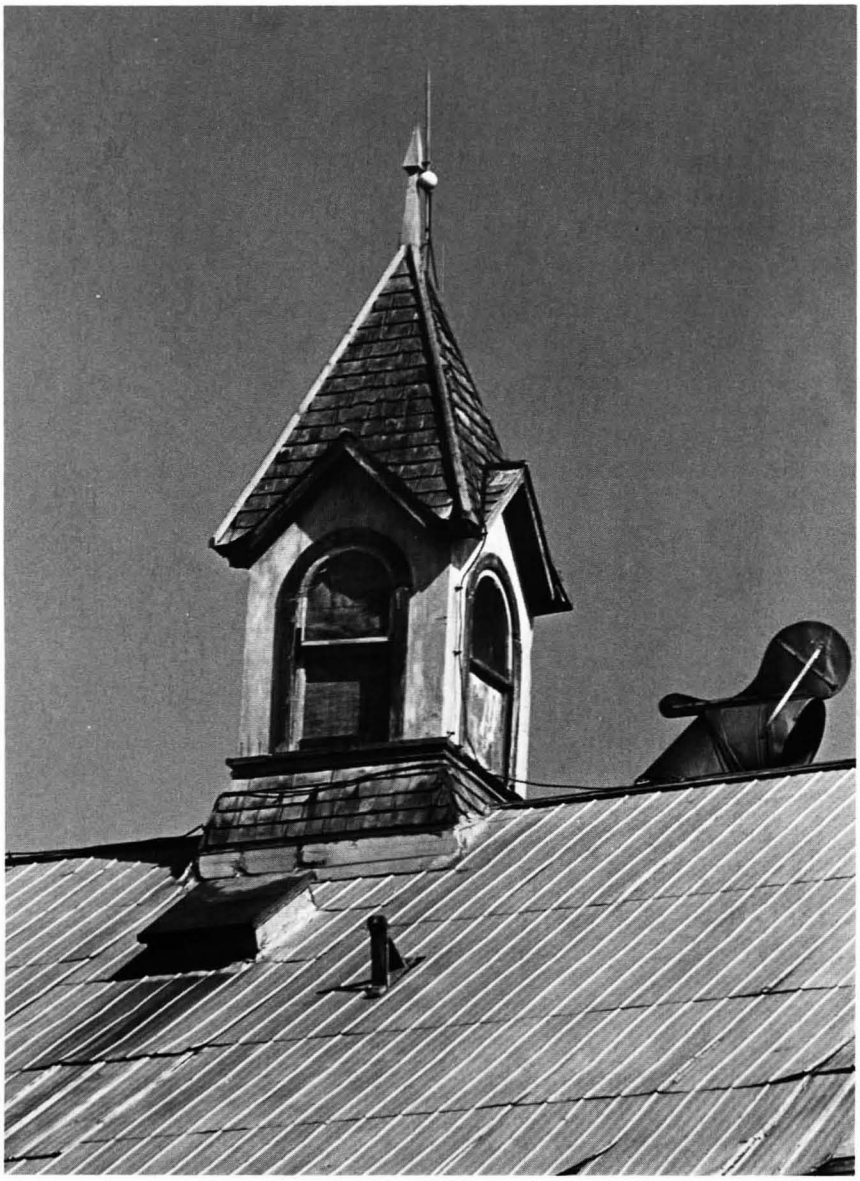
Renewing a wooden roof requires removal of accumulated surfaces, repair of any deterioration in the underlying substructure, and provision for sufficient ventilation beneath the roofing to prevent future problems. Here, following traditional designs, the rain gutter is being reincorporated into the edge of the roof rather than as a separate trough.



Gables, eaves and dormers

- ❖ Inspect all roof valleys very carefully at regular intervals, especially the tops of short valleys at dormers, and repair any problems immediately.
- ❖ Make flashings secure at every junction or penetration of the roof. Do not rely on mastics or adhesives alone to prevent capillary action and moisture penetration. There are many traditionally proven details for such junctions; do not invent a new one where an old one will do quite well. Wherever water may run down a surface (such as fascia mouldings, soffits, sills or brackets), provide a drip edge (a groove or slot in the horizontal surface beneath) to keep a film of water from creeping into the joints below.
- ❖ Provide proper eavestroughs and downspouts to channel water away from the walls below. These should be discreet — retain and repair built-in gutters rather than attach new troughs. New troughs and downspouts should be visually "thin" and follow corners or angles in walls where possible. Add new downspouts especially where flat roofs do not drain away storm water fast enough.
- ❖ Keep rooftop decorations in good repair and flash very carefully where they are fastened through the roof. Ground all projections against lightning.
- ❖ Replace missing features only on the basis of conclusive documentation and use original materials and colours where possible.

See EXTERIOR WOODWORK and METALWORK.



Chimneys

- Inspect chimneys and flues regularly (at least annually) for structural soundness and proper operation. Ensure that chimney caps and linings are sound and that firestops and flues are in working order if the chimney is to be in use. Flashing is especially important; much roof deterioration is found around chimneys.
- Make sure the chimney is vertical and structurally stable. Ensure that flue gases over the years have not damaged mortar — if they have, it will probably be necessary to take the chimney down and rebuild it. If a furnace has been converted to natural gas, look carefully for chimney problems caused by excessive condensation. In repointing, follow the general guidelines for mortar mixing and application. Make sure all flashing is secure and effective.
- Replace masonry with units of the same type, colour, dimension and durability; do not replace proper brick or stone chimneys with metal pipes.
- Protect and retain ornamented chimneys and chimney pots, which are important parts of the building profile. Repair or replace cracked or otherwise damaged chimney pots; replacements should be new pots of similar size and shape.

See MASONRY.

All projections and structures on the roof, from finials to chimneys, cupolas, hatches and attic dormers, require careful flashing and regular inspection to keep water and dampness from causing damage beneath the weather-resisting covering.

Masonry: brick, stone, block, terra cotta

Principles

2.2 Co-operation among specialties
2.3 Work in order
2.4 Work at right pace
2.5 Appropriate skills
2.6 Second opinions when in doubt
4.1 Respect for (natural) aging process
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.7 Reconstruction for wholeness
5.9 Façadism as last resort
6.2 Maximum retention
6.3 Patina preserved
6.4 Respect for craft
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.4 Cautious high-tech repair
7.5 Recipes tested before application
7.6 Maintainable repairs
7.7 Gentle cleaning

References

There is a great deal of general coverage of masonry repairs in the bibliography. For new masonry, the best source is BEAL87. For conservation treatments, the most comprehensive are general DAVE80/86, FEIL82, JOHN84, MEAD86 and STAH84. See also BOWY80, FACA87/87a, FROI86, GRIM84, HUTC80, INSA72, LOND84b, LYNC82a, MELV73, OEHR80, RAMS88, REMP80, SMIT85, TECH82, TIMM76 and TRIL72/73.

For stone in particular, see CONS82, PRIN81, SCHO85 and WEIS82; for brick, NASH86. Older technical treatises include HODG07, MACE98, RADF83 and WARL53.

For cleaning and pointing, see ASHU77, ASHU83, HIGG85, MONC83 and WILL83.

Types and materials

Masonry construction consists of heavy individual load-bearing units — bricks, blocks of stone, concrete block, clay tile, pre-cast units in terra cotta (clay) or cast stone (cement), and even blocks of glass — bedded and consolidated by mortar. Masonry is almost ideal for resisting compressive forces, but terrible for tensile forces. Its principal use has been in exterior walls of buildings. Though some important older engineering works have been made in stone or brick, the European traditions of massive arched or vaulted masonry structures gave way to lightweight framing techniques in the 19th century, and few such structures survive in Ontario. Masonry construction will last centuries if its units are properly manufactured and erected.

Mortars for masonry combine sand, lime and cement in varying proportions to permit the entire wall to act as a unit in resisting compressive stresses (even where that wall is only a skin over the principal structure behind). Mortar itself is not a very strong structural material. Modern construction uses mortar with a great deal of cement to bind hard bricks into very rigid walls with frequent control joints to allow for thermal expansion and contraction. Historic construction (almost every pre-1920 building) used softer mortar with very little cement, binding together bricks or building stone of varying hardness to produce walls that could absorb stresses and thermal movements with few if any control joints.

The greatest danger to historic masonry construction is usually from relatively recent repairs using hard mortar of high cement content. The "philosophy" of mortar has been reversed in this century. In historic practice, a small portion of cement was added to the lime to help stiffen the mix and keep the mortar in place while it cured; in modern practice a small portion of lime is added to the cement to keep the mortar workable long enough to be laid smoothly. Hard mortar transmits stresses to the brick or stone; soft mortar absorbs stresses *from* the masonry. Hard-mortar repairs simply crack and crush the relatively soft stone or old brick, often in very short time.

Many conservation projects must pay more attention to repair of damage caused by *previous* "modern" repairs than to simple deterioration of aging originals.

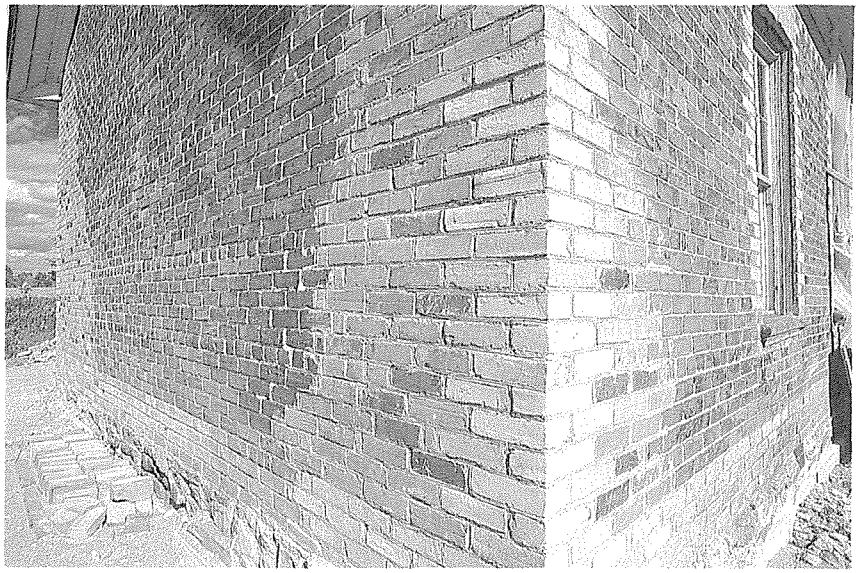
Brick

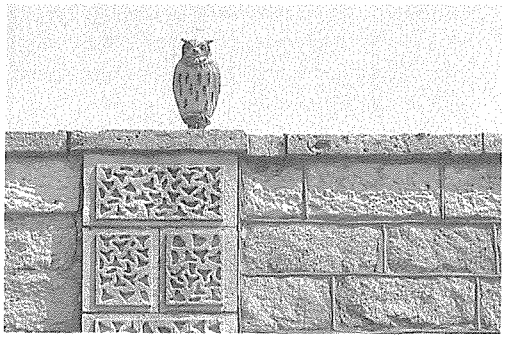
Bricks are manufactured from clay and tend to take their colour and chemical properties from that clay. Their porosity and hardness depend on their firing, often on their location in the kiln. Most historic brick masonry was produced in small batches and fired as a batch in a small kiln; modern bricks are produced and fired in a continuous process with far greater uniformity. In old buildings, face brick is usually far more durable than interior brick, or sometimes even the side or rear walls. Not all brick was unpainted — in some neighbourhoods, soft brick was used instead of face brick for all exterior walls, and paint provided the weatherproof skin.

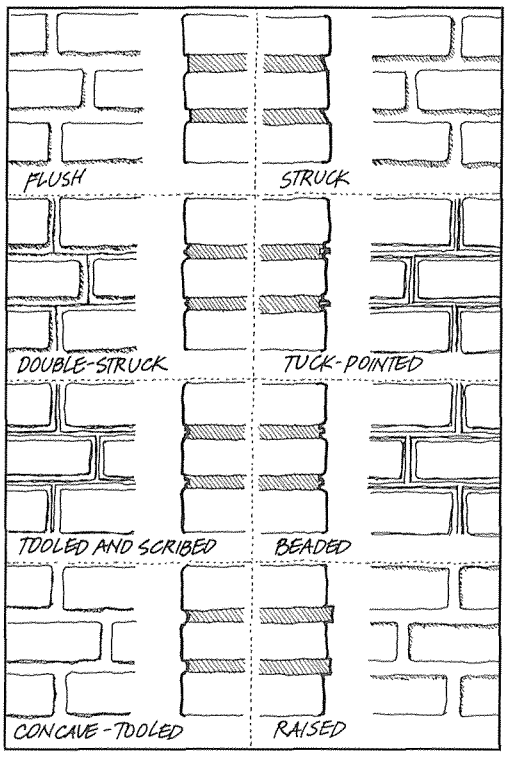
Bricks are vulnerable to mechanical damage from overstressing, freezing, and crystallization of salts in migrating moisture. Their long-term preservation requires that moisture be kept out of the walls or can escape in a non-damaging way if it *does* get inside. Soft flexible mortar is the traditional safety valve for older brick. Periodic repointing may be needed to repair deterioration and is far preferable to replacing the bricks themselves.

- Finish structural repairs, especially around door and window openings vulnerable to movement, before working on visible masonry repairs.
- Repair vertical fractures, both structurally and cosmetically, from bottom to top; if reinforcement of the brickwork is necessary, use only non-rusting (non-ferrous or stainless steel) ties.
- Do not seal brick surfaces with silicones or consolidants, which trap water vapour behind the surface of the brick; when that vapour condenses, it may freeze or leach salts that will eventually destroy the brick face. Similarly, do not slap stucco on a deteriorated brick surface to hide the problem; it will simply mask further deterioration that will eventually crumble both brick and stucco. Far more acceptable is repointing with porous mortar that lets the wall "breathe" to the outside, allowing moisture to migrate and evaporate through the mortar, not the brick.

See BEAL77 for the most thorough treatment of all masonry types and techniques, though its emphasis is on modern practice. Early texts on masonry offer excellent information on how things used to be done, and thus on how to make compatible repairs: for instance, see MACE98 or HODG07 (out of print, but accessible through libraries), or WARL53 (available as a reprint). See also the advice in HIGG85 and STAH84.







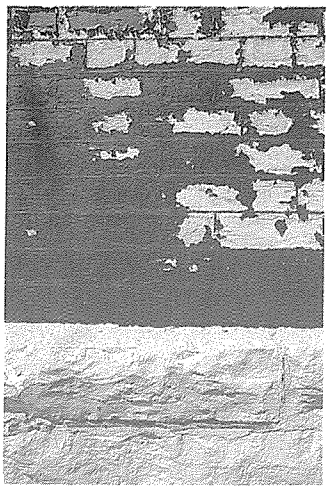
Varieties of masonry materials and techniques.

REGIONAL VARIETY

There has been a tremendous variety of masonry construction in Ontario; the historic use of specific types and colours of brick or stone has given many areas a distinct character. Many areas were built almost entirely in brick, because of fashion and to prevent the spread of fire in towns. The Victorian taste for polychrome brickwork, often accented in stone, combined with the timing of development to dominate the look of many southern Ontario towns and villages. This regional identity broke down with subsequent centralization of larger brickyards and abandonment of quarries as stone construction gave way to concrete.

- Once the source of brickwork decay has been repaired, repoint only in areas where mortar is loosened or crumbling. As much as possible, do not remove sound mortar. But poke and probe to make sure that what is left really is sound.
- Before repointing, cut out crumbled material until you reach sound mortar to which the new mortar can adhere. Use hand tools to reduce the risk of damage to the brick. Only skilled and experienced operators should use power-chisels, and then only lightweight models. Do not use a power-saw. No matter how carefully used, power tools will damage bricks if you cannot see what you are working on. Look at the piles of brick dust around sites where power tools have been used to cut out mortar. Most of that dust is from the no-longer weather-resistant brick faces and edges.
- Repoint masonry walls using as close an approximation as possible of the historic formulation, profile, width and colour of mortar. Use sand for colouring rather than less permanent pigment (unless the original really did use pigment). Match the colour of a freshly exposed section of original mortar rather than a weathered area — eventually, the "new" mortar will age and weather to match the existing surface. Do not "butter" or "scrub" the joints; besides looking very sloppy, the thin feathered edges of such joints crack and break easily, funneling water into the joint and creating even worse damage.
- Before repointing, thoroughly wet the adjacent bricks to keep the mortar from drying too quickly before it cures properly.
- Use a mortar mix no stronger or stiffer than the historic mortar. *Do not use modern formulations with high proportions of Portland cement.* If possible, take a sample of *sound* original mortar (whose lime content has not been leached away or altered in subsequent repointings), have it analyzed by a laboratory, and use that specific formula for repointing. Laboratory analysis should take into account the variabilities of the original application and the effects of impurities in the original mixture.
- Never apply lime mortars in temperatures near or below freezing or in hot, direct sunlight. In either case, the mortar will never attain its structural strength and other properties.
- Never use caulking as a replacement or covering for mortar.
- Where the faces of bricks have spalled and crumbled, replace them in kind, matching the bonding pattern and the units' dimensions, colour, and texture. For matching purposes use actual samples, not just pictures of samples. Use only first-quality face brick for exterior replacements. Use old bricks from a salvage yard or, if necessary, bricks scavenged from an inconspicuous part of the same building to match on a conspicuous face. Do not use salvaged bricks that have been sitting directly on the ground for any length of time — they may have absorbed ground salts that will cause efflorescence later on.
- In replacing special shapes of brick, do not expose cut or rubbed edges to weathering if posssible. Custom-shaped replacement bricks are almost impossible to find and may have to be made by cutting down a standard brick. (This may be the one condition where coating a brick with a water-repellent treatment may be satisfactory, *but only on new brick*; regular inspections and recoating may be necessary).
- Where isolated brick surfaces in a generally uniform wall require replacement, consider refacing the brick with a synthetic surface made up of brick dust and an appropriate resin bonded to the sound remnants of the original. This will require great skill in matching colour, porosity and surface texture and should be considered a last resort, but it may prove satisfactory. This is similar to the more typical "plastic" repairs of stone (see below). Very skilled hands may be able to replicate unobtainable custom-shaped units.

Making rough bricks into fine ones — a traditional but rarely surviving pointing method that is difficult to recover once painted over.



MIXING MORTAR

In general, the cement content of mortars for historic masonry must be no greater than one-twelfth of their dry volume, and this must be *white* Portland cement rather than gray.

For very weak or soft bricks, use an ASTM (American Society for Testing and Materials) type K mortar: 1 part white Portland cement, 3 parts hydrated lime, 12 parts sand. For more typical machine-made face bricks in more exposed conditions, use an ASTM type O mortar: 1 part white Portland cement, 2 parts hydrated lime, 9 parts sand. Do not use additives such as plasticizers in any of these mixes. And, above all, do not use caulking as a mortar substitute.

Stone requires similar caution, especially for sandstones and the weaker limestones. As for brickwork, use a "weak" mortar mix compatible with the existing formulation and with the stone. Whenever possible work from a laboratory analysis of the existing mortar, but for most sandstones, the ASTM type O mortar should be satisfactory. Limestone in good condition and granite can both stand a more cementitious mix if necessary (ASTM type N: 1 part white Portland cement, 1 part hydrated lime, 6 parts sand) but do not let the cement content exceed the lime. As above, avoid plasticizers and caulking.

Cautions: repoint in temperate, shaded conditions and keep pointing wet long enough for it to cure properly. See ASHU83 and BEAL87 for more technical information on mortars.

Stone

Though the appearance of most Ontario towns, at least in the south, is dominated by brick construction, building stone appears in an extraordinary variety of types and forms throughout the province. Though churches and public buildings offer the most conspicuous examples of stone masonry, there are concentrations of limestone commercial buildings in towns as far apart as Perth and St. Marys, farmhouses in granite "fieldstone" all along the glacial ridges north of Lake Ontario, and even cobblestone façades in Paris and in Sidney Township. The Rideau Canal and its adjacent houses and towns comprise a special concentration of stone architecture, and even a few stone-arch bridges survive, from Pakenham to St. Marys.

For most coursed and dressed masonry, limestone has proved generally more available, workable and durable than sandstone, but many large mansions and public buildings used the reddish Credit Valley sandstone to good effect in contrast with smooth brick of similar colour. As the railway network widened at the end of the 19th century, construction stone moved far beyond the immediate locale of specific quarries. Many of the province's larger stone-faced structures of the 20th century were clad in limestone imported from Indiana or Manitoba. Marble (metamorphosed from, but softer than, limestone) has been imported for decorative exterior work, but since it weathers poorly in extreme climates, few Ontario examples survive.

Building stone's physical and chemical properties vary tremendously, and even the most solid-looking of stone can be eroded rapidly by weathering. Though weathering does give most building stone a protective hardened crust or patina, stone is more or less porous to moisture and is no less vulnerable than brick to deterioration caused by hard-mortar repairs. Apart from granite, building stone is normally sedimentary in formation, built up in layers or bedding planes. Limestones and sandstones are best quarried and laid with those planes horizontal, but there are examples of stones laid with their planes vertical, and these exposed faces may simply spall off in thin flakes or sheets as trapped water freezes or its dissolved salts crystallize. Though early stone structures were of bearing-wall construction, most late-19th- and 20th-century stone walls were often simply cladding on a steel or concrete frame beneath.

Good building stone can be worked or sculpted into astonishing varieties of forms, though the requisite skills have become exceedingly rare. The exposed face of coursed stonework may be either rusticated or dressed smooth (ashlar); there are also many examples of decorative surface treatments such as vermiculation. High Victorian Gothic and Romanesque Revival tastes often combined different surfaces on the same wall, including sculpted heads and simulated vegetation. Many buildings exhibit puzzling projecting blocks of unfinished stone, testimony to the construction budget having given out before the stonecarver could finish his work.

Few Ontario quarries still provide building stone apart from gravel. Accordingly, finding precisely matching replacements from the original quarry is almost impossible. Because of Europe's much longer tradition of stone construction, there have been many attempts there to develop chemical consolidants to prevent further deterioration of already decaying stone surfaces. These imported compounds must be considered experimental, even though some have been tested for a decade or more. They should be applied only by experts under very careful controls, and only on surfaces beyond other repair techniques.

- Finish structural repairs, especially around door and window openings vulnerable to movement, before doing visible masonry repairs. Repair vertical fractures, both structurally and cosmetically, from bottom to top. In the case of bearing-wall construction, consolidate the insides of the walls with cementitious grout if there are voids or weaknesses; use only non-rusting reinforcing bars of stainless steel or non-ferrous metal (see FOUNDATIONS and SUPERSTRUCTURE).
- Repoint only in areas where mortar is loosened or crumbling. Do not remove sound mortar. Cut out deteriorated mortar by hand and repoint using the historic formulation, profile, width and colour of mortar (see above). The above-mentioned

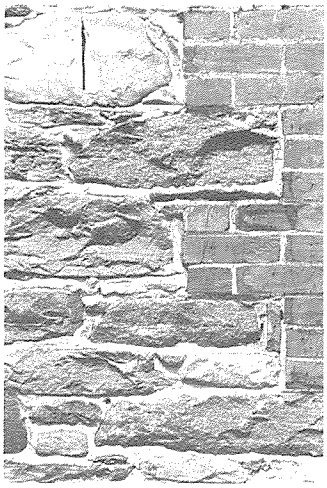
EXPERIMENTATION

Be extremely wary of chemical treatments claiming to arrest masonry deterioration. Do not use brick consolidants to reintegrate deteriorated surfaces. But there is some justification for experimental testing of such compounds — in inconspicuous places — in order to build a body of experience that will be useful in the future. The chemical technology for stone consolidants is not yet fully proved over time; that for brick is much further behind. Inspect and document such experiments regularly and maintain contact with other experiments through professional associations such as APT or ICOMOS.

caution about "buttered" joints applies doubly for stone, especially rubblestone; no matter how irregular the joints, resist the temptation to even up the wall surface by plastering it with mortar; the inevitable water penetration may eventually weaken the wall.

- When applying lime-based mortars, respect the same cautions as those for brick — never apply mortar in extreme temperatures and thoroughly wet the surrounding stone to keep the moisture from leaving the mortar before it cures properly (see above).
- Whenever possible, replace irreparably deteriorated stone in kind. Ideally, replacement stone should come from a similar bed in the same quarry, quarried and bedded similarly (unless the decayed stone was improperly quarried in the first place). Where closely matching stone is unavailable from any source, consider swapping stone from inconspicuous parts of the building to more conspicuous areas, using less critical substitutes for the first area.
- Ensure that replacements for ashlar and other coursed work are horizontally (naturally) bedded and that in arched, vaulted, or decorative repairs the bedding is oriented to use its strength in the best direction.
- Where substitutes are hard to find, and the material is a fairly strong limestone or granite, consider carefully "quarrying" the units already on the building. With suitable reinforcement, a damaged stone may be moved forward in its place and its surface re-dressed. Alternatively, a skilled mason can split a thick unit in two, dress the new surface to match the old, and reintegrate it into the structure with non-ferrous bolts or dowels. Only a specialized and experienced contractor should attempt this rather destructive form of rescue, and only after testing first in an inconspicuous area.
- An alternative substitute may be a cast-stone replica of the damaged masonry, using cement, appropriate epoxies, stone dust and aggregate to match the colour, texture and structural capacity of the original. With skill, cast stone technology can produce units as durable as natural stone, but it is critical to match colour and texture to avoid an unacceptably pasty, concrete-like surface. This may be the only satisfactory means to replace or replicate missing or badly damaged decorative masonry (see "Replacements and substitutions", below) but should be considered a last resort.
- If replacing stone from a different source, take special care to use the same type of stone; substitute sandstone for sandstone, limestone for limestone, and so on. Limestone and sandstone are particularly incompatible in one respect — acid precipitation washing the surface of limestone creates a mildly carbonated water that leaches the calcium carbonate out of any sandstone beneath it, and calcium carbonate may be the only thing keeping the sandstone from becoming structurally useless sand.
- Because they are irreversible, use chemical consolidants only with *extreme* caution and expert advice. For instance, alkoxysilanes have been used successfully to consolidate siliceous sandstones — but if your sandstone isn't siliceous, or if your silane isn't applied properly, you will end up with even worse deterioration. The only traditional consolidant generally recommended is a lime wash on limestone — essentially application of a protective coating of the stone itself in liquid form. Do not apply a lime wash to sandstone.
- Repair impact damage or broken stone with a "dutchman", an insert of matching natural stone or compatible cast stone facsimile cut to size by a skilled stonemason and put in place with a stable epoxy filler and non-rusting anchor or dowel.
- "Composite patching", using mixtures of stone dust, lime, cement and possibly epoxy, may be an acceptable interim treatment for decayed stone where it is necessary to protect the remaining sound stone from further weathering and decay. Such patches must be removable when a more durable repair can be made. It is extremely difficult to avoid a very pasty, concrete-like surface texture in the poorly

Though some of this pointing may be rough and in need of repair, its sloped profile has kept water from running into the wall.



See MEAD86 for more technical information and further references on terra cotta. Also useful are early editions of "Architectural Graphic Standards" (see RAMS88).

controlled conditions of the construction site (and too much epoxy may interfere with moisture movement in surrounding stone). Match the chemistry and physical properties of the surrounding stone and use non-rusting ties and reinforcements to bind the patch securely to the stone. This technique requires a rare combination of skills and generally should be confined to inconspicuous areas.

Terra cotta and clay tile

Terra cotta and its more mundane cousin, structural clay tile, are fired clay products still in production, but much less popular than they were from the 1880s to the 1930s. Terra cotta is hollow and much lighter than stone.

In its heyday, terra cotta was moulded to imitate carved stone or almost any other shape and simply bolted onto a substructure. Its composition and manufacture limited the size of individual pieces, but these could be readily combined as masonry units to emulate larger features in the same way small wooden mouldings could be assembled to make large cornices. The characteristic ceramic glaze on most terra cotta was applied in a separate operation from the shaping of the basic unit.

Most terra cotta in Ontario was imported from huge factories in the northeastern United States. None of these plants survives. Though small workshops can produce custom units and a few small factories in the United States still make production runs, decorative terra cotta on existing buildings is essentially irreplaceable.

Elegant glazed terra cotta surrounded many windows in early 20th century commercial architecture (regrettably, the window itself has not been so well treated as the frame).

Terra cotta is a brittle material that deteriorates quickly when stressed beyond its limited capacity. It is quite difficult to repair. Most problems are caused by failure of fastenings. Bolts and brackets rust and fail, often weakened by thermal expansion and contraction in the terra cotta itself or by structural movements behind the units. Individual units jostle one another, creating added stress and finally cracking or breaking completely. The ceramic glaze is vulnerable to extremes of temperature, but the frequent light crazing of the glaze does not mean that the unit has lost its strength or integrity.

- Even if the glazing has hairline cracks from ceramic crazing, do not paint or cover terra cotta with waterproof coatings. Just as with brick, water vapour will inevitably penetrate the unit from behind and needs to be able to evaporate to the outside. If sealed beneath the surface, water will condense and in cold weather frost will destroy the glaze.
- Ensure that the mortar between the units is soft and flexible, to absorb stresses and movements. If necessary, add control or relieving joints to long runs of units to remove external stresses. Remove and replace any rusting bolts or anchors with new non-rusting connectors.
- Never use heavy-duty acidic compounds to clean terra cotta; hydrofluoric acid, even well diluted, causes great damage to the ceramic glaze.
- Secure cracked but otherwise sound pieces with reinforced resins of tested formulation. Large sections or those with more severely deteriorated anchorages can be refixed with non-ferrous anchors grouted in epoxy.
- If it is necessary to replace a unit, try to find craftworkers or small shops familiar with casting and firing ceramics for outdoor conditions. If using an existing unit as a pattern, enlarge the mould for the replacement slightly to allow for shrinking during firing. Take the opportunity to make and store spare units. Ensure that new units are fastened with rustproof connectors and bedded in soft mortar.
- Consider substitute materials for replacements only in extreme cases. It is very hard to match the glazed finish of terra cotta (though acrylic/epoxy finishes come close). Cast stone may be a satisfactory substitute for unglazed terra cotta, but it is heavy and special care is needed to prevent damage to adjacent units. Glass-reinforced plastic or cement has been used as a substitute for cornices and panels. Consult recent technical literature for advice, and follow expert advice (see "Replacements and substitutions", below).

Cast stone and block

With the right touch and mixes, cast or "artificial" stone can be moulded into different shapes as easily as clay. Very similar in composition to concrete, cast stone involves preparing a dry mix of cement and sand or other aggregate and adding a specific amount of water to form a paste that can be cast or moulded into any required shape. It came into common use for steps, lintels, garden ornaments and other small elements in the late 19th century, but its more sophisticated use as a coping and facing material for buildings emerged about 1900 as concrete technology matured. The most conspicuous use of cast stone was to clad steel- or concrete-frame structures with panels that emulated carved stone ornament and dressed stone walls (for a good deal less money than either). Cast stone came reinforced or unreinforced, in a variety of colours, textures and trade names, such as Roman stone or angel stone.

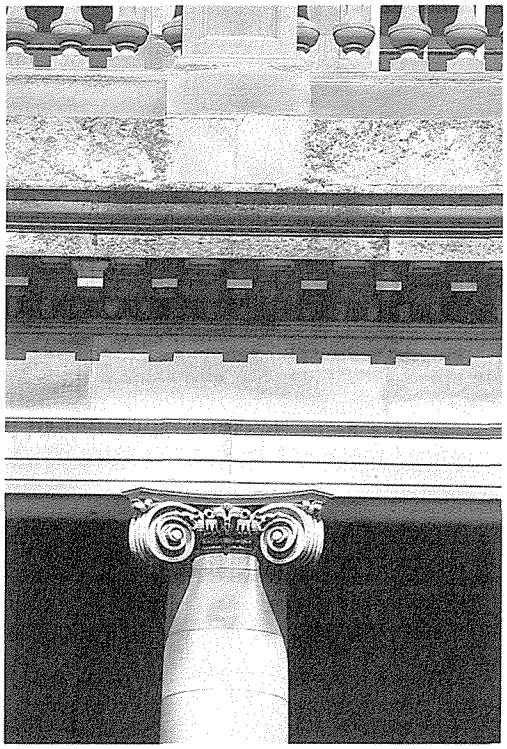
There were and are many different formulations for cast stone (some proprietary), and not all have proved durable over time. The material may break down through faulty mixtures, poor casting, corroded reinforcement or fastenings, and all the other agents of chemical decay that afflict natural stone. Nevertheless, cast stone is very durable, in some respects even sturdier than some of the natural stone it can emulate. Its technology survives primarily in the making of garden ornaments. Epoxies and resins now offer additional strength to the cement and aggregate mixtures. Cast stone remains useful as a substitute for stone masonry, to repair both deteriorated natural stone and "historic" cast stone.

Concrete "breeze" block first appeared early this century, as another aspect of concrete's leap to prominence in construction, but was rarely used as a visible material. In the suburbs and small towns built in the 1910s and 1920s, examples survive of houses and even the odd church in moulded blocks of standard size made to look something like rusticated limestone.

- Before any attempt at repair of cast stone features, undertake a laboratory analysis of a sample. There was and is a tremendous variety of mixes and aggregates, some incompatible with one another. Matching the material accurately requires detailed investigation of additives used to produce colouring and texture.
- Arrest any moisture problems, repair underlying structural deterioration, and ensure the soundness of all anchors and joints before starting cosmetic work. Make sure that reinforcing within the feature has not weakened or rusted — remove any rusted metal before patching. If deterioration is severe it may be best to recast the unit altogether.
- Patch cracks or pits in cast stone with a plastic repair made from a mix of cement and aggregate similar to that used originally. Make sure the patch is well keyed to sound original material. Dutchmen repairs may also be satisfactory. Any coatings or paints must "breathe", letting interior moisture escape and evaporate.
- For replacements, make moulds from a sound original, recast the elements using the same formula, colour and texture, and reinstall with non-rusting anchors. Moulds can be made to the same size as the copy; cast stone does not shrink significantly in preparation.
- Consider using cast stone for its historic use, as a material to replicate expensive or missing stonework; investigate the current technical literature for its use as a substitute (see "Replacements and substitutions", below).

Concrete block has never become an elegant construction material, but it has appeared and reappeared in many patterns for modest residential and commercial buildings — even the occasional church — since the early 1900s.

Romanesque and Classical styles of carved stone ornamentation — the rusticated styles gained particular popularity in the late 19th century for the pragmatic reason that they weathered and aged more graciously than the precise and polished styles.



The problems of bad masonry cleaning have been so widespread in Ontario that provincial heritage advisers asked a conservation expert to prepare and publish sample specifications for both cleaning and repointing — see HIGG85. See MEAD86 about replacements and substitute materials.

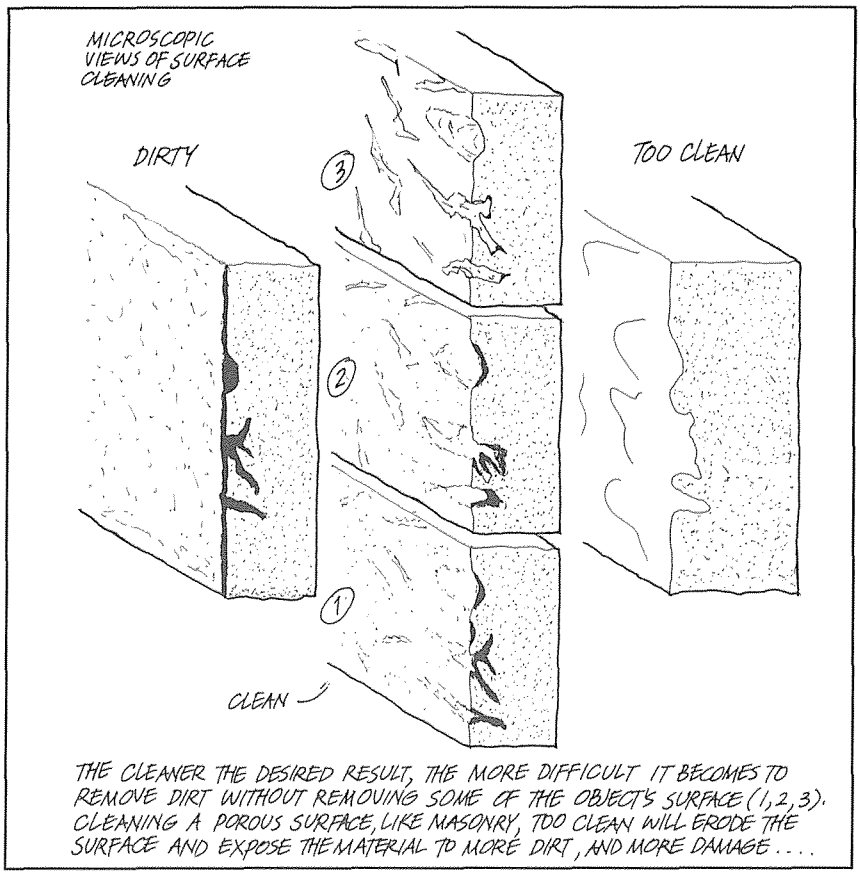
Cornices, corbels, and carvings

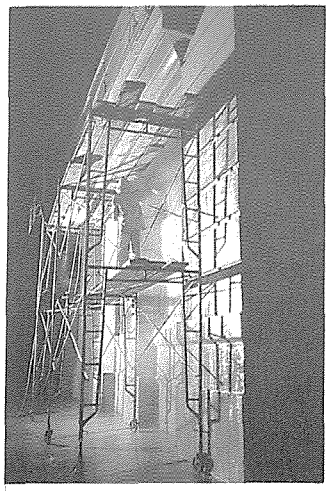
There is a great wealth of decorative detail in brick and stone ornaments and projections, especially in the Gothic and Romanesque revivals of the late 19th century. These especially fine details are unfortunately very vulnerable to erosion, and there are few stonecarvers able to carve replacements or new decoration in the style of the historic details.

- Inspect all projecting masonry features regularly. Ensure that anchorages are solid and rust-free, and flashings intact and sufficiently sloped to let water drain away quickly. Take immediate action to correct problems and prevent further decay.
- Use chemical consolidants only with great caution, and only on the basis of expert advice (see above).
- Follow the advice under "Stone", above, regarding the uses of dutchmen and plastic repairs.
- Only when important ornamentation has severely and irreversibly deteriorated due to atmospheric pollution or other long-term influences — and preventive maintenance has failed to stop this decay — should removal and storage of original work and replacement with replicas be considered. Substitutes must maintain the visible character of the original features without creating conditions for further deterioration.

Cleaning

Masonry does not need to be cleaned nearly as often as it is, or as deeply. Careless cleaning can seriously damage masonry. Many buildings sandblasted barely a decade ago have lost much of their exterior because of weathering of the raw surfaces exposed as the protective skin of the brick or stone was literally blown away. Water jets at high pressure may do even worse damage, both eroding the surface and driving water deep into the wall. Poor chemical cleaning deposits salts inside the masonry that come out as stains and crystals, crumbling the surface microscopically just as surely as a blast of sand.



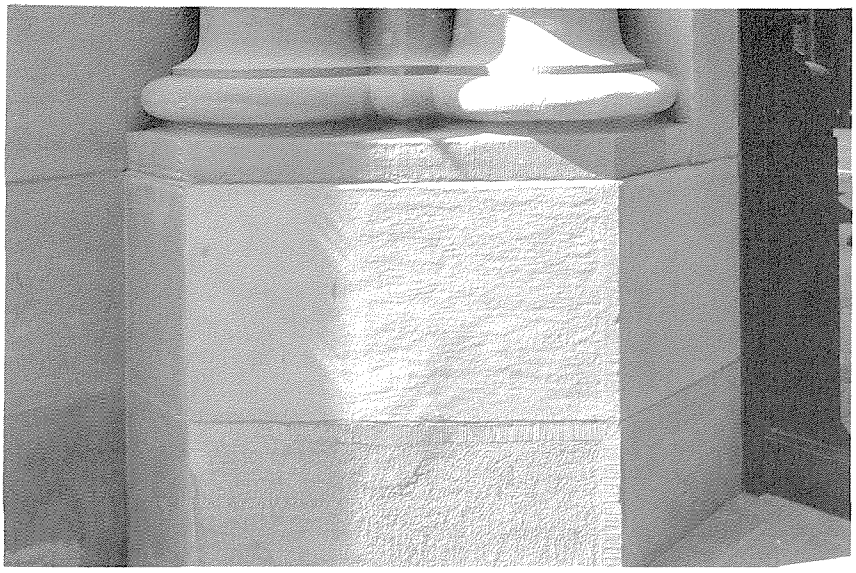


A low-pressure water-soaking for limestone — slow but effective, so long as the water can evaporate without harming the interior of the walls (above). Sandblasting on the other hand produces harrowing results — and here it did not even remove all of the paint (right).

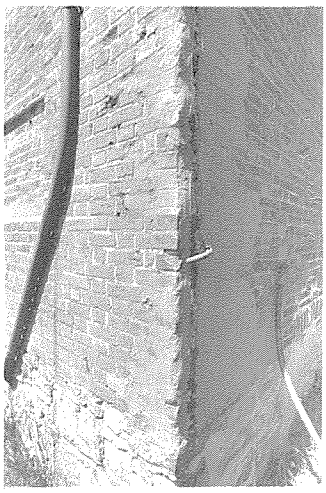
It is vital to establish the *level of clean* required for the specific job and not to clean any more deeply than absolutely necessary.

- Clean masonry only to uncover deterioration, to halt further deterioration, or to remove organic deposits. Do not remove patina that protects the interior of the unit, but do ensure that the patina is not itself a source of chemical decay.
- Where masonry has been painted during most or all of its existence, do not strip the paint to the unprotected masonry, except to repaint. Use vapour-permeable paints to prevent moisture build-up from inside.
- Do not erode the building surface. Do not clean so deeply into the surface that the surface itself is removed along with the dirt. Use the gentlest cleaning method possible and use more time rather than caustic chemicals and high pressure to complete the job. Do not sandblast or use abrasive high-pressure water or compressed air blasts on any historic masonry.
- Clean exterior masonry only in suitable weather, preferably in moderate conditions in spring or early fall. Do not use cleaning chemicals in hot, direct sunlight. Do no exterior cleaning in winter.
- Mask delicate surfaces carefully. Use no chemicals that will form salts in reaction to the masonry. Do not let cleaning residues get absorbed into the masonry. Test-clean inconspicuous sample areas first and follow proper conservation specifications fully. Test patches of cleaning methods in inconspicuous places. Make these patches big enough to be reliable samples — at least 1.5 metres square. The architect, client and contractor must all agree on the test results and on the method to be used overall.

See PAINT, COLOUR AND LIGHT for other cautions about exterior cleaning.



Plastic repairs require frequent inspection and maintenance if underlying deterioration has not been corrected, and in any case require the skill of a sculptor to match the texture of the adjacent masonry. Repairs that look more like stucco than the stone or brick they intend to emulate cannot be considered satisfactory.



Replacements and substitutions

Modern construction products — fibreglass (glass-fibre-reinforced plastic), glass-fibre-reinforced cement, and polymer concrete — may or may not be useful substitutes for decayed masonry. Each of these, as well as the "historic" substitute, cast stone (see above), has advantages and disadvantages as a masonry substitute. Because conservation work emphasizes durability far more than new-building technology, even such well-known substitutes as fibreglass must still be considered experimental for conservation. The lifespan of historic masonry is properly measured in centuries, but modern substitutes may last only decades. Substitutes should thus be considered more as items of long-term maintenance rather than as permanent replacements. The best and most durable replacements are the original materials themselves.

- Attach replacement elements securely to the structure, with non-rusting bolts and anchors. Do not permit replacement features of substitute materials to carry loads other than their own. And do not let the weight of replacements bear on other non-structural elements.
- As much as possible, use modern substitutes that are long-lived and durable for the particular situation, especially with regard to their finishes and colours, both wet and dry. Because these factors change with new developments, check the most recent technical literature for data on longevity. For example, though glass-reinforced plastics are generally long-lived, they deteriorate under the ultraviolet component of daylight, meaning that they must be painted or coated and maintained no less rigorously than, say, painted ferrous metal (for which they may be a substitute, as well as for masonry).
- Always allow for shrinkage in moulding new materials from existing features — each material has different thermal characteristics.
- Ensure that drainage details do not channel water into existing elements. Do not rely for moisture protection solely on mastics or caulking, which must be regularly maintained and renewed.

Exterior woodwork

Principles

2.3 Work in order
2.4 Work at right pace
2.5 Appropriate skills
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.7 Reconstruction for wholeness
6.2 Maximum retention
6.4 Respect for craft
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.3 Reversible repair
7.4 Cautious high-tech repair
7.5 Recipes tested before application
7.6 Maintainable repairs
8.1 Distinctive new work

Woodwork repairs — for both cladding and ornament — have long been the subject of do-it-yourself and home-repair magazines and books. For the most part, their advice is accurate and sensible, but special care must be taken to keep as much of the existing sound woodwork as posssible and to make repairs that won't hasten further decay. Good conservation-minded guides include BOWY80, CUNN84, HANS83, HOLM75, KAPL78/86, KIRK84, LOND86, MELV73, MILN79, POOR83, REMP80 and TECH82. Other more popular treatments have good advice , but use with care; see FINE86, JOHN83, LITC82, READ73, READ82 and WOOD83.

More technical background is available in FEIL82, FROI86, INSA72, LOCK86, LOCK86a, MULL81, MUNN83, PRIN81, RAMS88, STAH84, TIMM76, WOOD86 and WRIG86. Old building catalogues and manuals can also be helpful; see MACE98 and RADF83.

For examples of woodwork style and ornament, see BLAK69, BROL82, LANG78, MACR63, MACR75, MCAL84 and VICT84.

Properties, manufacture, deterioration

Wood is the most common of building materials. It is strong yet light and easily worked; variously coloured and grained yet a good base for paints and coatings; structurally durable yet ideal for ornamental carving and furnishings. It has always been relatively cheap and readily available throughout Ontario from the beginning of settlement. The temperate forests of the south offered a vast profusion of species, from the white pine for ships' timbers to the cherry, oak and elm sought by cabinetmakers. The coniferous forests of the Shield produced excellent softwoods for structure and ornament.

Most historic structural and exterior woodwork was of softwood, most interior finishes and furnishings hardwood. Only the ubiquitous pine seemed equally at home inside and out. Almost every stick of wood in historic Ontario buildings and furnishings came from domestic forests, often a mere stone's-throw away, but the province's modern timber production is concentrated instead on pulp, paper and plywood.

For all its advantages, wood is also afflicted with numerous weaknesses. It is flammable. It is vulnerable to biological decay from moisture, insects and fungus, especially under certain combinations of darkness, humidity and temperature. Dampness is wood's enemy, just as it is masonry's. Rapid cycles of alternating wet and dry conditions in unfinished or poorly protected wood cause cracking and checking that will admit water and lead to further decay. Most species used for exterior woodwork thus require at least one water-repellent coating. Wood's most common "overcoat" is paint, which itself weathers and requires regular renewal.

General repair and preservation

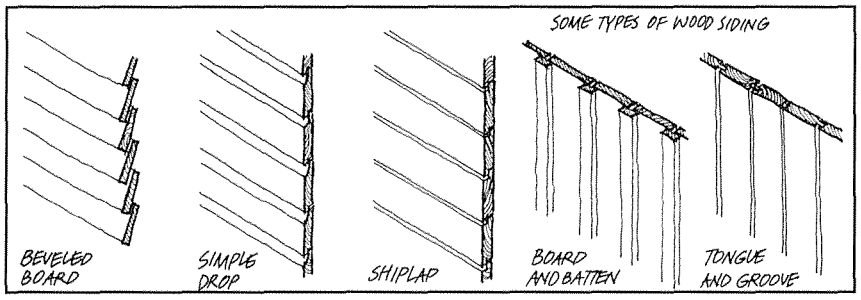
- Keep all exterior woodwork well maintained and painted. Inspect regularly and frequently for any signs of deterioration. Decay is often first evident in blistering or peeling paint, generally symptomatic of moisture problems.
- Correct any source of degradation, whether infestation or moisture penetration, and ensure structural stability before making cosmetic repairs.
- Use only gentle means to clean or strip wood of finishes before repairing and refinishing. Do not remove sound, well-bonded paint. Do not sandblast or water-blast wood under any circumstances. Beware of scorching wood with hot-air guns or electric heat plates. Use chemicals only as part of a cleaning process (to soften paint for scraping, not to dissolve it altogether) — do not risk permanently impregnating wood with them.
- Make sure all exterior wood is properly finished to prevent its deterioration; only rot-resistant woods such as red cedar can be left unfinished with relative impunity. Paint is the most frequent historic form of protection to prevent constant wetting/drying cycles from attacking the wood. Follow traditional practices for scraping, sanding, cleaning, filling, splicing, treating, priming and painting wooden surfaces.
- Consider replacing decayed exterior woodwork with a sound substitute only when the wood has lost its material integrity and its ability to hold its surface coating. Substitute in kind, with wood of the same species, and with the same moisture content. Store replacement timbers at the worksite long enough to permit their moisture content to match the existing woodwork.
- Use preservative-treated or water-repellent-treated wood for all exterior work, *but ensure that preservatives do not interfere with paint adhesion.*
- Do not cover wood with ostensibly "impervious" coverings (vinyl or aluminum cladding, for instance) that trap moisture against wooden surfaces in darkness. Such conditions are ideal for insect infestation and fungus growth.
- Use traditional subtle details such as drip edges to prevent water films running into wood junctions and joints. Do not rely exclusively on caulking for such purposes. Take special care to protect exposed end grains against water penetration.

See also SUPERSTRUCTURE; PAINT, COLOUR AND LIGHT; and WOOD AND PLASTER.

Wood has provided opportunities for amazingly rich wall textures, even on modest buildings — vinyl or aluminum cannot replicate such richness, and as replacement siding will cause damage both aesthetic and material.

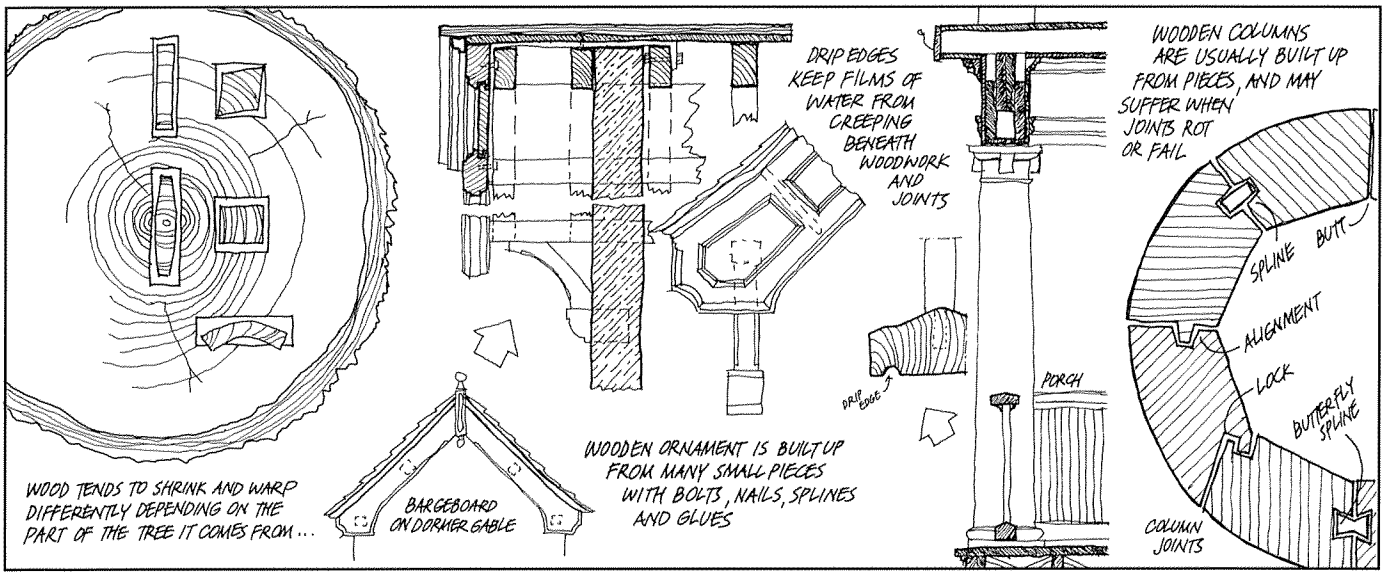
Cladding

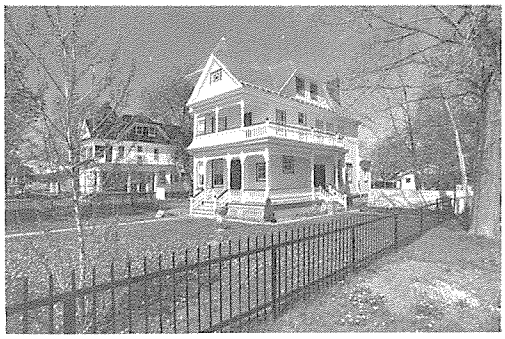
Wooden cladding is a frequent feature of residential and agricultural buildings, especially in areas once well-served by local sawmills. There are two primary types: boards and shingles. Traditional board siding is usually horizontal, but it is not only "clapboard"; it may also be drop, bevel or shiplap. Vertical board-and-batten siding is found most often on 19th-century rural cottages or farm buildings. Though much more common on seacoasts than in Ontario, shingle siding appeared on many buildings in mid-19th-century settlements on the Canadian Shield and reappeared as a decorative feature of eclectic revivals in the 1880s and 1890s.

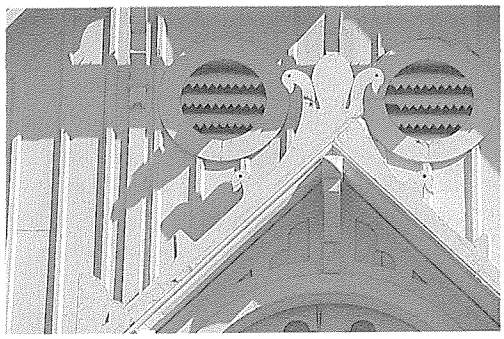


Cladding deteriorates primarily because of trapped moisture and consequent rot as well as insect infestation. Despite nail holes and other damage, sound cladding may survive beneath stucco, aluminum or vinyl coverings. If maintained and protected by periodic painting or staining, wood cladding will last as long as the structure, but at certain points, especially corners and near the eaves or the ground, it can be vulnerable to attacks by dampness, fungus or insects. Moisture is almost always the primary culprit, and good ventilation almost always the saviour.

- ❖ Make spot repairs to wooden siding in kind. Keep its surface well maintained and regularly painted (if painted originally).
- ❖ Before undertaking cladding repairs in response to visible deterioration, first cure any moisture penetration from eaves or other sources, and make all needed structural repairs.
- ❖ Follow the instructions in a good home repair manual in making any spot repairs. Use the same species of wood and install it with the grain running the same way. Use only exterior-grade galvanized nails. Use only one nail per stud to permit thermal movements.
- ❖ Entire walls requiring replacement on account of advanced decay should be replaced in wood, with the same dimensions and profiles as original.
- ❖ Do not replace or cover generally sound wooden cladding with allegedly maintenance-free materials. Aluminum and vinyl emulations of wood are not maintenance-free; they are far more vulnerable to impact than wood and difficult to repair. They also cover over decay that will inevitably worsen.


WOOD TENDS TO SHRINK AND WARP DIFFERENTLY DEPENDING ON THE PART OF THE TREE IT COMES FROM...
BARGEBOARD ON DORMER GABLE
WOODEN ORNAMENT IS BUILT UP FROM MANY SMALL PIECES WITH BOLTS, NAILS, SPLINES AND GLUES
DRIP EDGES KEEP FILMS OF WATER FROM CREEPING BENEATH WOODWORK AND JOINTS
DRIP EDGE
PORCH
WOODEN COLUMNS ARE USUALLY BUILT UP FROM PIECES, AND MAY SUFFER WHEN JOINTS ROT OR FAIL
SPLINE
BUTT
ALIGNMENT
LOCK
BUTTERFLY SPLINE
COLUMN JOINTS



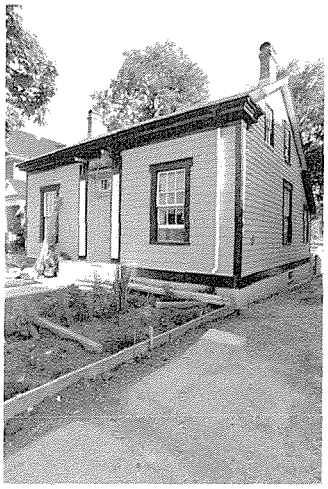


AN ALTERNATIVE TO "PENTA"

A non-toxic formula for water repellent: 3 cups exterior varnish and 1 ounce paraffin, topped up with paint thinner or turpentine to make 1 gallon; brush or dip both old and new wood 1 to 3 minutes; by minimizing water penetration in the first place, this may be just as effective in preventing rot as toxic pentachlorophenol preservatives. Before priming stripped woodwork, brush on boiled linseed oil as an additional water resister.

(opposite)
Ensembles of wood cladding and ornament require regular maintenance and painting (upper left), vulnerable as they are to weathering from above (middle left) and damp and chemicals from the ground beneath. But paint can't be permitted to accumulate indefinitely — from time to time, with great care, it must be removed (middle right) and rotted elements repaired or replaced (bottom right).

Occasionally, advanced deterioration forces replacement of large areas of cladding — careful attention needs to be paid to the minor irregularities of the original as well as to the integration of gutters and downspouts (below).



Detail and ornament

Even modest historic buildings may display a wealth of mouldings, window and door surrounds, gingerbread, scrollwork, turned work, shutters and louvres. The 19th and early 20th centuries maintained a considerable craft tradition in woodworking, even in the midst of the mass-produced millwork of industrialized construction. Cabinetmaker and carpenter were not divorced from one another as radically as now. Countless small mills and shops dotted the province, yet there was a recognizable consistency to much decorative work, representing not only a formal tradition (shared through millwork catalogues and pattern books) but also the limitations of habit, similar tools, and factory production. Great effort went into making the mass-produced appear ornate and hand-tooled, but wood's workability and availability kept the small woodworker in business too.

Carved, sawn and turned detail is very vulnerable to decay and requires constant attention. Its relative vulnerability is matched, however, by its relative ease of reproduction by skilled hands.

- Ensure that fastenings of wooden ornament are secure, and that they are free from rust. Correct causes of deterioration before any repairs and look especially at *earlier* repairs for signs of decay.
- Patch cracks and holes with chemically compatible wood fillers or with wood splices of same species and cut. Use epoxies carefully, ensuring that their thermal and moisture properties match those of the surrounding wood.
- Replace only wood that has irreparably deteriorated, leaving all sound wood intact. Use stable, non-shrinking glues (for instance, calcium caseinate is a strong bonding agent, with centuries of use to prove its reliability). Treat stripped and exposed wood with a water-repellent mixture before refinishing (see above).
- Wherever wood is structurally sound and its surface reasonably undamaged, repair rather than replace it. Make any replacements precisely according to the existing feature, an obvious mate, or pictorial evidence of the original. Use the same species or another with similar cut, moisture content and material performance. Use stock items for replacements only when they match originals accurately.
- Make new details carefully to prevent water absorption and consequent rot. Changes from traditional practice (for instance, use of built-up sections to replicate solid timbers) may lead to problems unless the new elements are properly protected. Do not rely on caulking to keep water out. Make sure that horizontal surfaces have sufficient slope to shed standing water, and provide drip edges along sills, cornices and similar features.
- In areas of highly modelled woodwork, wood repair must be the first choice, but fibreglass replacements can be satisfactory if accurately moulded to match details and if painted to match the historic appearance. Fibreglass will not be as durable as properly maintained wood. Make sure that junctions between fibreglass and wood do not inadvertently force water into end grain or concealed pockets in the existing woodwork.
- Take complex pieces such as ornate scrollwork or columns and their capitals and bases off the building to repair and refinish them in controlled workshop conditions. Repair their anchorages and reattach them with non-rusting connectors, allowing for the wood to expand and contract with changes in moisture and temperature. Do not fasten or re-fasten wood so tightly that stress cracks appear later.
- Maintain or restore the operation and hardware of shutters, paying special attention to removal of paint build-ups that have restricted or blocked movement. Restore missing operable shutters (as operable) only where historical and material evidence indicates their earlier existence.
- Inspect ventilation louvres regularly to ensure that they function as designed; install rustproof interior screens, inspect constantly for bird and animal infestations, and make sure that any signs of rot are arrested quickly.

Metalwork

Principles

2.2 Co-operation among specialties
2.3 Work in order
2.5 Appropriate skills
4.1 Respect for (natural) aging process
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.7 Reconstruction for wholeness
6.2 Maximum retention
6.3 Patina preserved
6.4 Respect for craft
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.4 Cautious high-tech repair
7.5 Recipes tested before application
7.6 Maintainable repairs
7.7 Gentle cleaning

References

See GAYL80 for technical information on most exterior metals and repair techniques. MEAD86 deals comprehensively with repairs and substitutions for metalwork on façades, and includes more recent technical references.

Other technical references include FEIL82, FROI86, INSA72, JAND83, KEMP81, STAH84 and TIMM76. More modest maintenance and repair methods may be found in CHAM76, DAVE80/86, JOHN84, LOND84 and SHOP86.

Architectural metals: materials and types

Though lead and copper had been used as building materials for millennia, the 19th and early 20th centuries added a tremendous variety of metals for uses in structure, cladding, hardware, and even humble utilities. For architectural conservationists, their variety is both exhilarating and daunting:

- ❒ Cast iron for structure: columns, plumbing
- ❒ Cast iron for ornament: fences, shop windows, shopfronts, lamp standards, street and park furniture, hardware, small sculpture
- ❒ Wrought iron for structure: beams, joists, fasteners, and engineering structures, especially bridges (superseded by steel)
- ❒ Wrought iron for ornament: hardware, fences, gates, grilles, window frames
- ❒ Cast brass/bronze, monel metal (nickel/copper): hardware, sculpture, doors and doorways
- ❒ Steel for structure: beams, columns, reinforcing bars
- ❒ Steel for ornament: windowframes, stainless or enameled panels
- ❒ Copper: sheet roofing, flashing, shingle roofing, sculpture, doors and doorways, plumbing
- ❒ Sheet iron (zinc-galvanized, tin-plated, terne-plated, or painted; usually both coated *and* painted): ceilings and panelling (interior and exterior), ornamentation, cornices, window surrounds, sheet roofing, shingle roofing, flashing
- ❒ Lead: sheet roofing, flashing, small sculpture, plumbing
- ❒ Aluminum (extruded, sheet and cast): windows, doors and doorways, hardware, sculpture

Stamped sheet iron used to imitate carved woodwork (which in its turn mimicked stone).

Metals are exceptionally durable yet surprisingly vulnerable to deterioration. Though hard and able to sustain loads that either compress or stretch their molecular structure, they tend to react with water-borne chemical agents that radically reduce their strength. Metals conduct heat very easily and expand and contract with even small changes in temperature. All installations and fastenings of structural or decorative metal must accommodate thermal expansion and contraction. Traditional sheet-metal fabrication and details took this into account by having lots of angles that could flex in response to movements (ornate decorations in metal were as much functionally apt as aesthetically fashionable), but age makes metal brittle and the flexing begins to cause cracking.

Most metal failures are due to the rusting of ferrous (iron) elements, especially connectors between elements. Except for stainless steel — iron alloyed with chromium — all ferrous metals (cast, wrought and sheet iron) require coating or painting to prevent rust. All architectural metals are vulnerable to acid precipitation, though even clean water can lead to problems when it enables electrolytic currents to pass between adjacent dissimilar metals. This "galvanic action" ionizes metal surfaces and causes a chemical reaction that eats into the metal. Copper and iron or steel are the most unfriendly of metals in this respect, and iron corrosion is often traceable directly to adjacent copper. Even stainless steel is corroded by galvanic action when in contact with aluminum.

- ❖ Before any conservation work identify the metal accurately. Clean thoroughly before diagnosis, treatment and repainting or recoating. Cover metals meant to be covered (ferrous); uncover metals meant to be uncovered (copper, bronze, stainless steel).
- ❖ Replace badly deteriorated metal in kind; do not under any circumstances replace one metal with any other metal that may lead to corrosion. If using non-metallic materials as substitutes (see below), ensure that new metallic connectors do not establish galvanic action.

Decorative cast iron

Prefabricated building components of cast iron were used extensively world-wide in the mid-19th century for both structural and decorative purposes. Because of the ready availability of timber in Ontario, decorative cast iron did not make much of a mark on the province's architecture, and cast-iron catalogue-type commercial façades were rare (though iron fences, gates, ornaments and lamp standards were widespread). Cast iron has good compressive strength and, though less susceptible to oxidation than sheet iron, rust is a constant problem. Cast iron is very brittle and resists tension poorly.

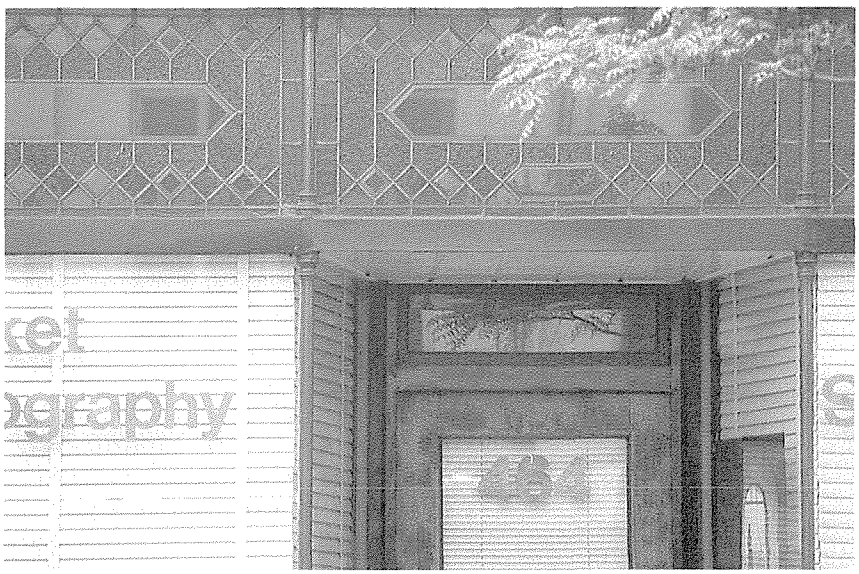
Cast iron deteriorates if poorly installed or not maintained; it may also suffer structural fatigue and failure if poor casting techniques build stresses into the metal. The chief agent of deterioration is water, especially getting into joints and connectors, where it leads to corrosion unseen and unchecked.

- Arrest all sources of water penetration and corrosion first — repair structural connections and drainage and ensure maximum protection from moisture penetration, either liquid or vapour. Remove every sign of rust or corrosion. Cast iron is very brittle — do not bang or try to bend it.
- Ensure that no copper flashing or decoration directly touches iron and that water does not run down from any copper or copper-alloy element onto iron.
- Tighten bolts and connectors to draw loosened sections together but make sure thermal expansion and contraction are still permitted. To seal gaps, use only the highest-performance elastomers (these synthetic compunds are hard to paint over but can be pigmented in mixing). Alternatively, use panels or fillers of galvanized sheet metal, carefully prepared, to bridge large gaps. Use auto-body putty for small holes and cracks — its expansion factor is similar to iron's.
- Clean cast iron mechanically, with wire brush, scraper, or very low-pressure dry-grit blasting (maximum 100 psi). Use chemical rust removers with great care and protect adjacent surfaces (for these to be most effective, consider removing the element and reinstalling it after cleaning and priming under workshop conditions). *Use neither water nor water-based chemicals, nor high-pressure grit.* Remove any previous cement or other incompatible patches that may attract moisture to the iron.
- Prime cast iron *immediately* after cleaning, within no more than a few hours. Use an appropriate rust-inhibiting primer: red lead in an oil vehicle is best for long-term protection, but it covers poorly and is especially poisonous. Alternatives are zinc phosphate and zinc chromate. For both priming and painting, alkyd or oil vehicles provide a better paint bond than latex, because they dry more slowly.
- If cast iron is too weakened or corroded to repair (and where the original pattern exists), recast and replace decayed components. New cast-iron replacements are both difficult and expensive if the original pattern no longer exists. A sound existing component may be used as a pattern, but the mould must be about 1.5 per cent larger than the final dimensions, to allow for shrinkage in cooling. Use substitute materials such as cast aluminum only with the greatest care — see "Replacements and substitutions", below.

Decorative sheet metal

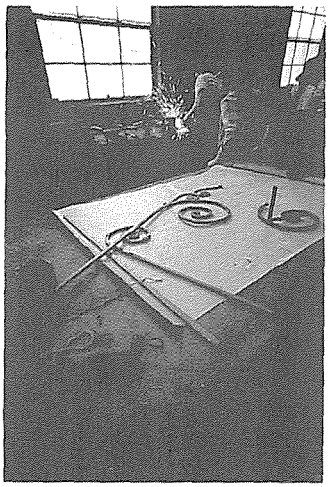
Decorative sheet metal — usually galvanized and painted iron in 19th-century practice, and as often unpainted copper or other non-ferrous alloy in the present century — often imitated other forms of wood or stone. The complexities of these forms and their attachments, and general lack of maintenance of features out of reach of the ground, have enabled corrosion of such elements to proceed unchecked, making many repairs very difficult.

- Repair or replace wooden or metal supports and backing as necessary before working on metal surfaces. In most small buildings, the backing is wood, often decayed from rot or infestation (good historic precedent for not slapping modern metal siding on top of sound wood). Make sure that any concealed metal anchors or brackets are themselves sound; remove all signs of rust.



- Ensure that there are sufficent expansion joints and that they function without overstressing sheet metal or connectors; carefully add expansion or relief joints where needed.
- All connectors must match the metals they connect. Remove all connectors that show signs of corrosion from galvanic action and replace with ones that do not. Be especially careful to keep copper and iron well apart.
- Clean sheet metal extremely carefully. Be even more cautious than for cast iron so as not to erode the plating — no grit-blasting, not even at low pressure — and leave sound paint layers intact. Use no water-based cleaning treatments. Repair any broken soldered joints with equivalent solder and flux.
- For sheet metal, particularly galvanized iron, use auto-body putty to patch and fill small holes and dents.
- For large patches with new metal, use a similar metal/plating combination as that of the base to accommodate thermal expansion and to prevent galvanic action in the old material. Solder or rivet the new patches, sealing with an elastomeric compound to keep out water.
- Large patches with glass-reinforced plastic may be a satisfactory alternative only if they accommodate the thermal expansion of the metal; the plastic must be fully primed and painted to protect it from ultraviolet light.
- To paint sheet metal follow the same procedures as for cast iron — prepare a clean surface (do not clean to the bare metal if older paint is sound), use the proper primer (compatible with existing paint chemistry), and build up several coats of primer and finish enamel.
- Consider artificially "aging" copper with weak acid only with very great caution, and only to reduce the contrast with existing patina, not to attain it instantly; beware of acid runoff causing problems below.

For flashing, see also ROOFING.



Some of the range of historic architectural metals, from cast and wrought iron fencing, to pressed metal replicas of stone, to copper, brass and lead in commercial windows (opposite), and to structural steel (above, top). For repairs beyond basic maintenance, it may be necessary to detach metal elements and work on them indoors (above).

Brass, bronze and other non-ferrous sculptural metals

- Do not assume that a discoloured surface on a non-ferrous metal is a beneficial patina. Consult with a specialist to determine if the patina is protecting the metal; if there is pitting or obvious loss of metal, then the patina is probably corrosive and should be removed.
- Use domestic brass- and bronze-cleaning compounds or impregnated polishing cloths for non-ferrous features. A weak oxalic acid solution with fine pumice powder seems especially effective for most exterior dirt. A controversial treatment that some experts advocate and others oppose is mechanical cleaning of exposed sculptural surfaces with *very* low pressure glass-bead peening (80 to 100 psi), after masking surroundings carefully or removing the feature altogether for treatment in controlled workshop conditions and subsequent reattachment. This technique will alter the surface of the metal and may or may not be acceptable — accordingly, get more than one expert opinion about its suitability for particular conditions.
- Where surfaces such as doors, railings and hardware are subjected to constant public use, apply protective lacquer to the metal surface and maintain it regularly.
- Consider replacing individual elements only where deterioration is far advanced, that is, when metal is weakened or missing. Replace elements in the same metal wherever possible — use fine-art conservation skills for repairs.
- Maintain all metal hardware in working order. Keeping fasteners and hinges properly tightened and lubricated will reduce wear and tear. Do not paint unpainted surfaces.
- Pay constant attention to maintenance; never use corrosive de-icing salts near non-ferrous metals.

Replacements and substitutions

Because modern materials and fashions have completely overwhelmed many earlier "high-tech" materials and suppliers, it may not be possible to find identical replacements for metal features. Reproduction of badly deteriorated features in the appropriate metal from moulds taken off sound existing material is possible, though it will require the expertise and workshop of a specialist, such as a specialty hardware supplier or even a fine-art craftworker. Satisfactory substitute materials may include cast aluminum, glass-fibre-reinforced cement, and fibreglass (glass-fibre-reinforced plastic). But the use of substitutes must be a last resort, used only where necessary to re-establish overall visual integrity of the whole.

- Do not use substitute sculptural materials to carry heavy loads; for instance, cast aluminum is much weaker in compression than a cast-iron original it may replace, requiring structural reinforcement.
- Establish long-term durability of substitutes, especially their finishes and colours (both wet and dry), before considering their use. Check recent technical literature for data.
- Allow for shrinkage in moulding new materials from existing features. Each material has different thermal characteristics; for instance, cast aluminum shrinks twice as much as cast iron in cooling.
- Make sure that structural connections are secure and non-rusting. Do not transfer loads to any existing non-structural features.
- Design and fabricate drainage details that channel water away from existing material; do not rely for water protection exclusively on mastics or caulking, which must be regularly maintained and periodically renewed.

Stucco, concrete and composites

Principles

2.2 Co-operation among specialties
2.5 Appropriate skills
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.7 Reconstruction for wholeness
6.2 Maximum retention
6.4 Respect for craft
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.4 Cautious high-tech repair
7.5 Recipes tested before application

References

For basic repairs to stucco, see KAPL78/86 and POOR83. Other books dealing with small-scale stucco and cement work include FINE86, HANS83, KITC83, LEGN79, LITC82, OLDH85 and READ82. For more technical help, including old building texts, see HUGH86, MACE98, MEAD86, RADF83, RAMS88 and STAG76.

The most concise yet useful book dealing with the range of historic and modern formulations for stucco, mortar and plaster is ASHU83.

Concrete and terrazzo repairs are far more demanding technically, and require special expertise, borrowing chemistry and technique from both limestone and plaster conservation; see MEAD86 and TIMM76.

Stucco

Stucco, sometimes known as rendering, is simply a lime (or lime-and-cement) mortar plastered onto a lath hung on the exterior walls of a building. It is a very old technique. Properly formulated and applied, stucco can be as durable as the mortar between bricks. Indeed, stucco's composition is very much like masonry mortar (though stiffer), with different proportions of cement, lime, and sand or other aggregate.

Early stucco was much like interior plaster, primarily a lime-and-sand mixture with animal hair, straw or other binders to improve material integrity. Its surface was built up in two or three coats for maximum strength and durability — the rough first ("scratch" or "brown") coat tied the mix to the lath, and the final finish coat provided texture and colour. In some cases, its surface was scored to imitate ashlar or moulded with a pattern of "bricks", the grooves painted to simulate mortar lines. In the late 19th- and early 20th-century revival styles, various textures were added to the finish coat with plasterer's tools to imitate traditional European textures.

As Portland cement became commonly available, late 19th- and early 20th-century stucco used a mix that added increasing portions of cement to the lime until the mix was about half and half, with a further four or five parts of sand or fine gravel for surface texture. Metal lath also came into common use before 1900.

Traditionally, stucco was seldom painted (once painted it requires regular *re*painting). Rather, it usually took its colour from the aggregate and any permanent pigment mixed in to the finish coat.

Like exposed mortar, stucco is quite stiff and vulnerable to cracking and crumbling. Water may penetrate behind the surface and lead to rot in the wooden lath, or foundations and structures may settle and shift, or the stucco may lose its bond with the supporting lath because of poor formulation or application. Sometimes later repair patches with high cement content will worsen conditions in the older and softer lime stucco.

❖ Ensure that any textured or decorated stucco is accurately recorded before repairs begin. Note carefully the thickness of stucco relative to wood trim and maintain that dimension in any repair. Take careful and accurate colour samples of existing stucco, using both weathered and freshly broken samples, and store these for colour-matching purposes. Measure accurately the locations and dimensions of simulated ashlar or other motifs and replicate these in the course of any major repairs.

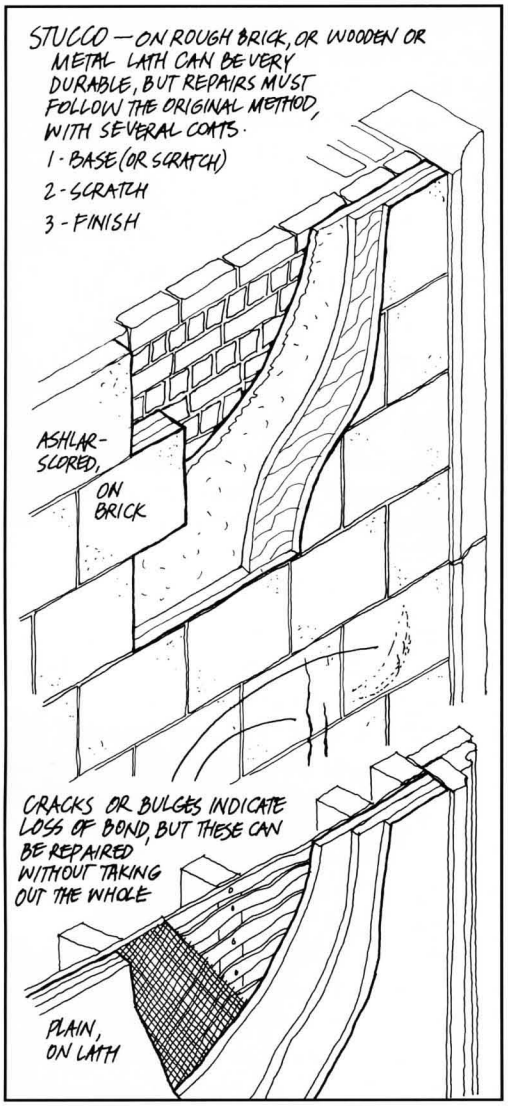
❖ Remove cracked, crumbling or damaged stucco to a sound base (in most cases the wooden or metal lath). Repair the lath as required. Duplicate the original stucco formulation in strength, composition and texture as well as possible, adding if necessary stabilizing material to keep the mix from shrinking as it dries.

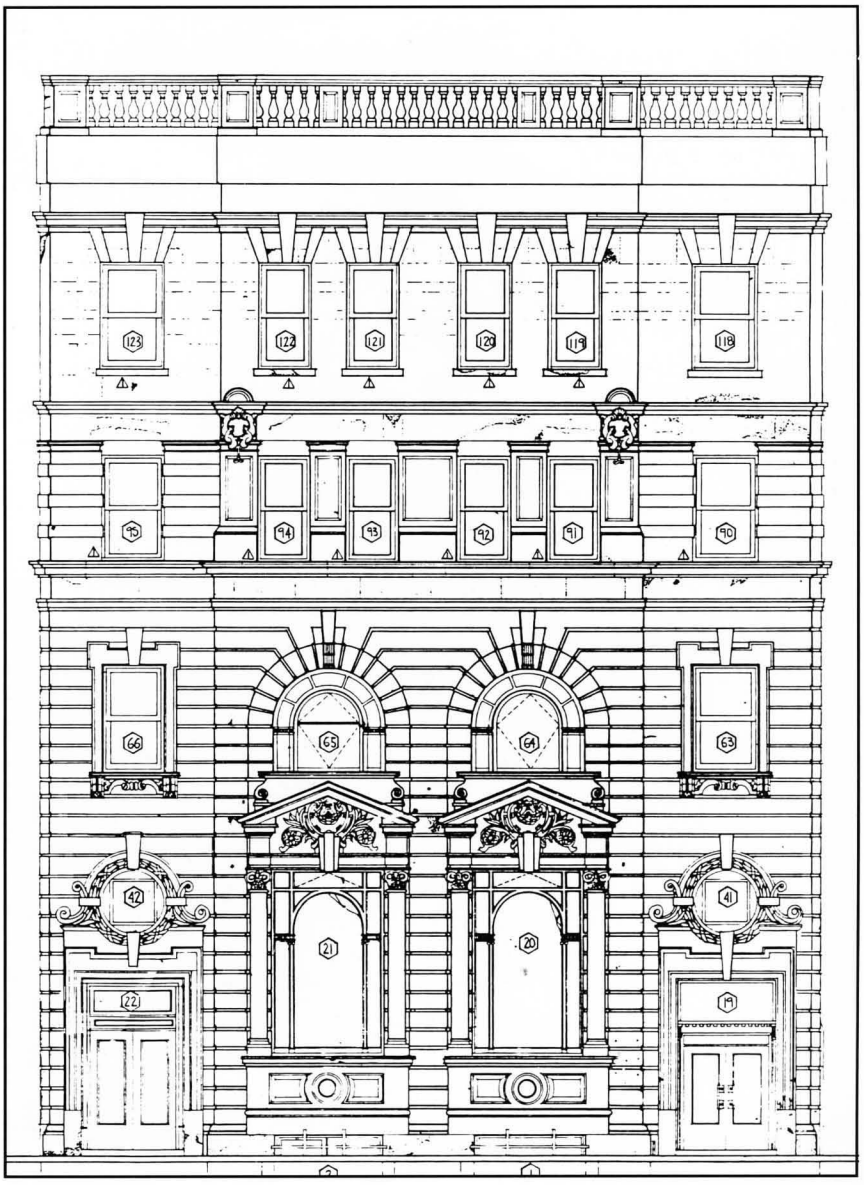
❖ Match the historic finish colour and texture carefully in any repairs, using a sample of freshly broken material, and take into account the different colour of wet and dry materials and the effects of time (weather-borne dirt may darken the surface over time, but fading pigments may lighten it). Size and colour of aggregates in the mix are essential characteristics — all sorts of ingredients have been added to stucco, such as pulverized cinders, to accent its finished surface. Try to reproduce the conditions of the original application and the effects of impurities in the original mixture (in difficult cases, laboratory analysis may be necessary).

❖ Reproduce any special markings, such as "ashlar" scoring, based on the recorded features.

❖ In the case of a primary elevation, consider repairing the entire wall plane where it is critical to have a consistent colour, but generally do not remove sound stucco. Do not paint stucco if it is not already painted.

❖ Moisture content is critical to successful stucco patches — don't make patches too wet (they will crack as they dry) but do keep them damp for a couple of days once applied. Dampen the stucco surrounding the repair as well. As in traditional practice, build up repairs in at least two or three coats to ensure sound bonding and curing.



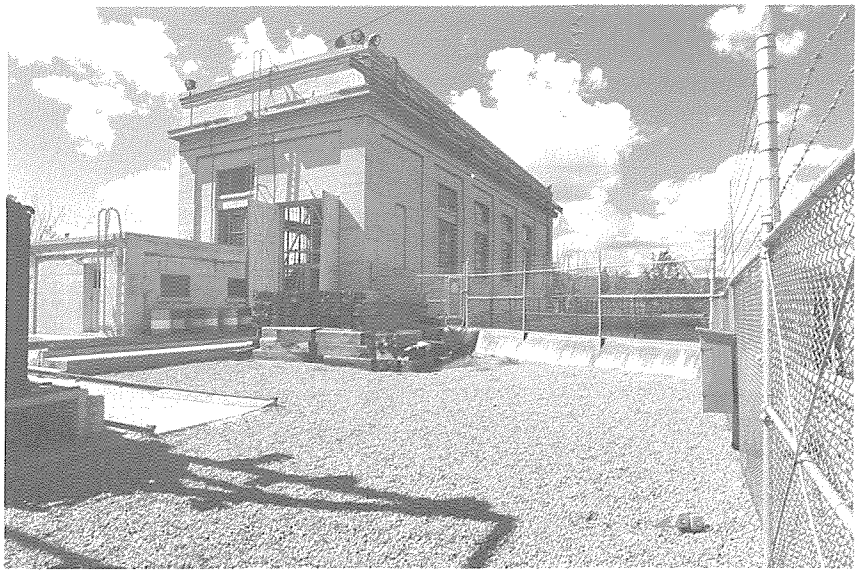


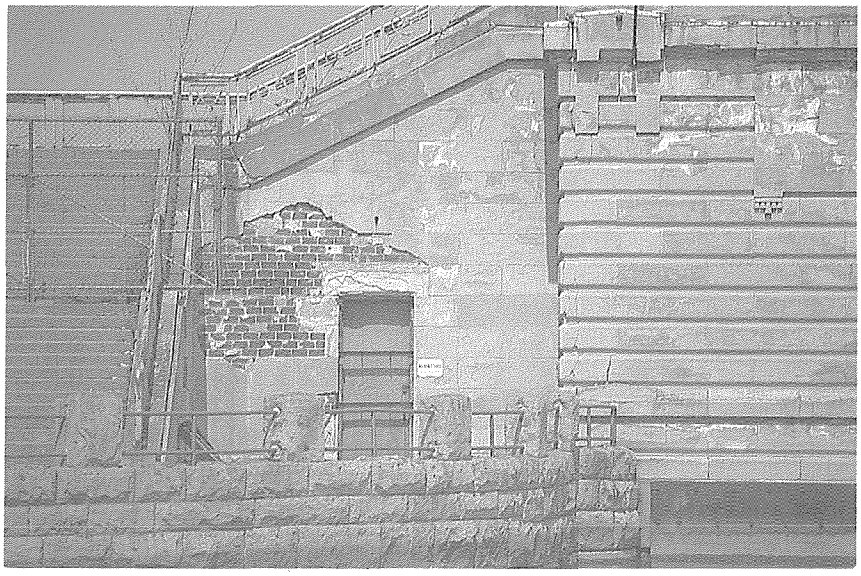
Stucco has been a much-used exterior surface in every era of Ontario architecture, from the ashlar imitations of Upper Canadian Georgian fashion (above right), to the classical revivals of the early 20th century (right), where the traditional lime-and-sand stucco has been "modernized" into cast-in-place and factory-made cement ornament.

Cast-in-place concrete and terrazzo

Reinforced concrete was invented in the mid-19th century, but its use as a deliberately exposed surface began only early in the present century on bridges and other engineering structures. Concrete is made of cement, sand and gravel in varying proportions, cast into a temporary container around an armature of steel reinforcing bars or mesh. The combination of steel and concrete bonded together is far stronger than concrete alone, enabling the entire assembly to carry forces of both tension and compression. Concrete can be moulded with surfaces other than flat and even textures, but exterior curing conditions vary so much that cast-in-place ornament has not proved very durable. Terrazzo is a special application of concrete with marble chips in the aggregate, with the final surface of the mass ground down and polished.

Concrete can be a durable surface as well as a structural material (below), but its early 20th-century use as a cast-in-place artificial stone has turned out to have been very vulnerable to high humidity and corrosion beneath its surface. It is almost impossible to patch discreetly (bottom).





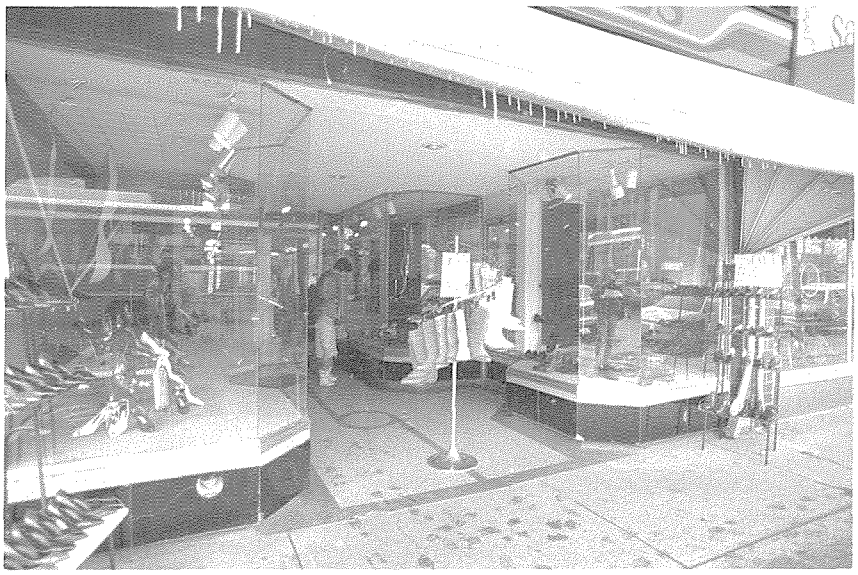
Concrete is in effect artificial limestone. It deteriorates in the presence of moisture and dissolved salts, which break down the bonding within the hardened mix and attack the steel reinforcing bars, which then rust. The rust in turn removes the essential bond between the steel and the concrete and drastically reduces the assembly's overall integrity and strength. The very nature of the material means that all repairs must be done on site.

- Before any concrete repair, undertake a full laboratory analysis of a sample taken from an inconspicuous, sound area. There has been a tremendous historical variety of mixes and aggregates, and some combinations of cement and aggregate will be incompatible with one another and with the original work.
- Complete the necessary structural repairs before working on finished surfaces, especially around openings. Repair vertical fractures from bottom to top.
- Make sure that any reinforcing exposed in the course of repair is fully de-rusted before applying patches; if necessary, add reinforcing bars or mesh to tie in the repair and strengthen the assembly where the structure is weak.
- Most concrete surfaces can be patched with identical material as a plastic repair; make sure that patches are pre-tested to be chemically compatible and are well keyed to the original work. Epoxy resins can be used to help bind the new patch into the original material. It is impossible to patch exposed concrete without leaving visible signs of the work, so concentrate instead on matching the surface texture.
- Clean concrete as if it were limestone masonry — *use no acids*.

See also MASONRY.

Composite, eclectic, and other modern materials

Just as with architectural metals, a great wealth of new decorative treatments arrived early in the 20th century to cover exterior walls and floors, especially in commercial buildings. These "modern" materials included ceramic tiles, asphalt blocks, plastics, "structural" glass facing and glass masonry. Not all have proved durable. Many are no longer in current use, replaced by newer fashions and materials. Most of these "composite" surfaces are very brittle and vulnerable to impact. Some can be repaired or replicated with current materials, though conspicuous factory-made materials such as solid-coloured structural glass (known by brand names such as vitrolite or Carrara glass) are very difficult to replicate unit-by-unit while maintaining the smoothness or consistency characteristic of their "look". There are few standard procedures for conserving these materials.



Mid-20th-century storefronts often combine several "modern" (or modernized) materials — terrazzo floors, structural glass panels, frameless glazing and aluminum trim (above). Glass block is another modernistic material that has cycled in and out of fashion for commercial buildings (right).

- In dealing with irreplaceable "modern" materials, follow the general principles of regular inspection and maintenance, correcting basic causes of deterioration first, replacing in kind, and not transferring deterioration to adjacent features with poor repairs.
- Consult specialists and follow their advice, especially artists and craftworkers using similar technology and materials.
- Most storefront glass or tile facings were installed as veneers over an earlier surface or structure — seated on shelf angles, fastened with asphalt-type mastic, and flashed with aluminum moulding. In attempting repairs, carefully remove mouldings, then panels or tiles. Remove dirt and repair any hidden deterioration, reapply panels with high-grade mastic, reinstall metal trim, and caulk carefully. Inspect the finished work regularly.
- It is no longer possible to find perfect replacements for damaged "structural" glass in most colours, except from wreckers' yards — most colours of structural glass are no longer produced (check with manufacturers for colours still available). Coloured acrylic or polycarbonate sheets, rear-painted clear glass sandwiches, or enamelled substitutes may suffice, depending on colour and location. Consider moving sound panels from inconspicuous areas (as in last-resort masonry repairs) to maximize consistency in highly visible areas.
- Glass blocks are fairly durable but may crack because of undue stress or washing out of mortar. Repair causes of stress as for masonry and arrest any water penetration. Replace damaged units in kind as far as possible, bedded in soft mortar that matches the original. Do not substitute caulking for mortar. Consult manufacturers for availability of new units to match old; sometimes a skilled craftworker can fine-tune finishes of interior faces of glass blocks to match the originals.

Windows

Principles

2.5 Appropriate skills
3.5 Specifics of uniqueness (pattern, ensemble, detail)
4.2 Respect for period/historic continuity, sequence
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.7 Reconstruction for wholeness
6.2 Maximum retention
6.4 Respect for craft
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.4 Cautious high-tech repair
7.6 Maintainable repairs
8.5 Energy conservation
9.2 Faithful maintenance

References

Advisory texts on window repair seldom emphasize preserving existing forms or materials. Among the best conservation-minded sources are DAVE80/86, HAYN87, KAPL78/86, LOND84a/85 and POOR83. Others include BOWY80, CUNN84, DUTO85, FINE86, HANS83, JOHN83, JOHN84, KIRK84, KITC83, LITC82, LYNC82, MELV73, MULL81, OLDH85, PYKE80, READ82, SHOP86, SMIT84, STLOnd, TECH82 and VILA81.

Some sources describe dimensions, materials and operation of historic windows; these will be useful in replacing vanished originals with appropriate substitutes. See BRAY80, CHIT80, EHRE84, JAND83, MACE98, MCAL84, NATI80, POWY29, PRIZ75, RADF83, REMP80, TUNI86 and VICT84.

Modern replacements, even in the same material, seldom replicate precisely the dimensions and profiles of historic muntins and mullions. For cases where this difficulty has been overcome, see HAYN87. See SEDW83 and HERI87a/87b for sensitive energy retrofits of existing windows.

The special importance of windows

Windows are not simply glass. They are assembled from several materials and components and present almost all of the conservation problems of a building in miniature. They are also among the most conspicuous of any building's features. Their arrangement and design define much of the style and even the "personality" of a building. Windows help define building character because they catch the eye from the outside, directing the viewer's attention from one part of the elevation to another, punctuating the façade. Windows are the most-used part of a building (visually, physically, decoratively), where human contact between inside and outside is maintained. They permit and define views both in and out, provide light and ventilation for human occupants, and enable a whole range of environmental adjustments — the building's own "breathing". The original windows give us something of the experience of the original view, the opportunity to see out of the building in the way its early occupants did, even if the view itself has changed.

Because they are used a great deal, windows are very vulnerable to wear and tear, weather and weathering, and the requirements of changing interior uses. They require considerable maintenance but don't often get enough. They thus require repairs in the course of almost every conservation project. As with more basic materials, the essential conservation principles are to repair rather than replace and replace in kind when too far decayed for repairs.

When evaluating the importance of windows in any project, from a district study to actual repairs, consider the following characteristics:

- ❒ Date/era of installation (original, early alteration, late alteration)
- ❒ Location, stylistic association with building as a whole, with other windows in building
- ❒ Size, shape, glazing divisions (typical and atypical)
- ❒ Manner of operation (see types, below)
- ❒ Materials, profiles and dimensions (frame, sash, muntins, mullions, surrounds, etc.)
- ❒ Glazing type (crown, cylinder, plate, stained, etc.)
- ❒ Craftsmanship of components and assembly (quality of materials; handwork v. millwork)
- ❒ Rarity of type (technologically or stylistically)
- ❒ Hardware and accessories (awnings, shutters)

Frame, sash and glass

The frames and sash of almost all 19th-century windows in Ontario were assembled from wooden millwork, usually softwood (though softwood and hardwood were used for larger windows). Only timber provided the strength and flexibility to hold the delicate (and expensive) glass panes, to open and close for ventilation, and to tolerate the extremes of the local climate. Even within the cast-iron commercial fronts, the windows themselves were invariably framed in wood.

Until the turn of the 20th century, almost all windows except fixed-pane shopfronts and leaded stained-glass church windows were operable (ventilation for these was provided through small transom openings). Only with the eclectic Queen Anne styles were some of the larger parts of residential windows permanently fixed, and from that time even the top panes of "double-hung" windows have often been fixed. The most common frame type, the double-hung wooden sliding sash window, is usually labelled by the subdivisions of its major halves — six (panes) over six, one over one, and so on. The wooden window remains the most common in use for small buildings even today, though often transformed by vinyl coatings, aluminum storms and even vacuum-sealed double glazing.

Metal windowframes appeared late in the 19th century, but their common use takes off with mass-produced steel sash after 1910, for commercial, industrial and even residential windows. Leaded glass appears in historic Ontario church and residence windows as a reminder of historic fashion rather than through any need to use small panes.

Within the sash itself, the glass is normally held in place by metal glazier's points and flexible putty within an angle of wooden moulding known as a muntin (or astragal). In

WINDOW TYPES

Fixed sash
- ❒ Fixed wood
- ❒ Fixed metal

Sliding sash
- ❒ Double-hung wood
- ❒ Double-hung metal, hot-rolled
- ❒ Double-hung metal, cold-rolled

Hinged sash
- ❒ Wood casement, in-swing
- ❒ Wood casement, out-swing
- ❒ Wood projected (awning)
- ❒ Wood/metal basement
- ❒ Metal casement, in-swing
- ❒ Metal casement, out-swing
- ❒ Metal continuous
- ❒ Metal projected (awning)

Pivot sash
- ❒ Horizontal wood
- ❒ Horizontal metal
- ❒ Vertical wood
- ❒ Vertical metal

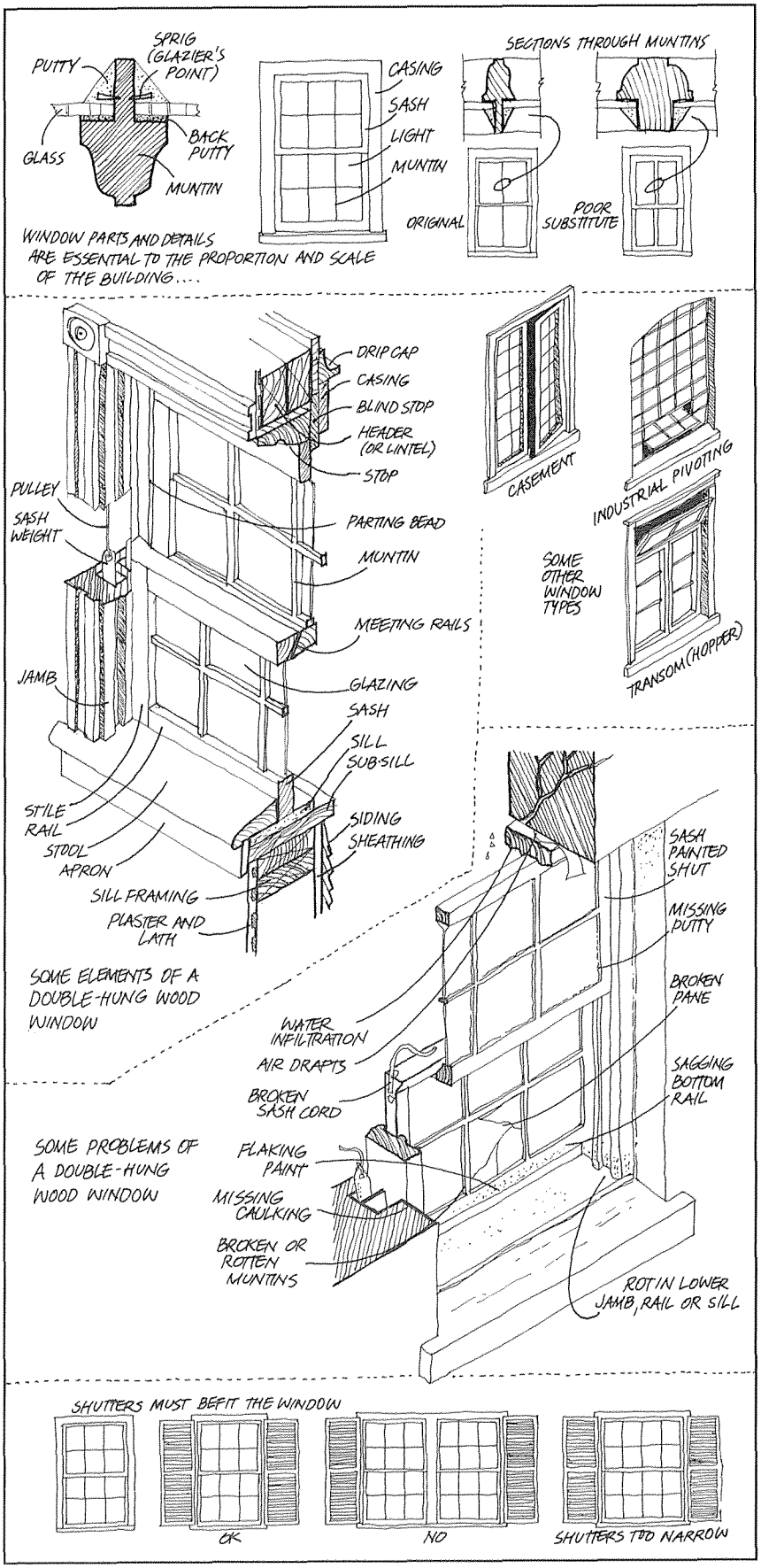
Rarities and modernities
- ❒ Folding sash
- ❒ Horizontal sliders

larger windows a secondary wooden glazing strip may reinforce the muntin. The profile of the muntin — often unique to an individual worker or mill, though within the limits of a given style — is an extremely valuable artifact of the locale and era of the building. A knowledgeable eye can date a window, and often the building itself, by the profile and dimension of its smallest member.

Most 19th-century windowpanes were made as crown glass (blowing and twirling the molten glass into a large disk) or as cylinder glass (blowing the glass as a large "bottle", slicing off the ends, and laying the cylinder out as a small flat sheet). Available by the 1840s, the much larger and stronger panes permitted by the plate-glass method enabled a major change in the look and function of windows as the need for muntins disappeared (to reappear later as a conspicuous element of the many revival styles). Factory-made glass flooring, glass block and wired glass (or "fire-glass") emerged as important new materials around 1900, especially in response to insurance demands and fire codes.

Repair and rehabilitation

- ❖ Carefully inspect and record each window, comparing its present state closely with historic photographs whenever possible. Test the window's operation and look for deterioration of frame and/or sash, failure of putty, caulking or glazing, obvious air or moisture infiltration or condensation, and paint failure, especially on bottom rails and at the sill. Most deterioration occurs in the bottom third or so of a unit — but check the soundness of the upper part as well. Ensure that metal-covered window elements (especially shopfronts with sheet brass or copper over a wooden frame) do not hide rot in the wood beneath.
- ❖ Make sure that all wood is free from rot, damp and infestation, that all metal is free from rust, and that glazing putty is sound and remains flexible without cracking.
- ❖ Repair windows rather than replace them if they contribute greatly to architectural character and are largely sound and intact. When a window can be repaired with readily available techniques and materials, can have its broken panes replaced without damage to sash, and can fit together and operate properly, repair it.
- ❖ Replace badly deteriorated components in kind when the rest of the window is sound or can be repaired. In making replacements, maintain the integrity and appearance of the entire window and maintain or restore its operability, wherever possible, in its original mode. Reproduce wooden mouldings precisely according to those in existing windows of the same vintage; avoid modern stock mouldings unless their match is perfect.
- ❖ Retain the existing glazing as much as possible, especially where it has irreplaceable aesthetic qualities of form, light and colour; make special efforts to protect and retain curved glazing. Ensure that replacement panes have sufficient thermal expansion room within the sash and that the putty is sufficiently flexible to allow movement without damaging either muntins or glass.
- ❖ For wooden windows, use linseed-oil-based putty and assure its proper bonding with cleaned and prepared wood. Prepare the wood with a linseed-oil treatment and very carefully paint over the putty (but not the glass) to maintain its softness and flexibility. Do not "butter" putty on sloppily — besides looking bad, the thin feathery edges will allow water to creep in to the wood.
- ❖ Retain and repair historic window hardware; replace missing hardware in kind. Do not cover over old windowframes with metal or plastic. Restore the operation of the upper sash of a double-hung window wherever possible: apart from "authenticity", an open upper sash offers much-improved warm-weather ventilation.
- ❖ Remove excessive paint build-up but leave sound paint that adheres well and does not interfere with the window's operation. Determine previous paint types and colours through paint analysis in course of repair and add that information to the project records for use in both current and future work.

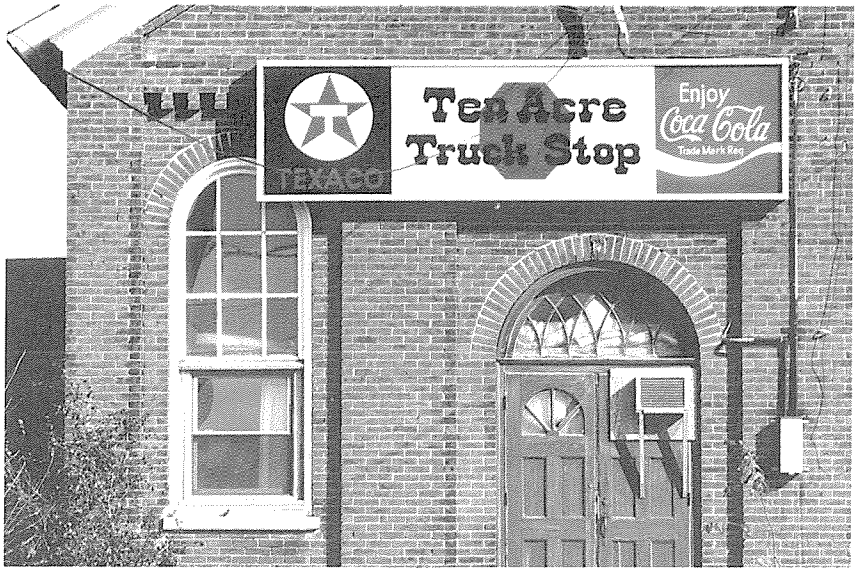


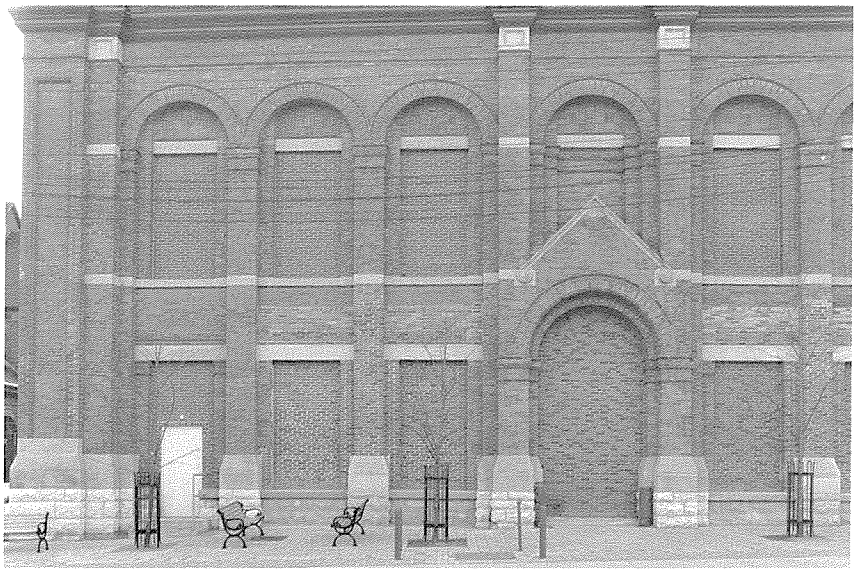
- Remove all rust from metal frames and sash; prime metal surfaces immediately after cleaning (see METALWORK).
- Repaint in suitable colours — either in those of the original or in colours more generally authentic to the neighbourhood in an earlier period (see PAINT, COLOUR AND LIGHT).
- Replace or add proper weatherstripping at all openings, as either compression seals or sliding seals. Metal, vinyl, rubber, polypropylene, and felt strips each have their best locations and are far more durable than adhesive-backed foam, which does not allow sliding. Do not let weatherstripping bind or restrict window operation. Caulk carefully, and discreetly, to provide an air seal between mouldings and walls.
- Take special care, if inserting second panes of glass into wooden sash, to maintain original muntin dimensions and profiles. If accuracy is not possible without severely weakening the window or damaging existing glazing — or if the existing glazing is original or of special importance and survives generally intact — use an alternative form of double glazing (see below).

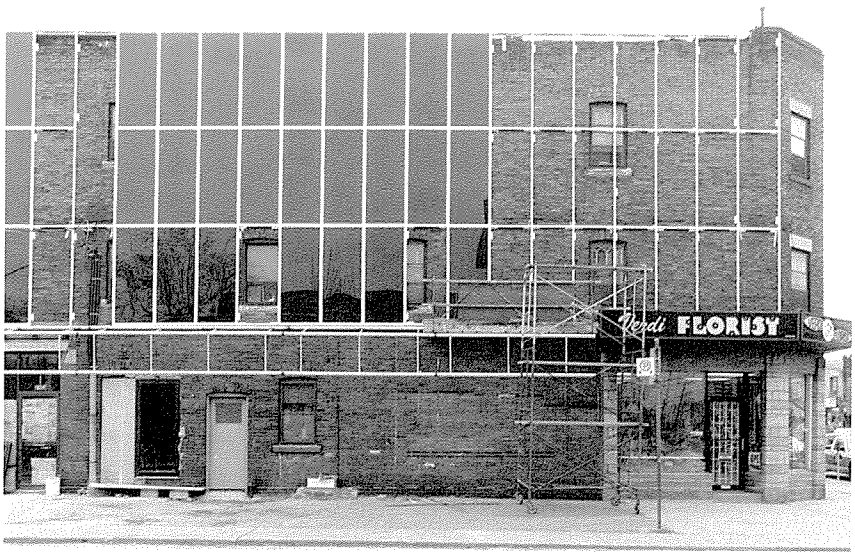
See also EXTERIOR WOODWORK and METALWORK.

Replacements and restorations

- Replace a window unit only when the majority of the window is missing or severely damaged or where it no longer fits properly and cannot be adjusted to fit and maintain its function. Even where there is historical evidence of an earlier window, do not pull out a reasonably well-fitting, compatible, and functioning window from a later period unless necessary. Do not replace an existing and fitting one-over-one double-hung window with an "earlier" six-over-six or other restoration of a presumed earlier window. The existing window may have its own value and authenticity which a restoration would lack, and that value should be taken into account in making decisions.
- Replace inappropriate "modernizations", such as horizontal metal sliders and fixed



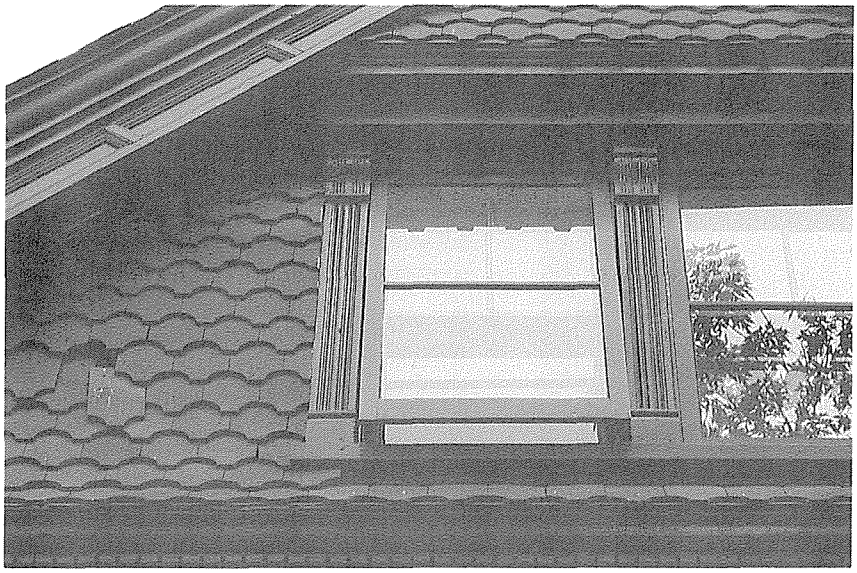


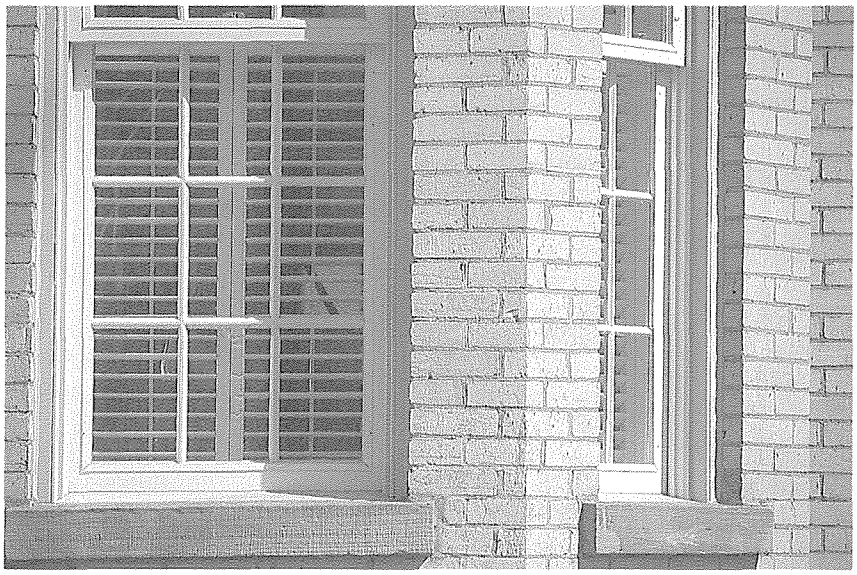


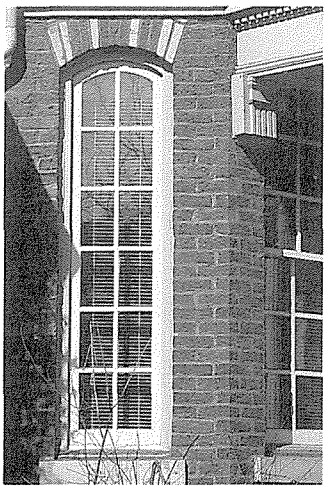
What not to do to historic windows.

modern frames, where these compromise or distort the overall architectural character of the building, as evident in neighbouring buildings or historic photographs and drawings. Choose conscientiously (that is, on the basis of research) whether to restore to an authentic original or simply to a compatible model.

- ❖ Do not replace inconsequential or neutral windows that may have replaced earlier windows but nevertheless fit reasonably and do not detract from the overall character of the building or from other windows.
- ❖ Maintain or if necessary recover the historic size and shape of all window openings. Neither expand the openings, nor fill them in, except to make good previous damaging modifications. If interior ceilings are to be lowered or furred down, ensure that the ceiling drop is set back sufficiently from the window to enable its visual and functional continuity.
- ❖ If windows must be blocked in because of major functional change, look hard at the program to determine if the function cannot be satisfied with windows retained in their historic forms and locations. If, as a very last resort, windows must be covered over from the interior, maintain their *exterior* appearance as windows.
- ❖ In replacing windows, match (from documentary sources or surviving mates) historic profiles, shapes, dimensions and divisions of frame, sash, muntins and surrounds. Add hardware and window accessories such as awnings and shutters only on the basis of evidence from thorough research.
- ❖ Take special care, if using double-glazed replacements, to maintain accurately the muntin dimensions and profiles of the originals — use alternative double glazing otherwise (see below).





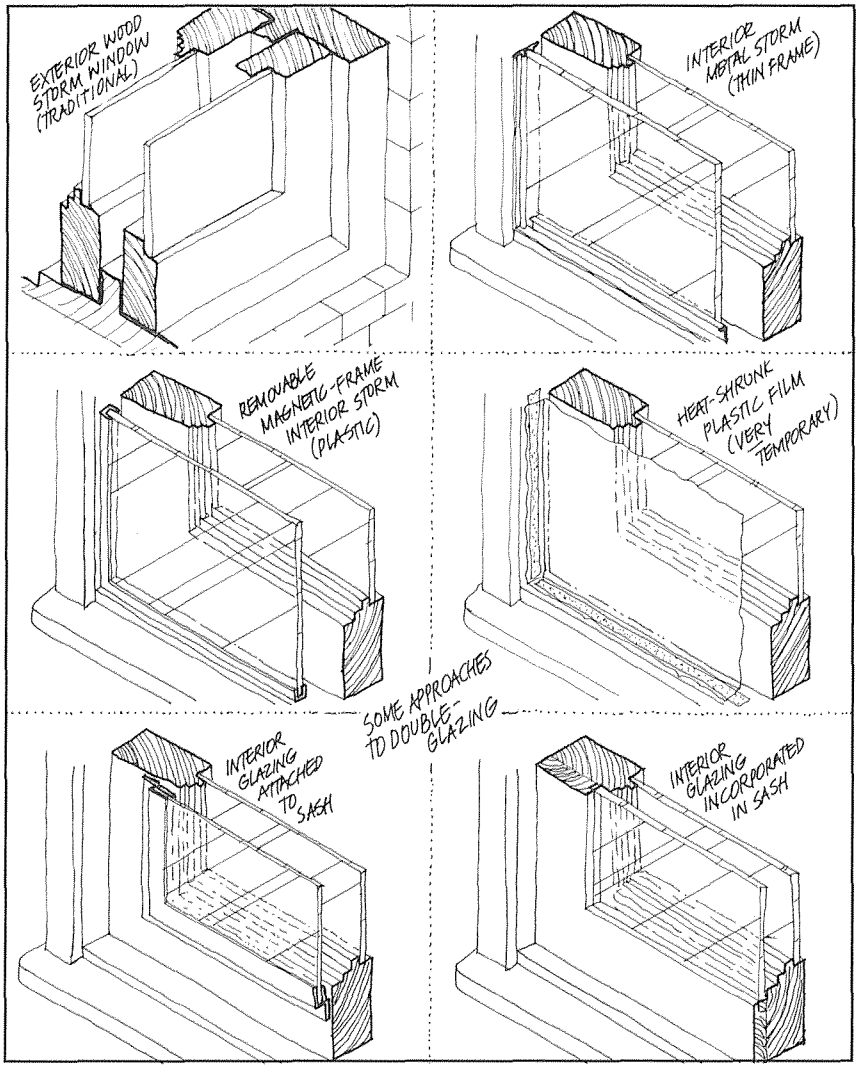


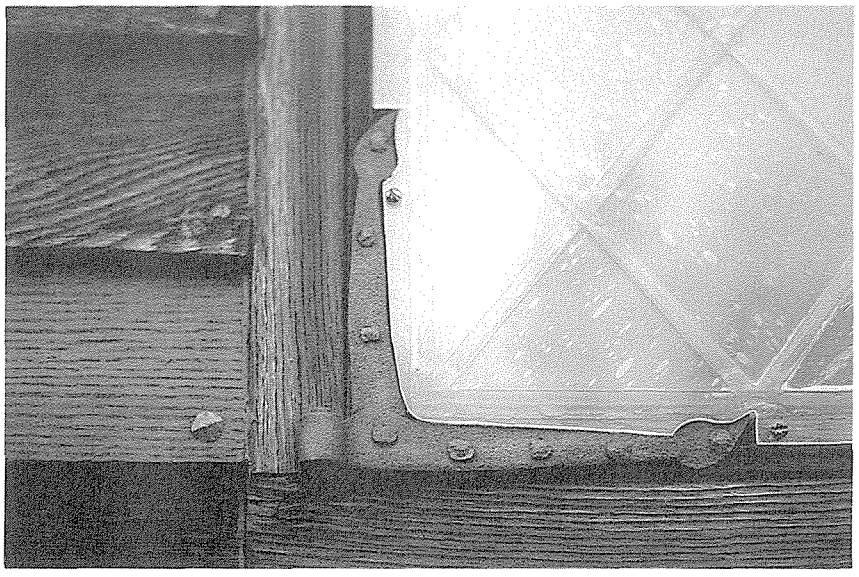
Operable exterior storm windows are traditional energy-conserving features of historic buildings, especially residences and small commercial buildings (top). It is possible to add a layer of glazing within the sash itself, taking care to maintain the operation and appearance of the window (above). And though it is also possible to double-glaze individual panes or lights, taking care to preserve the distinctive profiles of the historic sash and muntins, this particular example (right) loses that historic appearance.

Storm windows, double glazing

There exist several options for upgrading the insulation and acoustical performance of windows, including removable exterior storms, fixed operable exterior storms, interior operable storms, interior fixed glazing on sash or on removable magnetic frames, and sealed-unit replacement. Selecting the most appropriate depends on how important is the character of the existing window, relative cost of the work, and potential savings over time in reduced energy expenditures. Historic windows should be upgraded only when the work can be done without permanently damaging or compromising their visual and material character. Simple air-sealing measures — weatherstripping and caulking — will improve a window's thermal and acoustic performance considerably. Keep energy-saving ambitions realistic: windows account for no more than 15 to 20 per cent of the heat moving into or out of a building.

- Consider using either independent storm windows or double glass for sliding sash. For other types, double glazing will often be more satisfactory than storms because of conflicting movements and unduly restricted ventilation.
- Where they exist, retain and use wooden storm windows. Usually custom-made, they may be as old as the original windows.
- Where there are no existing exterior storm windows and where interior storms are impracticable, install new exterior storms as discreet (and discrete) complements to historically valuable windows. Make glazing divisions coincide, using the same or larger (not smaller) divisions. Wooden storms are preferable to aluminum, as better visual matches and insulators, but thin aluminum or steel sections, anodized or painted to blend in with the frame and sash, may be satisfactory.
- Be *very* cautious about using fixed exterior glazing (whether glass or polycarbonate) over leaded or stained glass — the greenhouse effect will heat the air space between the panes and weaken leading. Make sure that the air space is as deep as possible, and ventilate it fully to the exterior. This is not an energy-saving





A difficult case — though energy conservation, security and preservation of hardware are achieved, is its appearance satisfactory (and is it properly ventilated)?

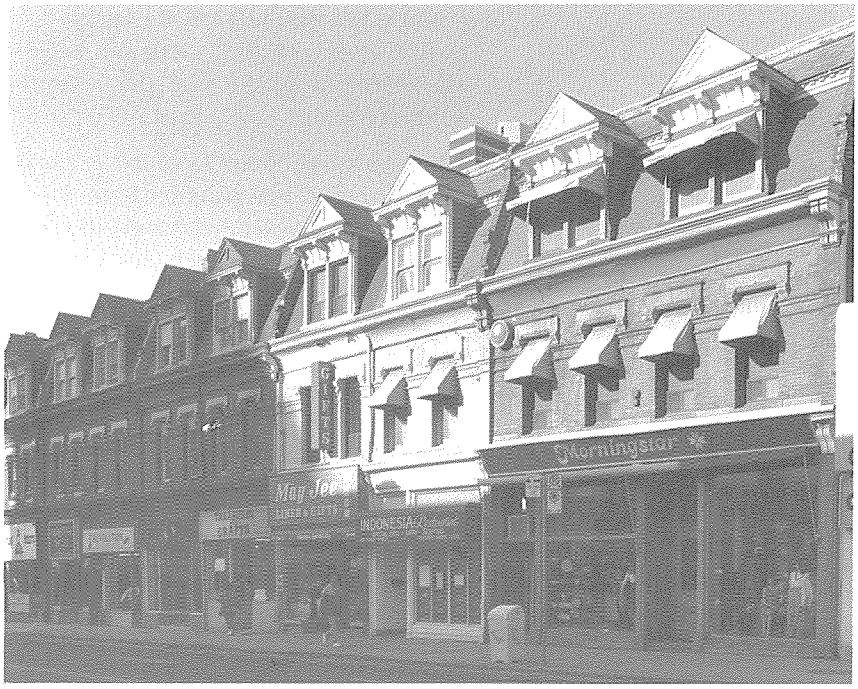
measure, but rather a form of security against windstorms and vandalism. Never use curved or bubble-formed plastics over historic glazing.

- Interior storm windows (operable or fixed) are preferable to new exterior storms in terms of maintenance and preservation of exterior appearance, though they do leave the existing window exposed to the elements. To reduce or eliminate condensation between fixed interior glazing and exterior glass, assure proper ventilation of the air space — small openings at top and bottom of the exterior sash will permit condensation to evaporate quickly. Do not rely on dessicant materials, which must be constantly renewed. The fixed pane should be removable for cleaning.
- To double-glaze non-sliding types of sash, it is possible to use a pane of lightweight glass or plastic fastened to the interior of both fixed and moving parts of the sash, with neoprene gaskets to prevent air leakage and condensation between panes. A lightweight addition rather than standard glass will obviate the need to replace hinges and hardware with heavier-duty substitutes. Additional panes must clear the moving parts of the window.
- Do not install double vacuum-sealed units in delicate muntins in good condition — this does away with sound existing glazing, and the wooden section is seldom deep enough to rabbet out without weakening the sash or to conceal the spacer in the insulated unit. And the weight of glass will more than double.

See BALANCING HERITAGE, COMFORT AND ENERGY EFFICIENCY.

Details

- Make supreme efforts to maintain and preserve special forms of glazing — early irregular ("antique") glass, curved glass, leaded glass, stained glass, art glass, etched glass, moulded glass — their variety, especially around the turn of the century, was extraordinary. These are very rarely replaceable and give distinction to many buildings. Particularly vulnerable are manufactured types no longer in

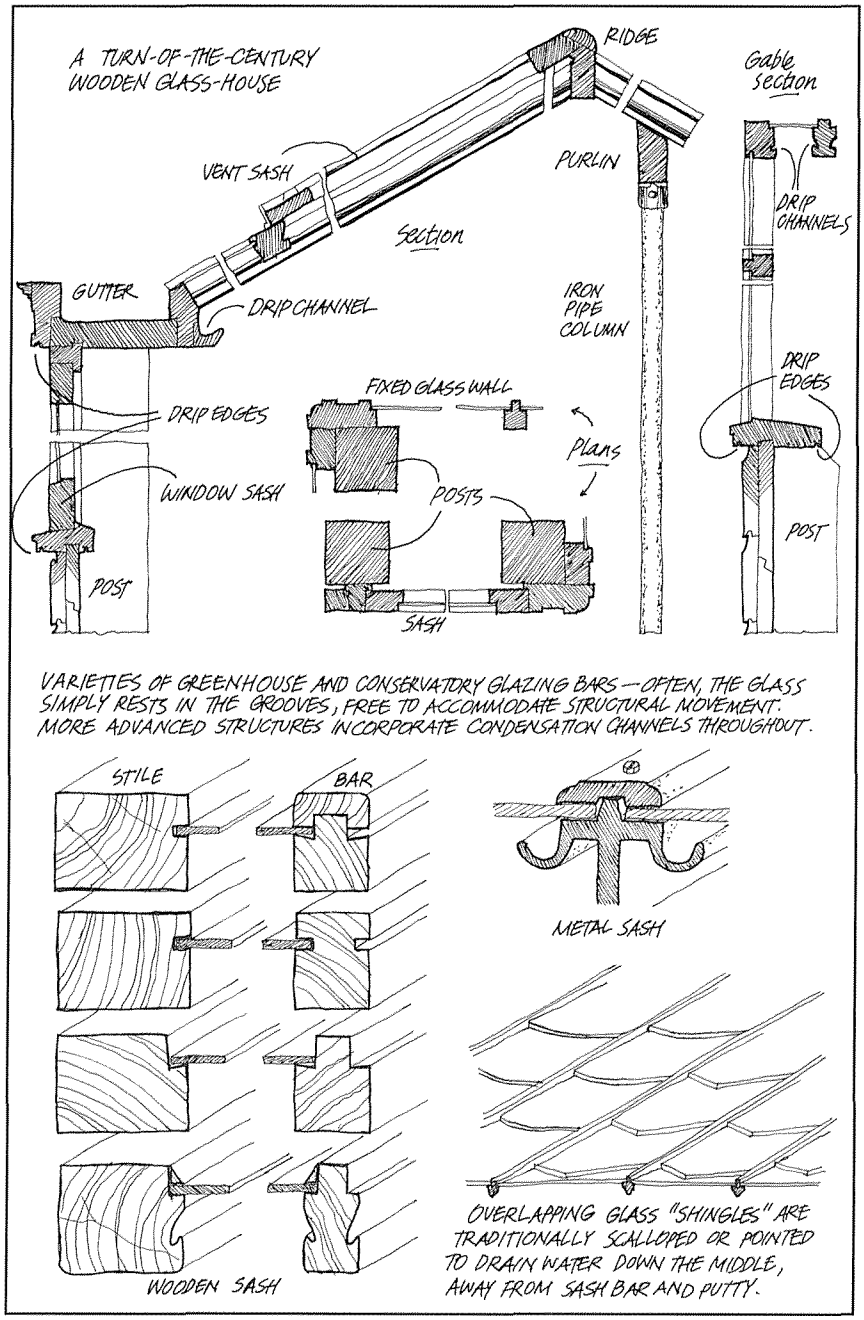


Operating fabric awnings were almost universal window accoutrements early this century, and can still be useful — but care must be taken to follow traditional forms and materials, as here (top). Very eclectic façades (above) may require different conservation treatments for each window.

production and extremely difficult to repair or replicate, even in custom workshops.

- ❖ Be especially careful in repairing frames and sash with curved glass. If broken, replace with curved glass of same dimensions whenever possible. Consider only pre-formed polycarbonate sheet as a substitute — bent acrylic sheets are not durable, and segments of flat glass are completely unacceptable visually and functionally.
- ❖ Make sure that the lead cames of stained or leaded glass are sound and that any glazing putty is still flexible; remove excess, "plastered" putty. Restore missing glass only where there is good photographic evidence of its original appearance. Remove the window for any major repairs. Refer conservation of any irreplaceable historic stained or leaded glass to a specialist.
- ❖ Maintain and restore the use of original window hardware — sash locks, latches, sash balances, hinges, cranks and pivots. Where such hardware has gone missing, consider rearranging what survives among similar windows within the building — rehabilitate and recycle original hardware in more conspicuous locations and use new or reproduction hardware elsewhere.
- ❖ Replace decayed awning fabric and rehabilitate operable awnings. Never use metal or plasticized awnings as substitutes.
- ❖ Maintain operable exterior shutters in working order. Under no circumstances replace them with non-operable plastic or metal simulations. Restore missing shutters only on the basis of research, and then only as operable elements. If there is any doubt about the historical existence of shutters, do not put new ones on.
- ❖ Where they survive, retain and repair built-in interior shutters. Maintain and continue to use interior shades, blinds, draperies, as part of window operation (see FIXTURES).

For glass block and panels, see STUCCO, CONCRETE AND COMPOSITES.



Skylights and conservatories

High year-round humidity and thermal extremes between inside and outside can cause great stresses and deterioration in cast-iron glasshouses, and dampness and putty deterioration can afflict wood-frame structures with rot. Well-detailed glasshouses have features to drain away the inevitable condensation without damaging the structural frame, as well as ventilating louvres to prevent both heat and humidity from building up to excessive levels.

- Inspect glass structures regularly for signs of putty failure and paint deterioration and ensure that condensation does not accumulate as standing water anywhere in the structure. Keep the ventilation system in good repair and ensure its regular use.
- Assess the existing structure and glazing very carefully and repair any flaws in structure and drainage before working on glazing repairs. Where glass is laid as overlapping "shingles", its lower edges are sometimes scalloped. Maintain these, even in replacements — this elemental detail keeps water away from putty and frame.
- Where iron elements or structures are so badly rusted as to be irreparable, use replacement sections cast or built up in metal that match the original profiles and dimensions (concealing any structural reinforcements within hollow sections as much as possible). Provide for both ventilation and drainage following historic practice — do not rely on modern mechanical equipment.

See METALWORK and EXTERIOR WOODWORK.

Entrances: doors, porches, steps, ramps

Principles

1.3 Balance of use and preservation (cautious conversion)
2.5 Appropriate skills
3.5 Specifics of uniqueness (pattern, ensemble, detail)
4.2 Respect for period/historic continuity, sequence
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.7 Reconstruction for wholeness
6.2 Maximum retention
6.4 Respect for craft
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.4 Cautious high-tech repair
7.6 Maintainable repairs
8.3 Complementary additions
8.4 Independent additions
8.5 Energy conservation
8.6 Aided access
9.2 Faithful maintenance

References

Most entrance and porch problems and repairs for residences involve wood; see the references in "Exterior woodwork", particularly BOWY80, CUNN84, DAVE80/86, HANS83, HOLM75, KAPL78/86, KIRK84, LOND86, MELV73, MILN79, POOR83, REMP80, STLOnd and TECH82. For examples of appropriate historic styles and patterns, see BLAK69, GREE74, MACR63, MACR75, MCAL84, TUNI86 and VICT84.

More technical background may be found in FEIL82, FROI86, INSA72, LOCK86, LOCK86a, MULL81, MUNN83, PRIN81, STAH84, TIMM76 and WOOD86. On handicapped access, see BALL83; on energy-conserving retrofits, see SEDW83.

The importance of entrances

The entrance of a building complements its windows — the "invitation" and attractiveness of the façade can be confirmed or destroyed by the way the entrance itself appears and works. Doorways set the visual, tactile and spatial "tone" for the functional relation between inside and outside. *Using* a building means going in and out of its doors constantly. Entrances establish the human scale of a building (or its lack of scale). They also establish a protocol for its use — there is always a *primary* entrance, in addition to one or many subsidiary ways in, even if the visual distinction is only ceremonial. The most elaborate historic entrances were "aedicules" — little buildings in themselves.

Porches expanded these little buildings into useful exterior spaces. Ontario's climatic extremes prompted builders to provide a shelter that not only protected an important entrance in winter but also offered a shaded platform for the enjoyment of its often sub-tropical summers. The generous porch or verandah was among the most conspicuous features of North American residential architecture in the late 19th and early 20th centuries, spanning stylistic boundaries with a profusion of forms. The grandest porches belonged to the inns of coaching and early railway travel, covering principal façades with two or even three levels of porch, accessible from every room.

Because they are close to hand and eye, finishes and details of doorways and porches are much like those of furniture — and closely related to what most people consider, whether justifiably or not, the "style" of the building. They are details more of cabinetmaker than carpenter.

Because they are so heavily used and have so many parts, entrances (like windows) require considerable maintenance to repair the damages of weathering and human wear and tear. Lack of maintenance at the entrance leads to the most obvious (though not necessarily the worst) deterioration in the building.

For the relation of entrances to the property beyond the building's walls, see SPATIAL DEFINITION AND HARD LANDSCAPING; for main-street commerce, see STOREFRONTS.

Doors and doorways

- As far as possible, maintain the primary entrance in its historic location in both plan (functionally) and elevation (visually) — retain the historic patterns of access and building entrances in any new use. Do not insert a *new* entrance in a front or other principal elevation. Whenever possible, satisfy code requirements for increased exit dimensions without modifying architecturally valuable doorways — use other existing access points or add new ones discreetly.
- Inspect and record existing entrances very carefully. Before any work — even temporary repairs — look carefully for and record archaeological traces of earlier features (colour changes, stains, nail holes, left-over paint ridges indicating historic trim, and so on).
- If the original or an early door survives, make very special efforts to retain and repair it. Use surviving original or early doors as models for accurate reproductions in other locations on the same building. Unfortunately, doors are often treated like furniture and are often removed. If you are fortunate enough to have an original door, or one that appears to have been in place for a long time, hang onto it.
- *Do not fake historic doors and details.* Do not install "period" doors emulating originals that cannot be documented from historic photographs, and most certainly none that antedates the building itself. To be considered compatible, modern complements should be similar in material, size, depth, proportion and styling and should not dominate the overall impression of the doorway or building.
- Retain, repair and maintain historic hardware where it survives. If hardware is missing, use complementary modern fittings or reproduction hardware that coincides with the original era of building or some later period — never an earlier period.
- Maintain the features comprising the door surrounds (entablatures, sidelights, fanlights, pilasters and the like). Restore missing features only with firm evidence

ENTRANCE ELEMENTS

Doorways

- ❒ Principal doors (single, double, solid, paneled, composite, glazed)
- ❒ Pilasters and engaged columns
- ❒ Sidelights
- ❒ Fanlights and transoms
- ❒ Pediments and entablatures
- ❒ Hardware (hinges, handles, locks, etc.)
- ❒ Storm and screen doors

Porches and verandahs

- ❒ Vestibules
- ❒ Columns and piers
- ❒ Railings and balustrades
- ❒ Floors
- ❒ Lighting fixtures
- ❒ Planters and benches
- ❒ Steps and ramps

(documentary, photographic and archaeological). Repair deteriorated glazing in kind. Use clear glazing and simple patterns unless there is sufficient general documentation to permit a sympathetic and artistic modern substitute that evokes the colour and pattern of the appropriate period.

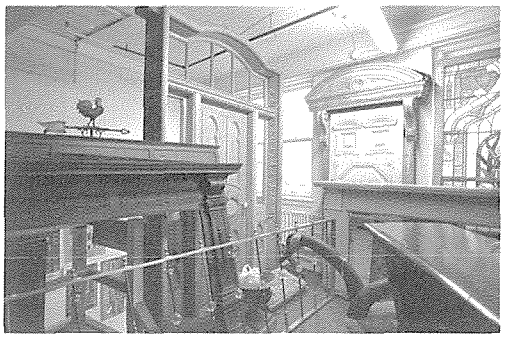
❖ Do not embellish secondary entrances as if they were formerly more important by adding (fake) reproduction sidelights, fanlights, and so on.

❖ Maintain the physical integrity of historic doors. Do not bolt panic hardware, automatic closers, locks, and other such additions *through* the door — indeed, try to avoid such hardware by, for instance, using non-historic entrances and modern doors to satisfy code-related exit requirements.

❖ Storm and screen doors should be simple and compatible in colour and proportion to the main door. Follow an approach similar to the guidelines for exterior storm windows: make a storm door a discreet complement to the existing door; make glazing and screening divisions coincide, using the same or larger rather than smaller divisions; use wooden members rather than metal where possible (though a thin-section aluminum or steel door, anodized or painted to blend in, may be a satisfactory alternative). Remove incompatible storm doors and replace them with more fitting designs. Where feasible, use an interior door to make a heat-conserving vestibule in lieu of a storm door.

❖ Maintain all doors and doorways faithfully and frequently, repairing any damage at the earliest opportunity.

See EXTERIOR WOODWORK and WINDOWS.

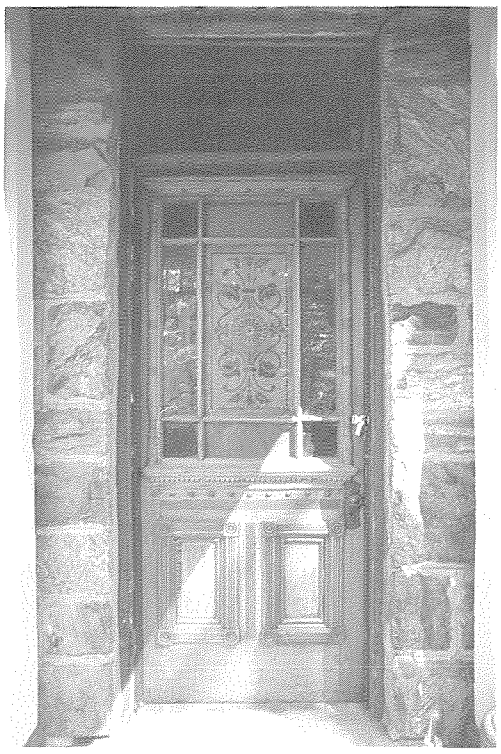


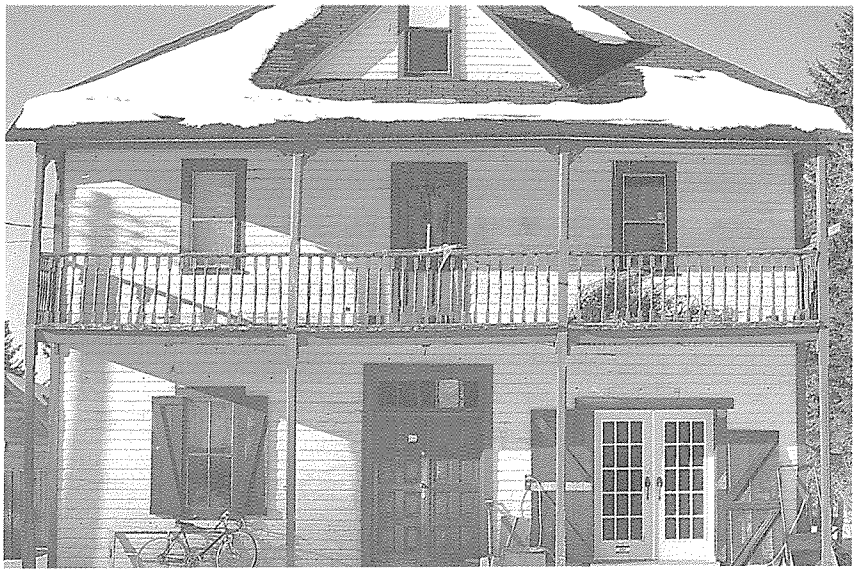
Original or early doors (far right) — even vintage screen doors (right hand door, above) — are vital to the unique character of entrances. Treating them as portable artifacts (right) simply steals from the original location to dress up another place with false antiquity.

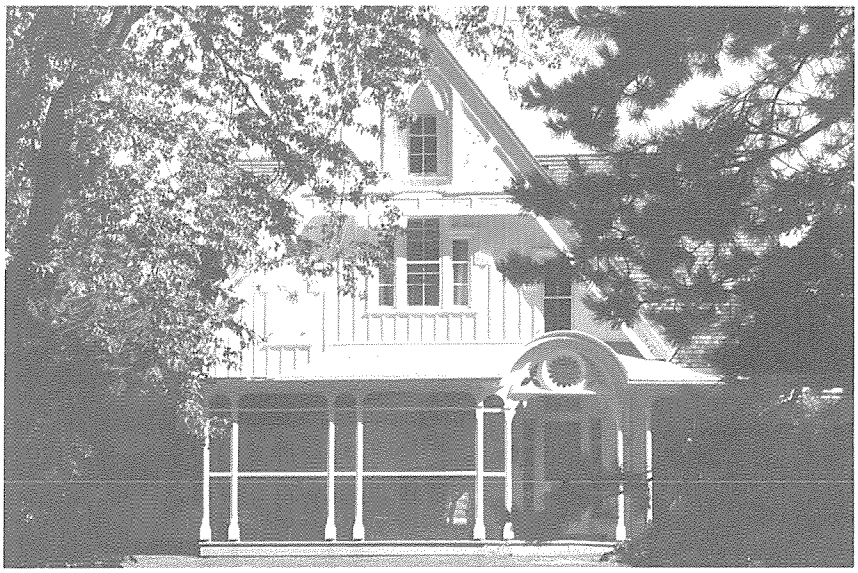
Porches and verandahs

❖ Inspect carefully for water-related damage, especially around posts and balustrades. Repair all structural flaws before working on details, ensuring that foundations are sound and well drained.

❖ Ensure that stone or cast-stone balustrades are well anchored. Remove all superficial







rust and protect iron connectors and elements with suitable primer and paint. Replace any seriously corroded cast-stone connectors with non-ferrous or stainless bolts. Repair damaged units with "plastic" or dutchman inserts. Replace units only as a last resort, and then only in the original material (moulded from adjacent sound elements; see MASONRY).

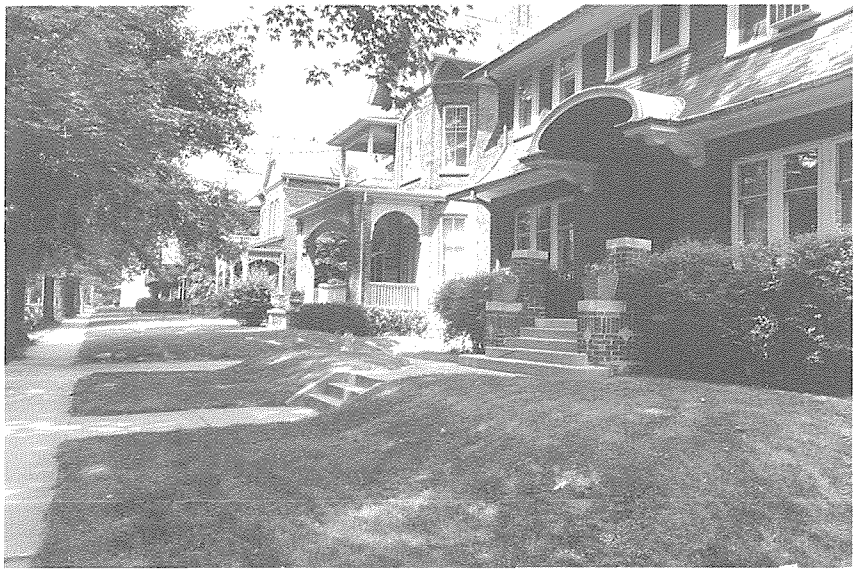
- Renew the anchorages of cast- or wrought-iron railings in stone following historic practice (usually molten sulphur or lead in a reverse-cut cavity). As an alternative, use modern epoxy fastenings very carefully, ensuring that any expansion of the epoxy will not destroy surrounding stone.
- Treat wooden porch floors and other exposed woodwork with water-repellent preservatives before refinishing. Replace only irreparably rotten members — clean, sand and fill the others as necessary (see EXTERIOR WOODWORK).
- When considering the permanent enclosure of open porches, follow the model of the historic practice used for summer screening. Keep glazing and screening behind the perimeter columns and balustrades, use the thinnest possible framing members, and maintain the integrity of all perimeter features as both visually and structurally separate. Retain the historic "transparency" of the porch as much as possible — do not use smoked or reflective glass to enclose it.
- Retain and conserve upper-storey porches and balconies, even where not original, where these have become important to the historic character of the building. Ensure that they are well founded and properly fastened and flashed at walls and roofs. Make sure that the porch does not compromise the foundation and exterior of the building — provide for independent structural movements. Restore missing features only on the basis of historical photographs and archaeology.

Porches to suit their houses — from small Regency porticos, to double height porches of former inns (though the new door unfortunately violates an original window), to ornate Victorian verandahs.

Steps and ramps

- Make sure that the foundations of exterior steps are secure. Since they usually lack a basement beneath, steps are often vulnerable to the heaving of freezing and thawing ground. Ensure that surroundings are well drained. Exterior steps should be level, with only just enough slope to drain water away quickly. The steps should be sound, with no deep cracks or missing chips.
- In repairing stone steps, ensure that patching matches colour, texture, profile and hardness of existing steps. For small patches, use stone dust mixed into a lime-and-cement mortar and make sample mixes to test colour, curing, and ultimate strength and hardness. Let these tests stand at least several weeks and compare their hardness with that of the existing stone; the mortar must be neither harder nor softer. Use only stainless-steel reinforcing to help bond larger mortar patches. Allow sufficient curing time in moist conditions and match the final profile and surface carefully to the original (a very dilute muriatic acid solution may help harmonize the grain and surface of such repairs).
- For more severe damage, consider dutchman repairs or replacement of steps with stone of matching qualities (see MASONRY).
- Keep wooden steps well maintained. Replace rotten or heavily worn steps in kind. Renew the paint on wooden steps more frequently than on decorative ornament or walls but do not let layers of paint build up so much on top that deterioration from below is masked or even aided (see EXTERIOR WOODWORK).
- Where there is or will be elevator access within a building, plan handicapped-access ramping to descend into the building rather than rise to it, adding a second principal entrance while preserving the original entrance (see PROGRAMMING AND USING SPACE).
- Where new raised ramps prove necessary, use forms and materials similar to or sympathetic with those of the building. New work should defer visually to what exists. Ramps should seem "light" in mass, proportion and detail — they should not (and need not) obscure significant views and elevations. In planning spaces and access, consider the ramp entrance as a second principal, not second-*class*, entrance but do not compromise the integrity of the historic entrance (see SPATIAL DEFINITION AND HARD LANDSCAPING).
- Do not use corrosive de-icing agents on any exterior steps or ramps — especially not sodium chloride (see TAKING CARE).

The design and materials of steps should complement the architecture of the building — for instance, though wood is often the traditional material for front steps of 19th-century houses, concrete is often the proper material for steps to early 20th century dwellings.



Storefronts

Principles

2.1 Co-ordinated work
2.2 Co-operation among specialties
2.3 Work in order
2.4 Work at right pace
2.5 Appropriate skills
2.6 Second opinions when in doubt
3.5 Specifics of uniqueness (pattern, ensemble, detail)
4.1 Respect for (natural) aging process
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
5.3 Minimal alteration, minimal intrusiveness
5.6 Minimal removals
5.9 Façadism as last resort
6.2 Maximum retention
6.4 Respect for craft
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.2 Replacement in kind/ recycled materials
7.3 Reversible repair
7.4 Cautious high-tech repair
7.5 Recipes tested before application
7.6 Maintainable repairs
7.7 Gentle cleaning
8.1 Distinctive new work
8.6 Aided access
9.4 Conservation commemorated

References

Storefront conservation requires first of all an appreciation of context and planning; see BROW80, CAPP86, CUMI85, DUTO85, EDWA46, FACA87/87a, FLEM82, HOLD85, JOHN84, NATI80, REAL81, RESE85, THUR83, WARN78, WILL78 and WORS69.

For materials and details, see references in other *Exterior features*, but especially GAYL80, MEAD86, NIBS80, SHOP86 and TECH82. Helpful older texts include MACE98 and RADF83.

See also GREE74, LONG87 and STEN81 for background on storefront forms.

Display and the street

Storefronts are rather peculiar architectural assemblages, standing (physically, and in time) between the rapidly changing commercial displays inside and the usually very stable historic main-street façades above. Conservation of historic storefronts must be considered within constantly altering contexts: the store and its stock change, neighbouring stores change, the community changes. Co-ordination of old and new is thus a constant preoccupation. It is often difficult to balance the rapidly changing cycles of retail style and the architectural heritage of the building. The challenge is to maintain the continuity of main-street change over time, to recognize and respect changes and contrasts between façade and storefront.

Having begun as the front parlours of merchants' houses, storefronts took their modern form as soon as their proprietors were able to afford large glass display windows. The multi-paned cylinder-glass windows of Georgian storefronts gave way to large Victorian plate-glass fronts in the 1840s and 1850s. The display window dominated the ground floor. The shop entrance lay in a deep, narrow passage in the centre or to the side, and the doorway to the upper storeys was also pushed to one side. The window became a deep space within the shop, almost a separate room. This basic organization has persisted, with some changes in location and depth of doorways and in the frames for glass and surrounding panels.

Storefront architecture must make a strong impression for its retail space, with little regard for, often in spite of, the rest of the building. For historic storefronts, visual contrast has been the rule much of the time. To attract the eye, the large glass display windows and their slender pillars contrasted with the masonry and ornament of the façade above. The floor of the entrance contrasted in colour and material with the sidewalk. The large and vivid signs contrasted in scale and colour with their sedate architectural frames. But as hard as it tried, the storefront was always subordinate to the larger frame of the entire façade. The plane of the façade defined quite clearly the line between public and commercial territory. Even the most garish signage sat in frames within the façade or hung discreetly at its edges. And even the generous canvas awnings withdrew into a pocket within the front of the building itself.

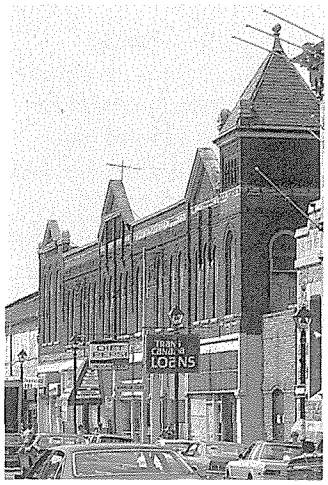
Just like the entrances of other buildings, storefronts require considerable maintenance because of constant heavy use. They are vulnerable to human wear and tear, to the weather, and of course to constant and often arbitrary changes in retail functions and fashions. The details of storefronts are furniture-like, but not domestic — they are closely related to what most people consider to be the "style" of the shop and of shopping, not of the larger building.

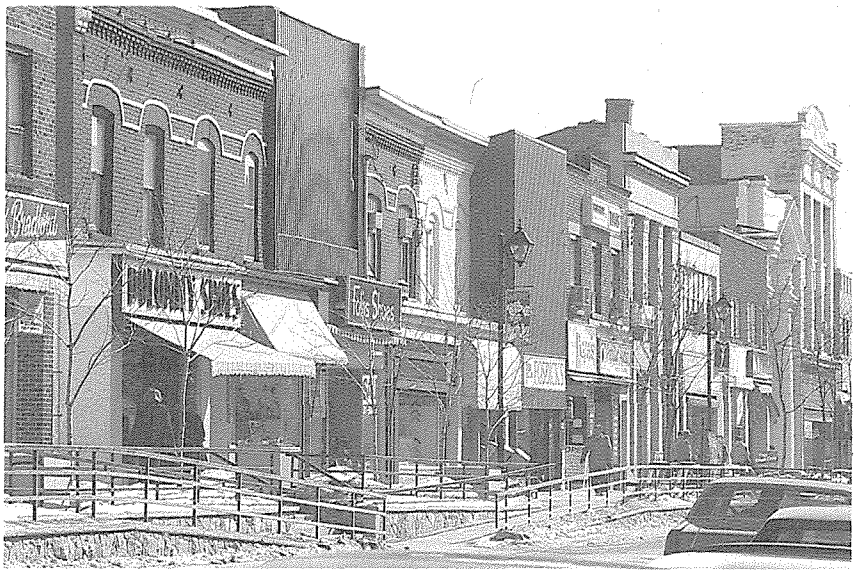
It is vital to distinguish, both historically and currently, between the more or less permanent architecture of the storefront as part of the overall façade and the changeable displays *within* the storefront. It is absolutely essential to maintain these in balance so that changing retail fashion does not destroy the heritage value of the architecture above and adjacent.

- Where an existing storefront is physically sound and compatible with overall building façade through its design, details and proportions — even though of a different "period", subsequent to the original building — maintain and repair it rather than replace it. Maintain the generally characteristic containment of the storefront by the façade by removing additions attached in front of or outside this "frame" (including fluorescent sign boxes along the fascia), unless these are actual originals or restorations based on early historic photographs.
- Where an existing storefront does not fit with the historic character of the building, consider replacing it by revealing the earlier front beneath (if recoverable), by installing a more fitting modern design, or by restoring (with proper research and documentation) an authentic earlier appearance. Consider any storefront replaceable that covers over historic material with bland or poorly fitting materials and features of no intrinsic merit, or that encroaches into the street beyond the historic edges of the building, or that is profoundly dissonant when seen in context with its neighbours, so long as the overall façade is not damaged or devalued.

See CAPP86, HOLD85 and FLEM82 for more discussion about the matter of respect for historic façades in commercial areas in the course of changing retail fashions. See LONG87 for a unique guide to the historic variety of main-street building forms that frame storefronts.

So long as the many changes in store fashion are contained within the storefront, the upper storeys of a comercial block can be maintained and conserved (though this one, below, has lost a cornice). Covering historic façades merely to contain store signs mocks the neighbouring buildings and makes the street as a whole much less attractive (bottom).



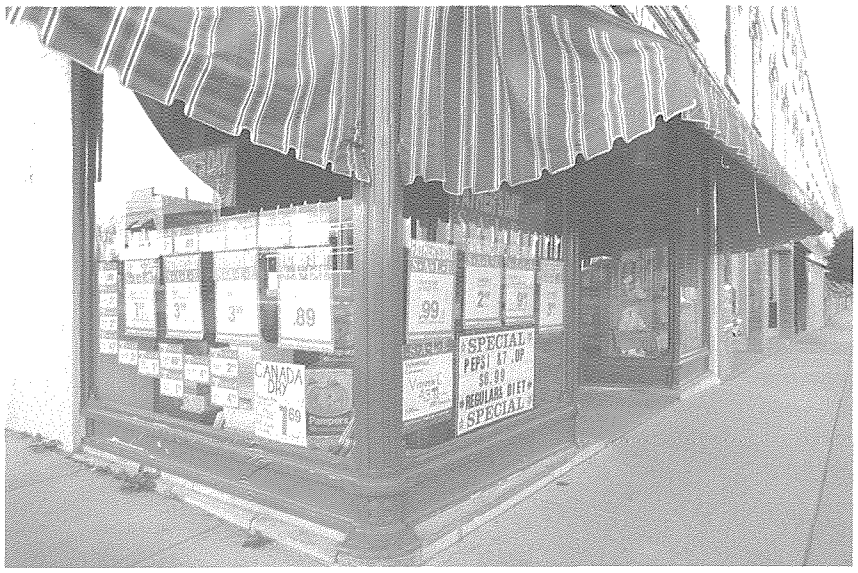


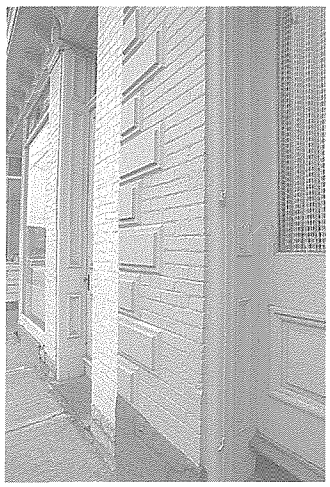
- Where the physical condition of a storefront (either existing or concealed) is too poor to repair without massive replacement and where it is considered appropriate to recover a genuine earlier appearance, restore that appearance using existing materials, building archaeology and archival photographs, with as little conjecture as possible. Use firm evidence to reproduce an earlier front rather than conjectural evidence about the actual original. Use surviving materials as models for colour and detail, reproducing in kind as much as possible.
- Keep the established store *front* distinguishable from the changing store *display*.
- *Do not falsify history.* Do not give a storefront a "period" look antedating the era, status and locale of the original building — no American Colonial coach lamps, for instance. Do not put a Georgian front on a Victorian building, nor a Victorian front on an Art Deco building. But maintain fitting historic "modernizations" where they enhance the building and street (see above). Use historic photographs and building archaeology as guidance for any modification or reproduction to an earlier appearance.

See VISUAL APPROACHES AND RESULTS.

Façade/storefront/sign

- Inspect very carefully for finishes and materials hidden behind existing storefronts. Assess likely damage to concealed surfaces: holes for nails and bolts, missing projecting elements such as cornices and pilasters, and so on. Assess as well the historic, aesthetic and functional merits of the existing front before considering re-exposing concealed fronts (there may be more than one).
- Use historic photographs to establish the styles and types of sign appropriate to a building within its district during the era of its construction and early life and use these as models for contemporary signs. New signs may be far more adventurous and bold than modern false-historic modesty may consider appropriate yet remain architecturally compatible if they are based on evident local historic practices and fitting modern designs.
- Do not automatically remove all projecting signs, as often mandated in commercial area improvements. Determine if they are themselves important historic and character-defining features of intrinsic value and rarity that should be repaired and maintained. Evaluate such signs with the same criteria as those for non-original storefronts that may deserve retention and repair (see above). Pay particular attention to retaining early non-standardized, non-illuminated or neon-tube signs unique to that building or street.
- Ensure that fixtures and fastenings of projecting signs are well anchored and are not causing deterioration of the masonry or woodwork of the façade.
- Do not use back-lit fluorescent sign boxes against the fascia and remove them during major repairs. Apart from their poor fit with the façade — they project beyond the historic "frame" — they are seldom if ever properly flashed to prevent water penetration and lead to material deterioration behind. Consider their continued use only if boxes and fittings can be recessed into the fascia without damage to the historic structure.
- Retain, repair and maintain operable canvas awnings where they survive and





consider restoring missing operable awnings in appropriate locations where there is evidence for their earlier existence. Awnings reduce summer heat gain tremendously and provide shelter from rain. Keep awnings and mechanisms in good repair, replace fabric when it begins to deteriorate. Do not use fixed canvas, plastic or metal canopies as substitutes.

- Follow historic practices in lighting storefronts and upper façades. Illuminate buildings in colours and patterns that bring out the essential forms and profiles visible in daylight. Use incandescent or similar light sources to render accurately building and material colours. Use front-illuminated signs.

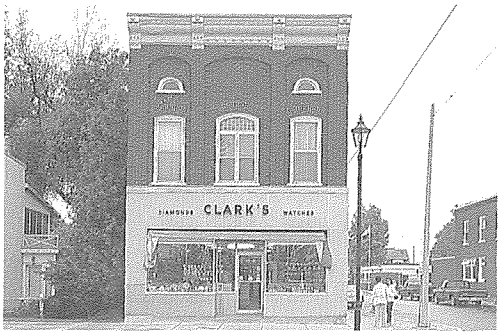
See PAINT, COLOUR AND LIGHT.

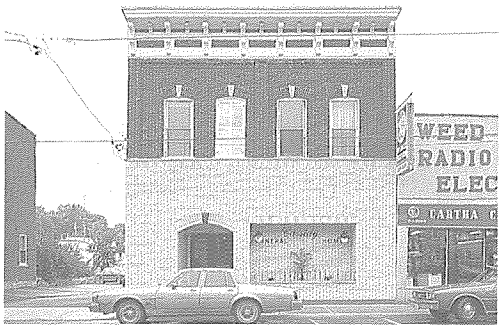
Windows, doors and details

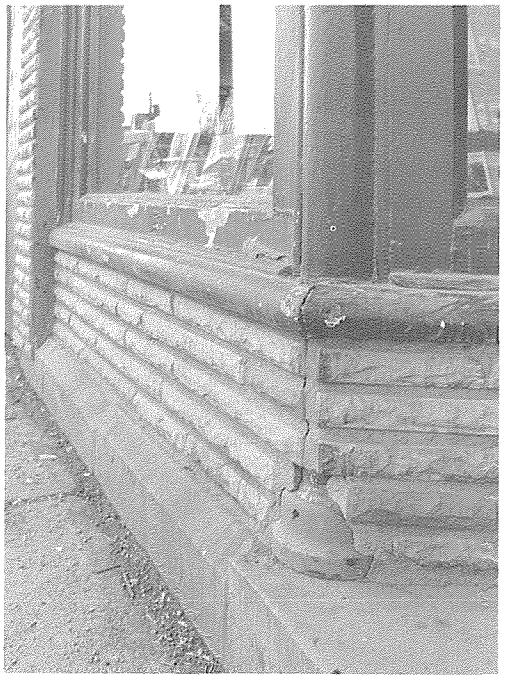
Despite the many changes in storefront fashion, there has been remarkable continuity in storefront features. The major element has always been glass — though each era may have framed the glass differently, the recessed entrance allowing the display apparently to "project" has remained the basic configuration for a century and a half.

- Maintain the distinctive setbacks, recesses, framing structure, materials and details of storefront glazing in repairs or replacements.
- Maintain the proportions of glass to solid characteristic of the historic storefront. Do not brick in or block up portions of windows or replace large panes of glass with false "period" subdivisions. Maintain glazed transoms above the entrance doors. Conceal air conditioners in sleeve units in panelled areas rather than obstruct glazing (better still, move the unit to the rear of the store).
- Clean, restore and maintain any painted-over non-ferrous metal surfaces. Pay particular attention to conservation of copper and bronze frames — clean carefully, making sure to correct any structural problems. Make any necessary reinforcements as discreet as possible.
- Conserve energy in existing storefronts by glazing the rear of the display area defined

(opposite)
Traditional main-street details still attractive and useful for shoppers and residents: the retractable awning (top); the double-glazed display window that helps insulate the interior of the store (middle); the front-lit sign over a double-height deep-bay window to display goods and let both daylight and artificial light reach the interior (bottom left); and doorways to upper-storey residences or offices that maintain the style and detail of the whole (bottom right).







(right)
A false "period" look is out of place when it confuses what is genuinely historic about the building (top). Some renewed storefronts co-exist peacefully with the older façade above by respecting general symmetry and proportion (upper middle), but others collide badly (lower middle). Sometimes the traces of earlier historic elements show through, awaiting recovery (bottom).

by the window and entrance recess or by using blinds or curtains to separate the display area as an intermediate thermal buffer. Just as for any other type of window, effect the greatest savings by simple caulking and weatherstripping.

- Avoid stock modern replacement doors and hardware; recycle or reproduce existing features when upgrading doors to modern requirements.

See EXTERIOR WOODWORK, METALWORK, WINDOWS, and ENTRANCES.

Panels and paving

- When attempting to recover earlier hidden finishes, remove existing materials very carefully to avoid worsening the damage to hidden surfaces.
- In making repairs, use substitute materials discreetly; consider rearranging panels of irreproducible materials such as "structural" glass to maintain its continuity in conspicuous locations, especially near and below eye level.
- Protect and maintain ornamental paving: terrazzo, brass inlays, contrasting tile, concrete, asphalt or brick patterns. These sometimes contain names or symbols of earlier shops. Maintain glass-block paving where it survives, within the storefront or beneath the sidewalk in front.
- Maintain sidewalk hoists in good repair. If a hoist is not used often, test its operation regularly.
- If it is necessary to install a unit air conditioner in a panelled area, conserve and store the removed panels for future re-use. Make vents and drainage for the unit discreet. Do not let condensate from the unit drain across paving.

See SPATIAL DEFINITION AND HARD LANDSCAPING, and STUCCO, CONCRETE AND COMPOSITES.

Paint, colour and light

Principles

2.2 Co-operation among specialties
2.3 Work in order
2.4 Work at right pace
2.5 Appropriate skills
2.6 Second opinions when in doubt
3.5 Specifics of uniqueness (pattern, ensemble, detail)
4.4 Respect for uniqueness (pattern, ensemble, detail)
4.6 Minimal conjecture/informed invention
5.1 Priorities of features, priorities of work
6.3 Patina preserved
6.4 Respect for craft
6.5 Safe working conditions
7.1 Traditional repair (proven technology)
7.3 Reversible repair
7.4 Cautious high-tech repair
7.5 Recipes tested before application
7.6 Maintainable repairs
7.7 Gentle cleaning

References

Since paint must be renewed periodically, there are many references on cleaning, preparation and applying new paint; see READ82, SHAK85, CUNN84, FERG86, KAPL78/86, KIRK84, LANG78, LYNC82, OLDH85, POOR83, SHOP86, TECH82 and VILA81.

Good conservation practice requires careful analysis of what exists — its chemistry, physics and colour — and involves more specialized technical aid. Such specialized problems are covered in JAND83, CHAM76, DAVE80/86, FEIL82, HUGH86, JOHN84, SCHO85, STAH84, TIMM76 and WRIG86.

On historic and contemporary approaches to colour, see LENC82, PRIZ75, MOSS87, POMA87, MILL77, ONEI71, PARR85 and PORT82. For guidance on paint sampling, and on matching colour and chemistry, see KITC83, MILL77 and FEIL82. For help on preparation and repainting for conservation projects, see OLDH85, POOR83 and DAVE80/86.

There are few published sources for exterior lighting; see FLEM82 and JAND83.

The mechanics of exterior paint

Until the late 19th century, the most common exterior paint was whitewash, a mixture of lime and water with some linseed oil mixed in for good measure. Though many different vehicles and binders were used for indoor painting (casein, tempera, and so on), few of these were durable or inexpensive enough for exterior use. Coloured pigments in linseed oil were expensive and used only on the buildings of the wealthy. Stucco was coloured with pigment laid into the finish coat; woodwork was most commonly stained and varnished, or whitewashed. Mixing paints was itself a skilled trade. Pre-mixed oil-based exterior paints as we know them today did not become widely available until the 1870s.

Exterior paint must be renewed regularly. Even in the 19th century, the recognized life of an exterior linseed-oil-based paint was 5 to 15 years. Whitewashing was an *annual* job. Accordingly, many historic surfaces, where not stripped to their base material, may retain traces of a dozen or more applications of paint, two or three coats for each application. Some exterior surfaces were painted with sand mixed in for a roughened, stone-like texture. The profusion of exterior colours we now associate with the 19th century did not appear until the broad distribution of paint manufacturers' catalogues late in the century.

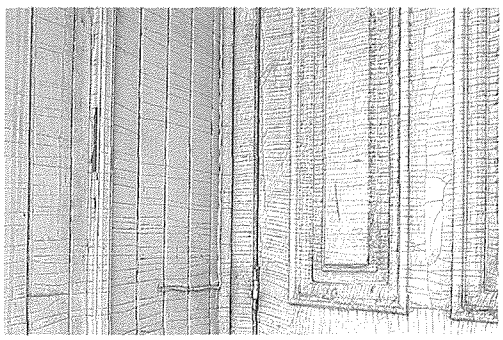
A well-formulated exterior paint (historic or modern) deteriorates very slowly from the effects of weathering, but much more rapidly from moisture penetrating and compromising its bond with previous layers or with its base material. Paint is flexible and forgiving, to a point. It may blister, check, craze, crack, peel, alligator or simply fall off a deteriorated surface. Indeed, paint deterioration is a very useful symptom of worse problems beneath.

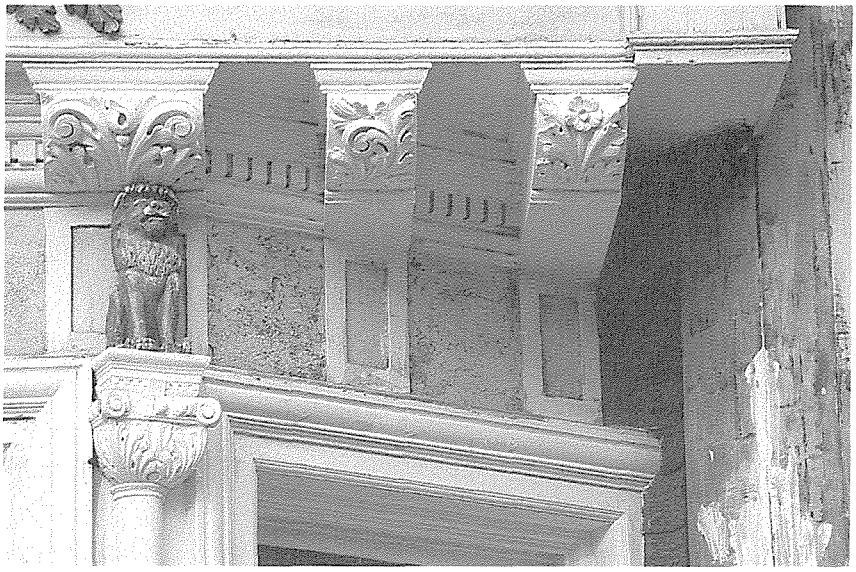
Modern pigments tend to be more stable than historic colours. Modern alkyd (resin) and latex vehicles tend to show brush marks less than do oil-based paints. On the other hand, latex emulsions bond poorly to historic paints unless very well primed and they still do not cover as well as alkyds or oils. Generally, alkyd or old-fashioned linseed-oil paints provide more covering power and a more durable finish for old-building work than do latex paints. Some people believe that oil paint has a depth of colour subtly different from latex that is more appropriate to historic settings.

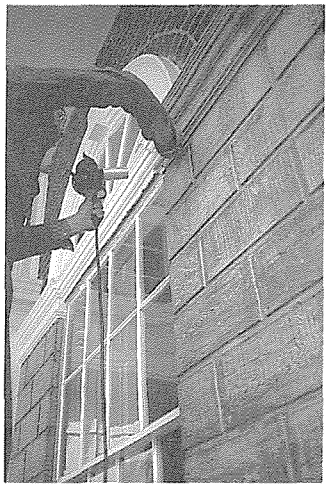
Regular repainting should destroy as little as possible of what lies beneath; ideally, it should physically erode or be sanded down at each renewal only as much as needed to prevent excessive build-up.

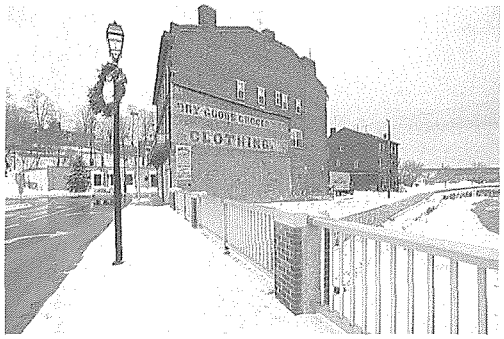
- Do no cleaning or repainting until samples of paint are taken from all exterior surfaces. Save, catalogue and analyze samples for colour and, if necessary, paint chemistry. Catalogue samples fully and accurately, keying locations to photographs and drawings. Store paint samples along with project records for future reference.
- Take paint samples from many places, even on what appears to be the same surface, and especially on any raised or embossed surfaces — these are likely to have had accents of several colours at one time or another.
- Take paint samples both as chips of peeled or broken paint and as feathered or sanded patches that indicate the layering of colours over time.
- Paint all surfaces that were historically painted. Do not strip previously painted wood to its base and varnish or seal it to appear unpainted — this is historically inauthentic, and exterior varnish will break down under ultraviolet light and expose the wood to atmospheric damage unless regularly renewed (and it must be renewed more frequently than paint).

Though this paint has clearly "failed", its underlying woodwork shows no decay.

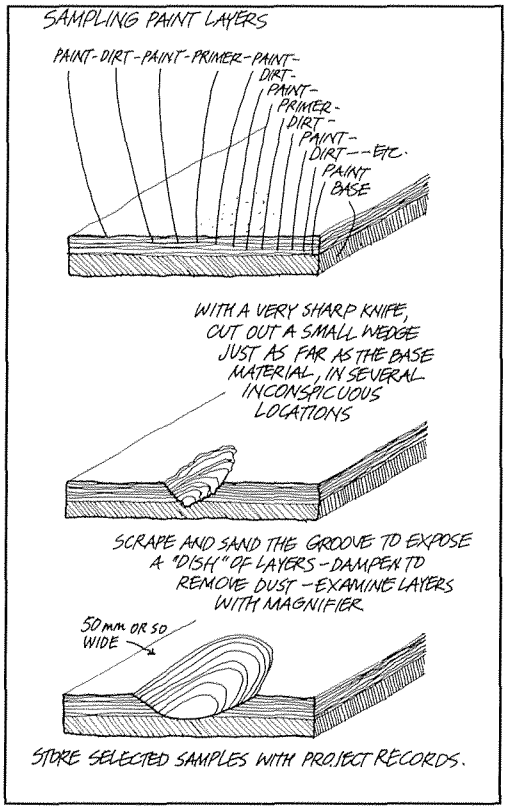








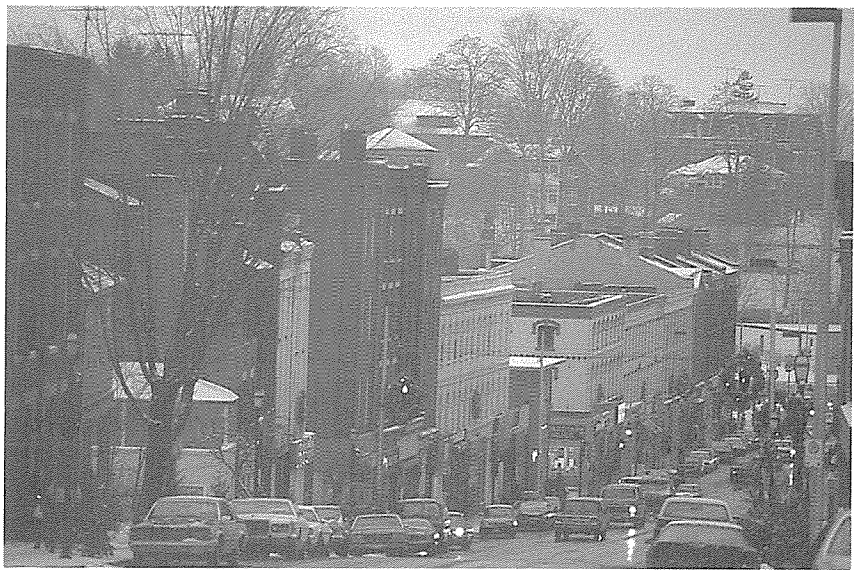
Detailed ornament cannot accept many coats of paint before it loses its focus and texture. Preparing it for fresh paint must be a very careful job (top and above). Sometimes (in this case because of an unfortunate demolition), long-obscured painted signs are revealed, and these deserve protection as virtual archaeological resources (above right).

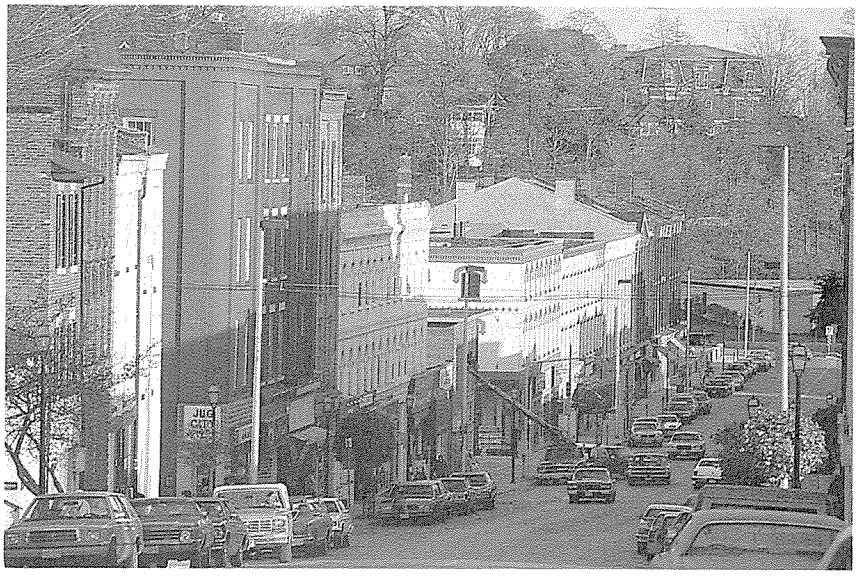


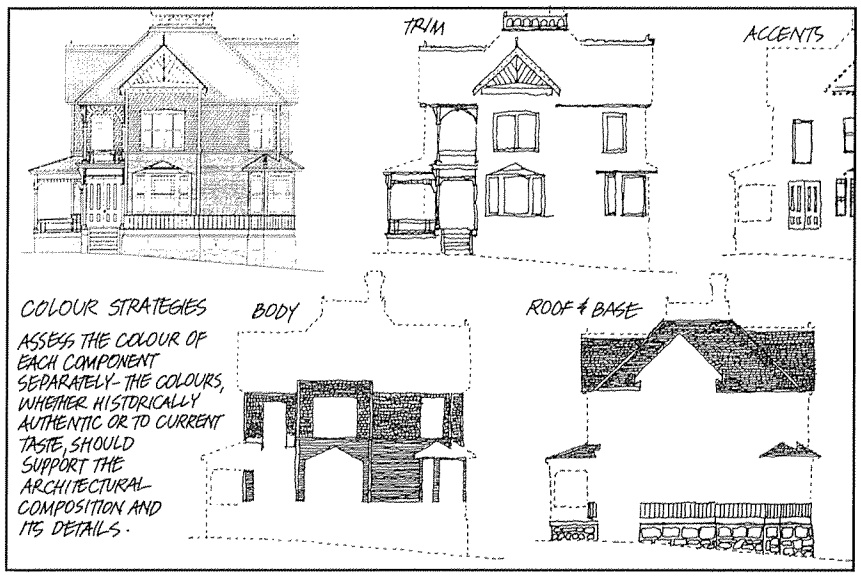
Cleaning and preparation

There are many guides to proper exterior painting practice; the notes below refer specifically to repainting conserved elements.

- Complete all basic repairs and replacements and remove surface dust and grime, before preparing, priming and painting. Be sure that surfaces to be painted are *dry*. The best times for exterior painting are spring and fall.
- Scrape and sand painted surfaces only as deep as necessary to reach a sound base, whether previous paint or base material. Do not strip *all* previous paint except to repair base-material decay, to restore operation of a movable feature (for instance, window sash), or to reveal the profile and modelling of details obscured by paint build-up. Once they are exposed, prime all unfinished wood surfaces, taking special care to mask knots.
- Take appropriate safety precautions when removing lead-based paint: wear a face mask and coveralls and dispose of the very poisonous residues carefully.
- Use an air gun or electric heat plate to help remove paint rather than a blowtorch, which may ignite trapped dust or the wood beneath the paint or release toxic fumes from lead-based paint.
- Clean and sand all surfaces and completely remove residues of any sanding, brick or mortar dust, and cleaning chemicals. Sanding alone will not remove mildew or mould — use a proper fungicide.
- Choose the appropriate primer to bind finish coats of paint to base material; there are different primers for metal, wood and masonry. Consult paint manufacturers' technical specifications to be sure of the right choice.
- As much as possible use, oil or alkyd exterior primers and paints over existing paints, which are likely to be oil-based themselves (unless quite recent). If using latex, cover the previous oil paint with an oil-based primer; even a latex primer will not bond well to oil enamel. Always sand between coats of primer and finish paint.



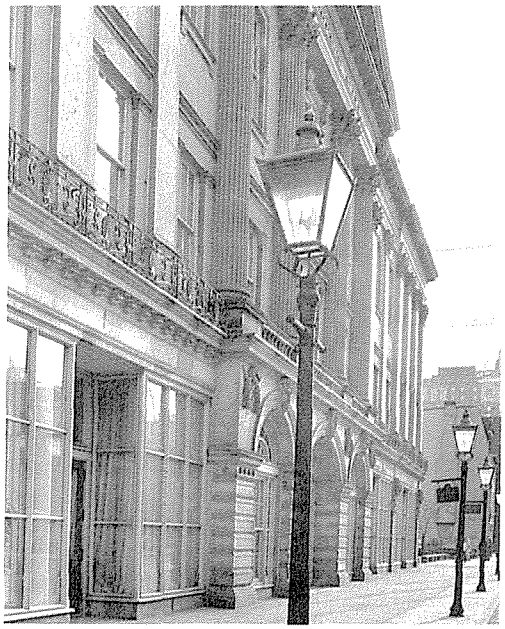




The right colours

- In matching historic colours, consider above all the very changeable quality of daylight; its colour temperature (visual coolness or warmth) varies during the day and during the year. As much as possible, assess and compare colours under a variety of lighting conditions, especially those that affect the building itself.
- When judging historic colours from paint samples, do not confuse primer and finish colours. A high-powered magnifier or low-powered microscope should reveal traces of dust on the exterior surface of the actual finish colour.
- Since many pigments oxidize and fade with time and with varying exposure to light, start to determine historic colours from samples taken where sunlight does not reach or from the underside of a colour layer (viewed under the microscope). The oil vehicle holding the pigment will yellow in darkened areas, including those covered by subsequent layers of paint. Historic colours may not be as yellow as they would first appear from such samples. A paint sample with a pale blue surface and a deep green interior may well have been deep blue originally. And in historic practice, pigments were not ground as finely as they are today, so that old painted surfaces may seem to have a somewhat different visual depth than those painted recently. When in doubt, consult a conservation expert familiar with the chemical and physical aging of paint.
- When matching historic and contemporary colours, use dry samples with similar finish; the colour of paint in the tin will be quite different from its finished appearance (matte, gloss, or in between). Even if periodically cleaned, and apart from their photochemical fading, all colours will soften with dust.
- Do not be slavish about matching the original colour, but do pick a colour appropriate to the era and style(s) of the building. Paint is as much a maintenance item as a permanent feature; every cleaning operation will reveal many layers of paint, often of different colours to suit the changing moods of the owner.

The wall mural is becoming popular as a focus of community activity and pride (and occasionally reviving as an advertising medium). It can coexist with historic architecture if care is taken not to conflict with the form and details of the building. Side walls are thus far more suitable for artwork than principal façades.



Few original exterior lighting standards or fixtures survive — in recreating their presence, it is important to base replicas on those used formerly in the given community, not on generic models (right). Rather than using the now virtually universal backlit fluorescent boxes, historic building fronts and signs should be illuminated from in front and above, following historic precedents (bottom).

(opposite)
Colours vary in appearance by time of day and time of year — selecting or matching old and new must involve careful understanding of the colour and quality of light, both natural and artificial.

- Select colours from a spectrum appropriate to the neighbourhood and period; if the original woodwork was painted a horribly murky maroon that you desperately don't want, choose another dark colour of that period, perhaps one that a neighbour might have used — but refer to local historical and archaeological evidence for the choice.
- For most mid- to late-19th-century buildings, follow the general Victorian colour strategy of reinforcing the effects of projecting and receding planes; use darker colours for doors and window sash than for their surrounding frames, to emphasize openings receding into the façade.
- Use a matte or dull finish on painted metal surfaces to make them appear solid; the play of light on inevitably irregular gloss finish weakens their visual presence.

Exterior lighting

- Maintain historic lamp standards and lighting fixtures where they survive; consider reproducing missing lamp standards from historical photographs and documents. Though there are numerous cast-aluminum reproductions of cast-iron originals available, use only those that match closely the size and proportions of surviving originals or as shown in documentary sources. Paint lamp standards to match original colours, based on paint samples from the existing or a nearby standard.
- Use incandescent luminaires to correspond to historic colours of light.
- When floodlighting or illuminating buildings, ensure that wiring and lighting are fastened to the building in a manner that will not cause deterioration of masonry or woodwork and will not create combustible conditions.
- Illuminate buildings in colours and patterns that bring out the essential forms and profiles visible in daylight. Use incandescent or similar light sources to render accurately building and material colours. Use front-illuminated signs.