# PRECAST CONCRETE

## A SELECTION GUIDE FOR SURFACE FINISHES

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Reprinted from *Constructional Review* Vol.60, No.4, November 1987

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Decorative finishes for precast concrete products combine the traditional skills of the concrete artisan, the design skills of the professional engineer and the practical experience of the precaster.

Knowing that he has these skills at his disposal, the architect can direct his efforts towards combining shapes, textures and colours to achieve the desired effect on the structure and its surrounds, and accordingly, on the environment.

The increasing requirement to provide fire rating (2, 3 or 4 hours) to industrial developments has generated the incentive for clients and developers to select the cost-effective option of providing hollow-core cladding with exposed aggregate finishes. The result is a significant improvement in the light industrial and commercial environment. The upgrading of such establishments has been achieved with only a small percentage increase in cost.

A similar trend is apparent in the multi-storey commercial building sector. Greater emphasis is now being placed on achievement of the architect's concept, self-cleaning facades energy conservation and maximum quality rather than minimum cost.

The following finishes for precast concrete have been selected on the basis of:

- practical precasting;
- architectural appeal;
- application to precast units which will provide structural solutions to project requirements.

Finishes considered include:

- off-form finishes;
- water-washed exposed aggregate;
- chemically retarded exposed aggregate;
- sandblasted exposed aggregate;
- acid-etched finishes;
- polished reconstructed stone;
- honed or polished and acid-etched;
- polished and sandblasted finish.

These finishes have been selected as the most useful group of finishes that the precaster can offer to architects and clients. The list is obviously not intended to cover all finishes nor is it intended to suggest limitations in developing new finishes.

Mix design, careful selection of materials and the need for practical and innovative mould design are of vital importance in achieving pleasing results for the architect, satisfactory structural solutions and a profitable result for the precaster.

A number of factors require consideration in the preparation of mix designs and trial mixes for all finishes.

These include:

- the finish required;
- the shape and size of the units;

- the workability required to allow the mix to be placed and consolidated in difficult areas;
- the required compressive strength (usually governed by the precaster's requirement for a 24-hour casting cycle);
- the durability requirements (water absorption) freeze thaw conditions, exposure to salt water spray, etc;
- trial mixes should be carried out using techniques and finishing methods that follow proposed production methods as closely as possible.

The concrete produced must provide the required surface finishes and comply with the appropriate standards and project specification.

All materials should be tested for compliance with the appropriate codes and for any inclusions that could cause long-term staining. Stockpiling aggregates is recommended to ensure uniformity.

## Off-Form Finishes

Whilst a smooth off-form finish may be one of the more economical finishes, the production of off-form concrete to a consistent colour and standard of finish will require a high degree of production control if problems are to be avoided.

Cement and sand colour to a lesser extent will control the final colour of the unit, with the fine aggregate contributing to some extent. The colour of the coarse aggregate may not be significant unless the particular unit requires extremely heavy vibration, in which case some aggregate transparency may occur, causing a blotchy and irregular appearance. Grey cements are more likely to cause colour irregularity than are off- white or white cements.

Moulds need to be carefully designed to ensure against any leakage whatsoever. Wherever possible tapers should be built in so that the mould can be permanently sealed. After each casting, meticulous cleaning will be necessary, followed by regular burnishing with steel wool (assuming a steel mould). A very thin coating of mould oil, usually sprayed on and then wiped with clean rags, will ensure high quality castings from steel moulds.

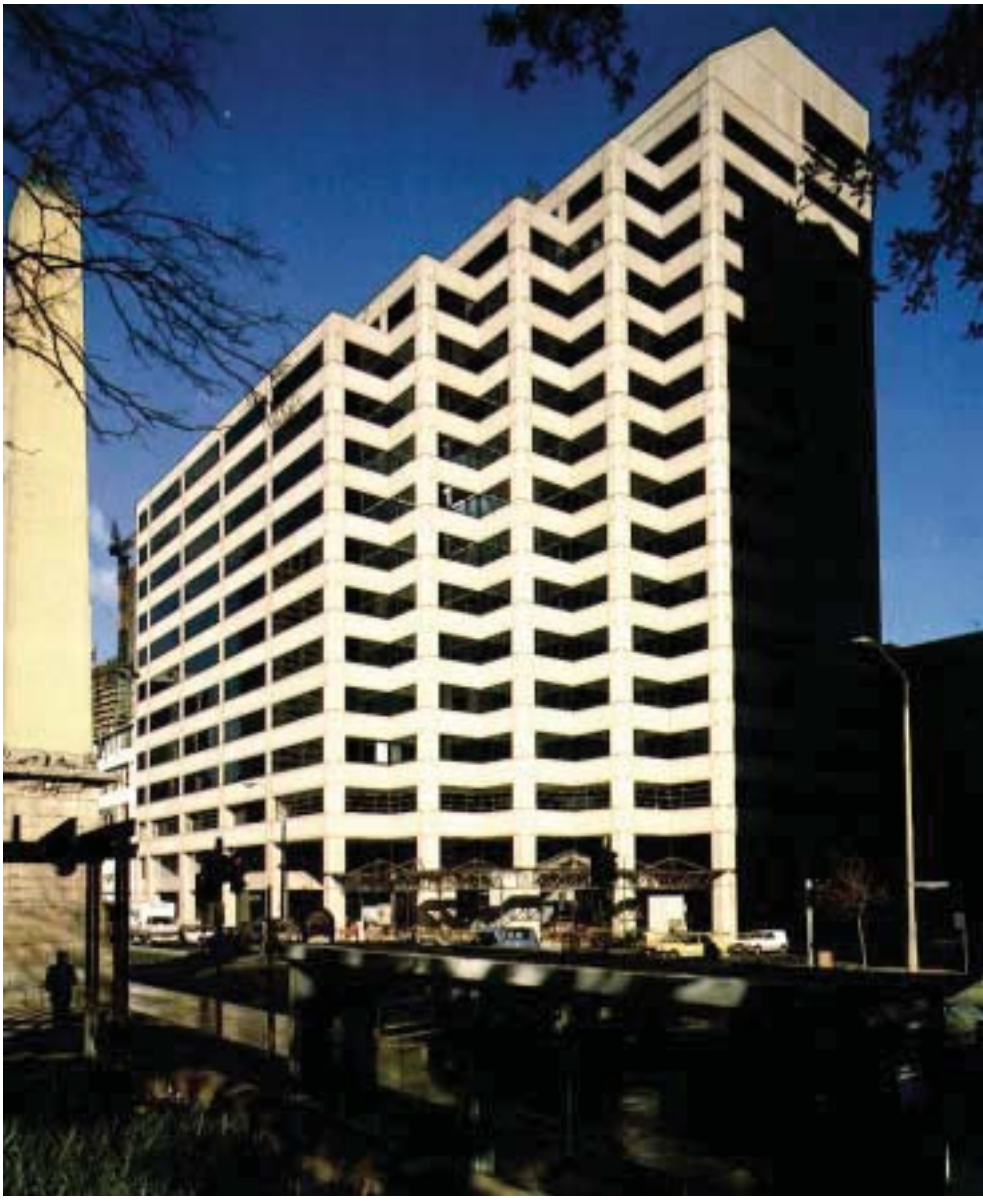
Off-form units usually will have some surface imperfections. Joints in steel plates, minor variations in the surface texture of a steel casting table, voids caused by air trapped in the vertical mould surfaces, etc, will be obvious on this finish. As with all other finishes, a sample programme should be undertaken before casting commences to ensure that the architect is aware of the surface finish that will be finally achieved.

Off-form units produced with concretes with high cement content may exhibit some surface crazing after curing. This is a surface defect which is usually only visible on careful close examination. However, if exposed to the atmosphere, accumulation of atmospheric grime will accentuate these cracks. Other than affecting the appearance, these~ cracks do not affect the structural properties of the unit nor its long term durability

Uniformity of manufacturing procedures is most important. Procedures that ensure consistent techniques for cleaning the mould, application of mould oil, uniformity of concrete quality, consistent curing processes and careful storage procedures will all contribute to produce a quality off-form product.

Handling procedures and materials should be designed to minimise chipping and other damage. A smooth off-form finish is probably the most difficult of all precast finishes to repair.

It is recommended that wherever possible, off-form surfaces should be modulated by grooving, sculpturing or profiling. Any introduction of shapes to provide shadow effects will enhance the final result.



***Facing page – polished reconstructed-granite-aggregate panels on the CML Building, Brisbane.***
***Top – OTC House Sydney - a combination of polished and sandblasted finishes.***
***Bottom – detail of OTC House showing recessed polished borders contrasting with the sandblasted central area of the panels.***

Materials other than steel may be used for the moulds. Plastic liners can be used to provide a variety of surface textures and shapes. TImber and plywood also may be used. When considering materials other than steel for off-form finishes, it is also necessary to consider the effects of the curing process on these alternatives. Steam curing will adversely affect timber and plywood mould surfaces.

A plaster-of-paris mould sealed and then treated with a wax will provide an excellent off-form surface for sculptures.

Finishes such as hammered nib follow on from off-form casting techniques. As with other off-form finishes, consistency is of vital importance. Hammered nib finishes are produced by breaking the nibs on an off-form unit in a consistent and uniform manner.

Trials to establish the mix and aggregates which provide the required appearance on the broken surface are essential.

A similar technique is a rope finish formed by fixing ropes over a plywood or timber mould, moistening them before casting and then after casting, the ropes are pulled out of the hardened concrete by mechanical means. As in all other finishes full scale trials are essential to achieve a satisfactory result.

**Water-washed Exposed Aggregate**

A dense, round or crushed aggregate water-washed finish is useful and attractive. Aggregates should be selected for colour and consistent grading. Aggregates that crush to flaky angular shapes may not give a consistent appearance. Round river aggregates are ideal and generally a gap graded mix should be considered. The washing process will remove intermediate sized aggregate from a fully graded mix thus reducing the density of the finished surface.

The ideal maximum aggregate size for a given project will depend on a number of factors:

- The washing process will remove a large volume of matrix. The larger the aggregate, the greater the depth of matrix to be removed.
- The washing process should leave about two thirds of the aggregate embedded.
- Depth of washing, ie the maximum size of aggregate, affects the unit thickness as the required cover for reinforcement may need to be increased to include the depth of aggregate exposure.

It is desirable to vary the matrix colour wherever possible to match or blend in with the colour of the aggregate. This match can be achieved by careful selection of

***Facing page: top – example of vertical casting to obtain a smooth off-form finish on both sides; middle – aggregate exposed by water-washing in the casting yard; bottom – water-washed aggregate finish.***

***Top left – application of retarder to mould face; bottom – panels cast face down with aggregate exposed by chemical retardation; top right – cement matrix washed off by high-pressure water jet.***

cement and sand colours. Good matrix to aggregate match will pre vent "patchy" effects which sometimes show up only after erection on site.

Water-washing is suitable for use on all flat architectural units which can be cast face up, from 600 x 600 mm paving slabs to longline prestressed wall panel systems. With careful mould design heavily profiled window units, etc, are feasible and economical.

Mould design of such units should incorporate tapers to allow mould sections to be "slid" off the precast unit rather than lifted off. The "sliding" process will minimise slumping and aggregate dislodgement problems.

Plant requirements include an adequate water supply and water recycling facilities. The washing process creates a large volume of slurry for disposal.

Water-washed exposed aggregate is the most economical finish available and, in some circumstances, is less costly than trowelled finishes.

Heat-accelerated curing methods are suitable. Condensation stains from steam curing are readily removable with a light hydrochloric acid wash. Regardless of the curing method, a light acid wash is necessary to thoroughly clean the aggregate and exposed matrix. The unit should be thoroughly wetted with water before applying acid and, after allowing a short period for acid cleaning, all traces of acid should be removed with high pressure water.

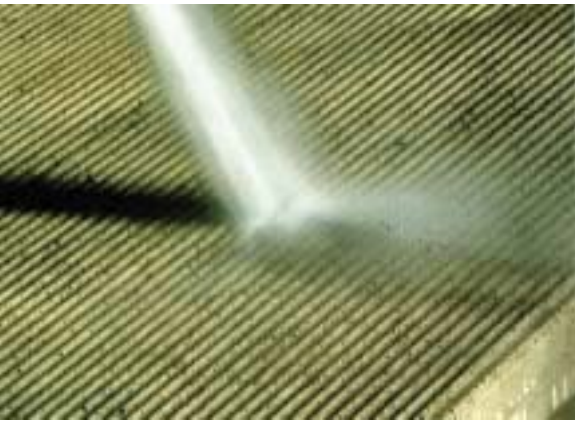
## Chemically Retarded Exposed Aggregate

This process requires the application of a chemical retarder to the face of the mould. A curing period is required to allow the retarder to set prior to casting the concrete. The selection of the retarder will depend upon the depth of exposed aggregate required. Retarders are available for light, medium and heavy surface finishes. The effect of the retarder is to delay, but not to prevent, the set of the cement matrix so that after the concrete has been cured usually overnight the cement matrix may be removed from around the aggregate by brushing and/or the use of high-pressure water jetting.

The selection of the appropriate retarder to produce the depth of cut required will depend upon the size of the aggregate to be exposed. After the selection of the aggregate and the design of the mix (usually gap graded) a number of sample panels should be prepared to evaluate the ability of the particular retarder to provide the depth of exposure required. The manufacture of the samples should follow as closely as possible the proposed manufacturing procedure. Variations in accelerated curing procedures will affect the ability of the retarder to maintain sufficient cement matrix in a plastic state to allow its removal without excessive difficulty and labour costs.

As retarders are normally used for those exposed aggregate surfaces with considerable architectural detail, the ability of the retarder to resist abrasion on vertical and sloping faces during the concrete placing process, and still maintain an even retardation, will be critical.

Samples, wherever possible, should include the more detailed portions of the proposed product. If the concrete during placement is able to pick up retarder and cause it to accumulate in corners, grooves and rebates, the effect will be heavily exposed details and under-exposed adjacent surfaces. The preparation of a series of samples complying with the retarder-manufacturer's recommendations and the precaster's requirements, will ensure that production problems are minimised.



In production, the retarder may be applied by roller, brush or spray Considerable care is needed to ensure that the coatings are even to minimise variable depth of exposure. When production commences it will be necessary to maintain a reasonably uniform time delay between placing the retarder, allowing it to dry and then placing the concrete. Concrete should be placed with great care to minimise flow under vibration so as to prevent, as far as possible, the concrete causing an accumulation of retarder. Cloths and paper impregnated with retarders are also available.

After curing, the cement matrix may be removed by brushing and washing by hand, or by the use of a high pressure water jet combined with some brushing, to achieve uniformity Again this process should take place immediately after stripping and if possible at a predetermined time after casting.

The production of good retarded finishes requires consistent and high-quality concrete, uniform curing procedures and maximum adherence to a uniform time cycle.

As with other exposed aggregate finishes, the finished unit should be cleaned with a dilute solution of hydrochloric acid after wetting down with water. The acid should be removed using a pressure spray and sufficient water to ensure that all traces of acid have been removed.

A retarded surface can also be produced by casting the product face up and then spraying a surface retarder to achieve the same result as described for the face down process.

This process has only limited applications because the same result can be achieved by water washing at significantly less cost.

**Sandblasted Exposed Aggregate**

Sandblasting using water as the carrier provides a dense even "sandstone" textured precast panel. As the finished surface comes "off the form", profiled shapes, ribs, reveals, etc are all possible, thus giving the architect great freedom in the design of the exposed face.

The sandblasting process requires a great deal of operator skill. The area being cut by the sand is hidden with a film of water and can be assessed for the required depth only when the cutting stream of sand and water is moved, usually in a circular motion, to the next area. The cutting stream of sand and water must be continually moved to ensure even cutting. Angle of cutting can also be important to ensure heavily profiled units are cut evenly on all exposed surfaces.

Sandblasting using air as the carrier allows better operator visibility but may be restricted because of pollution effects (dust) or Government regulations. Cutting materials that could cause "silicosis" must be avoided. Copper slag is a suitable alternative.

Depth of cut is usually comparatively light varying from a minimum "wash" blast, which is only sufficient to remove the cement skin from the off-form surface, to a "deep" cut

***Facing page: top left – Wet sandblasting of striated finish; bottom – spandrels with striated finish; top right – offices, Mary Street, Brisbane - sunhoods cast face down, then sandblasted.***

***Top left – light acid-etched finish used at Parliament House ACT; top right – etching with phosphoric acid; bottom left – CML Building, Brisbane - polished reconstructed-granite-aggregate panels; bottom right – polishing a panel using a twin-head Hensel machine.***

removing some cement and sand to reveal some aggregate colour.

Cement and sand colour should be chosen to blend with the slightly "bruised" colour of the sandblasted aggregate as the cement sand matrix colour will predominate.

Casting is generally economical provided reasonable repetition is available.

Concrete needs to be carefully placed in the moulds to ensure full mould coverage before vibration. Slurry lines exposed during blasting can be caused by uneven placing. Moulds need to be sufficiently rigid to prevent local "hot spots" developing, as these areas will lack surface aggregate density after sandblasting. Units should be crack-free at the time of sandblasting as cracks, including very fine shrinkage and structural cracks, are opened out and accentuated by sandblasting.

Heat accelerated curing methods are suitable.

A light hydrochloric acid wash (after wetting down) is necessary after sandblasting to expose the natural colour of the sand and aggregate. Finally clean with high pressure water.

Plant facilities required include a semi-enclosed blasting area and adequate cranage. Product needs to be:

- lifted from casting bed to storage area;
- moved to sandblasting;
- possibly rotated;
- then lifted to storage.

Sandblasting equipment should be selected to provide an adequate cutting rate within the operator's control. Overpowered equipment can lead to excessive cutting which may not be repairable, thus causing unit rejection.

## Acid-Etched Finishes

This finish is produced by cutting the cement matrix from the face of the product by etching with hydrochloric acid.

Acid etching carries with it a significant risk of reinforcement corrosion because of residual chlorides. Accordingly it should be used only after the engineer has considered and specified the additional cover to reinforcement required to ensure adequate protection.

Acid etching is a fine finish - the materials exposed are primarily the cement and sand with only a small percentage of coarse aggregates being visible. Consequently, stockpiling of sand is important to ensure uniformity as variation in sand colour will show on the finished product.

The etching process is executed by applying acid, allowing a reaction period and then removing all traces of acid by high pressure water spray The product should be thoroughly wet before the application of acid. Dipping is NOT recommended.

The introduction of a small percentage, eg 1-2%, of marble dust will accelerate the process and ensure that all of the acid applied will be neutralised.

The acid should not be allowed to lie on the surface but should be scrubbed or brushed as the formation of silica 'gel" will slow down acid attack and if allowed to dry out will be most difficult to remove.

## Polished Reconstructed Stone

Polished reconstructed granite and stone finishes compare favourably with polished natural stone facings giving the architect the freedom to design a building facade using the full structural capability of precast panels.

This finish is produced by grinding approximately 3mm off the off- form face of the precast components.

Degrees of surface finish may be produced depending on the grade of the last grinding stones used:

- No.3 stone = coarse hone
- No.4 stone = fine hone
- Felt pad and polishing powder = full polish.
- Honed finishes do not bring out the full colour potential of the stone; however, they provide an attractive finish suitable for floors or paving.

A fully graded mix is preferred, carefully designed to provide maximum aggregate density on the surface to be polished. Even placement of the concrete over the full face area followed by heavy vibration will provide the necessary maximum aggregate - minimum matrix surface required for this finish.

Surfaces cast vertically will require special attention to ensure that slurry lines do not show between concrete placements.

The use of "poker" vibrators will result in vibration patterns and slurry concentrations and are therefore not recommended.

It is possible to hand float a surface to be polished; however, careful attention will be required to prepare the dense aggregate surface. Additional grinding will be necessary to match the off-form surfaces after polishing.

Careful detailing to maximise the use of automatic polishing equipment and minimise hand polishing will ensure minimum cost. Product dimensions should provide for grinding allowances. Moulds need to be sufficiently rigid to transfer vibration to the concrete without creating vibration "hot spots".

Hand polishing of arrises, returns, etc not accessible with automatic equipment, is slow and costly and should be designed out where possible.

Components requiring uniform finish on all surfaces will need special attention and care to match hand finished faces with vertical faces and horizontal surfaces.

As with other finishes, final appearance and uniformity will benefit if it is possible to match or blend matrix colour with aggregate colour.

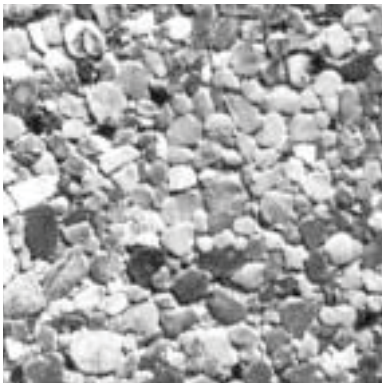
Heat-accelerated curing methods are suitable.

## Combined Finishes

**Honed and Acid Etched** – the combination of a machine finished, polished or honed surface, and acid etching provides a surface which exposes a very high percentage of stone. After the grinding process, the acid then removes the cement matrix and fines from between the larger aggregate particles. This surface is highly resistant to weathering and is self-cleaning to a high degree.

This combination is very suitable for paving. The recesses created by the acid etching provide a surface that is reasonably non-slip. Provided a high degree of aggregate density is achieved on the surface this finish can be wear-resistant and retain its appearance for many years.

The comments on polished reconstructed stone finishes and acid etching apply However, in this instance, because of the effect of the etching,



***Facing page – State Parliament Offices, Sydney, where yellow-brown quartzite aggregate was exposed by honing and acid-etching; top – panel shape requiring some costly hand-finishing; bottom – finish of precast panels, State Parliament Offices, Sydney***

aggregate colour predominates. Unusual effects can be achieved by using round river pebbles as the aggregate. As the external surface of the aggregate is exposed by the acid etching and the internal surface by the grinding process, interesting and attractive results can be achieved.

Additional cover to reinforcement should be allowed to provide for p05sible effects of residual chlorides from the acid etching process.

Sealing of the mould to prevent any leakage of cement matrix under vibration is essential to prevent discolouration at the point of leakage.

All of the cautions previously given for honed, polished and acid etched finishes should be considered.

Surfaces cast vertically tend to show a finer aggregate configuration than horizontal surfaces cast against a mould face. Hand-finished (horizontal) surfaces which are intended to match vertical and off- form surfaces after finishing, are difficult to achieve and should be avoided wherever possible.

The structural design of the product should provide for crack- free stripping and handling of the product. Acid etching of fine, bending or shrinkage cracking will dra
matically emphasise the cracks. Rectification of these faults can be most difficult. After stripping, the surfaces to be finished should be stored on "dipple pad spacers". These spacers will allow air circulation so ensuring that the contract surface at the point of support will cure to the same degree as the remainder of the unit. Storage of unfinished product on timber; plastic or any other material which prevents air circulation will result in a "curing mark" which can take a very considerable period to weather out.

All exposed metal work, fittings, threaded inserts and projecting reinforcement should be properly protected from acid attack.

In the interests of economy, the precast units should be designed to allow maximum use of automatic polishing equipment.

**Polished and Sandblasted Finishes** – whilst the polished/acid-etching combination provides a surface finish in which the colour of the aggregate predominates, the polished/sandblasted finish provides a dramatic contrast between the polished aggregate and the sand- blasted matrix of the concrete.

The possible use of this combination requires the designer-architect to take an early decision to ensure that the overall concept makes allowance for the change in colour and texture of the two finishes and that a suitable demarcation is detailed to separate them - usually a V groove. The exact shape of this V groove will require consultation with and trials by the precaster to ensure that the angle within the V
groove is sufficiently Hat to prevent chipping the edge in the grinding process and causing an unsightly line on one side of the groove.

The designer will also need to consider that the polishing process will create a step in the surface between the polished and the sandblasted finish of approximately 3mm which can cause problems when aligning precast units on site. This can be overcome during the design process. Casting a series of trial panels is strongly recommended to provide full knowledge of the combined effects.

It is necessary to mask the polished finish during the sandblasting process. The polishing process is completed before sandblasting. The normal light hydrochloric acid wash to the sandblasted finish is applied with care to ensure that any acid that may be applied to the polished finish is removed immediately before it can attack the matrix.

## Summary

Surface finishes offering architectural and structural solutions considered from a precaster 5 viewpoint. Finishes considered include:

- Off-form: usually regarded as the least expensive finish but problems can occur with colour uniformity
- Water-washed Exposed Aggregate: a low cost solution that has been tested over many years.
- Chemically Retarded Exposed Aggregate: an excellent solution when water-washing is impractical.
- Sandblasted Exposed Aggregate: offers good fine finishes for profiled shapes.
- Acid Etching: an attractive finish with some possible long-term durability risks.
- Polished Reconstructed Finishes: prestige appearance and excellent self-cleansing properties.
- Combination Finishes: offer excellent possibilities for architectural use of tones and textures in facade treatments

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*The author wishes to acknowledge the assistance of Boral Ltd in providing photographs.*