Architectural Surface Finishes

Introduction

Reinforced concrete is unique among the ever-increasing range of building materials the designer can choose from. When used as a massive element in a building it can provide the required structural capacity, can define space and be seen as the architectural surface, all in one. It is also the only contemporary construction material that in the hands of the contractor passes through a plastic state that allows it to take on the shape of the formwork into which it is cast. Moreover, the process allows the surface to be rendered as the negative of the surface it is cast against.

Catholic Cathedral of Los Angeles.
Coloured in-situ concrete.

The appropriate use of exposed concrete elements can enhance a building in many ways, among them the architectural qualities. Concrete can be produced with a broad range of surface finishes, making it ever more attractive to architects and designers. With renewed interest in materials and surface finishes evident over the past decade designers are also exploring how concrete can affected as an architectural element.

When concrete is exposed as the visible architectural surface it is most likely contributing to the:

- Cost efficiency of the initial building project by not requiring application of surface finishes costing time and money
- Thermal and energy efficiency by allowing the density of the material to dampen temperature swings over the course of a day.

It is also likely that the exposed concrete will be more durable over its life than any other lightweight cladding or finish.

Objective of this I.B.

To provide general information to specifiers and builders on the many various concrete surface finishes that can be achieved.

This bulletin is not intended to provide all the technical information necessary to achieve these finishes nor is it possible to present all the various finishes that can be achieved. Many of the references given at the end of this bulletin are a useful source of further technical background.

General Background

The care exercised in the selection of the raw materials and in the shaping of the formwork will

be reflected in the quality of the final surface. It is therefore important before selecting the forms, materials or mixes to have a clear understanding of the different modes of treatment possible. The presentation of information in this bulletin is grouped under the three categories for finishes established by NZS 3114: 1987 Specification for Concrete Surface Finishes. These three categories are:

Type A: Concrete surfaces that are produced by manipulating the surface of the form before casting the concrete.

Type B: Concrete surfaces that are produced by manipulating the surface of the fresh concrete before it has set.

Type C : Concrete surfaces that are produced by manipulating the surface of the hardened concrete.

These three methods of achieving the concrete surface can be applied to cast-in-situ or precast concrete construction.

It would be difficult to represent the full range of surface finish possibilities in any one publication. The examples have been included to help illustrate the qualities of each surface finish. The examples are largely found in New Zealand, a fact that should give designers confidence in specifying these finishes. It is clear that all can be successfully manufactured by the local concrete industry.

It is important that designers work with the contractors and manufacturers to achieve the desired results. We are very fortunate in New Zealand to have an industry that is approachable and willing to rise to any challenge. By working closely the designer will better understand the processes allowing him or her to work with or in some cases change the process to enable a better outcome. The manufacturer may enhance the outcomes with suggestions to the designer.

Type A Surface Finishes

This is the most common, often being referred to as fairfaced concrete. The finish is produced by the pattern of the concrete form being mirrored on the concrete. It may be the most economical form of production provided that adequate measures ore taken to avoid the need for remedial work after the formwork is stripped. Such measures demand the following precautions be taken:

1. Attention to detailing, with adequate provision for joints, edges, corners, drips and other weathering details. Adequate measures must also be taken to allow smooth form removal that does not lead to damage requiring remedial attention.

2. Clean, well maintained and watertight forms (See also Information Bulletins 29 and 41).

3. A concrete mix with adequate cement content, low water/cement ratio and high density.

4. Adequate consolidation and uniform curing to help ensure uniformity of colour and texture.

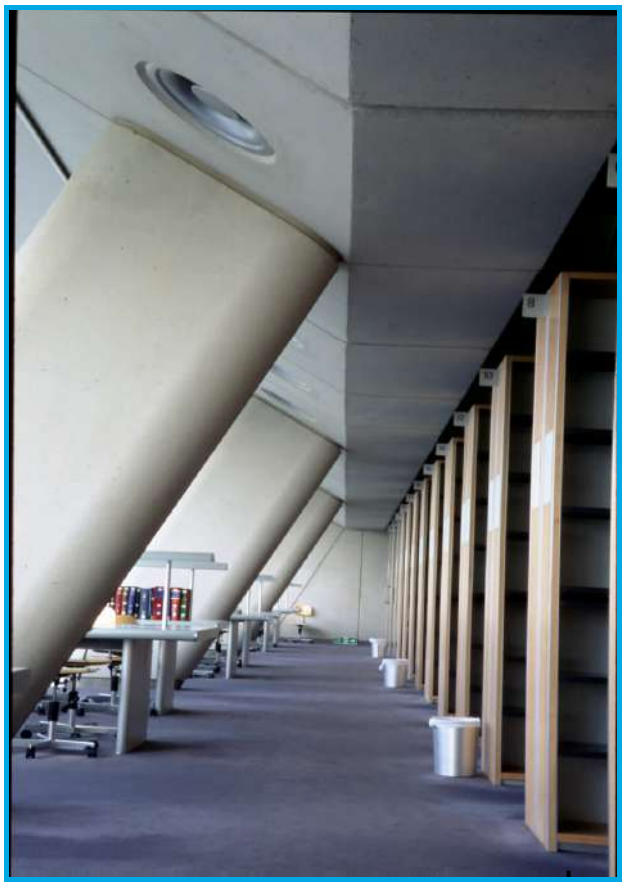
5. Protection to reduce the likelihood of chipping and damage after casting.

Steel or Plywood Sheet Formwork

Sheet formwork can be used to achieve a concrete surface with minimal texture and minimal evidence of joints. The joints between steel sheets can in fact be welded and finished to be almost imperceptible in the concrete. A shortcoming with the use of sheet formwork that is highly impermeable is the likelihood of blowholes in the surface of the concrete. This will occur more often in concrete that is cast face down and arises from small pockets of air that are not eliminated through vibration. A great advantage of using impermeable formwork is the increased consistency of colour that can be achieved.

St Paul's Cathedral, Wellington.
Cast in-situ concrete.

Lyons TGV Station, France.
Cast in-situ concrete.



University of Cambridge, United Kingdom.
Precast concrete.

Board Formed

Timber boarding has been one of the more common formwork materials throughout the history of concrete use. During the 1960's in New Zealand architects began to exaggerate the imprint the timber would leave by lightly blasting the surface to raise the grain and by using a vee joint between T & G boards. Another method of creating desirable surface texture is to band saw the timber boards.

Uniformity of colour can be enhanced with all porous formwork by thoroughly sealing the surface prior to the first use.

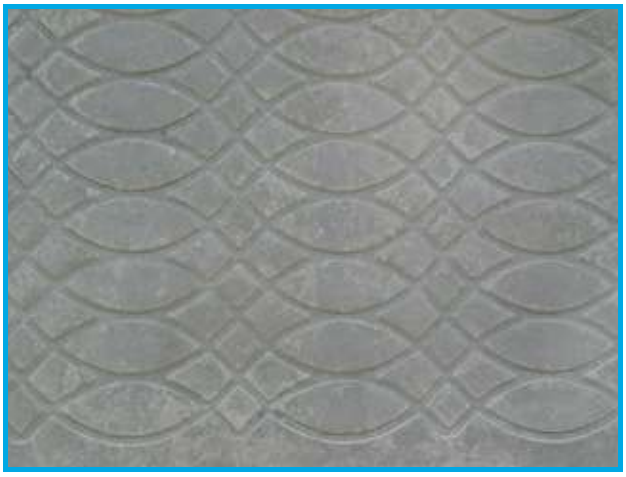
Mølster Museum, Voss, Norway.
Board formed cast in-situ concrete.

Form Liners

Concrete surfaces can be enlivened through texturing or modelling. This is also an effective way of disguising surface imperfections.

Form liner materials include styrene foam, rigid plastics, fibreglass, polyurethane rubbers, silicone rubbers, profiled steel sheet and timber battens. The choice of the form liner material will be based on the complexity and depth of the modelled surface, and the number of reuses.

Cement hydration produces temperatures up to 60°C. High temperatures may degrade the form liner material.



St. Joseph's Church, Wellington.
Precast concrete using form liners.

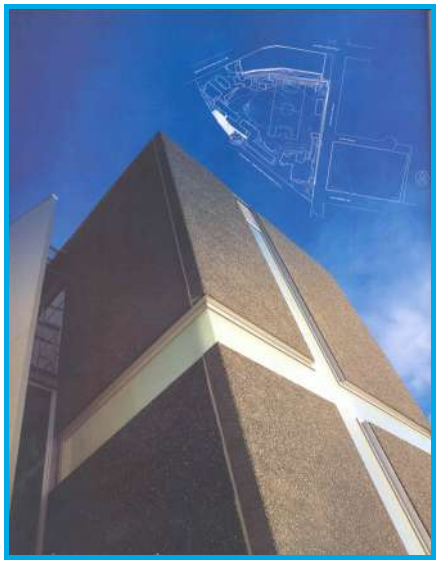
Poetry Panels, Wellington.
Precast concrete using form liners.

Plastic Rumpled Appearance – Lyon University.
Cast in-situ concrete using form liners.

Colouring Pigments

Integrally coloured (or colour-through) concrete refers to colouration to the full depth of an in-situ or precast concrete element. The mineral oxide powder is added to the concrete mix and thoroughly dispersed.

A monolithic topping is a layer of concrete that is placed on top of a prehardened structural slab or precast panel while it is still in its 'plastic' or workable state. This allows bonding of the two as they harden simultaneously, effectively producing a monolithic unit. The appearance can be the same as for integral colour, but of course the colour appears only on one side. There are, possibly, cost savings as a result of reducing the amount of oxide required.



St Peter's School, Auckland.
Precast concrete. Eexposed aggregate and coloured concrete.

Lyons TGV Centre, France.
Coloured cast in-situ concrete.

Barcelona Convention Centre, Spain.
Cast in-situ coloured concrete.

Controlled Permeable Formwork

Concrete is normally cast against impermeable formwork that leads to a relatively smooth concrete surface finish.

Controlled permeable formwork (CPF) has been developed to improve surface durability of the cast concrete. Air and excess water that remain trapped at the formwork can result in surface imperfections in the concrete. CPF works by allowing air and water to be absorbed into the surface of the formwork. As a result cement grains pack more closely and the concrete surface is smoother, in some cases glass-like.

Type B Surface Finishes

These effects result from special treatment of the concrete surface while still in its plastic state.

Exposed Aggregate – Water Washed

One of the earliest and still most popular of the Type B techniques is that of exposed aggregate. Here the outer paste is removed through the application of water to reveal the aggregate within. The exposed stone may be the normal coarse aggregate or it may be a special material selected for its appearance.

This technique requires skilled technicians to achieve the best results. Variables to be accounted for include weather conditions, mix design and geometry of the area to be treated. Careful thought must be given to the control of the runoff as indiscriminate release can cause environmental harm.

Christchurch Casino, Christchurch.
Precast concrete. Exposed aggregate and polised concrete.

Wellington Public Library, Wellington.
Precast concrete with exposed aggregate.

Set Retarders

Printing set retarders on form liners to reproduce patterns or images in the surface of precast panels is another area of development.

Trials in Melbourne (ii) have successfully transferred large-scale digital images (up to 1.2 m x 2.5 m) onto precast concrete by first reproducing the reverse image on the plastic form liners in a concrete set-retarding medium. After hardening for 24 hours, the influence of the set retarder is washed from the face and the images emerge from the pixel-like dots etched 0.5 mm into the surface.

The potential exists for creating increasingly sophisticated imagery and aesthetic effects.

© Mix 5. April 2000.

Pfaffenholz Sports Centre in Basel, Switzerland by Architects Herzog and De Muron.

Exposed Aggregates – Trowelled in Aggregates

Another method of realising an exposed finish is to trowel selected aggregates into the still wet surface.

This method allows the designer to specify a normal concrete mix. This method will give a consistent and uniform appearance to the concrete.

This technique can only be achieved with unformed surfaces, that is those not cast against formwork

Trowelled in Colour Pigments

Coloured topping products can be supplied as pre-bagged mixtures of mineral oxide, cement and sand. They can also contain a surface hardener to increase the strength of the concrete surface and consequently its resistance to abrasion.

The method involves broadcasting the powder by hand onto the surface of prehardened concrete, following the evaporation of bleed water. The surface is floated and finished in the same way as general concrete. Curing requires care to avoid patchiness of colour. After hardening, a thin monolithic coloured layer results.

Pressed Surface Finishes

Pressed surface finishes are made by altering the surface of the concrete after the mix has stiffened but before the concrete is fully hardened.

The process for stamping is relatively simple but the timing of each stage is critical to the success and durability of the finish. Pressed surfaces can resemble traditional finishes such as stone or timber or can be abstract and capitalise on the plastic nature of concrete.

The method and implements used to stamp the concrete surface is largely up to the ingenuity of the designer to achieve the desired appearance.

Residential Driveway.
Cast in-situ with exposed aggregate.

Type C surface finishes

Acid Etching

Diluted acids are used to remove the surface skin of cement paste to reveal the underlying aggregates — usually sand and smaller stones. Concrete must be well-compacted, high density, free from cracks and have sufficient cover for reinforcement.

Textures resembling fine sandpaper are commonly specified, although deeper etching that reveals coarse aggregate is possible.

Etching involves controlled and deliberate action over small areas at any one time. Different personnel may produce slight variations in finish. Therefore results are improved if the same person works on the entire panel. Personnel should be coordinated to improve consistency between adjoining panels. Panels or elements are inclined during etching to prevent ponding, which should be avoided. After etching the surface must be thoroughly washed with water to remove any residual acid. Acid etching is often done to improve the colour uniformity of panels. However, during the manufacturing process different panels may be subjected to varying levels of ambient humidity. Initially, tonal variations in colour might be considered unsatisfactory, but are likely to moderate when the panels have balanced moisture content. The combination of etching and honing produces a surface characterised by flat coarse aggregate, which is slightly proud of the underlying matrix. Pavements are treated in this way to improve slip resistance.

Abrasive Blasting

Abrasive blasting produces a cost effective finish with good weathering characteristics. The inherent appeal of the aggregates is revealed. Abrasive media include airborne or air/water borne sand, boiler slag and carborundum.

The choice of medium is best left to the contractor to decide on the basis of the specified finish. Ensure good placement and compaction. Sandblasting reveals air voids from inadequate vibration (compaction) and aggregate segregation from uneven vibration. Sandblasting is followed by a light acid wash to clean the surface. Generally four grades of abrasion: brush blast, light, medium, heavy blast. Sample panels are useful to make selections and become the basis for approvals. Brush blasting is a light surface texturing that feels like sandpaper. It does not reveal the coarse aggregates. The resulting colour is that of the cement paste. Brush blasting can be done any time after seven days.

St Paul's Apartments, Wellington.
Precast concrete using form liner.

Honed Finish

Honed or polished concrete surfaces are achieved by grinding the concrete surface and exposing the aggregates. Smoother surfaces (more polished) can be achieved through extended honing using progressively finer abrasives (finer grinding grit heads/pads). Alternatively, surface sealants may be employed to provide a surface lustre to the honed surface.

Factors which affect the final appearance include:

- The colour and hardness of the coarse aggregate exposed through the grinding.

- The colour of the matrix.
- The quality of the concrete.
- The depth of grinding.

Te Papa, Wellington.

Polished Finish (Terrazzo)

Polished finishes are an extension of honed finishes and are achieved by using very fine grinding media.

Terrazzo floors may be slippery when wet.

The layout of terrazzo floors must reflect the existing control joints in the substrate. Well-finished terrazzo is extremely durable.

Louis XIV Bedroom, Versailles, France.
Precast concrete – polished.

Musee D'Orsay, France.
Precast concrete – coloured and polished.

Burnished Finish

Burnishing is a term applied to the finishing of concrete surfaces to provide a hardwearing, durable finish with a surface lustre. The application may incorporate integral or broadcast surface dry shake colourants, colouring dyes and or staining. By the nature of the process, burnishing results in

densification, and therefore darkening, of the surface from overworking.

Floor waxes, liquid polishes and resin-based coating applications can also be used to produce a burnished finish. These are multi-layer applications which, after the recommended curing period, are burnished using polishing equipment. The polishing action produces friction, the heat from which melds the layers and induces the bond to the concrete surface. The degree of lustre achieved is dependent on the quality of the concrete (particularly the surface density), the quality of the particular product and the burnishing technique.

Te Papa Panel, Wellington.

Te Papa Floor, Wellington.

Broken Concrete Surfaces

Broken concrete finishes provide the strongest texture of any discussed here. A popular technique has been to create thin fins in the surface that are broken on each face with a club hammer to expose the aggregate.

The geometry of the nib, the size and type of aggregate and the strength and colour of concrete will all influence the overall effect.

National Library of New Zealand, Wellington.

Christchurch Public Hospital, Christchurch.

Summary

Around the world architects, designers and building owners are looking to distinguish their projects with interesting and innovative material surface finishes.

Concrete has been experimented with more than most materials because it invites participation.

Designers can easily engage with the manufacturing processes individually. Most of the successful processes have now become mainstream and can be reproduced locally by willing and capable tradespeople.

Recent developments such as controlled permeability formwork and printed surface retardant combines with traditional methods such as form liners and exposed aggregate to give the industry an exciting range of surface finish possibilities.

The range of finishes will continue to expand as new materials and processes combine with designers' imaginations.

References and Further Reading

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