Modern, honest, textural: concrete is a surprisingly versatile product, whose natural beauty has (again) caught the attention of the design world. From the imposing raw substance of Christchurch's Town Hall to the smooth 'terracotta' curve of the Wellington City Council's administration building to the vaulted interior of the capital's St Paul's Cathedral - the different faces of concrete range from minimalist modern to intricately detailed 'stonework'.

**The rough with the smooth: Concrete finish options**

1. Sandblasting, seen here on the Neurosciences Building in La Hoya, requires considerable control to get a uniform finish.

This article gives an overview of the range of different concrete finishes available - for external cladding, walls, floors, landscape - and some tips about how to achieve the best results. Depending on the finish you want, concrete can be manipulated at different points in the construction process. Here, we outline these techniques: detail the variety of textures and effects possible; and give examples of their use in projects around New Zealand and internationally.

The Built Environment

Imagination and flair can be seen in the work of architects and engineers using the form, colour and texture of concrete to good effect. Concrete elements can be finished in a range of profiles and textures to bring out the natural beauty of the aggregates: mimic the impression of hand-crafted masonry; or create striking patterns.
5 & 8. A chamfer on the edge of each concrete panel results in a proud 'v' at the joints on the new addition to the Salk Institute.

7. Polypropylene rope, 1/4 in diameter, was used in the base of the precast bed to give this rope detail to the panels at Christchurch Hospital.

8. Texture from rough board formwork on the walls of a Queenstown house.

The categories of finish available can be categorised by three different approaches to concrete during the construction process.

Type A concrete surfaces are produced by manipulating the surface of the form before casting the concrete. Type B are produced by manipulating the surface of the fresh concrete before setting. Type C are produced by manipulating the surface of the hardened concrete.

Off the Form - plain or textured

Type A, in which concrete is cast against a prepared form, is the most common surface finish. This is also referred to as 'off the form' finish.

Louis Kahn’s Salk Institute, designed in the 1960s, is a famous example of natural off the form concrete. A recent addition to the complex, a separate pavilion designed by architects Anshen + Allen, is also off the form in situ concrete. The expressed joints between the formwork panels show a high degree of skill and craft in manufacture.

Concrete also allows three-dimensional textures to be specified as an integral part of a building’s design. The options range from heavy vertical ribs, as seen at the German Embassy, to rough-sawn board-marked finishes. These effects can be produced by battens fixed within moulds, to stylish patterns that use purpose-made formliners from plastic, rubber, fibreglass, or GRC.

Lengths of rope can be attached to formwork at close spacing, then pulled from the young concrete surface to form a pattern. At Christchurch Hospital, Cutter Douglas Partnership specified rope patterned precast panels with a fair face band across the top. The texture of the resulting panels, which were sealed with a weatherproofing material, produced an even pattern that has weathered well.

Patterned concrete panels to any style or specification can be created using rubber and plastic formliners. Thinking laterally, at the St Paul’s Apartments in...
9. At the Nelson Polytechnic Library, designed by Athfield Architects, a fish symbol made in resin by students was set into the wet concrete of the forecourt after it was floated. The symbol is repeated inside the building, in vinyl.

10. The texture provided by aggregates can be used to highlight particular features or contrast elements. At Wellington's Public Library, Athfield Architects left the window reveals plain inside exposed aggregate panels.

Exposed Aggregate

Type II effects involve special treatment of the concrete while still in its plastic condition. Exposed aggregate is a popular Type B technique, produced using a variety of methods that give different depths of exposure and texture. The exposed stone, revealed when the mortar component of the concrete is removed from the outermost layer, may be normal coarse aggregate or an aggregate selected for a particular colour, shape or size. The surface can be 'seeded' with selected aggregates, which is more cost effective than using expensive aggregates throughout the mix. The background matrix can be grey sandcement mortar, white, or coloured with a variety of pigments.

The Media Associates building in Christchurch, designed by Warren & Mahoney, is clad in exposed aggregate precast concrete panels, with recessed weather seals. For these panels, aggregate of a particular size has been specified and the majority of the cement paste in the outer region washed away.

At Aucklands St Peter's College (see p6), Architectus has used exposed aggregate thermomass panels as an external wall for the new school technology building. The panels, which wrap around the building along the adjacent motorway edge, have 5% black oxide added to the cement mix by manufacturers Wilco Precast, to give a black rather than grey appearance.

Water washing, which is also used to reveal aggregate, results in deep exposure of stones in the mix. Water washing does not modify the appearance of the exposed aggregate - glossy stones stay glossy - and in combination with abrasive blasting can result in a subtle relief effect.

Concrete Images

Mimicking the silk screening process to imprint an image on a concrete surface is one of the more recent concrete finish techniques being used in the world. The key to this process is a surface set retarder. Surface set retarders, which can be either solvent or water based, are used to slow concrete setting time - in the case of the image 'printing: the retarder prevents hardening on the image area while the rest of the concrete hardens normally; the entire surface is then washed or blasted, and the aggregate is revealed on the image area only. For more information on this process, which would be most
Acid etching produces a fine 'sandpaper' texture. Similar results can be achieved with abrasive (sand or grit) blasting. Several variations of this technique exist:

- Brush blasting is a light surface texturing, which does not reveal the coarse aggregates and leaves the colour of the cement paste to dominate.
- Light blasting reveals the fine aggregates (sand) and a few stones. The sand dominates the colour.
- Medium blasting exposes the coarse aggregate so it projects about 6mm proud of the surface.
- Heavy blasting results in the coarse aggregates, which dominate the colour, projecting up to one third from the surface.

Unlike exposed aggregate, where the cement paste is washed away, sandblasting has a more finely textured result, as seen at the Neurosciences Building in La Hoya, California, by US architects Williams and Tsien.

Closer to home, horizontal 'hands', created by alternating sandblasted panels with fair face panels, have been used to create interest on the street facade of St Paul’s Apartments in Wellington. Athfield Architects chose to sandblast some of the panels a couple of days out of the mould to create the contrasting textures.
Mechanical tooling of the surface, using tools such as a needle gun, bush hammer, point tool or chisel, will give more pronounced exposure of the coarse aggregate. A wide range of textures can be achieved, from 'light needle-gunning' to a broken rib pattern.

**True Colours - natural flair or added impact?**

While colour isn't strictly a concrete finish, its impact means it can have a significant role in concrete building design. At Canterbury Trust House in Christchurch, for example, architects Warren & Mahoney specified integral black colour in the concrete panels forming the lift shaft and service core, to contrast the largely glass-clad office space.

In all concrete applications surface texture is important. It determines the way light is reflected and how we see the object. Surface finish also affects the way we perceive colour. Photograph 15 shows a concrete path that contains a sandstone colour pigment. One side has been broom finished, the other steel trowelled. The two halves appear to be different shades, but the concrete is exactly the same. These shade variations generated by differing surface texture can be used to create subtle but interesting features on a building or pavement.

Designers need to be aware that smooth flat surfaces highlight the natural variations in concrete construction much more than textured surfaces. The natural colour of concrete is affected by many factors, including water content, cement type, method and duration of curing, form oils, release agents, aggregates, admixtures, and type of formwork. Stockpiling raw materials sufficient to complete a job will help consistency of colour.

Mineral oxide pigments can be added to the concrete or render mix, either as integral colour or contained in a topping layer. Mineral oxide colour can also be applied to the surface using the 'dry-shake' method, which requires additional care to avoid patchiness, or colour can be introduced using chemical stains. For more in-depth information on these alternatives, refer to the March 1999 concrete magazine, available from the CCANZ Library.

**Applied Finishes**

Applied finishes, which include cement renders, applied coatings and paint, are durable and cost effective. This is, however, a very specialised subject, and success is dependent on taking into account environmental factors, quality and usage.

**Specifying Surface Finishes**

Specification guidelines are an important tool in achieving a particular surface finish, and sample panels must be used to establish and verify the desired effect.

Finishing requirements as set out in NZS 31 141987, Specification for Concrete Surface Finishes, designate six classes of finish for smooth or textured formed finishes, referred to as F1 to F6 (see Table 1). Exposed aggregate finishes are 'E', and unformed finishes 'U'.

**Ground Up: concrete floors**

Once the domain of factories and unfinished houses, visible concrete floors are now often the preference of architects and owners alike.

The smooth flat U3 trowelled finish is probably the most commonly specified floor. This durable surface, used in both industrial and residential applications, is achieved with machine trowels. The quality of the end product depends on the skills of the concrete placer: if trowelling is commenced too early, the bleed water may mix with the surface cement paste, resulting in a weak surface prone to dusting.

Timber hardwood battens can be laid as a grid in the concrete slab, in place of expansion joints. Grinding and polishing the top layer of the concrete after two weeks' curing results in a finish that has a real glow: complemented by the wooden battens.

Specialist floor finishes range from traditional terrazzo - once a honed and polished marble aggregate, now available in a range of modern alternatives - to coloured concrete, stamped to resemble tiles or pavers.

Stamped concrete uses metal moulds or rubber mats to create a pattern - such as large pavers, slate tiles or cobblestones - in a thin monolithic coloured topping. Two colours can be used to provide shading that emphasises the surface texture. The thickness of a stamped slab should be measured from the bottom of the impression to the underside of the slab.

**Stencilling** is used to achieve a pattern by altering the surface after the concrete has stiffened but before it has hardened. A cardboard stencil is laid on the surface of
Table 1 - Classes of surface finish

<table>
<thead>
<tr>
<th>Clause reference</th>
<th>Finish</th>
<th>Description</th>
<th>Typical uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>105.1 F1</td>
<td>Surfaces where roughness is not objectionable. No surface treatment is required other than filling the holes and repair of defective concrete. Colour variations and certain physical irregularities permitted.</td>
<td>Concealed surfaces which are to be covered as in foundations, or in walls to be strapped and lined. Upstream faces of dams that will normally be under water.</td>
<td></td>
</tr>
<tr>
<td>105.2 F2</td>
<td>Surfaces which provide a key for plaster and other thick surface coverings.</td>
<td>All types of interior or exterior surfaces.</td>
<td></td>
</tr>
<tr>
<td>105.3 F3</td>
<td>All permanently exposed surfaces smooth or textured which are not prominent or subject to close or frequent scrutiny.</td>
<td>Surfaces of buildings and civil engineering structures which will not be seen, or observed only from a distance.</td>
<td></td>
</tr>
<tr>
<td>105.4 F4</td>
<td>All smooth or textured surfaces of structures where appearance and accurate alignment is important as they will be exposed to frequent dose scrutiny.</td>
<td>Walls, panels, columns, beams, etc. in areas of secondary importance such as basements, work-hops.</td>
<td></td>
</tr>
<tr>
<td>105.5 F5</td>
<td>All smooth or textured surfaces of structures where appearance and accurate alignment is important as they will be exposed to frequent dose scrutiny.</td>
<td>Walls, panels, columns, beams, bridges, piers, softsills, parapets and railings, etc. in areas of greater importance such as office areas, foyers, public areas but where the concrete does not form a feature of the space.</td>
<td></td>
</tr>
<tr>
<td>105.6 F6</td>
<td>All smooth or textured surfaces of structures where appearance or accurate alignment and evenness of surface are of the greatest importance.</td>
<td>Architectural or feature panels and high velocity water channels where it is essential to prevent the destructive effects of water action.</td>
<td></td>
</tr>
</tbody>
</table>

*The latter include portions of outlets, draft tubes, and spillway tunnels and channels of high dams where flow velocity exceeds 12 m/s.

Table 2 - Classes of floor, exterior pavement, and invert finishes

<table>
<thead>
<tr>
<th>Class</th>
<th>Finish</th>
<th>Technique</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>Screeded</td>
<td>Hand sawing motion with straightedge or mechanical vibrating screed.</td>
<td>Finisher covered by backfill or concrete. Footpaths, yards and driveways. First stage far placement.</td>
</tr>
<tr>
<td>U2</td>
<td>Floated</td>
<td>Wood or bull boat, or both. Generally manual but power driven equipment may be used.</td>
<td>As for U1 where a higher standard of finish is required. Floors to receive carpet with underlay or similar coverings. Inverts of siphons, flumes, floors of canal structures, spillways outlet works and stilling basins. Surfaces which are intended for use by ambulant or wheelchair-bound persons.</td>
</tr>
<tr>
<td>U3</td>
<td>Trowelled</td>
<td>Manual or mechanical steel trawelling of floated surface after the concrete is sufficiently hardened, to prevent excess fine material and water being extracted to the surface. May be done in one or two stages depending on degree of smoothness required.</td>
<td>Direct wearing floors such as factories, warehouses and processing plants. Floors to receive thin sheet coverings, carpet and similar coverings. Inverts of water, tunnels and tunnel spillways. Not generally used for pedestrian or vehicular traffic where a smooth finish could be dangerous in icy, wet conditions. Is not suitable even when dry, for surfaces which are intended for use by ambulant disabled or wheelchair-bound persons. See U2.</td>
</tr>
<tr>
<td>U4</td>
<td>Machine screeded</td>
<td>Vibrating or oscillating screed or vibrating plate, or both, which may be supplemented by long handled metal, wooden, or rubber floats.</td>
<td>Used for durability where resistance to erosion and cavitation under action of high velocity water is especially required; and as first and second stage finishing for roads and airfield pavements prior to texturing with U5, U6, or U8 finishes.</td>
</tr>
<tr>
<td>U5</td>
<td>Shallow textured</td>
<td>Hard or soh bristled brooms.</td>
<td>Footpaths, yards, driveways, roads, pavements for aircraft.</td>
</tr>
<tr>
<td>U6</td>
<td>Deep textured</td>
<td>Wire broom or rubber tyning.</td>
<td>Surfaces to receive a subsequent bonded concrete topping. Roads and runways where greater frictional resistances are required than can be obtained by U5 finish.</td>
</tr>
<tr>
<td>U7</td>
<td>Grooved</td>
<td>Saw cutting or flailing by mechanical means.</td>
<td>Treatment to existing roads and runways to provide Frictional resistance and drainage paths for run-off to minimize aquaplaning.</td>
</tr>
<tr>
<td>U8</td>
<td>Grooved</td>
<td>Mechanical grooving the fresh concrete surface after compaction and surface screeding techniques.</td>
<td>Roads and runways.</td>
</tr>
<tr>
<td>U9</td>
<td>Scabbled</td>
<td>Mechanical hammering of hardened concrete.</td>
<td>Can be used on any pavement surface to produce a textured effect or to reduce high surfaces to the correct level, or to rectify out-of-tolerance pavements.</td>
</tr>
<tr>
<td>U10</td>
<td>Special textured</td>
<td>The use of equipment to give special effects.</td>
<td>Architectural effects on pavements and slabs, produced by rollers with drums of expanded metal, or profiled lampers on screeds, and the like.</td>
</tr>
<tr>
<td>U11</td>
<td>Ground</td>
<td>Low speed coarse stone grinding to remove thin weak surface layers/minor ridges and to produce an even &quot;glasspaper&quot; textured surface, that is, not a polished surface. Used as a second stage finishing to U2, approximately 36 to 48 h after laying.</td>
<td>Direct wearing floors such as factories and warehouses.</td>
</tr>
</tbody>
</table>
the pre-hardened concrete and worked in with a roller or trowel; the stencil then masks the surface to the pattern of, for example, tiles, bricks or stone pavers during the application of the dry shake toppings.

Saw cut grooving, a U7 finish, is often used around the forecourts of petrol stations. The effect is easily achieved by cutting the concrete with a diamond saw after it has gained sufficient strength.

In road construction, US grooving is achieved by tyning the surface while the concrete is still plastic. Hessian was dragged over the grooved finish on the Pacific Highway in Queensland, shown at left, to help provide a low traffic noise surface with good skid resistance.

As with concrete walls, mineral oxide pigments are generally used to colour the entire mass of the concrete floor or to colour a topping slab. Dry shake toppings and chemical stains can also be used.

Existing - hardened - concrete can be coloured with an applied surface finish or coating. A number of products can be plastered onto existing concrete surfaces to produce either plain colours or a coloured and patterned finish identical to a stencilled pattern.

For a detailed review of terrazzo and other polished finish alternatives for concrete floors, turn to page 20; for more information on exposed aggregate, turn to page 30.

The Great Outdoors: landscape

Achieving effect with texture and colour is not limited to buildings. RDH Developments’ Northwood subdivision in Christchurch is a good example of the use of concrete in landscape design.

The coloured concrete paths at Northwood create an immediate atmosphere of permanence and quality. The ‘sea of black’ which results when asphalt is used for both the road and paths is avoided. In addition to the aesthetic effect, there are economic benefits: a study conducted in June 1999 on Auckland footpaths showed that the life cycle cost of concrete paths is superior to those of asphalt and red chip seal, with average maintenance costs for concrete paths 60% that of asphalt. Long life has the added advantage of less disruption due to repairs.

A light sandstone coloured concrete is used throughout for the paths and kerb and channel in this subdivision. Paths have a light broom finish (US), which provides an attractive matt surface. Considerable effort went into ensuring a quality end result. Sample path lengths were produced to trial different pigment strengths, finishing techniques (steel trowel, broom) and curing (various curing membranes). The sample of the selected combination was then used during the construction phase as a quality comparison tool. Similar trials were conducted for the kerb and channel to achieve the correct colour.

The subdivision also makes extensive use of concrete fenang. The fences, which have been precast and paint finished, give a sense of solidity and permanence.

A series of recreational grassed areas are linked by concrete paths. The entrances to these areas are announced by colonnaded concrete archways, reminiscent of the famous Canterbury nor-west arch: a clear signpost to the communal recreational areas, colour and materials link these different landscape elements.

Handy hint: how to achieve the desired result

Achieving superior concrete surfaces requires attention to detail. Hints on what to watch out for, gleaned from experienced operators, include:

Sample reference panels: Insist on sample reference panels for decorative concrete. All parties then understand the desired end product

Coloured concrete: When coloured aggregates or pigments are used it is recommended that sufficient quantities be stockpiled from the outset of the work. Variations in colour and composition are more apparent in this type of finish.
**Off the form finishes:**
- Pay attention to detailing, with adequate provision for joints, edges, corners, drips and other weathering details, and adequate measures to allow form release and removal;
- Use clean, well maintained and watertight forms;
- Use a concrete mix with adequate cement content, low water/cement ratio and high density;
- Ensure that you have adequate consolidation and uniform curing to ensure uniformity of colour and texture;
- Protect to minimise chipping and damage subsequent to casting.

**Care can help eliminate major blemishes.**

Some examples follow:
- **Hydration discolouration relates to the absorbency of the form face.** Areas where water is absorbed into the surface tend to be darker than non-absorbed areas. With impermeable surfaces it is possible to get a similar effect caused by form vibration, or wet concrete pressure variations.
- **Form faces that have an impermeable surface tend to have a higher incidence of blowholes, created when air bubbles are trapped against the form face.**
- **Glazed, smooth or polished impermeable forms can lead to fine crazed cracking.**
- To achieve maximum uniformity of colour, timber forms should be pre-treated by thoroughly oiling before the first use. Failure to seal the first use will result in a lightening colour effect after successive uses.
- **Steel forms need to be protected to prevent rusting.** The flexibility of the sheet steel facing means that attention should be paid to the jointing to prevent leakage during vibration.

**Acid etching:** the acid action is noticeably greater on poorly compacted concrete. Uniformity of compaction is therefore important in obtaining a consistent finish. Etching involves work by an individual on a small area at a time, and there can be slight variations in finish by different workers. If the same person works on an entire panel, and adjoining panels, the end results are improved. Tonal variations in colour of the finished product can moderate once panels have balanced moisture content.

**Light blasting:** this can be achieved using sand or other abrasives. It is a common misconception that abrasive blasting will improve the appearance of poor quality concrete. While it may remove colour variations it may actually accentuate physical defects in the surface. Abrasive blasting is a cost-effective method with good weathering characteristics. Good placement and vibration are key: sandblasting reveals air voids from inadequate vibration and aggregate segregation from uneven vibration.

Concrete, once perceived as the material of monolithic structures, is now adorning the floors and walls of design-conscious residential and commercial clients; making possible the reproduction of historical structures; a cost-effective 'tiled or cobbled' path and leading edge environmental cladding. The range and versatility can only be touched on briefly in this article. Elsewhere in this issue, we look in more detail at the impact of different concrete finishes, and how best to achieve the desired effect. For more information, check the resources list for each article.

**Further Reading**

*Briefing 01, July 2000: Colouring, Stencilling and Stamping Concrete Flatwork,* Cement & Concrete Association of Australia
*Briefing 03, July 2000: Colour and Texture in Concrete Walling,* Cement & Concrete Association of Australia
*TM01 Architectural Concrete Cladding,* CCANZ 1992

concrete, March 1999. CCANZ