Concrete: a strong tradition

Around since the early days of New Zealand settlement, concrete is everywhere, from paths to pools, foundations to fountains.

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Take an appropriate amount of Portland cement, some hard-wearing aggregate and sand to provide a dimensionally-stable and cost-effective filler, additives to modify the properties and some water. Mix together, leave for some time to harden, and you've got concrete. The relative proportions of the components vary depending on the desired properties. For example, leave out the coarse aggregate to create a mortar to hold together bricks or blocks, or for use as a coating to provide a smooth, durable surface finish.

This typically grey, multi-purpose, widely used construction material provides many benefits: excellent fire performance; strength in compression; thermal mass for comfort; ease of application; ability to be shaped; and a good imitation of stone. Add some iron or steel to create reinforced concrete and the improvement in strength, tension and resilience in an earthquake turns it into a solution to many building problems.

In New Zealand, concrete has been widely used, such as for building foundations, retaining walls, pipes, bridges, columns, dams, docks, sheep dips, decoration, sculpture and road kerbing. It features in residential, commercial and industrial buildings for the roofs, walls and floors.

Settlers' concrete ingenuity

Imported cement was in New Zealand from the early days of European settlement (see *Build* 106 June/July 2008, pages 86–87). Innovative settlers moved in advance of common European practice, using concrete for both public and private construction.

On 18 October 1848, the *New Zealander* newspaper advertised tenders for a hospital at Wanganui, 'the building to be 72 feet by 40, and 13 feet high, the walls to be of brick, stuccoed, and upon a concrete foundation'. The *Daily Southern Cross* newspaper of 9 December 1848 reported that Robert and David Graham of Auckland commissioned a stone and brick house with a concrete foundation, but failed to pay John Walker, the builder and architect, for all his work.

From early retaining to precast slabs

Geoffrey Thornton, in his 1996 book *Cast in concrete,* reports the earliest evidence of concrete construction he had seen was a 'rather crude retaining wall at Fyffe House in Kaikoura', which was built by 1857. Still visible are also the remains of the 1867 concrete piers, which had, in turn, replaced 1859 concrete piers, of a bridge over the Waiwakaiho River on the outskirts of New Plymouth.

Many concrete buildings have been built since the 1860s, but an unusual one is 'Homebush' designed by Charles Tilleard Natusch and built in the late 1880s. Natusch was known for his 'board and batten' style homes, but Homebush is constructed of precast concrete slabs fitted into wooden framing with the joints covered by timber battens. Presumably, the inspiration for this was a precast, reinforced concrete low-rise house system patented by William Lascelles in England in 1875, which was the subject of some discussion in Wellington in 1888.

Concrete can also be seen in decorative objects, whether moulded statues, gnomes or fountains, found around many cities. The highlight of the 1896 Wellington Industrial Exhibition was reportedly a fountain made entirely of New Zealand products, including a cement base manufactured by Jon Wilson and Co. and a basin made of bricks bedded in mortar. Five water fountains came from the mouths of four dolphins and the kit bag on the head of a terracotta Māori girl.

A very early example of a precast concrete slab house is Homebush, constructed in the late 1880s in Masterton.

Reinforced concrete

Although concrete is strong in compression (able to carry heavy weights), its tension performance is poor (when under a bending load). The solution was found in the early 1800s, when wrought iron bars, and later cast iron I-beams, were embedded in the concrete. Although various British, American and French researchers experimented with such techniques, it was France's François Hennebique who is credited with first understanding the most effective locations to place steel reinforcement in concrete elements so the engineering properties of the two materials complement each other. He patented his system in 1892.

Reportedly the first real use of steel reinforcing in New Zealand is the 1883 water tower at the former Railways Workshops, Christchurch. Eighteen metres tall, it was built by inmates from Addington Prison and used several tonnes of scrap metal. For comparison, the first reinforced water tower constructed in Britain was in Bournemouth in 1900. Both towers are still standing.

Techniques for concrete reinforcing have developed over the years. Modern construction uses complex reinforcing patterns with steel that is wired, bent or welded into shape to

safely distribute loads through the building structure. Much work has been carried out on the structural design and the overall durability of the composite steel-concrete system. For example, BRANZ researchers investigated the long-term behaviour of reinforcing steel and methods of minimising the penetration of potentially damaging agents such as air-borne salts and carbon dioxide.

Spalling destroys

Well-designed concrete shouldn't suffer from 'concrete cancer' or spalling that has prematurely ended the life of some older structures. Spalling is typically caused by corrosion of the reinforcing steel. Rust occupies more space than the bare metal so pieces of concrete can flake off, further exposing the steel for the process to continue, ultimately destroying the overall structural integrity. Well-compacted dense concrete inhibits this process by providing a beneficial alkaline environment and also assists fire protection.

Concrete tubs were once a common feature of the New Zealand washhouse.

Earthquake danger

During the 1800s, large earthquakes brought home the danger of unreinforced brick and masonry construction. The 1906 San Francisco earthquake was crucial in highlighting the issue, and reinforced concrete became the norm as a result. The 1931 Napier earthquake caused much destruction of the city heart and replacement buildings were readily sculptured in concrete, resulting in a showcase for the Art Deco style.

The Napier earthquake also resulted in recognition of the need for improved standards of building safety. This lead to the 1932 creation of the New Zealand Standards Institution (today's Standards New Zealand) and the 1935 first Standard Model Building Bylaw (predecessor of the New Zealand Building Code). It also led to the formation in 1959 of the Building Research Bureau of New Zealand, the parent of BRANZ.

Looking ahead

Concrete continues to play a crucial role in the construction industry. Environmental issues are of concern, both here and internationally. Work is being undertaken on concrete's contribution to greenhouse gas emissions – a critical issue under the Kyoto Protocol. As demand has increased in New Zealand, the availability of suitable aggregates has lessened in some parts of the country. A partial solution to this problem has been the use of recycled, crushed concrete as a replacement aggregate.