Recent research

Minimising the risk of reinforcement corrosion

Reinforcement corrosion, often salt-induced because of New Zealand's coastal environment, is the most significant form of concrete deterioration in New Zealand. Opus Central Laboratories has been investigating several ways to reduce the risk of corrosion in both new and repaired concrete.

Previous investigations by Opus have included assessments of the effectiveness of methods used to remove salt contamination from reinforcing bars before concrete is cast around them; the effect of supplementary cementitious materials on corrosion initiation and concrete properties; and the effectiveness of a cementitious reinforcement coating. These involve ongoing long-term monitoring.

The work is now being extended to evaluate how effective past design and material specifications have been in providing durable concrete, and how they can be adapted for current materials, construction technology and economic demands.

This research, funded by the Public Good Science Fund, is conducted by Sue Freitag at Opus International Consultants Ltd Central Laboratories.

Earthquake response of thin precast concrete elements

Difficulties and problems with interpretation of the current NZS 3101 provisions have been the subject of meetings between BRANZ and consultants in Auckland and Christchurch.

The meetings led to agreement that there are two situations that need to be considered. The first of these is the low axial load, thin, tall warehouse boundary wall situation; the other is the more highly loaded multi-storey apartment or office type structure.

The most urgent need is to address the issue of thin boundary walls. It was agreed that initially full scale testing would be the best way to actually determine the cyclic, post-elastic behaviour of currently used systems. Design rules can then be developed and modified to reflect the desired response of such systems under earthquake attack. Discussions are currently underway between BRANZ and the universities regarding the distribution of work between the organisations.

The Cement & Concrete Association of New Zealand supports this research work. For further information on this project, contact Graeme Beattie of BRANZ.

Aggregate testing and greywacke reactivity

A new mortar bar test for aggregate reactivity has come into widespread use overseas in the past ten years because of its ability to detect reactive aggregates relatively quickly, particularly greywackes, that are missed by other tests. Previous work by Opus Central Laboratories has established that the field performance of New Zealand aggregates can be predicted quite accurately by the 'quick chemical test', but international experience indicated the new method should be evaluated.

Results from the new mortar bar test suggested that Wellington greywacke might be reactive. Subsequent investigations of concrete bridges made from this aggregate and high alkali cement revealed no obvious alkali aggregate reaction (AAR) damage, and accelerated expansion tests on concrete core samples indicated little potential for future damage. This confirmed that this greywacke is unreactive, as predicted by the quick chemical test. It was concluded that for New Zealand aggregates the quick chemical test is more appropriate than the new mortar bar test.

More detailed investigation of the greywacke revealed subtle chemical interactions with Portland cement. It was suggested that the overseas problems with the quick chemical test could be overcome if sampling techniques were improved and the test duration increased, and that this would be more practical than dealing with the 'false positive' results that are characteristic of the new mortar bar test.

This research was carried out by Sue Freitag at Opus International Consultants Ltd Central Laboratories, and was funded by the Public Good Science Fund.

Wall thermal mass research

Recently completed thermal mass studies have revealed that overheating can be a serious problem in the timber building. In concrete buildings, however, the heavy walls significantly improved daytime comfort by providing up to 5°C cooling when the buildings were unventilated and up to 3°C when the buildings were ventilated. Even with the carpets removed the heavy walls significantly improved comfort.

Four trials on wall thermal mass were conducted over a 25-month period in two side-by-side test buildings at Lincoln University. The full results will be published in a BRANZ Study Report.

Energy savings because of the heavy walls were strongly related to ventilation requirements, which in turn were strongly related to the building's solar gain. Heavy walls typically saved energy each month. However, when both buildings were infrequently ventilated the situation was reversed. The research shows that solar gain and insulation need to be matched to the level of thermal mass in order to exploit the energy savings potential of concrete walls.

The experimental data was used to assess the accuracy of two building energy programs. The programs accurately predicted the energy savings due to heavy walls, but were less accurate in predicting the effect of heavy walls on comfort.

This research was carried out by Larry Bellamy and Don Mackenzie of Lincoln University, funded by the Cement & Concrete Association of New Zealand and BRANZ.

The wet/dry mechanical brushing test

At present in New Zealand there is no technique that can be used to assess the durability of a stabilised road base material. However a new South African method of assessing the durability of cement treated basecourse (CTB) should give pavement designers increased confidence.

A recent project sought to evaluate the suitability of the South African method for determining the durability of New Zealand CTB materials. This involved subjecting compacted cylinders of CTB to wetting, drying and abrasion in a rotational wire-brushing machine. Specimen loss is measured after 12 cycles of testing.

Materials tested included a premium quality basecourse that meets the requirements of the Transit New Zealand M/4 specification, a material that is just outside the weathering resistance requirements and a material that is well outside these requirements. Each material was tested at two cement contents typical of the quantity that would be required to give a 'bound' pavement layer. The range of cement contents across the sample suite was 2-7%.

Results were in the range 0.7% - 2.6% and correlated with aggregate durability as measured by weathering resistance. However, these losses are small in terms of the South African requirements.

Transit New Zealand has decided to incorporate the test into the M/22 Notes , which is a guideline performance-based specification for basecourse. Currently the requirement under consideration for the test is 5% loss, based on the minimum South African acceptance criterion.

Research was carried out by Hamish Stevenson and John Patrick at Opus International Consultants Central Laboratories, jointly funded by the Cement & Concrete Association of New Zealand and Transit New Zealand.

Susceptibility of lightweight aggregate concrete to seismic attack

This is an experimental and analytical project that aims to determine some of the key design parameters (performances) for concrete beams and columns, constructed of lightweight aggregate concrete, when subjected to seismic attack.

The current design codes in NZ, US, Japan and Europe are very restrictive on the use of such concrete members in buildings.

A 'general' stress-strain model for conventional and lightweight aggregate concrete has been developed as part of the project. Other preliminary outcomes indicate that the current Code requirements for the design of conventional concrete (NZS 3101:1995) may be directly applicable to lightweight aggregate concrete.


The research team

Testing of some 65 specimens (columns and beam/column subassemblies) has been completed. The first full draft of the thesis is expected by December 2000.

Chris Allington, the PhD candidate producing this research, recently presented a paper on his findings at an international conference in Norway.

Des Bull, Holmes Consulting Group, and Prof. Bob Park, Department of Civil Engineering, are acting as supervisors. The programme was instigated by Len McSaveney from Stresscrete Ltd three years ago, who continues to advise on the project.

Firth Industries and Stresscrete Ltd are providing the main funding for the experimental programme and student support, with supplementary support from the Department of Civil Engineering at the University of Canterbury.

Drying shrinkage of aggregate in concrete

Uncontrolled cracking in concrete floors is not only aesthetically undesirable, it can make the floor uneven and leads to accelerated wear. In other concrete structures, cracks increase the permeability of the concrete and thus potentially reduce its durability.

Designers sometimes specify a low drying shrinkage to reduce the incidence of uncontrolled drying shrinkage cracking, and in these situations shrinkage contributions from all sources need to be considered. In some parts of the country it can be difficult to meet the requirements with local aggregates. This is usually because aggregate particle shape and size distribution demands more cement paste to achieve a required workability. However, aggregates have an intrinsic moisture movement themselves, and there have been cases overseas where this has produced unacceptable concrete shrinkage.

To find out how aggregate moisture movement affects the drying shrinkage of concrete, Opus Central Laboratories selected 12 coarse aggregates and measured their water absorption, porosity and moisture movement. Major differences in moisture movement were reflected by water absorption, while smaller differences were related to the volume and size distribution of fine pores measured by nitrogen absorption.

Concretes of identical mix design were then made from aggregates with high, medium and low moisture movement, and their drying shrinkage was measured. The drying shrinkage was found to reflect aggregate particle shape, surface texture and elastic modulus as well as aggregate porosity. It was concluded that although simple measurements of aggregate porosity can indicate whether an abnormally high drying shrinkage is likely, concrete testing remains the best way to select aggregates to minimise concrete drying shrinkage.

This research has been carried out by Sue Freitag at Opus International Consultants Ltd Central Laboratories, and was funded by the Public Good Science Fund.

Seismic impact on precast floors in a moment resisting frame

Ductile moment resisting frames are designed to absorb earthquake energy by forming zones of plastic deformation (hinges) in the beams adjacent to the columns. Rotations in the beams and an elongation effect caused by the formation of these hinges have the potential to cause localised damage to the attached precast concrete floor slabs and concrete toppings.

The performance of a moment resisting frame with precast floors is currently being investigated under simulated seismic loading. Areas of interest include loss of load paths, elongation effects in the beam of the frames, loss of support for the floor units, and possibly detrimental effects on the flexural strength of the beams because of the presence of the precast hollowcore units running parallel to the beams.

The project involves testing a 12 m by 6.5 m section of hollowcore floor supported on full-sized columns and beams, and will incorporate two specimens. The first specimen is typical construction practice used over the past 25 years. The details of the second specimen will be developed once the first test is complete, aiming to produce details that will overcome the shortcomings in performance that may appear in the first test.

The construction of the first of the two specimens is 50% complete and submission of the thesis is expected in December 2001.

The project is the basis of PhD studies for Jeff Matthews at the University of Canterbury. Des Bull from Holmes Consulting Group is acting as primary supervisor, along with Len McSaveney, Stresscrete Ltd, who initiated this programme of investigation two years ago. Recently Prof. John Mander from the Department of Civil Engineering has kindly agreed to act as a co-supervisor on the project.

Funding for the acquisition of equipment is being provided by the Cement & Concrete Association of NZ. Further financial support for other aspects of the experimental set-up and student living costs are being provided by GRIF, Firth Industries, BRANZ, the Earthquake Commission, and the Department of Civil Engineering.

Stability of precast concrete tilt panels in fire

This research project analysed the behaviour of slender precast concrete tilt panel buildings when subject to fire. These panels, which are a feature of the current construction trend of industrial buildings, are cantilevered from the base and directly support the roof framing. The panels are not connected to columns or portal frames, but are connected directly to the steel roof structure. The intermediate panels between the rafters are indirectly connected to the roof framing with an eaves tie.

The structural analysis for this project was conducted using SAFIR, a non-linear finite element programme developed at the University of Liege, Belgium.

The analyses have shown that free-standing cantilever walls with slenderness ratios in excess of 50 experience large horizontal deflections due to thermal bowing, resulting in outward collapse. Concrete cantilever walls connected to unbraced steel frame can cause the whole frame to sway and collapse outwards.

Outward collapse of wall panels can be prevented by ensuring very good connection to the roof framing and providing diaphragm action in the roof by using diagonal bracing or the steel roofing material. The computer analysis showed that walls braced in this way will not buckle or collapse outwards if the slenderness ratio is less than 90. The most likely failure mode is the wall panel falling inwards, following collapse of the unprotected steel rafter into the fire. **C**

This research was conducted by Linus Lim and supervised by Associate Professor Andrew Buchanan. It is described in Fire Engineering Research Report No 00/11, available from the Department of Civil Engineering at the University of Canterbury.