Design of the RNZAF Base Ohakea Runway 09-27 Reconstruction

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Summary: The main runway at RNZAF Base Ohakea has undergone complete reconstruction. A flexible unbound granular pavement with a structural asphaltic concrete surface was designed for the replacement pavement. Unusual aspects of the design included removal of weak silts and clays to expose the "terrace gravel" as the subgrade. A subbasecourse was recycled runway concrete slabs crushed to produce an aggregate. The cost of crushing the concrete was similar to that of importing a subbasecourse-quality crushed rock. Recycling the existing material gave significant benefits to the community as less of the local aggregate resource was used, transportation of materials outside the site was reduced and dumping whole or broken concrete slabs was not required. A modern mix design Superpave asphaltic concrete was specified for the surfacing.

INTRODUCTION

The Royal New Zealand Air Force (RNZAF) has had the main runway at its Ohakea airbase reconstructed. This paper describes the design and construction of the new pavement. In particular, an environmentally sensitive approach was taken in design with the crushing and reuse of the existing concrete slabs, which provided significant benefits to the project and community in respect of aggregate resource use.

BACKGROUND

The Ohakea 09-27 iunway was originally constructed during World War II to 2134m length from 260mm thick hexagonal concrete slabs, poured directly on a levelled subgrade. A 60mm asphaltic concrete overlay was added directly over the original concrete slab pavement in 1970. The runway was extended eastwards by 305m in the 1970s to give an overall iunway length of 2439m. The asphalt overlay surfacing subsequently cracked along the underlying hexagonal joints, due to movements of the concrete slabs relative to one another. The reflective cracking gradually worsened over the following 20 years, in particular, spalling from the cracks became more prevalent resulting in an ever-increasing risk of damage to aircraft.

The runway was used through the 1970s, 1980s and until the late 1990s by military jet trainers and combat aircraft, mainly Strikemaster, A4 Skyhawks and Aermacchis. Less frequent traffic consisted of the air force transport aircraft such as C130 Hercules, Andovers and Boeing 727.

A 1988 study identified that the strength of the 09-27 iunway was sufficient for it to remain serviceable for some years provided aircraft weights did not increase. A sluivy seal treatment was recommended to mitigate the risk of Foreign Object Damage (FOD) to aircraft.

Since 1988 the runway has been resurfaced with more coats of slurry seal in order to seal the joints and rejuvenate the deteriorating asphalt surface. The reflective cracks propagated through the sluny seal layers within a few years each time and these cracks were treated with rubberised bandages. This treatment has effectively extended the pavement life by 14 years for relatively low expenditure. However, the method of treatment was seen as unsustainable long term as there would be an increasing risk of delamination of the built-up thicknesses of slurry seal.

DESIGN REQUIREMENTS

The new 09-27 runway was to be built on the same horizontal alignment as the old runway in order that flight paths remained unchanged, navigational aids such as approach lights, the instrument landing system and VORTAC did not need relocation and tie ins to all existing runways and taxiways could be reinstated. The old 09-27 runway had inward crossfall towards a slot drain which ran along the runway about one third across the width. One of the key requirements of the reconstruction was changing the cross-sectional shape to a crown with crossfalls towards the sides.

The target pavement strength was Pavement Classification Number (PCN) 65, compared to the old PCN rating of 42.

GEOTECHNICAL INVESTIGATION

Geology

The airfield is located on an alluvial flood plain terrace adjacent to the Rangitikei River in the Manawatu Region. The river deposited greywacke gravels from the Ruahine Range to the northeast, being well rounded at the Ohakea site.

Site Investigation

A programme of geotechnical testing was undertaken in 1988 in order to predict the pavement life remaining at the time and to recommend maintenance works.

The investigation work comprised:

- Benkleman Beam tests at about 20m spacing
- 21 hand auger bores along the runway centreline at 40 to 60m spacing with in situ CBR tests, Scala penetrometer testing and shear vane tests
- 2 plate load tests on the concrete surface and **5** plate load tests on the subgrade;
- Laboratory testing of soils and concrete core samples.

Soil Profile

The investigation showed that the existing concrete slabs were laid directly on a subgrade prepared by levelling out a gently rolling alluvial plain, which contains silts, sand and gravel, the majority being silt. Topsoil had generally been cleared but was encountered in 3 locations. Eight of the 21 bores encountered gravel directly below the concrete slabs.

All boreholes were terminated on teirace gravels, which varied in depth up to 1.7m, while typically 600mm to 1.0m deep. Excluding topsoil areas, the 90 percentile value of the CBR results in the sands and silts was found to be **5%** (i.e. 90% of values exceed CBR=5%). The terrace gravel layers including silty gravels areas were found to have an average CBR of 16%. and 24% where clean. For the new pavement design, a 90 percentile value for a saturated gravelly subgrade was assumed to be 10%.

The laboratory tests showed the silts to typically be of medium compressibility and plasticity.

PAVEMENT DESIGN

Aircraft Traffic

Table 1: Aircraft Traffic Used for Pavement Design.

Aircraft	Maximum Takeoff Weight (tonne)	Wheel Load (tonne)	Annual Passes	Total Passes after 40 years
C130 Hercules	70	16.7	1,429	57,160
Boeing 727	80	19.0	685	685
Boeing 757	116	13.8	685	26,715
P3 Orion	58	13.7	1,778	35,560
Boeing 737	69	16.5	1,512	46,240
Boeing 767	185	22.0	271	10,840
Boeina 747	395	23.4	204	8.160

The traffic spectrum for pavement design (summarised in Table 1) was developed on the assumption that aircraft currently operating at Base Whenuapai will be shifted to Ohakea (although they may not actually operate at Ohakea for at least several years) and annual movements (not expected to change) will be added to the current movements occurring at Ohakea. The traffic estimate included the B757. which replaced the B727 upon completion of the reconstruction. An allowance was also made for proposed touch-and-go training movements of Air New Zealand B767 aircraft.

RNZAF also made an allowance for likely commercial (ie. freight) aircraft traffic over the 40 year design life. This traffic estimate was made irrespective of runway length considerations, since lengthening of the runway could be carried out in future.

No allowance for annual growth of commercial traffic was made, recognising that this would be offset by the delay (ie. several years) for the actual traffic to build up to the design traffic volumes.

PAVEMENT LAYERS

Subgrade

The above traffic loading was checked for the two possible subgrades. In one case, the subgrade was assumed to comprise silts (with CBR = 4%). and elastic layer analyses indicated the total pavement thickness would need to be about 1m. Undercuts of weaker material such as topsoil would be required in certain locations.

The other case was to remove all the silts to expose a sandy/gravelly subgrade with an assumed CBR of 10%. Elastic layer analyses suggested that a lesser pavement thickness of around 800mm would be required. However, undercutting below this design thickness would need to be in some areas deeper than for the CBR = 4% design case.

The total pavement volumes required would therefore have been similar for the two cases. A combination of the two approaches could have been used, which would have resulted in places where a small thickness of clayey and silty materials would have remained beneath the pavement. However, the decision made was to remove of all of the weaker silty and clayey materials down to the terrace gravels. This allowed maximum benefit to be gained from the site's favourable geology, ie. the terrace gravel subgrade. This situation was seen as unusual in pavement design, especially for runways, which are so often built on alluvial plains or reclamations where substantial depths of weak subgrade commonly exist.

If clayey and silty materials were not removed there would have been several adverse effects:

- Settlement of the silt and clay resulting from the additional build up (about 500mm). This settlement would have resulted in unevenness in the pavement surface causing ponding.

- From experience of previous pavement construction at Ohakea, disturbance of the subgrade clay and silt materials during construction under dump truck wheel loads would have been a significant construction risk. Such disturbance may not have been detected during construction resulting in weak areas of pavement and possible delays to completion.
- The life of the pavement would have been limited due to greater susceptibility to rutting. Any future overlays would have needed to first fill any ruts, then provide the required additional thickness using new asphalt, resulting in greater cost.

Removal of all silt and clay materials down to the sand/gravel was considered feasible due to the relatively small additional undercut volume required. A disposal area on site was made available by RNZAF meaning transport and disposal outside the site was not required. Disposal was to a paddock leased by the RNZAF to local farmers. The benefit to the pavement of removing fine grained material is a substantially stronger pavement that will have lesser susceptibility to settlement or rutting under aircraft loading.

Superpave Asphaltic Concrete

A Superpave Mix 14 asphaltic concrete was selected for the surfacing. Superpave asphalt involves specifying relatively tight limits to aggregate grading, bitumen content and bitumen film thickness, which differ from conventional asphalt mixes (such as the Transit New Zealand mixes). Superpave uses less bitumen than the TNZ mixes and costs about the same. Other aspects of the mix design, construction and monitoring are conventional. The Contractor was required to make up a mix that suited the locally available aggregates to meet specified performance characteristics and to confirm this by laying a trial strip.

The Superpave mixes have been developed, used and proven in the US for the last decade to provide a more stable, less rut prone, long-term performance. Full-scale tests that were undertaken at Inchon (Korea) using a hlly laden **B747** wheel bogey effectively proved the mix design for over one million load cycles. Superpave mixes have been used at a number of recent large airports eg. Seoul, Chek Lap Kok (Hong Kong), Kansai (Osaka) and Kuala Lumpur. They have also recently been used on airside taxiway and apron pavements at Auckland International Airport and for the 2000/2001 runway overlays completed at Wellington, Dunedin and Queenstown airports.

Basecourse

Transit NZ specification M/4 (Reference 1) was used as the basis for procurement of the basecourse layer immediately below the asphalt surfacing. A higher density was specified than as required by Transit NZ B/2 (Reference 2).

Upper Subbasecourse - Crushed Concrete

A granular material of less demanding specification than the basecourse would normally be used for the subbasecourse. In this case it was proposed to crush the existing concrete slabs and recycle the material as an upper subbasecourse layer. The recycled crushed concrete provided a free draining, economical granular material. The old asphalt overlay, which included three slurry seal layers and rubberised bandaging material, was not separated from the concrete before crushing as this would have involved an additional demolition operation. The upper subbasecourse is therefore a mixture of broken concrete and some asphalt (about 20%). It was not clear at the design stage how successful the crushing operation would be in terms of the grading of the crushed concrete achieved and the practicalities of crushing such as potential clogging due to the presence of asphalt and bandages. Research showed that there was much experience of crushing concrete and recycling asphaltic concrete in the US and Britain, but previous cases of crushing concrete and asphalt together were not found. After discussions with contractors, it was predicted that crushing would be feasible and allowance was made for trialling the crushing early in the construction contract.

The cost of crushing the concrete was similar to that of importing a subbasecourse-quality granular material. However, recycling the existing material gave significant benefits to the community as less of the local aggregate resource was used, transportation of materials outside the site was reduced and dumping whole or broken concrete slabs was not required. The concrete could have been crushed to lower specification at less cost and used as a granular bulk fill in the lower subbasecourse but it was considered that there was potential benefit to the pavement from a degree of cementation forming in the compacted layer. The results of construction testing are discussed below.

Lower Subbasecourse

The river gravel material that is readily available near the Ohakea site was used for backfilling the undercuts and making up the rest of the required pavement thickness below the crushed concrete layer, ie. the lower subbasecourse.

Pavement Profile

The design pavement profile is therefore as follows:

Surface	125mm Mix 14 Superpave Asphaltic Concrete
Basecourse	350mm TNZ M/4 AP40
Upper Subbasecourse	280mm Crushed Concrete
Lower Subbasecourse	River gravel (thickness varies)
Subgrade	Terrace Gravels - CBR = 10% minimum

Analyses were undertaken using the computer programme APSDS (based on the multi-layered elastic analysis programme CIRCLY) to check the predicted life of the above pavements against the expected loading. The analyses confirmed that a substantially greater frequency of loading than predicted would be needed before the pavement would fail by fatigue cracking.

The thicknesses of asphalt and basecourse are the minimum required to resist the wheel loads of aircraft such as B747. particularly the shearing and shunting forces that occur as the aircraft brake and turn at the iunway ends and taxiway intersections.

CONSTRUCTION ASPECTS

Subgrade

As the required subgrade was teirace gravel, Scala Penetrometer testing was not always a practical means of verifying the subgrade strength. Visual inspection and proof rolling was undertaken once sufficient lower subbasecourse fill had been placed to form a level surface.

River Gravel Lower Subbasecourse

Quality control for this layer was readily and adequately achieved by proof rolling.

Crushed Concrete Upper Subbasecourse

A well-graded aggregate was readily obtained by crushing the slabs. Quality control testing comprised grading tests, weathering tests, CBR tests and crushing resistance tests, all of which the samples passed. Figure 1 shows several typical grading curves.

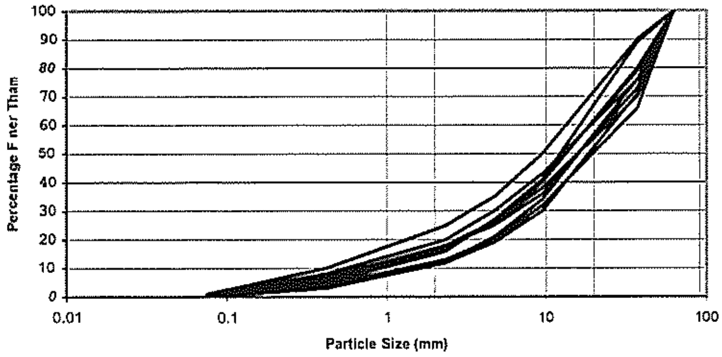

Figure 1 – Crushed Concrete Typical Grading Curves

Benkleman Beam testing was undertaken on the surface of the crushed concrete upper subbasecourse. The average deflection under 8.2t axle load was 0.59 mm and the 90 percentile deflection was 0.81 mm. These values were less than the specified value of 0.9 mm.

Photo 1 shows the potential for (weak) cementation of the compacted crushed concrete in that vertical faces were formed when loaders removed material from the stockpiles.

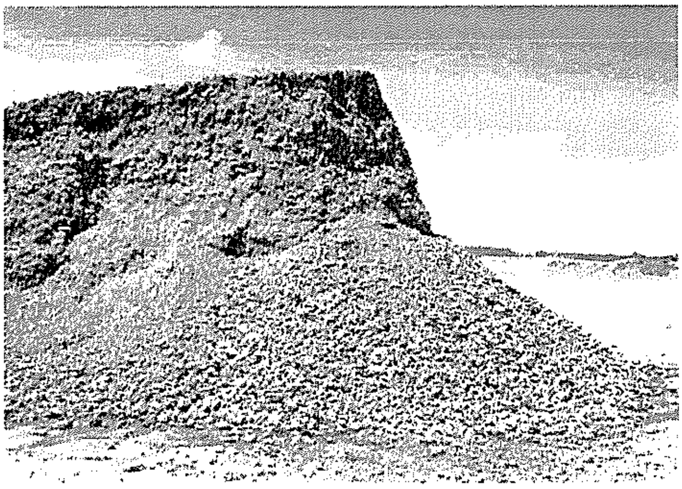

Photo 1 – Crushed Concrete Stockpile

Basecourse

Quality control testing of the basecourse included in situ density, Benkleman Beam and level tolerances.

Mix 14 Superpave Asphaltic Concrete

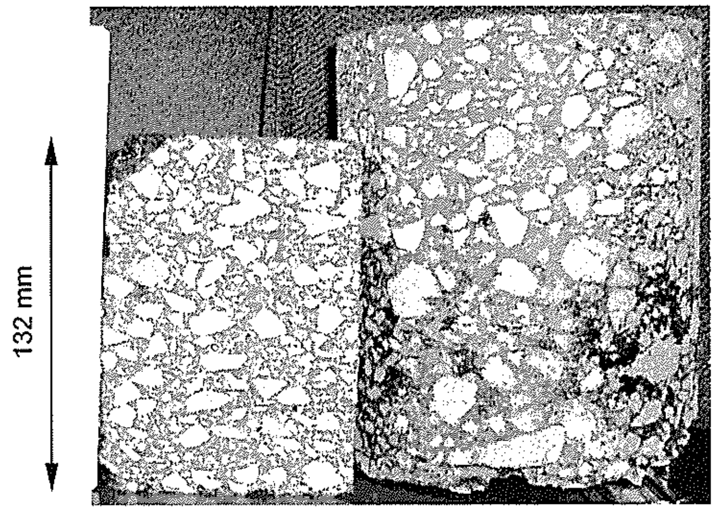

Photo 2 – Ohakea Asphalt Core (left) and Mix 14 Superpave Overlay on Transit NZ Mix 20 (AIAL) (right).

Photo 2 shows on the left a typical core sample of the Superpave asphalt placed at Ohakea. For comparison with conventional mixes, the core on the right is from Auckland International Airport, where an overlay of Superpave Mix 14 was placed over a layer of Transit NZ Mix 20. Of note is the apparent gap-grading of the TNZ mix, with a greater proportion of bitumen, and apparently less contact between the coarse aggregate particles.

The Superpave mix was found to be readily workable (ie. less subject to segregation than the equivalent TNZ or FAA mixes, particularly at the edge of the paver run) producing a uniform and high friction surface. Paver run joints bonded well to give integrity of the asphaltic concrete through the joints. Friction values achieved were consistently high in the range of 0.65-0.75 as measured using a Griptester (at 65 km per hour with a 1mm film of water on the surface).

CONCLUSIONS

- Reconstruction of Ohakea's 2439m long 09-27 runway has been completed, involving removal of the existing concrete pavement, crushing and reusing the concrete in a new flexible pavement with a Superpave asphaltic concrete surfacing.
- Excavation of silts and clays was undertaken to expose a terrace gravel layer at 1-3m depth, providing a relatively strong subgrade. Excavated materials were disposed of on site.
- The existing concrete slabs were crushed and reused giving several benefits – reduction in aggregate resource used, reduction in disposal of old concrete, reduction in transport of materials outside the site and improved strength of the new pavement. Engineers should be aware of potential benefits of reuse of crushed concrete as a pavement layer, ie. self-cementation, which can make the cost of crushing economic.
- Superpave Mix 14 asphaltic concrete was used for the runway surfacing, providing an economic, readily constructible surfacing with good friction qualities.

REFERENCES

1. Transit New Zealand, 1995, "M/4 – Specification for Basecourse Aggregate".
2. Transit New Zealand, 1997, "B/2 – Specification for Construction of Unbound Granular Pavement layer".