Use of Coral as an Engineered Construction Aggregate in Pacific Runways

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Introduction

What is coral and the forms

Project Examples

- Kiribati (Funding: NZ Aid / MFAT  Contractor: Downer)
  ▪ Cassidy Runway Short Term Repairs and Long Term Rehabilitation
- Solomon Islands (Funding: NZ Aid / MFAT  Contractor: Downer)
  ▪ Munda Runway Reconstruction
  ▪ Munda – Noro Road Reconstruction
  ▪ Nusatupe Runway Reconstruction
- Other Pacific Projects
- World Bank – Pacific Airports Improvement Program

Working in the Pacific

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Coral – What is it?

All coral is of marine origin and is scientifically classified as an organic sedimentary rock. It is light in colour and ranges from unconsolidated deposits of beach sand to dense reef deposits of coral limestone.

Typical coral consists of 95 to 99 percent calcium carbonate.

Coral grows and typically forms fringing reefs around volcanic seamounts throughout the pacific.
The forms of Coral preferred for Engineering
Christmas Island – Pacific ETOPs
Operation Grapple – 1950’s

[Images of a runway, aircraft on the ground, and an atomic explosion]

ABOVE: Vickers Valiant B.1 of No. 46 Squadron, R.A.F., on Christmas Island for Operation "Grapple". kidded in this group is Valiant XN921 which dropped Belton's first Fission bomb on 15th May 1957.

[Image of a beach with rows of buildings and a night sky with a glowing nuclear explosion]
Fast Forward 50 years.......... Not so flash.....
Stage 1 - Short Term Repairs – Roller Compacted Cold Mix Asphalt

Working with Downer, AECOM specified a 75mm deep cold mix asphalt to meet the Australian Standard AS4823 ‘Cold Mix asphalt for maintenance patching’

A special designed AC 20 “airport mix” was manufactured by Downer;
1. relatively high stiffness modulus to resist large wheel loads
2. specially imported additives to enable cold compaction
3. a relatively low diluent content to allow shipment to site.

SEST to all other airside pavement areas
STG 2 Proposed Rehabilitation Works – Design Assumptions

Design Aircraft Traffic
Boeing 737-7/800 Twice Weekly
Boeing 727-200 Freighter Twice Monthly
C130 and P3 military traffic

Design Life
20 Years (without major maintenance)

PCN requirements
Minimum 40 PCN

Standards
ICAO Annex 14 and FAA AC 150/5320-6E Pavement Design and Evaluation
Main Runway

Runway shape, dip in centre, past variable depth overlay to increase cross fall
Problem – Existing AC surfacing has significant reflective cracking. Underlying concrete slabs already failing under traffic loadings to date.
Proposed Rehabilitation Works – Runway Ends

Proposal - Full depth reconstruction

Remove under strength slabs, crushed into subbase sized aggregate, recycled back into pavement
Quarrying of Coral Aggregate

The rear of the beach “rumble mound” provided a source of high quality coral slabs for processing.
Quarrying of Coral Aggregate

Quarry site processing facility, primary and secondary crushing and initial screening.
Quarrying of Coral Aggregate

Full processing was implemented, primary and secondary crushing then transportation to the airport for final crushing and screening.
Coral Asphaltic mix

Absorption characteristics of the Coral is a critical aspect for asphaltic mix design

Initial sampling & testing of the existing asphalt surfacings indicated a around 7% bitumen content, with around a 2% absorption value

Production testing from the selected source revealed more like 3% to 4% absorption values, final mix design included 10% bitumen content
Solomon Islands

Munda Runway Reconstruction; Official opening 15th August
Munda – Noro Port 18km Road – End September
Nusatupe Runway reconstruction – 9th September
Solomon Islands: Munda Runway Reconstruction

Major WW II airfield and the site of extensive bombardments

After extensive on site sampling and testing, re-established the US Army Corp quarry as the preferred materials source
Pavement Reconstruction
Basecourse grading

![Basecourse grading graph]

- FAA LOWER LIMIT
- FAA UPPER LIMIT
- MUN SAMPLE PRE COMP
- MUN SAMPLE POST COMP
- NZ AP40 EXAMPLE

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Solomon Islands: Nusatupe Runway Reconstruction

Constructed in the 1960’s by bulldozing two small adjoining low lying islands together to form a 1.2km runway, rough unsealed runway

Large coral rock “mound” in the runway central area cut down and used as the aggregate supply source for the runway reconstruction
Other Current Pacific Coral Aggregate Runway Projects

Cook Islands

Aitutaki
  - SEST treatment to the 2003 runway surfacing

Rarotonga
  - Epoxy injection in co-ordination with Auckland Airport (AIAL) to stabilise PCC slabs
  - HWD survey and slab remediation program underway
Working in the Remote Pacific: Main Considerations

• Heat hydration
• Research First Aid facilities, usually v.poor quality, take supplies
• Water sources – consider salination plants for major usage requirements
• Tsunami risk low in Coral Atolls (sharp rise off seabed not conducive to a wave)
• Nearer the equator the UV is not as harsh as in NZ (personal opinion)
• Plant failure - expect it!
• Corrosion - expect it!
• Bring plenty of spare parts for all equipment
• Length of visit durations – 6-8 weeks should be considered a maximum without breaks.
Questions?
### Munda Airport UXO Findings to date…

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### References

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<tr>
<th>Author</th>
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<th>Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.A. Bowers</td>
<td>Coral airstrips on Pacific Islands</td>
<td>Engineering News Record, 1944</td>
</tr>
<tr>
<td>William F. Luce</td>
<td>Airfields in the Pacific – Coral used extensively for roads and runways</td>
<td>Civil Engineer, Vol. 15 No. 10, 1945, pp 452 – 455</td>
</tr>
<tr>
<td>P.J. Halloran</td>
<td>Building B-29 Bases on Tinian Island</td>
<td>Engineering News Record, 1945</td>
</tr>
<tr>
<td>F.R. Vines and G.D. Falconer</td>
<td>Experience with coral and volcanic road construction materials in Western Samoa</td>
<td>Australian Road Research, Vol. 10 No.1, March 1980</td>
</tr>
<tr>
<td>F.R.Vines</td>
<td>Experience with use of coral detritus as concrete aggregate in Western Samoa</td>
<td>Australian Road Research, Vol. 12 No.1, March 1982</td>
</tr>
<tr>
<td>F. Bullen and B.S. Heaton</td>
<td>Evaluation of Coronus Pavement Materials</td>
<td>13th ARRB / 5th REAAA, 1986</td>
</tr>
<tr>
<td>National Building Technology Centre</td>
<td>The use of coral as an aggregate for civil engineering purposes</td>
<td>The Centre, 1988</td>
</tr>
<tr>
<td>F. Bullen</td>
<td>The use of coral detritus in engineering projects in reef regions</td>
<td>ECRRC, pp. 81–86, 1991</td>
</tr>
</tbody>
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Thank You

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