WHANGAPARAOA ROAD FOUR LANING - SUSTAINABLE PAVEMENT CONSTRUCTION USING A MODIFIED LOCAL BASECOURSE

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ABSTRACT

While modified aggregate has successfully been used as basecourse for many years, as a pavement rehabilitation or upgrade process, it has not commonly been used on heavily trafficked arterial roads. The Whangaparaoa Road Four Laning Project in the Rodney District provided the perfect opportunity to incorporate a stabilised pavement design, minimise traffic disruption during construction and to achieve the client's objectives.

This project proved a very timely as Transit New Zealand and some of the country's leading pavement designers are currently advocating the use of modified aggregates in pavement construction to alleviate some of the issues facing the roading industry today, namely environmental considerations, pavement performance, limited premium aggregate resources and high supply and construction costs.

Whangaparaoa Road is a two lane road that provides the only route to the Whangaparaoa Peninsula and services some 29,000 residents and numerous businesses with a current population growth of 19%. Consequently the section between Red Beach Road and Vipond Road was experiencing escalating peak flow traffic delays and was in urgent need of upgrading.

The Rodney District Council awarded a competitively tendered, $13 million, contract to Works Infrastructure in late 2004 to widen an existing 1.8km length of two lane carriageway to new four lane configuration to reduce congestion and travel times. The conforming pavement construction consisted of a shape correction incorporating varying depths of structural asphalt and M/4 AP40 overlays to achieve geometric design and M/4 AP40 basecourse for the road widening.

Post the contract award, Works Infrastructure in conjunction with Hiway Stabilizers proposed an alternative pavement design which was adopted by the Rodney District Council. The alternative replaced both the structural asphalt overlay and M/4 AP40, with a modified, locally available GAP65 "marginal" aggregate. This alternative would greatly reduce construction time in addition to providing a more homogenous and robust pavement while achieving the pavement design life requirements.

The pavement reconstruction was completed in very difficult winter weather conditions and demanding traffic volumes and clearly demonstrated the benefits of aggregate modification as a sustainable pavement construction method.

1. BACKGROUND

Whangaparaoa Road is a two lane road that runs the entire length of the Whangaparaoa Peninsula come 30km north of Auckland's CBD. Over much of its length this road is the only collector arterial route serving a heavily populated area with a current population of around 29,000, numerous businesses and a growth rate of around 19%* which is projected to continue to at least 2011.

Figure 1: Whangaparaoa Peninsula showing Whangaparaoa Road (blue) and the four laned section (red).

The 1.8km section of road between Red Beach Road and Vipond Road intersections carries some 30,000 vehicles per day. In 2004 this section of road had become highly congested with escalating traffic delays during increasing peak periods. It had, in fact, reached its capacity as a two lane road back in 2001*.

Towards the end of 2004 the Rodney District Council awarded a $13 million contract to Works Infrastructure to widen and upgrade this highly congested 1.8km section of arterial road to 4 lanes including a flush median.

* From RDC Mayoral Presentation on Whangaparaoa Road Improvements, 2004.

2. ORIGINAL PAVEMENT DESIGN

2.1 EXISTING PAVEMENT

Whangaparaoa Road runs along a series of ridges, hill sides and gullies featuring generally low strength subgrade soils. Over the years it has been gradually upgraded from a very basic unsealed road into its pre four laning format. This gradual process of upgrades involved various construction designs and techniques as well as various remediation and “drop out” treatments. As a result the pavement, though performing adequately, was made up of areas of different aggregate types and depths and included various stabilisation and deep asphalt sections.

2.2 ORIGINAL DESIGN

The original pavement design for the four laning project consisted of widenings of varying widths on both sides of the road and a shape correction of the existing pavement. Design plans showed different pavement construction designs to accommodate the new pavement and to upgrade the existing pavement.

The widened pavement sections required TNZ M/4 AP40 (M/4) aggregate for a 200mm deep basecourse layer. The shape correction required M/4 aggregate for overlay depths ranging from 100mm to 700mm and structural asphalt for overlay depths less than 100mm.

The original contract schedule of quantities included 10,300m^3 (solid) of M/4 and 700m^3 (solid) of asphalt.

2.3 CONSTRUCTABILITY

Following contract award, a partnership approach was adopted by the principal (Rodney District Council), the contract engineer (GHD Consultants) and the head contractor (Works Infrastructure) with input from the specialist roading subcontractor (Hiway Stabilizers).

The aim was to review the pavement construction issues and to consider a proposal featuring a cost effective, quality pavement design and revised construction methodology while maintaining two way traffic at all times.

The major issue faced by Works Infrastructure was constructing the shape correction overlay to varying depths using two different materials on a very heavily trafficked road. This would require precise staging of relatively small areas and a lengthy construction period with considerable traffic delays.

The overall objective of revisiting the pavement design was to develop a faster construction sequence and more uniform pavement.

The other issues considered against the original pavement concept were:

- The high cost of the M/4 basecourse aggregate.
- The long haul distance (90 km) from the M/4 quarry to the site.
- Congestion on the aggregate haul route which utilised the southern and northern motorways.
- The high costs of structural asphalt.
- The non uniformity of the existing pavement.
- The non uniformity of the proposed pavement and associated tie ins and impact of construction sequencing.
- The uncertainty of performance of an unbound pavement under intense traffic loads.
- The time of year (May, June, July) that the pavement construction was programmed for and the associated risks.
- The high costs associated with the time required in preparing and maintaining an M/4 basecourse construction prior to surfacing especially considering the high traffic volumes and weather conditions.
- The forecasted traffic delays that would undoubtedly cause problems during construction.

3. ALTERNATIVE PAVEMENT DESIGN

3.1 ALTERNATIVE SOLUTION

The pavement carries up to 30,000 vehicles per day, and has been designed for a 25 year life. This equates to about 10 million Equivalent Standard Axles (ESA), and so the pavement can be described as intensely loaded.

Since the original concept of an unbound granular pavement for this project, awareness of the advantages of a modified pavement structure for high volume roads has been publicised, notably in the Transit New Zealand “Road Shows” held around the country earlier this year.

The intensely loaded pavement with modified basecourse will be significantly less susceptible to rutting than an equivalent unbound granular pavement, and consequently the risk of maintenance intervention is reduced. This finding from recent research is likely to be formally recognised in design procedures now in preparation by Transit New Zealand and Roading New Zealand

The solution was to adopt a design which resulted in a simplified and constructable pavement. By adopting a stabilised pavement construction comprising a modified basecourse overlay, constructability and performance issues were addressed. Consequently, in light of current thinking, this solution was timely and appropriate for the Whangaparaoa Road four laning project.

Conformin Conventional Pavement 1 x 10^7 ESA Design Life
Asphalt Surfacing
Structural Asphalt "Make Up" to 100mm
TNZ M/4 AP40 Aggregate "Make Up" 100mm - 700mm
Existing Pavement Variable Depth
Subgrade

Alternative Modified Pavement 1 x 10^7 ESA Design Life
Asphalt Surfacing
Modified GAP65 and Existing Pavement Aggregate 300mm
GAP65 Aggregate "Make Up" 300mm - 700mm
Existing Pavement Variable Depth
Subgrade

3.2 MODIFIED BASECOURSE DESIGN

The modified basecourse layer incorporated a locally available “marginal” GAP65 basecourse aggregate of volcanic andesite origin from Winstones Flattop quarry for both the shape correction and the widenings. The basecourse was modified to a consistent depth of 300mm and incorporated where necessary the existing pavement.

The aggregate overlay depths for the shape correction of the existing pavement were generally 200mm to 300mm but ranged from as little as 40mm up to 700mm in order to achieve the designed pavement geometrics.

The design for modifying the GAP65 basecourse incorporated 1% cement and 4% KOBM binder™, a road stabilising binder based on a slag waste product of the Glenbrook Steel Mill. This stabilisation treatment has a proven track record of successful use in the Rodney District and surrounding areas, but has mostly been used on existing moderately trafficked or rural roads as a rehabilitation or seal extension treatment.

Stabilised pavements incorporating the proposed GAP65 aggregate are well documented and come with a high degree of confidence. However this was the first use of modified GAP65 “marginal” aggregate as the upper basecourse layer on an arterial road in the Rodney District and possibly one of the few such uses on a major arterial roadway in New Zealand.

Due to the time of year, the weather conditions at the time of the works and the tight construction program, the GAP65 aggregate had become saturated. Drying this aggregate out by conventional methods was not an option due to the traffic congestion and time and space limitations. It was therefore decided that an additional 1% of lime oxide fines was to be added to the modification treatment to effectively dry back the excess water in the aggregate.

3.3 CONSTRUCTABILITY ISSUES

The table below outlines the issues addressed by this adopted pavement methodology:

Issues Relating to Original Design & Construction	Alternative Pavement Design & Construction
Difficult sequencing required to construct the shape correction using two different materials in heavy traffic.	Single overlay aggregate type capable of being placed quickly and efficiently and able to be trafficked immediately.
High cost M/4 basecourse and overlay aggregate.	Lower cost GAP65 aggregate to be modified.
High cost asphalt overlay material.	Structural asphalt layer replaced by more cost effective marginal GAP65 aggregate.
Long M/4 haul distance (90km).	Shorter haul distance (20km) for marginal aggregate.
Construction Non uniformity of existing and proposed pavements creating uncertainty of performance.	Modification of the GAP65 basecourse and overlay aggregate, including some existing pavement, to a uniform 300mm depth creating a homogenous strength basecourse layer.
Construction time required in laying and maintaining an M/4 basecourse for surfacing on a heavily trafficked road in early winter conditions.	Modification of the basecourse enabled virtually immediate trafficking and no maintenance was required prior to surfacing.
Unbound pavements are susceptible to premature rutting under intense traffic loads.	Modified basecourse provides rut resistance and reduced maintenance costs.

3.4 ALTERNATIVE DESIGN DETAILS

The alternative pavement had to have a design life of 25 years and $1x10^7$ ESA. Three major considerations favoured choice of a modified basecourse, namely:

- Minimisation of construction time and associated disruption to traffic.
- Capitol cost benefits through the use of cost-effective aggregates in a locality where premium aggregates incur large cartage costs.
- The benefit of a “homogenised” pavement structure with rut resistant properties.

3.4.1 Minimising Construction Time

An insitu recycled aggregate using stabilising equipment is recognised as particularly appropriate for high volume roads because of the speed and ease of construction compared with an unbound granular material. Furthermore a modified aggregate is less susceptible to rutting under intense traffic loading and the modifying agent and added water act as lubricants to facilitate compaction before the bonding reaction commences.

The application of a stabilising hoe across the full pavement width enabled shaping and compaction to continue apace, and avoided otherwise time-consuming treatment of transition sections.

Details of the timing and sequencing with which pavement construction and surfacing was completed is contained in the following section.

3.4.2 Cost-effective aggregates

Cost is an important factor for both Client and Contractor. Premium M/4 aggregate is scarce in the Rodney District and greater Auckland area and is relatively expensive due to high production and cartage costs. Selection of GAP65 material results in preserving premium aggregate. Recent analysis has confirmed that after stabilising a GAP65 aggregate will achieve close to an M/4 particle size distribution accounting for some grading modification due to the hoeing process.

Also importantly, the intent of the Land Transport Management Act (2003) is being fulfilled: scarce, non-renewable reserves of premium aggregate are being preserved, and a more readily available non-conforming product is brought to a state of conformance through modification and hoeing process.

3.4.3 A Homogeneous Pavement

Apart from the time required to properly construct transitions between existing and new pavement structures, it is desirable to have a consistent pavement structure across a section, in order to avoid rutting or otherwise loss of shape.

The process of hoeing, modifying and compacting across the full pavement width ensures that the top 300mm of basecourse is essentially homogeneous, whether it was part of the original pavement or the constructed widening. This intensely loaded part of the structure is thereby enabled to act in a more uniform and predictable manner in response to traffic loading.

4. CONSTRUCTION

4.1 TRAFFIC ISSUES

It was widely acknowledged by all parties that the pavement construction would cause traffic delays. Even though the road would maintain two lanes of traffic open at all times, the revised stabilised pavement option would beneficially result in reduced construction time and consequently traffic congestion and public disruption.

The shortened construction time, design life and cost implications were a major consideration in selecting the modified pavement design option.

4.2 RESOURCES

Following consultation with all parties involved it was decided to construct the bulk of the pavement in one continuous operation utilising the combined resources of Works Infrastructure and Hiway Stabilizers.

A grader crew from Works Infrastructure plus two from Hiway Stabilizers, two stabilisation crews from Hiway Stabilizers as well as additional compaction plant from Hiway Stabilizers were utilised on the project.

Specialist plant and experienced operators were employed to ensure the highest production outputs and quality was achieved and included:

- Two - Komatsu GS360-2 recycling stabilisers.
- Six - precision additive spreader trucks (for spreading KOBM slag).
- Two – heavy sixteen to nineteen tonne, vibratory, padfoot rollers for primary compaction.
- Five - ten to fourteen tonne vibratory smooth drum rollers.
- Three - Caterpillar 12H graders.
- Four - pressurised water carts with side and rear mounted spray bars.

4.3 PRODUCTION

The pavement was constructed in two sections with the bulk of the pavement being constructed over the Queens Birthday long weekend. The operation required strict management to coordinate the two grader and stabilising crews and the materials being delivered to site. Special consideration was given to the stabilisation construction plan with transverse construction joints planned for the road crown and in between the lanes.

The following productions were achieved which was a credit to all involved who worked long hours, weekends and nights to ensure the works were completed on time.

- 15,900 m^3 (loose) of GAP65 placed to precise levels in 6 days.
- 38,320 m^2 of modified basecourse in 4 days.
- 38,320 m^2 of pavement trimmed to precise levels in 5 days.
- 1,915 tonnes of asphalt surfacing placed in 3 nights including road markings.
- 750 tonnes of KOBM.
- 230 tonnes of cement.
- 200 tonnes of lime oxide fines.

4.4 SURFACING

The surfacing was carried out at night to limit traffic disruption and to provide an immediately trafficable and safe surface for motorists.

It was accepted that placing the asphalt on an uncured, modified basecourse posed some risk of failure especially as certain soft areas in the existing pavement which were noted prior to the placement of the GAP65. However to alleviate the traffic congestion it was decided not to wait for the modified basecourse to cure.

Instead of laying the full 50mm thickness of asphalt wearing course immediately it was decided that a 20mm thickness would be applied first and a second 30mm would be applied in early summer to cover over any pavement repairs or damage that may eventuate.

4.5 TESTING

The rapid construction program did not compromise the requirement for strict quality control and testing. Amongst other tests performed approximately 375 nuclear densometers and 50 CBRs carried out.

The nuclear densometers performed on the modified basecourse prior to surfacing produced average results of 109% of Maximum Dry Density indicating that the heavy rollers were achieving specified compaction levels for the 300mm deep modified layer.

The CBRs samples were taken from behind the stabilising hoe and taken back to the laboratory for testing. The average result was a CBR of 150 indicating that the basecourse achieved a good degree of modification.

4.6 TRAFFIC DISRUPTION

There was no way of eliminating significant traffic delays during the pavement construction program. During the week leading up to the Queens Birthday long weekend and despite two lanes of traffic being open at all times, the traffic delays were featured on most national news programs in New Zealand. However this was a relatively short period of inconvenience for motorists.

By the Tuesday following Queens Birthday, traffic was running smoothly on four lanes of newly surfaced road and in fact had to be slowed down through the work zone.

Overall the construction of the modified pavement took less than half the expected time it would have taken to construct the original pavement thus effectively halving the period of traffic delays.

5. BENEFITS

The benefits associated with the adopted modified basecourse pavement design and methodology on this project are varied and in many cases intangible. The intangible aspect of these benefits has been addressed in further detail in another paper titled “Quantifying the Intangible Benefits of Stabilisation” co written by Hiway Stabilizers and Opus International Consultants.

Undoubtedly the main benefit of the adopted pavement design and methodology was the reduced construction time which totalled a mere 12 days as opposed to the original design which would have taken closer to 30 days. This reduced construction time provided many benefits to the project and the road users.

5.1 CONSTRUCTION BENEFITS

- The speed of construction as detailed in Section 4 was the obvious benefit associated with the adopted pavement design and methodology.
- Creating a uniform 300mm deep modified basecourse pavement layer provided the benefit of a high strength homogenous basecourse with a high degree of confidence.
- Using a more readily available GAP65 aggregate preserves diminishing resources of premium quality M/4 aggregate.

5.2 ENVIRONMENTAL BENEFITS

- The difference in the haul distances between the GAP65 source and the M/4 source was 70km each way. This equates to around 120,000 less kilometres of truck and trailer travel to deliver the GAP65 to site as opposed to the M/4. The resulting reduction in carbon dioxide emissions and other road usage pollutants would be significant.
- The reduced construction time associated with the alternative pavement methodology reduced the amount of time that traffic was delayed and therefore provided the benefit on reduced carbon dioxide emissions from vehicles.
- The stabilisation design used a waste product, KOBM binder, from the Glenbrook Steel Mill that would otherwise be dumped in a landfill.

5.3 SOCIAL BENEFITS

- The M/4 aggregate would have been hauled through Auckland’s heavily congested motorways and was originally programmed to be delivered to the job site during the night. The anticipated 1,760 truck and trailer movements along the haul route would have caused noise and traffic issues with local residents.
- The reduced construction time and associated reduced traffic delays resulted in reduced disruption to daily life for the local road users.

5.4 ECONOMIC BENEFITS

- The reduced period of traffic delays resulted in reduced disruption to local businesses and reduced vehicle running costs for road users.
- The more homogenous semi bound pavement comes with a high degree of confidence and is expected to require less maintenance effort and cost over its intended life time than the non-uniform, unbound original pavement design.

6. SUMMARY

The Whangaparaoa Road Four Laning Project is a good example of the use of a modified basecourse pavement construction technique being used to replace a premium unbound aggregate in a high traffic environment and unsatisfactory weather conditions.

This stabilised pavement design is arguably a more sustainable pavement construction method as it conserves limited premium aggregate resources and recycles existing pavement materials.

The stabilised design enabled a construction methodology that provided significant benefits to the project and the local community.

This project proved very timely as Transit New Zealand and some of the country's leading pavement designers are encouraging the use of such construction techniques and are promoting the benefits of modified aggregates in pavement construction as an "insurance" means of avoiding premature rutting and associated pavement failures. This shift in policy is set to alleviate some of the issues facing the roading industry today, namely environmental considerations, pavement performance, limited premium aggregate resources and high supply and construction costs.

The partnering approach adopted on this project between the Rodney District Council, GHD Consultants, Works Infrastructure and Hiway Stabilizers is becoming more prevalent in the construction industry and this project highlights the benefits of such an approach.

7. REFERENCES

Rodney District Council Mayoral Presentation on Whangaparaoa Road Improvements: 2004.

Transit New Zealand Pavement Design Roadshow: March 2005.