Gold Coast Rapid Transit

Concept Design and Impact Management Plan

Volume 7 Technical Report - Concept Pavement Design for Bus Rapid Transit

TRANSLink

Gold Coast City Council

Queensland Government
Queensland Transport

Contents

1. Introduction 1
   - 1.1 Gold Coast Rapid Transit Project 1
   - 1.2 Concept Pavement Design for BRT 3
2. BRT Vehicle Frequency 4
3. Design BRT Vehicle and Loads 7
   - 3.1 Theoretical Design Vehicle 8
   - 3.2 BRT Vehicle Frequency & Traffic Volumes 11
   - 3.3 Design Vehicle Loads 12
4. Subgrade and Working Platform Structure 14
   - 4.1 Subgrade CBR 1.5% 14
   - 4.2 Subgrade CBR 3% 15
   - 4.3 Subgrade CBR 10% 15
5. Unbound Granular Pavement 16
   - 5.1 Pavement Materials 16
   - 5.2 Subgrade and Working Platform Modelling Parameters 16
   - 5.3 Base Thickness 17
6. Heavy Duty Deep Strength Asphalt Pavement Design 19
   - 6.1 Pavement Materials 19
   - 6.2 Subgrade and Working Platform Modelling Parameters 19
   - 6.3 Base Thickness 19
7. Heavy Duty Full Depth Asphalt Pavement Design 22
   - 7.1 Pavement Materials 22
   - 7.2 Subgrade and Working Platform Modelling 22
   - 7.3 Base Thickness 22
8. Heavy Duty Concrete Pavement Design 24
   - 8.1 Pavement Materials 24
   - 8.2 Subgrade and Working Platform Modelling 24
   - 8.3 Base thickness 25
   - 8.4 Detailing Requirements 29

9. Comparison of Results 31

10. Conclusions and Recommendations 34

10.1 Conclusions 34

10.2 Recommendations 34

11. References 35

Table Index

BRT Ops Report Table 13 Design Periods 4

BRT Ops Report Table 14 Proposed BRT System Operations to 2026 4

BRT Ops Report Table 15 Proposed System Operations Post 2026 5

Table 1 Summary of Theoretical Vehicle Axle Loads 10

Table 2 BRT Vehicle Passes – Helensvale to University Hospital 11

Table 3 BRT Vehicle Passes – University Hospital to Broadbeach South 12

Table 4 Design Vehicle Loads 13

Table 5 BRT Design Vehicle Pavement Loads – Helensvale to University Hospital 13

Table 6 BRT Design Vehicle Pavement Loads – University Hospital to Broadbeach South 13

Table 7 Unbound Granular Pavement Design Summary 18

Table 8 Asphalt Design Moduli 20

Table 9 Deep Strength Asphalt Pavement Design Summary 21

Table 10 Full Depth Asphalt Pavement Design Summary 23

Table 11 Continuously Reinforced Concrete Pavement Design Summary 26

Table 12 Expected Axle Repetitions – Helensvale to University Hospital 27

Table 13 Allowable Repetitions – 30 years 27

Table 14 Allowable Repetitions – 50 years 28

Table 15 Expected Axle Repetitions –University Hospital to Broadbeach South 28

Table 16 Allowable Repetitions – 30 years 28

Table 17 Allowable Repetitions – 50 years 29

Table 18 Reinforcing Details 29

Figure Index

Figure 1	Gold Coast Rapid Transit Project Stage 1 Investigation Corridor	2
Figure 2	Example Articulated Vehicle	7
Figure 3	Example Bi-Articulated Vehicle	7

Appendices

A Mass Limits for single axles and axle groups, Phileas vehicle specifications

B Axle Load Comparison, Adjusted Design Vehicle Axle Loads

C CIRCLY Analysis Summary Results

D Rigid Pavement Base Thickness and Reinforcement Detailing Calculations

E Generic Copy of MRSS.01.001 and MRSS.01.003

1. Introduction

1.1 Gold Coast Rapid Transit Project

The Gold Coast Rapid Transit (GCRT) project is a major Government initiative in creating a more sustainable Gold Coast City. The project will deliver a public transport system that is fast, frequent, reliable and integrated with the existing transport network.

In June 2006 State Cabinet approved the development of a Concept Design and Impact Management Plan and Business Case for two rapid transit mode options under Government's Value for Money Framework. The GCRT project is included in the South East Queensland Regional Plan and funded in South East Queensland Infrastructure Plan and Program. The lead Government Agency, TransLink, will develop the Concept Design and Impact Management Plan and Business Case in partnership with Gold Coast City Council who has also allocated future funding for public transport improvements on the Gold Coast.

The new rapid transit system is intended to link the Gold Coast Railway at Helensvale with the Griffith University/University Hospital precinct and the busy centres of Southport, Surfer's Paradise, Broadbeach, and ultimately Gold Coast Airport and Coolangatta Town Centre.

The rapid transit mode options under investigation are:

» A light rail transit (LRT) system with low floor air-conditioned vehicles on a standard gauge fixed track drawing power from overhead wires.

» A bus rapid transit (BRT) system that offers a much higher quality service than an ordinary bus, with specially designed buses running very frequent services and higher reliability and faster travel times than buses operating in mixed traffic.

Both systems will operate within a dedicated corridor, mostly centre running within existing roads. In some areas, a corridor adjacent to the road or mixed running with traffic has been considered. Regardless of the chosen mode, the technology option will use a dedicated carriageway 'at grade' with priority provided at traffic signals to promote fast and reliable journey times.

The Concept Design and Impact Management Plan and Business Case are based on detailed studies for Stage 1 (Helensvale to Broadbeach), with initial planning investigations of Stage 2 (Broadbeach to Coolangatta). The Stage 1 corridor, as shown in Figure 1, connects to the Gold Coast Rail Line at the existing Helensvale Rail station and terminates at Broadbeach at a new bus/rapid transit interchange. Stage 1 has been evaluated and planned in the following 3 sections:

» Section 1: Helensvale to University Hospital. Two corridor options are subject to detailed planning evaluation;

» Section 2: University Hospital to Southport; and

» Section 3: Southport to Broadbeach including Surfers Paradise.

Gold Coast Rapid Transit

532000 536000 540000

6912000 6908000 6904000 6900000

HOLLYWELL
RUNAWAY BAY
HELENSVALE
COOMBABAH
OXENFORD
MARBLE ARCH PLACE LOCAL STATION
ARUNDEL LOCAL STATION
BIGGERA WATERS
SOUTH STRADBROKE
HELENSVALE STATION REGIONAL STATION
BIGGERA WATERS REGIONAL STATION
LABRADOR
PACIFIC PINES
ARUNDEL
LABRADOR NORTH LOCAL STATION
LABRADOR SOUTH LOCAL STATION
GAVEN LOCAL STATION
MAIN BEACH
PARKWOOD
GAVEN
UNIVERSITY HOSPITAL DISTRICT STATION
GOLD COAST HOSPITAL DISTRICT STATION
GRIFFITH UNIVERSITY DISTRICT STATION
SOUTHPORT REGIONAL STATION
PARKWOOD WEST LOCAL STATION
PARKWOOD LOCAL STATION
SOUTHPORT
BROADWATER LOCAL STATION
MOLENDINAR
SOUTHPORT PRIMARY LOCAL STATION
SCARBOROUGH STREET SOUTH LOCAL STATION
MAIN BEACH LOCAL STATION
NERANG
ASHMORE
PARADISE WATERS LOCAL STATION
CYPRESS AVENUE DISTRICT STATION
CAVILL AVENUE DISTRICT STATION
SURFERS PARADISE
BENOWA
SURFERS PARADISE LOCAL STATION
BUNDALL
NORTHCLIFFE LOCAL STATION
HIGHLAND PARK
FLORIDA GARDENS LOCAL STATION
CARRARA
GILSTON
BROADBEACH WATERS
BROADBEACH NORTH DISTRICT STATION
BROADBEACH
WORONGARY
CLEAR ISLAND WATERS
BROADBEACH SOUTH REGIONAL STATION
MERMAID WATERS
MERRIMAC
TALLAI
MUDGEERABA
ROBINA

TransLink
Gold Coast Rapid Transit

DRAFT CDIMP

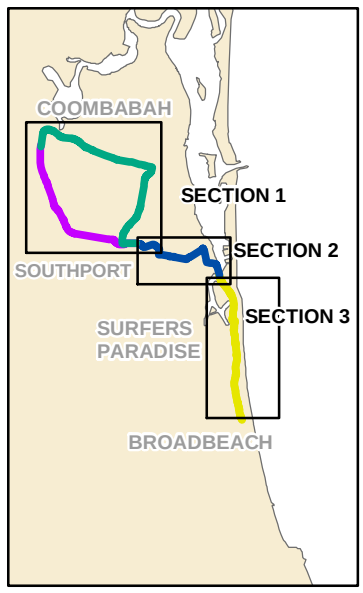
INVESTIGATION CORRIDOR

STAGE 1

FIGURE 1

Legend

- Stations
- Section 1: Option H1
- Section 1: Option H2
- Section 2
- Section 3



N W E S

0 500 1,000 1,500 2,000
Metres

1:50,000

Copyright: This document is and shall remain the property of GHD Pty Ltd. The document may only be used for the purpose for which it was commissioned and in accordance with the terms of engagement for the commission. Unauthorised use of this document in any way is prohibited.

Source: Imagery, Roads supplied by GCCC(2006). Precincts digitised from hardcopy supplied by ARCHAEO
Projection: MGA56 (GDA94)
Date Printed: 19-05-2008
File:G:\41\16445\GIS\MAP\Draft_CDIMP\Volume_7\TechnicalReports\MXD\Fig1_GCRT_Project_stage_1_investigation_Corridor_RevA.mxd
Size: A3

TRANSLink · Gold Coast City Council · GHD · Queensland Government Queensland Transport

1.2 Concept Pavement Design for BRT

This report details the BRT corridor and station concept pavement design. The pavement design is based on the Queensland Department of Main Roads (DMR) Pavement Design Manual Amendment 2, December 2005 (PDM). This report details four pavement configurations, being:

» Unbound Granular Pavement:

» Heavy Duty Deep Strength Asphalt Pavement;

» Heavy Duty Full Depth Asphalt Pavement; and

» Heavy Duty Concrete Pavement.

The heavy duty pavement configurations were selected as the most likely for the potential loads and design life expected for this project. While unbound granular pavements are not considered to be a viable pavement structure for this project, it was included in this concept pavement design to give a comparison with other commonly used pavement structures. Table 1.1 of the PDM also recommends the use of heavy duty pavements for this concept pavement design.

The two sections under consideration, are from Helensvale Station to University Hospital Station, and from University Hospital Station to Broadbeach South Station. These two sections have different frequencies of BRT operations and different total design traffic loading.

Three different subgrade conditions that typically occur along the proposed corridors have been used to model the subgrade conditions for the expected pavement.

We have assessed two different speeds of operation (asphalt pavement materials have different responses to loading under different vehicle speeds, i.e. slower speeds, weaker material response). This simulates the different pavement performance expected between stations and elsewhere along the GCRT corridor.

There are multiple scenarios developed for different pavement combinations to reflect the possible variability in design vehicles and subgrade conditions, so this report was necessarily extensive and conservative.

2. BRT Vehicle Frequency

The design traffic for the BRT operations is taken from "*Bus Rapid Transit Operations Assessment Stage 1: Helensvale to Broadbeach"*, GHD April 2008 (BRT Ops Report). The BRT Ops Report is based upon "*Assessment of BRT and LRT Vehicle Capacity and System Operations"*, GHD October 2007 (the Capacity Report). The Capacity Report and the BRT Ops Report identified the expected vehicle frequency and the passenger loads throughout the expected life of the BRT pavement.

The design periods used in the BRT Ops Report are provided in Table 13 below. Tables 14 & 15 are also extracts from the BRT Ops Report and detail the vehicle headway that will apply for each design period.

The design life required for the RT system is 50 years. The BRT Ops Report recommends the vehicle operating frequencies in stages for 2011, 2016, 2021, 2026, 2031, 2036, 2041 and beyond 2041.

BRT Ops Report Table 13 Design Periods

Period	Abbreviation	Time period
Morning Peak	AM	07:00 – 09:00
Day Time	DT	09:00 – 16:00
Evening Peak	PM	16:00 – 18:00
Night Time	NT	18:00 – 00:00 and 06:00 – 07:00
Owl Time	OT	00:00 – 06:00

As patronage data is only available for Monday to Friday, 07:00 – 00:00, assumptions have been made for operations on Saturdays, Sundays and Public Holidays and during 'Owl Time' as follows:

» Saturdays, Sundays and Public Holidays is assumed to be equal to the combined service frequency of the existing bus routes; and

» Owl Time with an hourly frequency.

BRT Ops Report Table 14 Proposed BRT System Operations to 2026

Year	2011				2016				2021			
Time period	AM	PM	DT	NT	AM	PM	DT	NT	AM	PM	DT	NT
	Headway (minutes)											
Helensvale – University Hospital	7.5	5	15	15	7.5	3.75	15	15	3.75	3	12	15
University Hospital – Broadbeach South	7.5	5	7.5	15	5	3.75	5	10	3.75	3	3	7.5

BRT Ops Report Table 15 Proposed System Operations Post 2026

Year	2026				2031				2036				2041			
Time period	AM	PM	DT	NT	AM	PM	DT	NT	AM	PM	DT	NT	AM	PM	DT	NT
	Headway (minutes)															
Vehicle Type	Tandem artic	Tandem artic	Tandem artic	Solo artic	Tandem artic	Tandem artic	Tandem artic	Solo artic	Tandem artic	Tandem artic	Tandem artic	Solo artic	Tandem bi-artic	Tandem bi-artic	Tandem bi-artic	Solo bi-artic
Helensvale – University Hospital	3.75	3	12	15	3.75	3	6	15	3.75	3	6	15	3.75	3	6	7.5
University Hospital - Broadbeach South	3.75	3	3	5	3.75	3	3	3.75	3.75	3	3	3.75	3.75	3	3	3.75

Tandem: Two vehicles operated consecutively with one trip in the timetable.

The following assumptions were also made in determining the traffic conditions for the purposes of pavement design:

- The general vehicle type, predetermined operating frequency and individual axle loads will not increase over the design life of the system. This assumption was made as there is currently no design vehicle for this concept design and any attempt to allow for such variations would be purely speculative and open to dispute no matter what conclusions are made.
- Only BRT vehicles will be running on the BRT pavement. Any areas of combined running with general traffic will need to be assessed and added to the traffic loading from the BRT vehicles during detailed design. GCCC have an indicative design traffic loading of $>1x10^7$ ESA's for major urban roads which would need to be considered in instances when the BRT and other surface traffic use the same section of pavement.
- The pavement design periods for the various pavement elements are 50 years for fatigue life of asphalt or cemented layers, 50 years for terminal rut condition for subgrade, and 15 years for surfacing layers (oxidation of bituminous surface layers or concrete joint sealants). For the concept design, we have included 30 year values as the BRT Ops Report recommends a change from articulated vehicles to bi-articulated vehicles at this time and there may be some advantages to reconstructing a pavement with the onset of larger vehicles. It has been assumed there will not be a staged approach to construction, due to the impact of major works to GCRT system operations, and the impact of raising the pavement surface level (kerb and channels, station platforms).

3. Design BRT Vehicle and Loads

The design BRT vehicle assessed for the concept pavement design is an articulated and a bi-articulated vehicle. An example of an articulated BRT vehicle already in service in Europe is shown below in Figure 2.

Figure 2 Example Articulated Vehicle

After 2041, to meet the expected demand, the BRT Ops Report recommends using bi-articulated vehicles. An example of a bi-articulated vehicle is shown below in Figure 3.

Figure 3 Example Bi-Articulated Vehicle

There are numerous manufacturers of articulated and bi-articulated vehicles that are currently operating and in future years it is expected that additional alternatives would be available for use on the GCRT system. As stated in Section 2 above, there is no design BRT vehicle for this concept design so a theoretical vehicle has been used for the purposes of this pavement design.

In determining the design vehicle load properties, several factors have been considered and several theoretical vehicles were compiled. They broadly fall into two categories:

1. BRT vehicles currently operating; and
2. Maximum bus axles loads currently applying under the Queensland "*Transport operations (Road Use Management) Act 1995*", (the Act).

The first category provides details of vehicles that could currently meet the BRT vehicle specifications and the second category was used to determine the maximum axle loads vehicles can currently use to operate in Queensland.

The pavement design was completed in accordance with the PDM and Section 7.1 describes design traffic as:

"The design traffic is expressed in terms of the number of standard axle load repetitions in one lane that are equivalent in destructive effect to the total number of repetitions of the actual axles using the pavement during the assessment period. The design traffic is given in terms of the equivalent number of standard axles (ESA's) or standard axle repetitions (SAR's), depending on the pavement material type being considered."

The number of ESA's per axle group for equivalent subgrade damage, the number of SAR's per axle group for equivalent asphalt damage and the number of SAR's per axle group for equivalent cemented material damage were obtained from first principles as the BRT vehicle loads are not standard. This approach is described in Section 7.2.3 of the PDM. The rigid pavement design is based on Section 11 of the PDM (which in turn is based on the Austroads "*Pavement Design Guide*", 2004), which uses heavy vehicle axle groups (HVAG's) with defined axle group types and axle group loads.

3.1 Theoretical Design Vehicle

As stated above, to arrive at the design BRT vehicle two categories of theoretical vehicles were considered. The first category considered vehicles currently in operation. Several makes were investigated, Phileas, Volvo and Volgren. These include articulated and bi-articulated buses with the main difference being the Phileas vehicles have single axles with wide base single tyres (super single tyres), while Volvo and Volgren vehicles have a single axle, single tyre configuration on the front steering axle and single axle, dual tyres on the drive and trailing axles.

While there has been some research done in Europe and Canada into the relative pavement damage of wide base single tyres compared to dual tyres, there are currently no accepted design parameters in Australia to allow for pavement damage caused by axles with wide base single tyres. For this reason, a conservative approach has been adopted for this concept pavement design and the relative damage factors for the wide base single tyres have been compared to conventional single tyred axles. This approach presents an opportunity for savings to be made when the actual design vehicle is selected.

This distinction is made is due to the current load restrictions under Queensland legislation (refer to Schedule 2 of the Act in Appendix A), where axle loads with single tyres are less than axle loads with dual tyres and the fact that heavily loaded axles with dual tyres have a greater contact area with the pavement surface when compared to single tyred axles, hence they will do less damage to a pavement for the same axle load.

Theoretical vehicles in the second category are made up of the current maximum axle loads regardless of whether or not a specific vehicle exists that has the same load configuration.

Some of the category 1 theoretical vehicles exceed the limits stated in the Act, but as the GCRT BRT vehicles would need a specific operating license it would be conceivable that load restrictions would be negotiated for the vehicles that are actually selected. The result of the comparison of axle loads for the theoretical vehicles is given in Appendix B.

To compare the category 1 theoretical vehicles, the following assumptions were used:

» For a total vehicle load, as quoted by vehicle makers, the axle loads were determined by either assuming all axles shared the load equally (all axles equally loaded) or the front steering axle had a lower axle load than the drive axle and trailing axles (rear axles equally loaded).
  – From this assumption, it was calculated that a lighter axle load for the steering axle, resulted in greater pavement damage per vehicle pass when compared to equal axle loads.
» The Phileas vehicles had a greater overall vehicle mass, so the Phileas total vehicle mass was used with dual tyres for the comparison. For the maker's details of this type of vehicle, refer to Appendix A.

To compile the comparison of category 2 theoretical vehicles, it was assumed that the total vehicle mass was not relevant as the main consideration was the pavement damage resulting from each pass of each design vehicle axle.

The design vehicle chosen was the theoretical vehicle that caused the maximum pavement damage for a single vehicle pass. A summary of the theoretical vehicles is given below in Table 1.

Table 1 Summary of Theoretical Vehicle Axle Loads

Description	Total Vehicle Mass (t)	ESA's for Equivalent Subgrade Damage	SAR's for Equivalent Asphalt Damage	SAR's for Equivalent Cemented Damage
Category 1 (vehicles currently operating)				
Artic, all axles equally loaded, all axles single tyres	23.4	13.05	18.87	247.47
**Artic, rear axles equally loaded, all axles single tyres*	*23.4*	*14.38*	*21.85*	*471.99*
Bi-artic, all axles equally loaded, all axles single tyres	30.7	16.52	23.60	282.64
**Bi-artic, rear axles equally loaded, all axles single tyres*	*30.7*	*17.28*	*25.30*	*398.50*
Artic, all axles equally loaded, rear axles dual tyres	23.4	5.99	7.85	83.59
Artic, rear axles equally loaded, rear axles dual tyres	23.4	4.40	4.93	12.33
Bi-artic, all axles equally loaded, rear axles dual tyres	30.7	6.47	8.01	72.07
Bi-artic, rear axles equally loaded, rear axles dual tyres	30.7	4.95	5.35	11.83
Category 2 (Max Qld bus axle loads)				
Artic, all axles single tyres	19.9	6.84	8.41	35.87
Artic, rear axles dual tyres	28.5	8.58	11.21	77.17
Bi-artic, all axles single tyres	26.6	8.21	11.35	49.18
Bi-artic, rear axles dual tyres	39.5	11.82	15.55	111.13

** Indicates the design vehicle for articulated and bi-articulated buses.*

Table 2 shows that the vehicles that have the rear axles equally loaded and the steer axle more lightly loaded with single tyres on all axles gave the highest equivalent pavement damage. Even though these rear axle loads exceed the limits in Appendix A, the loads are realistic as these vehicles are currently in operation overseas and the types of tyres they require are currently available in Australia with suitable load ratings.

3.2 BRT Vehicle Frequency & Traffic Volumes

From the BRT Ops Report Tables 14 & 15, the BRT vehicle frequencies differ for the section from Helensvale Station to University Hospital Station and for the section from University Hospital Station to Broadbeach South Station.

The tables below, Table 2 and Table 3, give the accumulative number of BRT vehicle passes, for Helensvale to University Hospital and University Hospital to Broadbeach South for each of the design periods.

Table 2 BRT Vehicle Passes – Helensvale to University Hospital

Period	Per day	Per Week	Per Year	Accumulative Total for Period
2011-2016	102	714	37,128	185,640
2016-2021	110	770	40,040	200,200
2021-2026	141	987	51,324	256,620
2026-2031	248	1,736	90,272	451,360
2031-2036	318	2,226	115,752	578,760
2036-2041	318	2,226	115,752	578,760
Total articulated vehicles				2,251,340
2041-2061	346	2,422	125,944	2,518,880
Total bi-articulated vehicles				2,518,880

Table 3 BRT Vehicle Passes – University Hospital to Broadbeach South

Period	Per day	Per Week	Per Year	Accumulative Total for Period
2011-2016	130	910	47,320	236,600
2016-2021	188	1,316	68,432	342,160
2021-2026	274	1,918	99,736	498,680
2026-2031	514	3,598	187,096	935,480
2031-2036	542	3,794	197,288	986,440
2036-2041	542	3,794	197,288	986,440
Total articulated vehicles				3,985,800
2041-2061	542	3,794	197,288	3,945,760
Total bi-articulated vehicles				3,945,760

3.3 Design Vehicle Loads

The BRT pavements have been designed differently for Section 1 and Sections 2 & 3, Helensvale to University Hospital and for University Hospital to Broadbeach. To obtain the design traffic for the BRT pavement, the number of vehicle passes given above in Table 2 and Table 3 were combined with the axle loads from the design vehicle.

Once the design vehicle was determined the axle loads were refined to reflect the expected load for each vehicle pass. The total vehicle mass used for the comparison of theoretical axle loads was taken from the maker's specifications and this allowed for 4p/m^2 for standees on artic and bi-artic vehicles. The number of seats, standee density and wheelchair capacity in the maker's specifications vary from what is recommended in the BRT Ops Report, however the total number of passengers are similar for both, e.g. 104 compared with 96 for artic vehicles and 142 compared with 137 for bi-artic vehicles. Because of this similarity with the maker's total vehicle data, the maker's vehicle mass data was considered appropriate for the purposes of this concept pavement design.

It was assumed that each BRT vehicle will be running at 100% seating and 90% standing capacity, on average, over a 24 hour period for the life of the pavement. The possible occurrence of high capacity loads during peak times, e.g. standees at greater than 3p/m^2, will be offset by the periods when the vehicles will be operating at a lower standees density.

Table 4 summarises the design vehicle loads that were used for the BRT pavement design. The details of the calculations are contained in Appendix B.

Table 4 Design Vehicle Loads

Description	Vehicle Mass (t)	HVAG for Rigid Pavements	ESA's for Equivalent Subgrade Damage	SAR's for Equivalent Asphalt Damage	SAR's for Equivalent Cemented Damage
Articulated	22.5	3	11.74	16.81	232.81
Bi-articulated	29.9	4	15.15	21.40	256.72

Based on the design vehicle loads and the number of vehicle passes, the BRT design vehicle pavement loads are given below in Table 5 & Table 6.

Table 5 BRT Design Vehicle Pavement Loads – Helensvale to University Hospital

Design Period (years)	Vehicle Passes for Rigid Pavements	ESA's for Equivalent Subgrade Damage	SAR's for Equivalent Asphalt Damage	SAR's for Equivalent Cemented Damage
30	$2.25x10^6$	$2.64x10^7$	$3.78x10^7$	$5.24x10^8$
50	$2.25x10^6$, artic $4.77x10^6$, bi-artic	$6.46x10^7$	$9.17x10^7$	$1.17x10^9$

Table 6 BRT Design Vehicle Pavement Loads – University Hospital to Broadbeach South

Design Period (years)	Vehicle passes for Rigid Pavements	ESA's for Equivalent Subgrade Damage	SAR's for Equivalent Asphalt Damage	SAR's for Equivalent Cemented Damage
30	$3.99x10^6$	$4.68x10^7$	$6.70x10^7$	$9.28x10^8$
50	$3.99x10^6$, artic $3.95x10^6$, bi-artic	$1.07x10^8$	$1.51x10^8$	$1.94x10^9$

Conventional pavement design includes a reliability factor (of 4 for major works) for flexible pavements and a load safety factor (of 1.35 for 97.5% reliability) for rigid pavements. These factors have not been included in the design as the frequencies used for the BRT and the controlled nature of the BRT operations provides an acceptable level of certainty for the predicted traffic loadings.

4. Subgrade and Working Platform Structure

The concept pavement design was undertaken for a range of possible subgrade conditions. This approach will need to be refined once the geotechnical investigations are completed and a design vehicle selected. Three different subgrade design CBR's were considered:

» 1.5% (considered plastic subgrade, addressed through the provision of a capping layer and/or treatments, raising the design subgrade CBR to 3%);

» 3%; and

» 10%.

For the concept design it is assumed the carriageway will be in low embankment or at grade. That is, the top of the pavement will be not more than 2m above the natural subgrade. Indicative design subgrades have consequently been based on the existing insitu materials along the corridor. This assumption will need to be confirmed during the detailed design phase.

The design CBR of 10% was assumed to be typical for the section from University Hospital to Broadbeach South and this assumption is justified as pavement maintenance data from Gold Coast City Council (GCCC) and previous projects undertaken by GHD show subgrade conditions in Sections 2 & 3 to be typically in the range of CBR 8% to CBR 15%.

For the section from Helensvale to University Hospital it is expected that lower subgrade strengths will be encountered in some areas, e.g. across Coombabah Wetland. For this section subgrade CBR's 1.5% and 3% have been assumed to allow for the weaker insitu soils. In other areas, it is expected that CBR 10% would be typically achieved.

The subgrade and working platform structure will need to be in accordance with the DMR Supplementary Specification: Checking Subgrade, Capping Layer, Drainage Layer, Controlled Subgrade, Working Platform, Temporary Pavement, Verge, MRSS.01.001. A generic copy of MRSS.01.001 is provided in Appendix E to this report. The following sections provide an assessment of the subgrade and working platform structure for each of the indicative subgrade conditions.

4.1 Subgrade CBR 1.5%

In descending order from the top, generally in accordance with MRSS.01.001:

1. Minimum **150mm** thick **working platform**. Notionally cement stabilised type 1.2 material.
2. Assume the lower subgrade will have a swell between 2.5% and 5%, so the required thickness of working platform, controlled subgrade and drainage layer needs to be at least 600mm, therefore following **controlled subgrade** layers will be required:
    a. **150mm** upper layer controlled subgrade (WPI < 1200, minimum CBR 8%) and
3. Assume there will be water or potential water issues in these areas, so a **drainage layer** will be required, consisting notionally of a geotextile wrapped (top, bottom and sides) **300mm** layer of free draining rock fill (drainage aggregate). Note that if there are no water issues, then the thickness of the controlled subgrade will need to be increased by 300mm.

4. As the above drainage layer is assumed to be required, no additional capping layer is needed. If the drainage layer is not needed, then a 300mm capping layer of granular material with a 4 day soaked subgrade CBR of 25% and WPI < 1200 or insitu stabilised subgrade would be needed.

The design CBR of this section then becomes 3%.

4.2 Subgrade CBR 3%

In descending order from the top, generally in accordance with MRSS.01.001:

1. Minimum **150mm** thick **working platform**. Notionally cement stabilised type 1.2 material.
2. Assume the lower subgrade will have a swell greater than 0.5%, but less than 2.5%, so the required thickness of controlled subgrade layers needs to be 150mm, which is catered for by the working platform and drainage layers.
3. Assume there will be water or potential water issues in these areas, so a **drainage layer** will be required, consisting notionally of a geotextile wrapped (top, bottom and sides) **300mm** layer of free draining rock fill (drainage aggregate).

4.3 Subgrade CBR 10%

In descending order from the top, generally in accordance with MRSS.01.001:

1. Minimum **150mm** thick **working platform**. Notionally cement stabilised type 1.2 material.
2. Assume the lower subgrade will have a swell less than 0.5%, so no controlled subgrade layers will be required.

5. Unbound Granular Pavement

5.1 Pavement Materials

This concept design is based on DMR Standard Materials, specifically DMR Specification MRS.11.05: Specification for Unbound Granular Paving Material. The following structure is based on the PDM, in ascending order from the surface.

» Wearing course – 35mm DG10HS, A15E polymer modified binder;

» Seal beneath the wearing course – polymer modified seal;

» Basecourse – refer below for thickness discussion, typical type 2.1 and 2.3 materials from MRS 11.05;

» Prime and seal on the working platform, designed by the constructor; and

» Working platform, controlled subgrade, drainage layer and capping layer, as discussed in Section 4 above.

5.2 Subgrade and Working Platform Modelling Parameters

5.2.1 Lower Subgrade CBR 1.5%

At the top of the drainage layer (capping layer), adopt a subgrade CBR 3%. Therefore:

» the design subgrade vertical modulus was 40MPa (from eqn 10.7 of PDM);

» the design subgrade horizontal modulus was 20MPa (degree of anisotropy 2.0); and

» Poisson's ratio 0.45.

To simplify the modelling at this concept stage, the 150mm controlled subgrade has not been included in the model.

The working platform has to be modelled as a granular material with a CBR of 15%. Therefore the vertical modulus was 80MPa. The degree of anisotropy was 2.0, so the horizontal modulus was 40MPa. A Poisson's ratio of 0.35 was used.

Therefore the CBR 1.5% case was the same model as the CBR 3% case.

5.2.2 Lower Subgrade CBR 3%

» The design subgrade vertical modulus was 40MPa (from eqn 10.7 of PDM);

» the design subgrade horizontal modulus was 20MPa (degree of anisotropy 2.0); and

» Poisson's ratio 0.45.

Again, to simplify the modelling at this concept stage, the drainage layer has not been included in the model.

The working platform has to be modelled as a granular material with a CBR of 15%. Therefore the vertical modulus was 80MPa. The degree of anisotropy was 2.0, so the horizontal modulus was 40MPa. A Poisson's ratio of 0.35 is used.

5.2.3 Lower Subgrade CBR 10%

» The design subgrade vertical modulus was 90MPa (from eqn 10.7 of PDM);

» the design subgrade horizontal modulus was 45MPa (degree of anisotropy 2.0); and

» Poisson's ratio 0.45.

There are no controlled fill, selected fill materials, drainage layers or stabilised subgrades in this situation, so no sub layer modelling.

The working platform has to be modelled as a granular material with a CBR of 15%. Therefore the vertical modulus was 120MPa. The degree of anisotropy is to be 2.0, so the horizontal modulus was 60MPa. A Poisson's ratio of 0.35 was used.

5.3 Base Thickness

The unbound granular pavement was modelled as single pavement layer with a vertical modulus of 500MPa. The degree of anisotropy is to be 2.0, so the horizontal modulus was be 250MPa. A Poisson's ratio of 0.35 was used.

It would be expected that the pavement would be constructed in layers not exceeding 200mm thickness, so materials in the lower layers of the pavement would be of lower strength to suit the maximum stiffness that can be developed. This is the typical method of design for the mechanistic design process.

Appendix C has the summary reports from each of the CIRCLY model runs. Note that the wearing course has not been included in the modelling given that it is a thin wearing course that will not add stiffness to the pavement structure. It should also be noted that environmental effects (primarily oxidation of the bitumen binder) necessitate replacement of the wearing course after (nominally) 8 to 12 years. This should not affect the overall pavement performance.

However resurfacing will be more difficult as overlays will not be possible due to the level constraints along the RT corridor. So the wearing course would need to be removed and replaced as part of the ongoing pavement maintenance regime.

The following table shows the summary of the base thickness calculations for the unbound granular pavement case.

The CBR 1.5% is the same as the CBR 3% case.

Table 7 Unbound Granular Pavement Design Summary

Pavement Type	Subgrade Condition (Design)	Section	Design Period	Design Traffic Loading	Total Granular Thickness (mm, from CIRCLY)	Total Granular Thickness (mm)	Total Pavement Thickness (mm)*
Unbound Granular	1.5% & 3%	Helensvale to Uni Hospital	30yrs	2.64×10^7	623	635	670
			50yrs	6.46×10^7	727	**740**	**775**
		Uni Hospital to Broadbeach	30yrs	4.68×10^7	687	700	735
			50yrs	1.07×10^8	791	**805**	**840**
	10%	Helensvale to Uni Hospital	30yrs	2.64×10^7	465	475	510
			50yrs	6.46×10^7	538	**550**	**585**
		Uni Hospital to Broadbeach	30yrs	4.68×10^7	510	520	555
			50yrs	1.07×10^8	582	**595**	**630**

** Total pavement thickness is the total thickness of pavement materials above the working platform, e.g. including wearing course.*

6. Heavy Duty Deep Strength Asphalt Pavement Design

6.1 Pavement Materials

This concept design is based on DMR Standard Materials, specifically DMR Supplementary Specification: Heavy Duty Asphalt MRSS.01.003 (generic copy provided in Appendix E). The following structure is based on the PDM, in ascending order from the surface.

- Wearing course – 45mm DG14HS, A15E polymer modified binder;
- Seal beneath the wearing course – polymer modified seal;
- Binder layer – 45mm DG14HS, A15E polymer modified binder;
- Base layer – refer below for thickness discussion, DG20HM, Class 600 binder;
- Primerseal – AMC4 binder with 10mm cover aggregate;
- Cementitiously stabilised layer – refer below for thickness discussion (less than 200mm, placed in one layer), Type 1.1 granular material treated with a cementitious blend of 75% cement and 25% fly ash to achieve a minimum UCS of 3 MPa at 7 days and a pre-cracking design modulus of 3500 MPa;
- Prime and seal on the working platform, designed by the constructor;
- Working platform, controlled subgrade, drainage layer and capping layer, as discussed in Section 4 above.

6.2 Subgrade and Working Platform Modelling Parameters

The subgrade and working platform modelling for the Unbound Granular and Full Depth Asphalt scenarios will be the same as for the Deep Strength Asphalt scenario. Refer to Section 6.1 above.

6.3 Base Thickness

The cementitiously stabilised layer is limited to a maximum thickness of 200mm. As discussed in Section 5.1 above, the material was assumed to have a pre-cracking design modulus of 3500MPa. Poisson's ratio in the pre-cracking phase was 0.2. In the post-cracking phase, a vertical modulus of 500MPa and a horizontal modulus of 250MPa, with a Poisson's ratio of 0.35 were used. A sensitivity analysis was undertaken to consider the impact of reducing the thickness of the cementitiously stabilised layer. For a 25mm reduction in thickness of this layer, the base thickness needs to be increased by approximately 30mm to 35mm. The cost savings resulting from reducing the cementitiously stabilised layer are outweighed by the additional cost of asphalt.

The asphalt layers are as described in Section 6.1 above. The presumptive speeds for modelling purposes were 50km/h for general running (noting that in sections the speeds will be up to 80km/h) and 10km/h for stations. Therefore, the design moduli for the asphalt layers are shown on the following table (derived from Table 10.5 of the PDM).

Table 8 Asphalt Design Moduli

Asphalt Mix Type	Asphalt Modulus (MPa) at speed:	
	10km/h	50km/h
Dense Graded Asphalt Surfacing / Binder Asphalt (DG14HS)	1000	1425
Base Asphalt (DG20HM)	1300	2500

Appendix C has the summary reports from each of the CIRCLY model runs. Note that the wearing course fatigue can be ignored as environmental effects (primarily oxidation of the bitumen binder) necessitate replacement of the wearing course after (nominally) 8 to 12 years.

The following table shows the summary of the base thickness calculations for the deep strength asphalt pavement case.

A nominal 10mm needs to be added to these base thicknesses, to allow for layer thickness tolerances.

The CBR 1.5% is the same as the CBR 3% case.

Table 9 Deep Strength Asphalt Pavement Design Summary

Pavement Type	Subgrade Condition (Design)	Operating Speed	Section	Design Period	Design Traffic Loading	DG20HM Base Thickness (mm, from CIRCLY)	DG20HM Base Thickness (mm)	Total Pavement Thickness (mm)*
Heavy Duty Deep Strength Asphalt	1.5% & 3%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	2.64×10^7	220	230	520
				50yrs	6.46×10^7	244	**255**	**545**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	237	250	540
				50yrs	1.07×10^8	260	**270**	**560**
		50km/h	Helensvale to Uni Hospital	30yrs	2.64×10^7	183	195	485
				50yrs	6.46×10^7	204	**215**	**505**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	198	210	500
				50yrs	1.07×10^8	218	**230**	**520**
	10%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	2.64×10^7	149	175	465
				50yrs	6.46×10^7	171	**185**	**475**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	165	175	465
				50yrs	1.07×10^8	186	**200**	**490**
		50km/h	Helensvale to Uni Hospital	30yrs	2.64×10^7	120	175	465
				50yrs	6.46×10^7	140	**175**	**465**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	134	175	465
				50yrs	1.07×10^8	152	**175**	**465**

** Total pavement thickness is the total thickness of pavement materials above the working platform, e.g. including wearing course, cement stabilised layer.*

7. Heavy Duty Full Depth Asphalt Pavement Design

7.1 Pavement Materials

This concept design is based on DMR Standard Materials, specifically DMR Supplementary Specification: Heavy Duty Asphalt MRS.01.003 (generic copy provided in Appendix E). The following structure is based on the PDM, in ascending order from the surface.

» Wearing course – 45mm DG14HS, A15E polymer modified binder;

» Seal beneath the wearing course – polymer modified;

» Binder layer – 45mm DG14HS, A15E polymer modified binder;

» Base layer – refer below for thickness discussion, DG20HM 600, Class 600 binder;

» Prime and seal on the working platform, designed by the constructor; and

» Working Platform, Controlled Subgrade, drainage layer and capping layer, as discussed in section 4 above.

7.2 Subgrade and Working Platform Modelling

The subgrade and working platform modelling for the Unbound Granular and Deep Strength Asphalt scenario will be the same as for the Full Depth Asphalt scenario. Refer to Section 5.2 above.

7.3 Base Thickness

The asphalt layers are as described in Section 7.1 above. The presumptive speeds for modelling purposes were 50km/h for general running (noting that in sections the speeds will be up to 80km/h) and 10km/h for stations. Therefore, the design moduli for the asphalt layers are shown in Table 8 above.

Appendix C has the summary reports from each of the CIRCLY model runs. Note that the wearing course fatigue can be ignored as environmental effects (primarily oxidation of the bitumen binder) necessitate replacement of the wearing course after (nominally) 8 to 12 years.

The following table shows the summary of the base thickness calculations for the full depth asphalt pavement case.

The CBR 1.5% is the same as the CBR 3% case.

Table 10 Full Depth Asphalt Pavement Design Summary

Pavement Type	Subgrade Condition (Design)	Operating Speed	Section	Design Period	Design Traffic Loading	DG20HM Base Thickness (mm, from CIRCLY)	DG20HM Base Thickness (mm)	Total Pavement Thickness (mm)*
Heavy Duty Full Depth Asphalt	1.5% & 3%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	2.64×10^7	299	310	400
				50yrs	6.46×10^7	347	**360**	**450**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	330	340	430
				50yrs	1.07×10^8	376	**390**	**480**
		50km/h	Helensvale to Uni Hospital	30yrs	2.64×10^7	251	265	355
				50yrs	6.46×10^7	293	**305**	**390**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	277	290	380
				50yrs	1.07×10^8	318	**330**	**420**
	10%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	2.64×10^7	243	255	345
				50yrs	6.46×10^7	286	**300**	**390**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	271	285	375
				50yrs	1.07×10^8	312	**325**	**415**
		50km/h	Helensvale to Uni Hospital	30yrs	2.64×10^7	206	220	310
				50yrs	6.46×10^7	244	**255**	**345**
			Uni Hospital to Broadbeach	30yrs	4.68×10^7	230	240	330
				50yrs	1.07×10^8	266	**280**	**370**

** Total pavement thickness is the total thickness of pavement materials above the working platform, e.g. including wearing course.*

8. Heavy Duty Concrete Pavement Design

8.1 Pavement Materials

This concept design is based on DMR Standard Materials. For the purposes of this concept design, it is assumed a concrete base pavement type of continuously reinforced concrete pavement (CRCP). The subbase shall be a bound subbase of 125mm lean mix concrete (LMC) (Austroads Table 9.1).

8.2 Subgrade and Working Platform Modelling

A composite CBR is required for the Heavy Duty Concrete Pavement Design, from which an effective subgrade strength can be estimated.

8.2.1 Lower Subgrade CBR 1.5%

The subgrade was modelled as follows:

a. 150mm thick working platform, design CBR 15%,

b. 450mm controlled subgrade, design CBR 8%, and

c. 400mm lower subgrade, design CBR 1.5%.

Using equation 9.1 from Austroads, the composite subgrade CBR was calculated as 5.0%. The effective subgrade strength (with the 125mm LMC subbase) was estimated as 52% (Austroads Figure 9.1).

8.2.2 Lower Subgrade CBR 3%

The subgrade was modelled as follows:

a. 150mm thick working platform, design CBR 15%,

b. 450mm controlled subgrade, design CBR 8%, and

c. 400mm lower subgrade, design CBR 3%.

Using equation 9.1 from Austroads, the composite subgrade CBR was calculated as 5.8%. The effective subgrade strength (with the 125mm LMC subbase) was estimated as 60% (Austroads Figure 9.1).

8.2.3 Lower Subgrade CBR 10%

The subgrade was modelled as follows:

a. 150mm thick working platform, design CBR 15%,

b. 850mm lower subgrade, design CBR 10%.

The composite subgrade is then 10.4%. The effective subgrade strength (with the 125mm LMC subbase) was estimated as 75% (the maximum value permitted from Austroads Figure 9.1).

8.3 Base thickness

For the purposes of this concept design, no load safety factor was applied. That is, the axle loads used in this design are considered conservative. Similarly, the frequencies of vehicles are considered conservative and do not warrant additional multipliers.

The typical cross section for the BRT consisted of 2 x 3.7 to 4.0 m running lanes, plus non-integrally cast kerbing. Therefore the concrete pavement design is based on “without shoulders” design (meaning a thicker base requirement due to the higher edge loadings).

The design 28 day characteristic flexural strength (modulus of rupture) was 4.5MPa.

The table below summarises the base thicknesses for both sections, for the design periods being considered.

Table 11 Continuously Reinforced Concrete Pavement Design Summary

Pavement Type	Subgrade Condition (Design)	Section	Design Period	Design Traffic Loading	Concrete Base Thickness (mm, calculated)	Concrete Base Thickness (mm)	Total Pavement Thickness (mm)*
Concrete	1.5% & 3%	Helensvale to	30yrs	6.75×10^6	185	195	320
		Uni Hospital	**50yrs**	2.58×10^7	190	**200**	**325**
		Uni Hospital to	30yrs	1.20×10^7	190	200	325
		Broadbeach	**50yrs**	2.78×10^7	195	**205**	**330**
	10%	Helensvale to	30yrs	6.75×10^6	180	190	315
		Uni Hospital	**50yrs**	2.58×10^7	190	**200**	**325**
		Uni Hospital to	30yrs	1.20×10^7	185	195	320
		Broadbeach	**50yrs**	2.78×10^7	190	**200**	**325**

** Total pavement thickness is the total thickness of pavement materials above the working platform, e.g. including lean mix concrete subbase.*

Note that the values given above in Table 11 are rounded up to the nearest 5mm and then have 10mm added from the calculated values to allow for construction tolerances in accordance with the design manuals. The following sections detail the base thickness calculations.

8.3.1 Helensvale to University Hospital

Rigid pavement design requires consideration be given to the axle loads on individual axle groups as they are very sensitive to axle load magnitudes and relatively insensitive to axle load repetitions. Due to the nature of the traffic loading on this project, the number of repetitions expected for each individual axle load has been calculated.

Table 12 Expected Axle Repetitions – Helensvale to University Hospital

Axle Group Load (kN)*	Expected Repetitions	
	30 Years	50 Years
60 (front axle)	2.25×10^6	7.02×10^6
80 (rear axles)	4.50×10^6	1.88×10^7

*The axle group loads have been rounded to the nearest 10kN as tabulated in Austroads, 2004.

Appendix D has the base thickness calculations summary.

The following table summarises the allowable repetitions, for a 30 year design period and a calculated **base thickness of 180mm**. This was based on an effective subgrade CBR of 75%, which is most likely to occur for a lower subgrade of 10%. A sensitivity analysis was undertaken for the potential subgrades with a lower CBR, e.g. 1.5% and 3%. An additional 5mm needs to be added to the base thickness in these areas.

Table 13 Allowable Repetitions – 30 years

SAST Axle Group Load (kN)	Fatigue Analysis		Erosion Analysis	
	Allowable Repetitions	Fatigue (%)	Allowable Repetitions	Damage (%)
60	unlimited	0.00	2.19×10^8	1.0
80	7.74×10^6	58.2	1.14×10^7	39.4
	Total Fatigue %	58.2	Total Erosion %	40.4

Note that 175mm fails under fatigue (284%).

The following table summarises the allowable repetitions, for a 50 year design period and a **base thickness of 190mm**. This was based on an effective subgrade CBR of 75%, which is most likely to occur for a lower subgrade of 10%. A sensitivity analysis was undertaken for the potential subgrades with a lower CBR, e.g. 1.5% and 3%. No additional base thickness needs to be added in these areas.

Table 14 Allowable Repetitions – 50 years

SAST Axle Group Load (kN)	Fatigue Analysis		Erosion Analysis	
	Allowable Repetitions	Fatigue (%)	Allowable Repetitions	Damage (%)
60	unlimited	0.0	$1.93x10^9$	0.4
80	unlimited	0.0	$2.20x10^7$	85.5
	Total Fatigue %	0.0	Total Erosion %	85.9

Note that 185mm fails under and erosion (121%).

8.3.2 University Hospital to Broadbeach South

Table 15 Expected Axle Repetitions –University Hospital to Broadbeach South

Axle Group Load (kN)*	Expected Repetitions	
	30 Years	50 Years
60 (front axle)	$3.99x10^6$	$7.94x10^6$
80 (rear axles)	$7.98x10^6$	$1.98x10^7$

*The axle group loads have been rounded to the nearest 10kN as tabulated in Austroads, 2004.

Appendix D has the base thickness calculations summary.

The following table summarises the allowable repetitions, for a 30 year design period and a **base thickness of 185mm**. This was based on an effective subgrade CBR of 75%, which is most likely to occur for a lower subgrade of 10%. A sensitivity analysis was undertaken for subgrades with a lower CBR, e.g. 1.5% and 3%. An additional 5mm needs to be added to the base thickness when these lower CBR subgrades are encountered.

Table 16 Allowable Repetitions – 30 years

SAST Axle Group Load (kN)	Fatigue Analysis		Erosion Analysis	
	Allowable Repetitions	Fatigue (%)	Allowable Repetitions	Damage (%)
60	unlimited	0.0	$5.07x10^8$	0.8
80	unlimited	0.0	$1.57x10^7$	50.7
	Total Fatigue %	0.0	Total Erosion %	51.5

Note that 180mm fails under fatigue (103%).

Appendix D has the base thickness calculations summary.

The following table summarises the allowable repetitions, for a 50 year design period and a **base thickness of 190mm**. This was based on an effective subgrade CBR of 75%, which is most likely to

occur for a lower subgrade of 10%. A sensitivity analysis was undertaken for the potential subgrades with a lower CBR, e.g. 1.5% and 3%. An additional 5mm needs to be added to the base thickness in these areas.

Table 17 Allowable Repetitions – 50 years

SAST Axle Group Load (kN)	Fatigue Analysis		Erosion Analysis	
	Allowable Repetitions	Fatigue (%)	Allowable Repetitions	Damage (%)
60	unlimited	0.0	$1.93x10^9$	0.4
80	unlimited	0.0	$2.20x10^7$	90.4
	Total Fatigue %	0.0	Total Erosion %	90.8

Note that 185mm fails under erosion (128%).

8.4 Detailing Requirements

This rigid pavement design was based on a CRCP type base. This base type has no transverse joints. It has substantial longitudinal reinforcing to induce multiple fine cracks (designed here to be 0.2mm), due to the proximity of the project to the marine environment. Longitudinal joints are tied joints, to allow warping or curling without excessive restraint.

The details given here are indicative only. Should the choice be made to proceed with a BRT vehicle mode, the detailed design phase of this project will need to investigate the reinforcing requirements in detail once the actual subgrade and vehicle properties are known.

A summary of the detailing calculations are contained in Appendix D.

8.4.1 Reinforcing

The indicative reinforcing required for this rigid pavement design is shown in the table below.

Table 18 Reinforcing Details

Section	Design Period	Concrete Base Thickness (mm)	Longitudinal Reo: N16 @ (2 layers, top & bottom)	Transverse Reo: N12 @
Helensvale to University Hospital	30 yrs	190	200 mm ctrs	720 mm ctrs
	50 yrs	200	190 mm ctrs	680 mm ctrs
University Hospital to Broadbeach South	30 yrs	195	200 mm ctrs	700 mm ctrs
	50 yrs	200	190 mm ctrs	680 mm ctrs

8.4.2 Longitudinal Joints

Longitudinal joints (tied) should be formed and sealed. Tie bars can be expected to be 12mm deformed steel, Grade 500N, 1m long, placed centrally in the longitudinal joint, spaced at 750mm maximum.

8.4.3 Base Anchors

Base anchors will be required at terminal ends, and where grades exceed around 4% (to arrest downhill creep), at around 300m centres.

8.4.4 Finishing

Given the design speed of the facility is expected to be up to 80km/h, noise generated from the tyre pavement interface is not expected to be a major issue. Nevertheless, attention will need to be given to the finishing of the concrete, to provide a surface that does not create undue noise affects for the surrounding community. Furthermore, a major measure of the project success will undoubtedly be the ride smoothness of the running lanes. Particular care and attention to construction will be essential to avoid a rough ride. If noise was to become an issue, a CRCP can be overlain with an asphalt wearing course.

9. Comparison of Results

Although detailed analysis was undertaken to determine the concept BRT pavement design for the GCRT, it should be noted that this design is subject to refinement when more information is known during the detailed design stage of the project, primarily due to:

» Actual BRT vehicle loads. This report has assumed the worst case scenario of single axle, single tyred vehicles. Should the actual vehicles have dual tyres on the rear axles, then the design traffic figures could be reduced by a factor of between 3 and 40 (depending on the failure criteria and material type). This will reduce the bound pavement thickness by approximately 10% -15%.

» Actual insitu subgrade conditions. The pavement design could be economised based on the various subgrade conditions within each subsection.

This comparison of results was therefore based on the relative comparisons between the various pavement design cases, not the actual differences.

When considering the most suitable concept BRT pavement design, several factors were considered.

Capital cost and efficiency of design

While the unbound granular pavement has the lowest capital cost for the pavement itself, this type of pavement would also require the deepest excavation to install the pavement in existing road reserves, hence the time taken to construct this pavement would be longer than the other three pavement types. The efficiency of this type of pavement would be highlighted in areas where the BRT corridor is not within an existing road or road reserve, e.g. in the vicinity of the Loders Creek Depot.

To assess the efficiency of the design of different pavement types, the pavement performance needs to be considered. A deep strength asphalt pavement uses a cementitiously stabilised layer beneath the asphalt base course. This layer is designed to crack and continue to perform as an unbound granular pavement for the remainder of the pavement life. To prevent the crack reflecting through the asphalt base to the pavement surface, the PDM recommends at least 175mm of structural asphalt, e.g. base, above the cementitiously stabilised layer. There are some cases, refer to Table 9, where the thickness to withstand the traffic loads was superseded by the depth required to prevent reflective cracking. Whereas with a full depth asphalt pavement, the pavement depth can be minimised to allow only for the design traffic and hence give a thinner overall design.

The indicative capital cost for each of the analysed pavement types, in ascending order, was:

» Unbound granular pavement, indicatively \$46/m^2

» Deep strength asphalt pavement, indicatively \$88/m^2

» Full depth asphalt pavement, indicatively \$94/m^2

» Continuously reinforced concrete pavement, indicatively \$101/m^2

These indicative rates are based on the design example with a subgrade CBR of 10%, 50 years design life for the design traffic on the RT corridor section from University Hospital to Broadbeach South and do not allow for the cost of subgrade improvements.

Constructability

The benefit of an asphalt pavement over the other pavement types is that asphalt pavements could be trafficable immediately after placement, which has enormous benefits for a site where the BRT corridor would need to be constantly used for construction traffic or temporary traffic diversions.

Another benefit of the full depth asphalt and concrete pavement over the unbound granular and the deep strength pavements is the amount of dust generated during construction is considerably less as all pavement layers are either placed as asphalt or concrete. Any unbound or cementitiously stabilised layers will generate dust during the placement and compaction activities. While the dust can be minimised, it would be a noticeable benefit to the surrounding community if no dust were generated. The asphalt pavement performs best from a constructability perspective.

A major disadvantage of unbound granular pavements and cementitiously stabilised layers when compared to asphalt, is the moisture and degree of saturation requirements during placement. This generally results in a lag time of between 2 to 4 days between placing subsequent layers on top of unbound granular or cementitiously stabilised layers materials. During which time the pavement cannot be subjected to any traffic and the exposed pavement is at risk of damage from wet weather. A lean mix subbase and a concrete base would require at least 7 days curing before any loads could be imposed, and preferably 28 days to get the maximum benefit from curing.

Given the timeframes required for the GCRT implementation and the amount of disturbance to the existing road network, it would be very beneficial to have a pavement structure that allows for construction traffic or temporary traffic diversions on a constant basis.

Ongoing maintenance

A pavement with an asphalt wearing course, would require resurfacing typically every 8 to 12 years as the wearing course oxidises due to environmental exposure. Usually, unbound granular and asphalt pavements are resurfaced via an asphalt overlay. Typically, each time an overlay is applied the level of the pavement surface level is increased by the depth of the overlay.

This type of strategy could not be easily applied to the GCRT corridor as the RT pavement surface is generally either flush with an adjacent traffic lane or flush with the adjacent kerb. Even in areas where the RT corridor is raised on a median, it would not be considered safe for BRT vehicles to have to negotiate a drop of potentially 105mm (3 overlays of 35mm depth) between the RT corridor and the adjacent kerb and then another drop of approximately 150mm to the adjacent traffic lanes should the BRT driver misjudge a corner.

To maintain the consistency of surface levels along the RT corridor, the replacement of a wearing course would require profiling to remove the existing asphalt wearing course and replacement of equal depth of the new asphalt wearing course. If the pavement beneath the wearing course were unbound granular pavement, the pavement surface would require some work to trim and reseal the unbound granular materials before the asphalt wearing course can be placed. Again, this would require the unbound surface to be exposed for several days before traffic can use the pavement again.

With either a deep strength or full depth asphalt pavement, the pavement base can be subjected to traffic before the wearing course is reinstated. This means that works can happen at night and the RT corridor can be fully operational between maintenance shifts.

Another maintenance issue would be the performance of each pavement type at particular locations along the RT corridor, i.e. at tight corners, within the braking and acceleration zones at stations, layover

areas. It would be expected that the braking and acceleration loads imposed at stations would be constant and consistent, i.e. the wheel loads would be applied at basically the same locations for all vehicle passes. Experience has shown that this type of load pattern is very difficult for an unbound flexible pavement to resist and these pavements tend to suffer from surface rutting and heaving reasonably early in the pavement life. This is also the case for pavements with deep asphalt layers beneath the asphalt wearing course, e.g. full depth asphalt and deep strength asphalt pavements. For this reason it is common to use a concrete pavement in areas where there is expected to be a continuous braking and acceleration loads, e.g. stations or toll booths. The South East Busway in Brisbane has such a pavement configuration at stations.

The implication of design life also needs to be considered for ongoing maintenance. If a 30 year design life is used, then some thought needs to be given to how the pavement can be rehabilitated after the design life. The risk is a major pavement reconstruction is required after 30 years and this would cause a lot of disruption to the RT services. The saving in initial capital cost between a 30 years design life and a 50 year design life is between approximately 8% (for concrete pavement) and 11% (for a full depth asphalt pavement). These cost savings, even when discounted, would be unlikely to justify the disruption to operations and adjacent traffic should the lesser design life be adopted. However, the proponent would need to complete their own cost benefit analysis during detailed design phase to satisfy themselves that the most efficient pavement maintenance strategy is implemented.

The asphalt pavement provides advantages above the other pavement types in relation to future maintenance estimates and impact of this maintenance upon BRT and other traffic.

Depth of underground PUP

The thicker the pavement structure, the more potential exists for underground PUP crossings to require lowering during construction. Thinner pavements also have an added benefit of providing more cover to underground PUP when subjected to construction traffic.

The deep strength asphalt, full depth asphalt and concrete pavements are comparatively thin, approximately 26%, 41% & 48% thinner respectively, when compared to the unbound granular pavement.

10. Conclusions and Recommendations

10.1 Conclusions

Even though the cost of the unbound granular pavement is significantly less than the other pavement types, it is also considered unsuitable given the heavy traffic loads expected along the RT corridor. It is also considered unsuitable in built up areas where speed of construction necessary to build the system and access to the corridor by construction vehicles due to width constraints is vital to the project delivery, i.e. Sections 2 & 3.

The concrete pavement, while the most expensive pavement type, would be used only in the immediate vicinity of stations and at BRT vehicle layover areas. This would make best use of the increased wear and heave resistance of a concrete pavement.

A full depth asphalt pavement offers advantages over the deep strength asphalt pavement as all layers within the pavement are asphalt and can be placed and trafficked quickly. The cementitiously stabilised layer within the deep strength asphalt pavement provides good pavement stiffness, but when cracking of this layer occurs monitoring of these cracks at the surface is essential to prohibit pavement deterioration.

A design of 50 years appears to provide a more efficient whole of life pavement cost, when consideration is given to the traffic management and RT service disruption caused by a pavement reconstruction after 30 years. The main risk of designing a pavement for 50 years, is determining the types and frequency of BRT vehicles that will be operating over the full life of the GCRT system.

10.2 Recommendations

The recommendations are as follows.

» The BRT pavement to be designed for a 50 year design life.

» A continuously reinforced concrete pavement to be used in the vicinity of all stations and layover areas.

» For the section of the RT corridor from Helensvale Station to University Hospital Station, the BRT pavement should be a full depth asphalt pavement.

» For the section of the RT corridor from University Hospital Station to Broadbeach South Station, the BRT pavement should be a full depth asphalt pavement.

» A full geotechnical investigation should be undertaken during detailed design to determine the properties of the existing subgrade materials.

11. References

» Department of Main Roads Queensland, Pavement Design Manual Amendment 2, December 2005

» Austroads, AP-G17/04 Pavement Design - A Guide to the Structural Design of Road Pavements, March 2007

» GHD, Bus Rapid Transit Operations Assessment Stage 1: Helensvale to Broadbeach, April 2008

» GHD, Assessment of BRT and LRT Vehicle Capacity and System Operations, October 2007

Appendix A

Mass Limits for single axles and axle groups, Phileas vehicle specifications

Queensland

Transport Operations (Road Use Management) Act 1995

Transport Operations (Road Use Management—Mass, Dimensions and Loading) Regulation 2005

Reprinted as in force on 1 July 2007

Reprint No. 1D

This reprint is prepared by
the Office of the Queensland Parliamentary Counsel
Warning—This reprint is not an authorised copy

Schedule 2 Mass limits for single axles and axle groups

schedule 1, section 1(3), (5) and (6)

Description of single axle or axle group	Mass limit (tonnes)
Single axles and single axle groups	
Single steer axles on—	
(a) a complying bus	6.5
(b) any other motor vehicle	6.0
Single axle or single axle group fitted with single tyres with section width of—	
(a) less than 375mm	6.0
(b) at least 375mm but less than 450mm	6.7
(c) at least 450mm	7.0
Single axle or single axle group fitted with dual tyres on—	
(a) a pig trailer	8.5
(b) a complying bus, or a bus allowed to carry standing passengers (other than an ultra-low floor route bus)	10.0
(c) an ultra-low floor route bus	11.0
(d) another vehicle	9.0
Twinsteer axle groups	
Twinsteer axle group without a load-sharing suspension	10.0
Twinsteer axle group with a load-sharing suspension	11.0
Tandem axle group	
Tandem axle group fitted with single tyres with section width of—	
(a) less than 375mm	11.0
(b) at least 375mm but less than 450mm	13.3
(c) at least 450mm	14.0

Phileas Vehicle Technical Specifications

Model	Phileas	Phileas	Phileas	
Type	18m	24m	26m	
Measures				
Length	18,44	24,45	25,97	m
Width	2,55	2,55	2,55	m
Height	3,20	3,20	3,20	m
Accessibility				
Kneeling	-70	-70	-70	mm
Floor-height	340	340	340	mm
Interior-height	2,25	2,25	2,25	m
Aisle width (minimum)	755-950	755-950	755-950	mm
Doors	Flexible (both sides)	Flexible (both sides)	Flexible (both sides)	
	1,20*2,00	1,20*2,00	1,20*2,00	m
Drivability				
Turning radius	12,50	12,50	12,50	m
Swept-path	4,40	4,40	4,40	m
Track-width (double lane)	6,60	6,60	6,60	m
Guidance (whole line)				
Principle	Magnetic	Magnetic	Magnetic	
Distance gap (door-stop)	50	50	50	mm
Max speed	60	60	60	km/h
Material body	Composite/Al	Composite/Al	Composite/Al	
Tyres	275/70R22,5	275/70R22,5	275/70R22,5	
	385/65R22,5	385/65R22,5	385/65R22,5	
Seats/Disabled/Standees	Adaptable	Adaptable	Adaptable	
4p/m2	29/1/74	46/1/83	52/1/89	
-total	103	129	141	
6p/m2	29/1/111	46/2/125	52/1/133	
-total	140	171	185	
Weight				
empty	**16.650**	**21.600**	**21.600**	kg
4p/m2	23.350	30.000	30.700	kg
6p/m2	25.800	32.700	33.600	kg
Traction	Parallel hybrid	Parallel hybrid	Parallel hybrid	
Powersource				
-Diesel	ok	ok	ok	
-Overheadwire/Trolley	ok	ok	-	
Topspeed	96	96	96	km/h
Max acceleration	1,4	1,4	1,4	m/s2
Grade	>13%	>13%	>13%	

Appendix B

Axle Load Comparison, Adjusted Design Vehicle Axle Loads

Axle Load Comparison

Max from Qld req'ts (& Aust stds)	Load (t)	Comments	Equiv. Std axle load (t)	ESA's for Equivalent Subgrade Damage	SAR's for Equivalent Asphalt Damage	SAR's for Equivalent Cemented Damage
Single steer axle	6.5	single steer axles		2.10	2.53	9.25
Single axle, single tyres	6.7	tyre width between 375mm & 450mm, such as Phileas (385/65R22.5 tyres)	5.4	2.37	2.94	13.31
Single axle, dual tyres	11	for ultra low floor bus	8.2	3.24	4.34	33.96
			EXP from DMR PDM	*4*	*5*	*12*
Category 1 vehicles						
Max from Phileas vehicle specs	**Load (t)**	**Comments**				
Single steer axle	7.8	assumed even spread across all axles		4.35	6.29	82.49
Single axle, single tyres	7.8	all 3 axles are single tyres		4.35	6.29	82.49
Single axle, single tyres	7.8			4.35	6.29	82.49
Total vehicle load	23.4	for Phileas 18m (artic), 4p/m^2	**Total per vehicle pass**	**13.05**	**18.87**	**247.47**
Single steer axle	6.5	assumed steer axle lower than other axles with Qld max limit for single steer axle		2.10	2.53	9.25
Single axle, single tyres	8.5	all 3 axles are single tyres		6.14	9.66	231.37
Single axle, single tyres	8.5			6.14	9.66	231.37
Total vehicle load	23.4	for Phileas 18m (artic), 4p/m^2	**Total per vehicle pass**	**14.38**	**21.85**	**471.99**
Single steer axle	7.7	assumed even spread across all axles		4.13	5.90	70.66
Single axle, single tyres	7.7	all 4 axles are single tyres		4.13	5.90	70.66
Single axle, single tyres	7.7			4.13	5.90	70.66
Single axle, single tyres	7.7			4.13	5.90	70.66
Total vehicle load	30.7	for Phileas 26m (bi-artic), 4p/m^2	**Total per vehicle pass**	**16.52**	**23.60**	**282.64**
Single steer axle	6.5	assumed steer axle lower than other axles with Qld max limit for single steer axle		2.10	2.53	9.25
Single axle, single tyres	8.1	all 4 axles are single tyres		5.06	7.59	129.75
Single axle, single tyres	8.1			5.06	7.59	129.75
Single axle, single tyres	8.1			5.06	7.59	129.75
Total vehicle load	30.7	for Phileas 26m (bi-artic), 4p/m^2	**Total per vehicle pass**	**17.28**	**25.30**	**398.50**
Max using above total vehicle loads, but dual tyres on rear axles						
Single steer axle	7.8	assumed even spread across all axles		4.35	6.29	82.49
Single axle, dual tyres	7.8			0.82	0.78	0.55
Single axle, dual tyres	7.8			0.82	0.78	0.55
Total vehicle load	23.4		**Total per vehicle pass**	**5.99**	**7.85**	**83.59**
Single steer axle	6.5	assumed steer axle lower than other axles with Qld max limit for single steer axle		2.10	2.53	9.25
Single axle, dual tyres	8.5			1.15	1.20	1.54
Single axle, dual tyres	8.5			1.15	1.20	1.54
Total vehicle load	23.4		**Total per vehicle pass**	**4.40**	**4.93**	**12.33**
Single steer axle	7.7	assumed even spread across all axles		4.13	5.90	70.66
Single axle, dual tyres	7.7			0.78	0.73	0.47
Single axle, dual tyres	7.7			0.78	0.73	0.47
Single axle, dual tyres	7.7			0.78	0.73	0.47
Total vehicle load	30.7		**Total per vehicle pass**	**6.47**	**8.09**	**72.07**
Single steer axle	6.5	assumed steer axle lower than other axles with Qld max limit for single steer axle		2.10	2.53	9.25
Single axle, dual tyres	8.1			0.95	0.94	0.86
Single axle, dual tyres	8.1			0.95	0.94	0.86
Single axle, dual tyres	8.1			0.95	0.94	0.86
Total vehicle load	30.7		**Total per vehicle pass**	**4.95**	**5.35**	**11.83**

Axle Load Comparison

Category 2 vehicles						
Assume max from Qld stds						
Single steer axle	6.5	Artic, all 3 axles are single tyres		2.10	2.53	9.25
Single axle, single tyres	6.7			2.37	2.94	13.31
Single axle, single tyres	6.7			2.37	2.94	13.31
Total vehicle load	19.9		**Total per vehicle pass**	**6.84**	**8.41**	**35.87**
Single steer axle	6.5	Artic, front axle single tyres, rear 2 axles are dual tyres		2.10	2.53	9.25
Single axle, dual tyres	11			3.24	4.34	33.96
Single axle, dual tyres	11			3.24	4.34	33.96
Total vehicle load	28.5		**Total per vehicle pass**	**8.58**	**11.21**	**77.17**
Single steer axle	6.5	Bi-artic, all 4 axles are single tyres		2.10	2.53	9.25
Single axle, single tyres	6.7			2.37	2.94	13.31
Single axle, single tyres	6.7			2.37	2.94	13.31
Single axle, single tyres	6.7			2.37	2.94	13.31
Total vehicle load	26.6		**Total per vehicle pass**	**9.21**	**11.35**	**49.18**
Single steer axle	6.5	Artic, front axle single tyres, rear 3 axles are dual tyres		2.10	2.53	9.25
Single axle, dual tyres	11			3.24	4.34	33.96
Single axle, dual tyres	11			3.24	4.34	33.96
Single axle, dual tyres	11			3.24	4.34	33.96
Total vehicle load	39.5		**Total per vehicle pass**	**11.82**	**15.55**	**111.13**

Super single tyre details	**Max axle load (t)**	**Comments**					
Bridgestone M748, 385/65R22.5	8.86	single axle, single tyres @ 825 kPa	Circly contact radius	0.129	m		
Toyo M149z, 385/65R22.5	9.00	single axle, single tyres @ 655 - 760 kPa	Circly contact radius	0.136	m	760	kPa
				0.146	m	655	kPa

Adjusted Design Vehicle Axle Loads

Max from Qld req'ts (& Aust stds)	Load (t)	Comments	Equiv. Std axle load (t)	ESA's for Equivalent Subgrade Damage	SAR's for Equivalent Asphalt Damage	SAR's for Equivalent Cemented Damage
Single steer axle	6.5	single steer axles		2.10	2.53	9.25
Single axle, single tyres	6.7	tyre width between 375mm & 450mm, such as Phileas (385/65R22.5 tyres)	5.4	2.37	2.94	13.31
Single axle, dual tyres	11	for ultra low floor bus	8.2	3.24	4.34	33.96
			EXP from DMR PDM	*4*	*5*	*12*
Design vehicle loads adjusted for 90% standee capacity						
Design vehicle specs	**Load (t)**	**Comments**				
Single steer axle	6.5	assumed even spread across all axles		2.10	2.53	9.25
Single axle, single tyres	8.0	all 3 axles are single tyres		4.82	7.14	111.78
Single axle, single tyres	8.0			4.82	7.14	111.78
Total vehicle load	22.5	for design artic, 100% seating and 90% standee capacity	**Total per vehicle pass**	**11.74**	**16.81**	**232.81**
Single steer axle	6.5	assumed even spread across all axles		2.10	2.53	9.25
Single axle, single tyres	7.8	all 4 axles are single tyres		4.35	6.29	82.49
Single axle, single tyres	7.8			4.35	6.29	82.49
Single axle, single tyres	7.8			4.35	6.29	82.49
Total vehicle load	29.92	for design bi-artic, 100% seating and 90% standee capacity	**Total per vehicle pass**	**15.15**	**21.40**	**256.72**

Phileas passenger load details	29/1/74	18m artic (seats/disabled/standing), total 104
	52/1/89	26m bi-artic (seats/disabled/standing), total 142
Ave passenger mass	65	kg
Empty vehicle mass	16.65	tonne, 18m artic
	21.60	tonne, 26m bi-artic
BRT Ops report capacity	32/2/62	18m artic (seats/disabled/standing), total 96
	46/2/89	25m bi-artic (seats/disabled/standing), total 137
90% standee capacity	32/2/56	artic, total 90
	46/2/80	bi-artic, total 128
Design vehicle mass	22.50	tonne, artic
	29.92	tonne, bi-artic

Appendix C

CIRCLY Analysis Summary Results

Gold Coast Rapid Transit System

Concept Pavement Design for Bus Rapid Transit - Pavement Options Summary

Pavement Type	Subgrade Condition (Design)	Operating Speed	Section	Design Period	Design Traffic Loading	DG20HM Base Thickness (from CIRCLY)	DG20HM Base Thickness *
Heavy Duty Deep Strength Asphalt	1.5% & 3%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	220	230
				50yrs	$6.46x10^7$	244	**255**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	237	250
				50yrs	$1.07x10^8$	260	**270**
		50km/h	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	183	195
				50yrs	$6.46x10^7$	204	**215**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	198	210
				50yrs	$1.07x10^8$	218	**230**
	10%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	149	175
				50yrs	$6.46x10^7$	171	**185**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	165	175
				50yrs	$1.07x10^8$	186	**200**
		50km/h	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	120	175
				50yrs	$6.46x10^7$	140	**175**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	134	175
				50yrs	$1.07x10^8$	152	**175**

45mm DG14HS Wearing course
PMB Seal
45mm DG14HS Binder Layer
* mm DG20HM Base
Primer Seal
200mm cementitiously stabilised layer Type 1.1 material
Prime and Seal
150mm cement stabilised type 1.2 material Working Platform
Controlled Subgrade, Drainage Layer, Capping Layer as required to provide subgrade matching design

Note: With the subgrade treatments specified, the pavement base thickness for 1.5% is the same as 3%.

Note: The design period is 50 years. The 30 year period is given for comparison

Note: The Design Traffic Loading quoted here is ESA's for equivalent subgrade damage

Note: The minimum thickness of asphalt base in DSA is 175mm, taken from PDM

Pavement Type	Subgrade Condition (Design)	Operating Speed	Section	Design Period	Design Traffic Loading	DG20HM Base Thickness (from CIRCLY)	DG20HM Base Thickness *
Heavy Duty Full Depth Asphalt	1.5% & 3%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	299	310
				50yrs	$6.46x10^7$	347	**360**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	330	340
				50yrs	$1.07x10^8$	376	**390**
		50km/h	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	251	265
				50yrs	$6.46x10^7$	293	**305**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	277	290
				50yrs	$1.07x10^8$	318	**330**
	10%	10km/h (including stations)	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	243	255
				50yrs	$6.46x10^7$	286	**300**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	271	285
				50yrs	$1.07x10^8$	312	**325**
		50km/h	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	206	220
				50yrs	$6.46x10^7$	244	**255**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	230	240
				50yrs	$1.07x10^8$	266	**280**

45mm DG14HS Wearing course
PMB Seal
45mm DG14HS Binder Layer
* mm DG20HM Base
Prime and Seal
150mm cement stabilised type 1.2 material Working Platform
Controlled Subgrade, Drainage Layer, Capping Layer as required to provide subgrade matching design

Note: With the subgrade treatments specified, the pavement base thickness for 1.5% is the same as 3%.

Note: The design period is 50 years. The 30 year period is given for comparison

Note: The Design Traffic Loading quoted here is ESA's for equivalent subgrade damage

Pavement Type	Subgrade Condition (Design)	Operating Speed	Section	Design Period	Design Traffic Loading	Total Granular Thickness (from CIRCLY)	Total Granular Thickness *
Unbound Granular	1.5% & 3%	Not relevan	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	623	635
				50yrs	$6.46x10^7$	727	**740**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	687	700
				50yrs	$1.07x10^8$	791	**805**
	10%	Not relevan	Helensvale to Uni Hospital	30yrs	$2.64x10^7$	465	475
				50yrs	$6.46x10^7$	538	**550**
			Uni Hospital to Broadbeach	30yrs	$4.68x10^7$	510	520
				50yrs	$1.07x10^8$	582	**595**

35mm DG14HS Wearing course
PMB Seal
* mm Granular Pavement
Prime and Seal
150mm cement stabilised type 1.2 material Working Platform
Controlled Subgrade, Drainage Layer, Capping Layer as required to provide subgrade matching design

Note: With the subgrade treatments specified, the pavement base thickness for 1.5% is the same as 3%.

Note: The design period is 50 years. The 30 year period is given for comparison

Note: The Design Traffic Loading quoted here is ESA's for equivalent subgrade damage

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.29E-04	1.67E-01
2	45.00	DG14-1000	ESA75-Full	-9.16E-05	3.03E-02
3	220.00	DG20-1300	ESA75-Full	-3.51E-06	6.13E-09

4	200.00	Cement3500	ESA75-Full	-6.57E-05	9.97E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.30E-04	5.56E-03
6	0.00	DMR_Sub3	ESA75-Full	1.81E-04	2.13E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.420
2	bottom	DG14-1000	ETH	0.006040	5.000	1.420
3	bottom	DG20-1300	ETH	0.005047	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.30E-04	4.26E-01
2	45.00	DG14-1000	ESA75-Full	-9.27E-05	7.80E-02
3	244.00	DG20-1300	ESA75-Full	-4.83E-06	7.37E-08

4	200.00	Cement3500	ESA75-Full	-6.14E-05	9.98E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.21E-04	1.04E-02
6	0.00	DMR_Sub3	ESA75-Full	1.70E-04	4.05E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.30E-04	3.07E-01
2	45.00	DG14-1000	ESA75-Full	-9.24E-05	5.60E-02
3	237.00	DG20-1300	ESA75-Full	-4.48E-06	3.68E-08

4	200.00	Cement3500	ESA75-Full	-6.26E-05	9.98E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.24E-04	8.16E-03
6	0.00	DMR_Sub3	ESA75-Full	1.73E-04	3.15E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.410
2	bottom	DG14-1000	ETH	0.006040	5.000	1.410
3	bottom	DG20-1300	ETH	0.005047	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.31E-04	7.23E-01
2	45.00	DG14-1000	ESA75-Full	-9.33E-05	1.33E-01
3	259.50	DG20-1300	ESA75-Full	-5.53E-06	2.38E-07

4	200.00	Cement3500	ESA75-Full	-5.89E-05	9.99E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.16E-04	1.46E-02
6	0.00	DMR_Sub3	ESA75-Full	1.64E-04	5.73E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.82E-05	8.09E-02
2	45.00	DG14-1425	ESA75-Full	-4.40E-05	1.46E-03
3	182.70	DG20-2500	ESA75-Full	-1.29E-05	1.34E-05

4	200.00	Cement3500	ESA75-Full	-6.57E-05	9.93E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.24E-04	4.67E-03
6	0.00	DMR_Sub3	ESA75-Full	1.73E-04	1.77E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.420
2	bottom	DG14-1425	ETH	0.005320	5.000	1.420
3	bottom	DG20-2500	ETH	0.003988	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.96E-05	2.11E-01
2	45.00	DG14-1425	ESA75-Full	-4.49E-05	3.95E-03
3	204.00	DG20-2500	ESA75-Full	-1.37E-05	4.31E-05

4	200.00	Cement3500	ESA75-Full	-6.14E-05	9.94E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.16E-04	8.71E-03
6	0.00	DMR_Sub3	ESA75-Full	1.62E-04	3.33E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.92E-05	1.51E-01
2	45.00	DG14-1425	ESA75-Full	-4.47E-05	2.80E-03
3	198.00	DG20-2500	ESA75-Full	-1.35E-05	2.93E-05

4	200.00	Cement3500	ESA75-Full	-6.26E-05	9.86E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.18E-04	6.81E-03
6	0.00	DMR_Sub3	ESA75-Full	1.65E-04	2.59E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.410
2	bottom	DG14-1425	ETH	0.005320	5.000	1.410
3	bottom	DG20-2500	ETH	0.003988	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.00E-04	3.62E-01
2	45.00	DG14-1425	ESA75-Full	-4.55E-05	6.93E-03
3	218.00	DG20-2500	ESA75-Full	-1.40E-05	8.09E-05

4	200.00	Cement3500	ESA75-Full	-5.88E-05	9.87E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.11E-04	1.21E-02
6	0.00	DMR_Sub3	ESA75-Full	1.55E-04	4.68E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.35E-04	2.10E-01
2	45.00	DG14-1000	ESA75-Full	-9.75E-05	4.15E-02
3	149.10	DG20-1300	ESA75-Full	-1.87E-06	2.60E-10

4	200.00	Cement3500	ESA75-Full	-6.57E-05	9.97E-01
5	150.00	WkgPltfm10	ESA75-Full	1.53E-04	1.08E-02
6	0.00	DMR_Sub10	ESA75-Full	1.47E-04	9.26E-03

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.420
2	bottom	DG14-1000	ETH	0.006040	5.000	1.420
3	bottom	DG20-1300	ETH	0.005047	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.36E-04	5.33E-01
2	45.00	DG14-1000	ESA75-Full	-9.93E-05	1.10E-01
3	171.00	DG20-1300	ESA75-Full	-2.56E-06	3.08E-09

4	200.00	Cement3500	ESA75-Full	-6.14E-05	9.99E-01
5	150.00	WkgPltfm10	ESA75-Full	1.43E-04	2.04E-02
6	0.00	DMR_Sub10	ESA75-Full	1.38E-04	1.77E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.36E-04	3.84E-01
2	45.00	DG14-1000	ESA75-Full	-9.88E-05	7.85E-02
3	164.70	DG20-1300	ESA75-Full	-2.29E-06	1.29E-09

4	200.00	Cement3500	ESA75-Full	-6.26E-05	9.96E-01
5	150.00	WkgPltfm10	ESA75-Full	1.46E-04	1.59E-02
6	0.00	DMR_Sub10	ESA75-Full	1.41E-04	1.38E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.410
2	bottom	DG14-1000	ETH	0.006040	5.000	1.410
3	bottom	DG20-1300	ETH	0.005047	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.37E-04	8.99E-01
2	45.00	DG14-1000	ESA75-Full	-1.00E-04	1.91E-01
3	185.50	DG20-1300	ESA75-Full	-3.13E-06	1.39E-08

4	200.00	Cement3500	ESA75-Full	-5.88E-05	9.88E-01
5	150.00	WkgPltfm10	ESA75-Full	1.37E-04	2.86E-02
6	0.00	DMR_Sub10	ESA75-Full	1.33E-04	2.51E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.02E-04	9.72E-02
2	45.00	DG14-1425	ESA75-Full	-4.74E-05	2.12E-03
3	120.10	DG20-2500	ESA75-Full	-1.16E-05	8.00E-06

4	200.00	Cement3500	ESA75-Full	-6.57E-05	9.96E-01
5	150.00	WkgPltfm10	ESA75-Full	1.47E-04	9.21E-03
6	0.00	DMR_Sub10	ESA75-Full	1.41E-04	7.87E-03

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.420
2	bottom	DG14-1425	ETH	0.005320	5.000	1.420
3	bottom	DG20-2500	ETH	0.003988	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.03E-04	2.52E-01
2	45.00	DG14-1425	ESA75-Full	-4.82E-05	5.63E-03
3	139.50	DG20-2500	ESA75-Full	-1.21E-05	2.33E-05

4	200.00	Cement3500	ESA75-Full	-6.14E-05	9.96E-01
5	150.00	WkgPltfm10	ESA75-Full	1.37E-04	1.72E-02
6	0.00	DMR_Sub10	ESA75-Full	1.32E-04	1.49E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.03E-04	1.81E-01
2	45.00	DG14-1425	ESA75-Full	-4.80E-05	4.01E-03
3	134.00	DG20-2500	ESA75-Full	-1.20E-05	1.63E-05

4	200.00	Cement3500	ESA75-Full	-6.26E-05	9.90E-01
5	150.00	WkgPltfm10	ESA75-Full	1.40E-04	1.34E-02
6	0.00	DMR_Sub10	ESA75-Full	1.35E-04	1.16E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.410
2	bottom	DG14-1425	ETH	0.005320	5.000	1.410
3	bottom	DG20-2500	ETH	0.003988	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.04E-04	4.31E-01
2	45.00	DG14-1425	ESA75-Full	-4.88E-05	9.77E-03
3	152.00	DG20-2500	ESA75-Full	-1.23E-05	4.15E-05

4	200.00	Cement3500	ESA75-Full	-5.89E-05	9.99E-01
5	150.00	WkgPltfm10	ESA75-Full	1.32E-04	2.40E-02
6	0.00	DMR_Sub10	ESA75-Full	1.27E-04	2.10E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.28E-04	1.63E-01
2	45.00	DG14-1000	ESA75-Full	-9.14E-05	3.00E-02
3	252.00	DG20-1300	ESA75-Full	-7.89E-06	3.53E-07

4	175.00	Cement3500	ESA75-Full	-6.55E-05	9.69E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.30E-04	5.58E-03
6	0.00	DMR_Sub3	ESA75-Full	1.81E-04	2.13E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.420
2	bottom	DG14-1000	ETH	0.006040	5.000	1.420
3	bottom	DG20-1300	ETH	0.005047	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.30E-04	4.26E-01
2	45.00	DG14-1000	ESA75-Full	-9.27E-05	7.80E-02
3	244.00	DG20-1300	ESA75-Full	-4.83E-06	7.37E-08

4	200.00	Cement3500	ESA75-Full	-6.14E-05	9.98E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.21E-04	1.04E-02
6	0.00	DMR_Sub3	ESA75-Full	1.70E-04	4.05E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.30E-04	3.07E-01
2	45.00	DG14-1000	ESA75-Full	-9.24E-05	5.60E-02
3	237.00	DG20-1300	ESA75-Full	-4.48E-06	3.68E-08

4	200.00	Cement3500	ESA75-Full	-6.26E-05	9.98E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.24E-04	8.16E-03
6	0.00	DMR_Sub3	ESA75-Full	1.73E-04	3.15E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSASt1 Title: Subgrade 3%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.410
2	bottom	DG14-1000	ETH	0.006040	5.000	1.410
3	bottom	DG20-1300	ETH	0.005047	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.31E-04	7.23E-01
2	45.00	DG14-1000	ESA75-Full	-9.33E-05	1.33E-01
3	259.50	DG20-1300	ESA75-Full	-5.53E-06	2.38E-07

4	200.00	Cement3500	ESA75-Full	-5.89E-05	9.99E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.16E-04	1.46E-02
6	0.00	DMR_Sub3	ESA75-Full	1.64E-04	5.73E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.82E-05	8.09E-02
2	45.00	DG14-1425	ESA75-Full	-4.40E-05	1.46E-03
3	182.70	DG20-2500	ESA75-Full	-1.29E-05	1.34E-05

4	200.00	Cement3500	ESA75-Full	-6.57E-05	9.93E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.24E-04	4.67E-03
6	0.00	DMR_Sub3	ESA75-Full	1.73E-04	1.77E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.420
2	bottom	DG14-1425	ETH	0.005320	5.000	1.420
3	bottom	DG20-2500	ETH	0.003988	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.96E-05	2.11E-01
2	45.00	DG14-1425	ESA75-Full	-4.49E-05	3.95E-03
3	204.00	DG20-2500	ESA75-Full	-1.37E-05	4.31E-05

4	200.00	Cement3500	ESA75-Full	-6.14E-05	9.94E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.16E-04	8.71E-03
6	0.00	DMR_Sub3	ESA75-Full	1.62E-04	3.33E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.92E-05	1.51E-01
2	45.00	DG14-1425	ESA75-Full	-4.47E-05	2.80E-03
3	198.00	DG20-2500	ESA75-Full	-1.35E-05	2.93E-05

4	200.00	Cement3500	ESA75-Full	-6.26E-05	9.86E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.18E-04	6.81E-03
6	0.00	DMR_Sub3	ESA75-Full	1.65E-04	2.59E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%DSA Title: Subgrade 3%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
6	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.410
2	bottom	DG14-1425	ETH	0.005320	5.000	1.410
3	bottom	DG20-2500	ETH	0.003988	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.00E-04	3.62E-01
2	45.00	DG14-1425	ESA75-Full	-4.55E-05	6.93E-03
3	218.00	DG20-2500	ESA75-Full	-1.40E-05	8.09E-05

4	200.00	Cement3500	ESA75-Full	-5.88E-05	9.87E-01
5	150.00	WkgPltfrm3	ESA75-Full	1.11E-04	1.21E-02
6	0.00	DMR_Sub3	ESA75-Full	1.55E-04	4.68E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.34E-04	2.04E-01
2	45.00	DG14-1000	ESA75-Full	-9.73E-05	4.09E-02
3	181.72	DG20-1300	ESA75-Full	-4.67E-06	2.55E-08

4	175.00	Cement3500	ESA75-Full	-6.56E-05	9.87E-01
5	150.00	WkgPltfm10	ESA75-Full	1.54E-04	1.10E-02
6	0.00	DMR_Sub10	ESA75-Full	1.48E-04	9.39E-03

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.420
2	bottom	DG14-1000	ETH	0.006040	5.000	1.420
3	bottom	DG20-1300	ETH	0.005047	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.35E-04	5.20E-01
2	45.00	DG14-1000	ESA75-Full	-9.89E-05	1.08E-01
3	203.10	DG20-1300	ESA75-Full	-5.55E-06	1.48E-07

4	175.00	Cement3500	ESA75-Full	-6.14E-05	9.99E-01
5	150.00	WkgPltfm10	ESA75-Full	1.44E-04	2.09E-02
6	0.00	DMR_Sub10	ESA75-Full	1.39E-04	1.81E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.35E-04	3.74E-01
2	45.00	DG14-1000	ESA75-Full	-9.84E-05	7.69E-02
3	197.00	DG20-1300	ESA75-Full	-5.32E-06	8.69E-08

4	175.00	Cement3500	ESA75-Full	-6.26E-05	9.91E-01
5	150.00	WkgPltfm10	ESA75-Full	1.47E-04	1.63E-02
6	0.00	DMR_Sub10	ESA75-Full	1.41E-04	1.40E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSAStn Title: Subgrade 10%, DSA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.410
2	bottom	DG14-1000	ETH	0.006040	5.000	1.410
3	bottom	DG20-1300	ETH	0.005047	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.36E-04	8.78E-01
2	45.00	DG14-1000	ESA75-Full	-9.98E-05	1.86E-01
3	217.20	DG20-1300	ESA75-Full	-6.06E-06	3.77E-07

4	175.00	Cement3500	ESA75-Full	-5.89E-05	9.97E-01
5	150.00	WkgPltfm10	ESA75-Full	1.38E-04	2.93E-02
6	0.00	DMR_Sub10	ESA75-Full	1.34E-04	2.57E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.02E-04	9.70E-02
2	45.00	DG14-1425	ESA75-Full	-4.74E-05	2.11E-03
3	150.00	DG20-2500	ESA75-Full	-1.45E-05	2.42E-05

4	175.00	Cement3500	ESA75-Full	-6.55E-05	9.65E-01
5	150.00	WkgPltfm10	ESA75-Full	1.46E-04	9.05E-03
6	0.00	DMR_Sub10	ESA75-Full	1.41E-04	7.70E-03

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.420
2	bottom	DG14-1425	ETH	0.005320	5.000	1.420
3	bottom	DG20-2500	ETH	0.003988	5.000	1.420
4	bottom	Cement3500	ETH	0.000350	12.000	18.110
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.03E-04	2.51E-01
2	45.00	DG14-1425	ESA75-Full	-4.82E-05	5.61E-03
3	168.70	DG20-2500	ESA75-Full	-1.48E-05	6.39E-05

4	175.00	Cement3500	ESA75-Full	-6.14E-05	9.90E-01
5	150.00	WkgPltfm10	ESA75-Full	1.37E-04	1.71E-02
6	0.00	DMR_Sub10	ESA75-Full	1.32E-04	1.47E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	bottom	Cement3500	ETH	0.000350	12.000	19.830
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.03E-04	1.80E-01
2	45.00	DG14-1425	ESA75-Full	-4.80E-05	3.99E-03
3	163.00	DG20-2500	ESA75-Full	-1.47E-05	4.57E-05

4	175.00	Cement3500	ESA75-Full	-6.26E-05	9.93E-01
5	150.00	WkgPltfm10	ESA75-Full	1.40E-04	1.34E-02
6	0.00	DMR_Sub10	ESA75-Full	1.35E-04	1.15E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%DSA Title: Subgrade 10%, DSA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	Cement3500	Iso.	3.50E+03	0.20			
5	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
6	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.410
2	bottom	DG14-1425	ETH	0.005320	5.000	1.410
3	bottom	DG20-2500	ETH	0.003988	5.000	1.410
4	bottom	Cement3500	ETH	0.000350	12.000	18.130
5	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
6	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 5: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-1.04E-04	4.29E-01
2	45.00	DG14-1425	ESA75-Full	-4.87E-05	9.75E-03
3	181.00	DG20-2500	ESA75-Full	-1.49E-05	1.08E-04

4	175.00	Cement3500	ESA75-Full	-5.89E-05	9.97E-01
5	150.00	WkgPltfm10	ESA75-Full	1.31E-04	2.39E-02
6	0.00	DMR_Sub10	ESA75-Full	1.27E-04	2.08E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDASt1 Title: Subgrade 3%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.07E-04	6.70E-02
2	45.00	DG14-1000	ESA75-Full	-7.97E-05	1.51E-02
3	299.40	DG20-1300	ESA75-Full	-1.54E-04	9.99E-01
4	150.00	WkgPltfrm3	ESA75-Full	2.57E-04	8.64E-02
5	0.00	DMR_Sub3	ESA75-Full	3.38E-04	2.58E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDASt1 Title: Subgrade 3%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.420
2	bottom	DG14-1000	ETH	0.006040	5.000	1.420
3	bottom	DG20-1300	ETH	0.005047	5.000	1.420
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.14E-04	2.21E-01
2	45.00	DG14-1000	ESA75-Full	-8.34E-05	4.59E-02
3	347.40	DG20-1300	ESA75-Full	-1.29E-04	9.96E-01
4	150.00	WkgPltfrm3	ESA75-Full	2.15E-04	1.03E-01
5	0.00	DMR_Sub3	ESA75-Full	2.85E-04	3.20E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDASt1 Title: Subgrade 3%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.12E-04	1.46E-01
2	45.00	DG14-1000	ESA75-Full	-8.21E-05	3.10E-02
3	330.00	DG20-1300	ESA75-Full	-1.37E-04	9.94E-01
4	150.00	WkgPltfrm3	ESA75-Full	2.29E-04	9.62E-02
5	0.00	DMR_Sub3	ESA75-Full	3.03E-04	2.94E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDASt1 Title: Subgrade 3%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.410
2	bottom	DG14-1000	ETH	0.006040	5.000	1.410
3	bottom	DG20-1300	ETH	0.005047	5.000	1.410
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.17E-04	4.20E-01
2	45.00	DG14-1000	ESA75-Full	-8.53E-05	8.47E-02
3	376.20	DG20-1300	ESA75-Full	-1.17E-04	9.98E-01
4	150.00	WkgPltfrm3	ESA75-Full	1.94E-04	1.15E-01
5	0.00	DMR_Sub3	ESA75-Full	2.60E-04	3.65E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDA Title: Subgrade 3%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-8.04E-05	2.98E-02
2	45.00	DG14-1425	ESA75-Full	-3.38E-05	3.93E-04
3	251.00	DG20-2500	ESA75-Full	-1.22E-04	9.93E-01
4	150.00	WkgPltfrm3	ESA75-Full	2.22E-04	4.80E-02
5	0.00	DMR_Sub3	ESA75-Full	3.01E-04	1.63E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDA Title: Subgrade 3%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.420
2	bottom	DG14-1425	ETH	0.005320	5.000	1.420
3	bottom	DG20-2500	ETH	0.003988	5.000	1.420
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-8.66E-05	1.05E-01
2	45.00	DG14-1425	ESA75-Full	-3.71E-05	1.51E-03
3	292.50	DG20-2500	ESA75-Full	-1.02E-04	9.97E-01
4	150.00	WkgPltfrm3	ESA75-Full	1.86E-04	5.74E-02
5	0.00	DMR_Sub3	ESA75-Full	2.53E-04	1.99E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDA Title: Subgrade 3%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-8.45E-05	6.77E-02
2	45.00	DG14-1425	ESA75-Full	-3.59E-05	9.42E-04
3	277.20	DG20-2500	ESA75-Full	-1.09E-04	9.98E-01
4	150.00	WkgPltfrm3	ESA75-Full	1.98E-04	5.37E-02
5	0.00	DMR_Sub3	ESA75-Full	2.69E-04	1.84E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%FDA Title: Subgrade 3%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
5	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.410
2	bottom	DG14-1425	ETH	0.005320	5.000	1.410
3	bottom	DG20-2500	ETH	0.003988	5.000	1.410
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-8.97E-05	2.05E-01
2	45.00	DG14-1425	ESA75-Full	-3.88E-05	3.12E-03
3	317.60	DG20-2500	ESA75-Full	-9.22E-05	9.98E-01
4	150.00	WkgPltfrm3	ESA75-Full	1.68E-04	6.36E-02
5	0.00	DMR_Sub3	ESA75-Full	2.30E-04	2.24E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDAStn Title: Subgrade 10%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.13E-04	8.61E-02
2	45.00	DG14-1000	ESA75-Full	-8.56E-05	2.15E-02
3	243.30	DG20-1300	ESA75-Full	-1.54E-04	9.98E-01
4	150.00	WkgPltfm10	ESA75-Full	3.04E-04	1.69E-01
5	0.00	DMR_Sub10	ESA75-Full	2.76E-04	1.15E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDAStn Title: Subgrade 10%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.420
2	bottom	DG14-1000	ETH	0.006040	5.000	1.420
3	bottom	DG20-1300	ETH	0.005047	5.000	1.420
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.19E-04	2.74E-01
2	45.00	DG14-1000	ESA75-Full	-8.85E-05	6.19E-02
3	285.80	DG20-1300	ESA75-Full	-1.29E-04	9.98E-01
4	150.00	WkgPltfm10	ESA75-Full	2.56E-04	2.06E-01
5	0.00	DMR_Sub10	ESA75-Full	2.34E-04	1.44E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDAStn Title: Subgrade 10%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.430
2	bottom	DG14-1000	ETH	0.006040	5.000	1.430
3	bottom	DG20-1300	ETH	0.005047	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.17E-04	1.83E-01
2	45.00	DG14-1000	ESA75-Full	-8.75E-05	4.27E-02
3	270.60	DG20-1300	ESA75-Full	-1.37E-04	9.92E-01
4	150.00	WkgPltfm10	ESA75-Full	2.72E-04	1.90E-01
5	0.00	DMR_Sub10	ESA75-Full	2.48E-04	1.32E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDAStn Title: Subgrade 10%, FDA 10 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1000	Iso.	1.00E+03	0.40			
2	rough	DG14-1000	Iso.	1.00E+03	0.40			
3	rough	DG20-1300	Iso.	1.30E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1000	ETH	0.006040	5.000	1.410
2	bottom	DG14-1000	ETH	0.006040	5.000	1.410
3	bottom	DG20-1300	ETH	0.005047	5.000	1.410
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1000	ESA75-Full	-1.22E-04	5.15E-01
2	45.00	DG14-1000	ESA75-Full	-9.02E-05	1.12E-01
3	311.60	DG20-1300	ESA75-Full	-1.17E-04	9.93E-01
4	150.00	WkgPltfm10	ESA75-Full	2.31E-04	2.29E-01
5	0.00	DMR_Sub10	ESA75-Full	2.13E-04	1.65E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDA Title: Subgrade 10%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-8.42E-05	3.75E-02
2	45.00	DG14-1425	ESA75-Full	-3.80E-05	6.98E-04
3	205.90	DG20-2500	ESA75-Full	-1.22E-04	9.97E-01
4	150.00	WkgPltfm10	ESA75-Full	2.62E-04	9.33E-02
5	0.00	DMR_Sub10	ESA75-Full	2.45E-04	7.14E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDA Title: Subgrade 10%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.420
2	bottom	DG14-1425	ETH	0.005320	5.000	1.420
3	bottom	DG20-2500	ETH	0.003988	5.000	1.420
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.03E-05	1.29E-01
2	45.00	DG14-1425	ESA75-Full	-4.08E-05	2.45E-03
3	243.50	DG20-2500	ESA75-Full	-1.02E-04	9.97E-01
4	150.00	WkgPltfm10	ESA75-Full	2.19E-04	1.11E-01
5	0.00	DMR_Sub10	ESA75-Full	2.06E-04	8.68E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDA Title: Subgrade 10%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.430
2	bottom	DG14-1425	ETH	0.005320	5.000	1.430
3	bottom	DG20-2500	ETH	0.003988	5.000	1.430
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-8.82E-05	8.39E-02
2	45.00	DG14-1425	ESA75-Full	-3.98E-05	1.57E-03
3	229.80	DG20-2500	ESA75-Full	-1.08E-04	9.96E-01
4	150.00	WkgPltfm10	ESA75-Full	2.33E-04	1.04E-01
5	0.00	DMR_Sub10	ESA75-Full	2.19E-04	8.04E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%FDA Title: Subgrade 10%, FDA 50 km/h

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	DG14-1425	Iso.	1.43E+03	0.40			
2	rough	DG14-1425	Iso.	1.43E+03	0.40			
3	rough	DG20-2500	Iso.	2.50E+03	0.40			
4	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
5	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
1	bottom	DG14-1425	ETH	0.005320	5.000	1.410
2	bottom	DG14-1425	ETH	0.005320	5.000	1.410
3	bottom	DG20-2500	ETH	0.003988	5.000	1.410
4	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
5	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 4: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	45.00	DG14-1425	ESA75-Full	-9.33E-05	2.50E-01
2	45.00	DG14-1425	ESA75-Full	-4.24E-05	4.86E-03
3	266.00	DG20-2500	ESA75-Full	-9.22E-05	9.98E-01
4	150.00	WkgPltfm10	ESA75-Full	1.98E-04	1.24E-01
5	0.00	DMR_Sub10	ESA75-Full	1.87E-04	9.80E-02

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%Flex Title: Subgrade 3% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
3	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	623.20	Gran_500		n/a	n/a
2	150.00	WkgPltfrm3	ESA75-Full	3.97E-04	4.90E-01
3	0.00	DMR_Sub3	ESA75-Full	4.74E-04	9.98E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%Flex Title: Subgrade 3% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
3	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	727.00	Gran_500		n/a	n/a
2	150.00	WkgPltfrm3	ESA75-Full	3.06E-04	4.26E-01
3	0.00	DMR_Sub3	ESA75-Full	3.79E-04	9.92E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%Flex Title: Subgrade 3% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
3	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	687.50	Gran_500		n/a	n/a
2	150.00	WkgPltfrm3	ESA75-Full	3.37E-04	4.51E-01
3	0.00	DMR_Sub3	ESA75-Full	4.11E-04	9.99E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 3%Flex Title: Subgrade 3% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfrm3	Aniso.	8.00E+01	0.35	5.93E+01	4.00E+01	0.35
3	rough	DMR_Sub3	Aniso.	4.00E+01	0.45	2.76E+01	2.00E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	791.08	Gran_500		n/a	n/a
2	150.00	WkgPltfrm3	ESA75-Full	2.66E-04	3.98E-01
3	0.00	DMR_Sub3	ESA75-Full	3.34E-04	9.96E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG30yr Title: Helensvale to Uni Hos 30yr 2.64x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	2.64E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%Flex Title: Subgrade 10% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
3	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	464.50	Gran_500		n/a	n/a
2	150.00	WkgPltfm10	ESA75-Full	4.74E-04	9.99E-01
3	0.00	DMR_Sub10	ESA75-Full	3.90E-04	4.57E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: HG50yr Title: Helensvale to Uni Hos 50yr 6.46x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	6.46E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%Flex Title: Subgrade 10% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
3	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	538.00	Gran_500		n/a	n/a
2	150.00	WkgPltfm10	ESA75-Full	3.79E-04	9.99E-01
3	0.00	DMR_Sub10	ESA75-Full	3.21E-04	5.10E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB30yr Title: Uni Hos to Brdbch Sth 30yr 4.68x10^7 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	4.68E+07

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%Flex Title: Subgrade 10% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
3	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	510.90	Gran_500		n/a	n/a
2	150.00	WkgPltfm10	ESA75-Full	4.11E-04	9.99E-01
3	0.00	DMR_Sub10	ESA75-Full	3.44E-04	4.90E-01

CIRCLY Version 5.0i (7 July 2006)

Job Title: Concept Stage Pavement Design for Bus Rapid Transit

Damage Factor Calculation

Assumed number of damage pulses per movement:
One pulse per axle (i.e. use NROWS)

Traffic Spectrum Details:

ID: GB50yr Title: Uni Hos to Brdbch Sth 50yr 1.07x10^8 ESAs

Load No.	Load ID	Movements
1	ESA75-Full	1.07E+08

Details of Load Groups:

Load No.	Load ID	Load Category	Load Type	Radius	Pressure/ Ref. stress	Exponent
1	ESA75-Full	SA750-Full	Vertical Force	92.1	0.75	0.00

Load Locations:

Location No.	Load ID	Gear No.	X	Y	Scaling Factor	Theta
1	ESA75-Full	1	-165.0	0.0	1.00E+00	0.00
2	ESA75-Full	1	165.0	0.0	1.00E+00	0.00
3	ESA75-Full	1	1635.0	0.0	1.00E+00	0.00
4	ESA75-Full	1	1965.0	0.0	1.00E+00	0.00

Layout of result points on horizontal plane:
Xmin: 0 Xmax: 165 Xdel: 165
Y: 0

Details of Layered System:

ID: 10%Flex Title: Subgrade 10% Flexible pavement for BRT comparison

Layer No.	Lower i/face	Material ID	Isotropy	Modulus (or Ev)	P.Ratio (or vvh)	F	Eh	vh
1	rough	Gran_500	Aniso.	5.00E+02	0.35	3.70E+02	2.50E+02	0.35
2	rough	WkgPltfm10	Aniso.	1.20E+02	0.35	8.89E+01	6.00E+01	0.35
3	rough	DMR_Sub10	Aniso.	9.00E+01	0.45	6.21E+01	4.50E+01	0.45

Performance Relationships:

Layer No.	Location	Performance ID	Component	Perform. Constant	Perform. Exponent	Traffic Multiplier
2	top	Wkg Pltfrm	EZZ	0.034000	4.000	1.000
3	top	DMR_Sub	EZZ	0.034000	4.000	1.000

Reliability Factors: Not Used.

Details of Layers to be sublayered:
Layer no. 1: Austroads (2004) sublayering
Layer no. 2: Austroads (2004) sublayering

Results:

Layer No.	Thickness	Material ID	Load ID	Critical Strain	CDF
1	582.00	Gran_500		n/a	n/a
2	150.00	WkgPltfm10	ESA75-Full	3.34E-04	9.99E-01
3	0.00	DMR_Sub10	ESA75-Full	2.87E-04	5.45E-01

Appendix D

Rigid Pavement Base Thickness and Reinforcement Detailing Calculations

Gold Coast Rapid Transit System

Concept Pavement Design for Bus Rapid Transit - Pavement Options Summary

Pavement Type	Subgrade Condition (Design)	Operating Speed	Section	Design Period	Design Traffic Loading	Concrete Base Thickness (calculated)	Concrete Base Thickness *	Longitudinal Reo: N16 @ (2 layers, top & bottom)	Transverse Reo: N12 @
Heavy Duty Concrete	1.5%	all (including Stations)	Helensvale to Uni Hospital	30yrs	6.75×10^6	185	195	200	700
				50yrs	2.58×10^7	190	**200**	**190**	**680**
			Uni Hospital to Broadbeach	30yrs	1.20×10^7	190	200	190	680
				50yrs	2.78×10^7	195	**205**	**190**	**660**
	3%	all (including Stations)	Helensvale to Uni Hospital	30yrs	6.75×10^6	185	195	200	700
				50yrs	2.58×10^7	190	**200**	**190**	**680**
			Uni Hospital to Broadbeach	30yrs	1.20×10^7	190	200	190	680
				50yrs	2.78×10^7	195	**205**	**190**	**660**
	10%	all (including Stations)	Helensvale to Uni Hospital	30yrs	6.75×10^6	180	190	200	720
				50yrs	2.58×10^7	190	**200**	**190**	**680**
			Uni Hospital to Broadbeach	30yrs	1.20×10^7	185	195	200	700
				50yrs	2.78×10^7	190	**200**	**190**	**680**

* mm S36/20 Continuously Reinforced Concrete Base
Bitumen layer over wax curing layer
125mm lean mix concrete subbase
Prime and Seal
150mm cement stabilised type 1.2 material Working Platform
Controlled Subgrade, Drainage Layer, Capping Layer as required to provide subgrade matching design (refer report)

Note: With the subgrade treatments specified, the pavement base thickness is the same irrespective of the lower subgrade conditions.

Note: The design period is 50 years. The 30 year period is given for comparison

Note: The Design Traffic Loading quoted here is HVAG's.

Rigid Pavement Design

Calculation of Concrete Pavement Thickness

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

Helensvale to University Hospital, 30 yr

Design Details

CRC/Dowelled Joints:	Yes		
Concrete Shoulders:	No		
Design Period:	30	Years	
Design Traffic:	6.75E+06	CV Axle Groups	
TRIAL BASE THICKNESS	**180**	mm	
	Accepted		
Total Fatigue	58%		
Total Erosion %	40%		

Characteristic (28 Day)		
Compressive Strength f'c	36 MPa	
Flexural Strength f'_{cf}	4.5 MPa	Clause 9.3.3
Subgrade CBR	5.0 %	
Subbase Thickness & Type	125 mm LMC	Table 9.1
Subbase Stiffness	5000 MPa	Table 6.6
Effective CBR	75 %	Figure 9.1
Load Safety Factor:	1	Clause 9.3.6
Project Design Reliability	0.95	Table 9.2

Equivalent Erosion and Stress Factors

	SS	SD	TAD	TRD
% of Each Axle Group	100%			

Table A7.4.3

Load	Load Distribution (%) SS	SD	TAD	TRD
10				
20				
30				
40				
50				
60	33.33			
70				
80	66.67			
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				
190				
200				
210				
220				
230				
240				
250				
260				
	100	0	0	0

Fatigue Table 9.4

Coefficient	Without concrete shoulders SS	SD	TAD	TRD
a	0.118	0.56	0.219	0.089
b	125.4	184.4	399.6	336.4
c	-0.2396	-0.6663	-0.3742	-0.134
d	26969	44405	-38	-10007
e	0.0896	0.2254	0.168	0.083
f	0.19	19.75	-71.09	-83.14
g	-352174	-942585	681381	1215750
h	-0.0104	-0.0248	-0.0218	-0.012
I	-1.2536	-46657	3.6501	5.2724
j	-1709	-4082	2003	4400

Erosion with Dowelled or CRC bases Table 9.6

Coefficient	Without concrete shoulders SS	SD	TAD	TRD
a	0.072	0.643	1.41	2.089
b	679.9	684.5	498.9	351.3
c	-0.0789	-0.0576	-0.168	-0.3343
d	-58342	-58371	-3943	-25576
e	0.0179	0.0128	0.0322	0.0723
f	6.7	4.61	13.8	29.58
g	2139330	2131390	1437580	923081
h	-0.0021	-0.0017	-0.0044	-0.0086
I	-0.5199	-0.2056	-0.038	-1.6301
j	-187	-185	-697	-1327

Fatigue and Erosion Analysis

Axle Load (kN)	Design Load/Tyre (kN)	Proportion of Loads %	Expected Repetitions	Fatigue Analysis Se	Sr	Allowable Repetitions (N_f)	Fatigue (%)	Erosion Analysis F_3	Allowable Repetitions (N_e)	Damage (%)
SINGLE AXLES/ SINGLE WHEELS (SS)										
10	5		0.00E+00	1.032	0.066	Unlimited	0.0%	2.321	5.5E+15	0.0%
20	10		0.00E+00	1.032	0.127	Unlimited	0.0%	2.321	5.5E+15	0.0%
30	15		0.00E+00	1.032	0.185	Unlimited	0.0%	2.321	5.5E+15	0.0%
40	20		0.00E+00	1.032	0.243	Unlimited	0.0%	2.321	5.5E+15	0.0%
50	25		0.00E+00	1.032	0.299	Unlimited	0.0%	2.321	5.5E+15	0.0%
60	30	33.33	2.25E+06	1.032	0.355	Unlimited	0.0%	2.321	2.19E+08	1.0%
70	35		0.00E+00	1.032	0.411	Unlimited	0.0%	2.321	3.4E+07	0.0%
80	40	66.67	4.50E+06	1.032	0.466	7.74E+06	58.2%	2.321	1.14E+07	39.4%
90	45		0.00E+00	1.032	0.520	3.2E+05	0.0%	2.321	5.0E+06	0.0%
100	50		0.00E+00	1.032	0.574	6.3E+04	0.0%	2.321	2.6E+06	0.0%
110	55		0.00E+00	1.032	0.628	1.4E+04	0.0%	2.321	1.4E+06	0.0%
120	60		0.00E+00	1.032	0.682	3.2E+03	0.0%	2.321	8.6E+05	0.0%
130	65		0.00E+00	1.032	0.735	7.3E+02	0.0%	2.321	5.4E+05	0.0%
SINGLE AXLES/ DUAL WHEELS (SD)										
10	5		0.00E+00	-4829.722	-160.814	Unlimited	0.0%	2.927	5.5E+15	0.0%
20	10		0.00E+00	-4829.722	-308.526	Unlimited	0.0%	2.927	5.5E+15	0.0%
30	15		0.00E+00	-4829.722	-451.666	Unlimited	0.0%	2.927	5.5E+15	0.0%
40	20		0.00E+00	-4829.722	-591.915	Unlimited	0.0%	2.927	5.5E+15	0.0%
50	25		0.00E+00	-4829.722	-730.054	Unlimited	0.0%	2.927	5.5E+15	0.0%
60	30		0.00E+00	-4829.722	-866.533	Unlimited	0.0%	2.927	2.0E+08	0.0%
70	35		0.00E+00	-4829.722	-1001.648	Unlimited	0.0%	2.927	3.3E+07	0.0%
80	40		0.00E+00	-4829.722	-1135.606	Unlimited	0.0%	2.927	1.1E+07	0.0%
90	45		0.00E+00	-4829.722	-1268.560	Unlimited	0.0%	2.927	4.9E+06	0.0%
100	50		0.00E+00	-4829.722	-1400.629	Unlimited	0.0%	2.927	2.5E+06	0.0%
110	55		0.00E+00	-4829.722	-1531.906	Unlimited	0.0%	2.927	1.4E+06	0.0%
120	60		0.00E+00	-4829.722	-1662.468	Unlimited	0.0%	2.927	8.4E+05	0.0%
130	65		0.00E+00	-4829.722	-1792.379	Unlimited	0.0%	2.927	5.3E+05	0.0%
TANDEM AXLES/ DUAL WHEELS (TAD)										
10	5		0.00E+00	1.256	0.022	Unlimited	0.0%	4.061	5.5E+15	0.0%
20	10		0.00E+00	1.256	0.042	Unlimited	0.0%	4.061	5.5E+15	0.0%
30	15		0.00E+00	1.256	0.061	Unlimited	0.0%	4.061	1.4E+09	0.0%
40	20		0.00E+00	1.256	0.080	Unlimited	0.0%	4.061	2.1E+07	0.0%
50	25		0.00E+00	1.256	0.099	Unlimited	0.0%	4.061	4.1E+06	0.0%
60	30		0.00E+00	1.256	0.117	Unlimited	0.0%	4.061	1.3E+06	0.0%
70	35		0.00E+00	1.256	0.136	Unlimited	0.0%	4.061	5.5E+05	0.0%
80	40		0.00E+00	1.256	0.154	Unlimited	0.0%	4.061	2.6E+05	0.0%
90	45		0.00E+00	1.256	0.172	Unlimited	0.0%	4.061	1.3E+05	0.0%
100	50		0.00E+00	1.256	0.190	Unlimited	0.0%	4.061	7.4E+04	0.0%
110	55		0.00E+00	1.256	0.208	Unlimited	0.0%	4.061	4.3E+04	0.0%
120	60		0.00E+00	1.256	0.225	Unlimited	0.0%	4.061	2.6E+04	0.0%
130	65		0.00E+00	1.256	0.243	Unlimited	0.0%	4.061	1.7E+04	0.0%
140	70		0.00E+00	1.256	0.260	Unlimited	0.0%	4.061	1.1E+04	0.0%
150	75		0.00E+00	1.256	0.278	Unlimited	0.0%	4.061	7.3E+03	0.0%
160	80		0.00E+00	1.256	0.295	Unlimited	0.0%	4.061	5.0E+03	0.0%
170	85		0.00E+00	1.256	0.313	Unlimited	0.0%	4.061	3.5E+03	0.0%
180	90		0.00E+00	1.256	0.330	Unlimited	0.0%	4.061	2.5E+03	0.0%
190	95		0.00E+00	1.256	0.347	Unlimited	0.0%	4.061	1.8E+03	0.0%
200	100		0.00E+00	1.256	0.364	Unlimited	0.0%	4.061	1.3E+03	0.0%
210	105		0.00E+00	1.256	0.381	Unlimited	0.0%	4.061	9.6E+02	0.0%
220	110		0.00E+00	1.256	0.398	Unlimited	0.0%	4.061	7.2E+02	0.0%
230	115		0.00E+00	1.256	0.415	Unlimited	0.0%	4.061	5.5E+02	0.0%
TRI - AXLES/ DUAL WHEELS (TRD)										
10	5		0.00E+00	0.998	0.012	Unlimited	0.0%	2.986	5.5E+15	0.0%
20	10		0.00E+00	0.998	0.023	Unlimited	0.0%	2.986	5.5E+15	0.0%
30	15		0.00E+00	0.998	0.033	Unlimited	0.0%	2.986	5.5E+15	0.0%
40	20		0.00E+00	0.998	0.044	Unlimited	0.0%	2.986	5.5E+15	0.0%
50	25		0.00E+00	0.998	0.054	Unlimited	0.0%	2.986	5.5E+15	0.0%
60	30		0.00E+00	0.998	0.064	Unlimited	0.0%	2.986	5.5E+15	0.0%
70	35		0.00E+00	0.998	0.074	Unlimited	0.0%	2.986	5.5E+15	0.0%
80	40		0.00E+00	0.998	0.084	Unlimited	0.0%	2.986	5.5E+15	0.0%
90	45		0.00E+00	0.998	0.093	Unlimited	0.0%	2.986	5.5E+15	0.0%
100	50		0.00E+00	0.998	0.103	Unlimited	0.0%	2.986	5.5E+15	0.0%
110	55		0.00E+00	0.998	0.113	Unlimited	0.0%	2.986	5.5E+15	0.0%
120	60		0.00E+00	0.998	0.122	Unlimited	0.0%	2.986	5.5E+15	0.0%
130	65		0.00E+00	0.998	0.132	Unlimited	0.0%	2.986	5.5E+15	0.0%
140	70		0.00E+00	0.998	0.141	Unlimited	0.0%	2.986	5.5E+15	0.0%
150	75		0.00E+00	0.998	0.151	Unlimited	0.0%	2.986	2.0E+10	0.0%
160	80		0.00E+00	0.998	0.160	Unlimited	0.0%	2.986	5.6E+08	0.0%
170	85		0.00E+00	0.998	0.170	Unlimited	0.0%	2.986	1.7E+08	0.0%
180	90		0.00E+00	0.998	0.179	Unlimited	0.0%	2.986	8.1E+07	0.0%
190	95		0.00E+00	0.998	0.188	Unlimited	0.0%	2.986	4.5E+07	0.0%
200	100		0.00E+00	0.998	0.198	Unlimited	0.0%	2.986	2.8E+07	0.0%
210	105		0.00E+00	0.998	0.207	Unlimited	0.0%	2.986	1.8E+07	0.0%
220	110		0.00E+00	0.998	0.216	Unlimited	0.0%	2.986	1.3E+07	0.0%
230	115		0.00E+00	0.998	0.226	Unlimited	0.0%	2.986	9.2E+06	0.0%
240	120		0.00E+00	0.998	0.235	Unlimited	0.0%	2.986	6.8E+06	0.0%
250	125		0.00E+00	0.998	0.244	Unlimited	0.0%	2.986	5.2E+06	0.0%
260	130		0.00E+00	0.998	0.253	Unlimited	0.0%	2.986	4.0E+06	0.0%

Total Fatigue **58%** Total Erosion % **40%**

Result
Accepted

Rigid Pavement Design

Calculation of Concrete Pavement Thickness

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

Helensvale to University Hospital, 50 yr

Design Details

CRC/Dowelled Joints:	Yes		
Concrete Shoulders:	No		
Design Period:	50	Years	
Design Traffic:	2.58E+07	CV Axle Groups	
TRIAL BASE THICKNESS	**190**	mm	
	Accepted		
Total Fatigue	0%		
Total Erosion %	86%		

Characteristic (28 Day)			
Compressive Strength f'_c	36	MPa	
Flexural Strength f'_{cf}	4.5	MPa	Clause 9.3.3
Subgrade CBR	5.0	%	
Subbase Thickness & Type	125	mm LMC	Table 9.1
Subbase Stiffness	5000	MPa	Table 6.6
Effective CBR	75	%	Figure 9.1
Load Safety Factor:	1		Clause 9.3.6
Project Design Reliability	0.95		Table 9.2

Equivalent Erosion and Stress Factors

	SS	SD	TAD	TRD	
% of Each Axle Group	100%				Table A7.4.3

	Load Distribution (%)			
Load	SS	SD	TAD	TRD
10				
20				
30				
40				
50				
60	27.21			
70				
80	72.79			
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				
190				
200				
210				
220				
230				
240				
250				
260				
	100	0	0	0

Fatigue Table 9.4

Coefficient	Without concrete shoulders			
	SS	SD	TAD	TRD
a	0.118	0.56	0.219	0.089
b	125.4	184.4	399.6	336.4
c	-0.2396	-0.6663	-0.3742	-0.134
d	26969	44405	-38	-10007
e	0.0896	0.2254	0.168	0.083
f	0.19	19.75	-71.09	-83.14
g	-352174	-942585	681381	1215750
h	-0.0104	-0.0248	-0.0218	-0.012
I	-1.2536	-46657	3.6501	5.2724
j	-1709	-4082	2003	4400

Erosion with Dowelled or CRC bases Table 9.6

Coefficient	Without concrete shoulders			
	SS	SD	TAD	TRD
a	0.072	0.643	1.41	2.089
b	679.9	684.5	498.9	351.3
c	-0.0789	-0.0576	-0.168	-0.3343
d	-58342	-58371	-3943	-25576
e	0.0179	0.0128	0.0322	0.0723
f	6.7	4.61	13.8	29.58
g	2139330	2131390	1437580	923081
h	-0.0021	-0.0017	-0.0044	-0.0086
I	-0.5199	-0.2056	-0.038	-1.6301
j	-187	-185	-697	-1327

Fatigue and Erosion Analysis

Axle Load (kN)	Design Load/Tyre (kN)	Proportion of Loads %	Expected Repetitions	Fatigue Analysis Se	Sr	Allowable Repetitions (N_d)	Fatigue (%)	Erosion Analysis F_3	Allowable Repetitions (N_e)	Damage (%)
SINGLE AXLES/ SINGLE WHEELS (SS)										
10	5		0.00E+00	0.949	0.061	Unlimited	0.0%	2.249	5.5E+15	0.0%
20	10		0.00E+00	0.949	0.116	Unlimited	0.0%	2.249	5.5E+15	0.0%
30	15		0.00E+00	0.949	0.170	Unlimited	0.0%	2.249	5.5E+15	0.0%
40	20		0.00E+00	0.949	0.223	Unlimited	0.0%	2.249	5.5E+15	0.0%
50	25		0.00E+00	0.949	0.275	Unlimited	0.0%	2.249	5.5E+15	0.0%
60	30	27.21	7.02E+06	0.949	0.327	Unlimited	0.0%	2.249	1.93E+09	0.4%
70	35		0.00E+00	0.949	0.378	Unlimited	0.0%	2.249	8.1E+07	0.0%
80	40	72.79	1.88E+07	0.949	0.428	Unlimited	0.0%	2.249	2.20E+07	85.5%
90	45		0.00E+00	0.949	0.478	2.7E+06	0.0%	2.249	8.9E+06	0.0%
100	50		0.00E+00	0.949	0.528	2.4E+05	0.0%	2.249	4.3E+06	0.0%
110	55		0.00E+00	0.949	0.578	5.8E+04	0.0%	2.249	2.4E+06	0.0%
120	60		0.00E+00	0.949	0.627	1.5E+04	0.0%	2.249	1.4E+06	0.0%
130	65		0.00E+00	0.949	0.676	3.8E+03	0.0%	2.249	8.8E+05	0.0%
SINGLE AXLES/ DUAL WHEELS (SD)										
10	5		0.00E+00	-4575.557	-152.351	Unlimited	0.0%	2.855	5.5E+15	0.0%
20	10		0.00E+00	-4575.557	-292.289	Unlimited	0.0%	2.855	5.5E+15	0.0%
30	15		0.00E+00	-4575.557	-427.897	Unlimited	0.0%	2.855	5.5E+15	0.0%
40	20		0.00E+00	-4575.557	-560.766	Unlimited	0.0%	2.855	5.5E+15	0.0%
50	25		0.00E+00	-4575.557	-691.635	Unlimited	0.0%	2.855	5.5E+15	0.0%
60	30		0.00E+00	-4575.557	-820.932	Unlimited	0.0%	2.855	1.6E+09	0.0%
70	35		0.00E+00	-4575.557	-948.936	Unlimited	0.0%	2.855	7.7E+07	0.0%
80	40		0.00E+00	-4575.557	-1075.845	Unlimited	0.0%	2.855	2.1E+07	0.0%
90	45		0.00E+00	-4575.557	-1201.802	Unlimited	0.0%	2.855	8.6E+06	0.0%
100	50		0.00E+00	-4575.557	-1326.921	Unlimited	0.0%	2.855	4.2E+06	0.0%
110	55		0.00E+00	-4575.557	-1451.290	Unlimited	0.0%	2.855	2.3E+06	0.0%
120	60		0.00E+00	-4575.557	-1574.981	Unlimited	0.0%	2.855	1.4E+06	0.0%
130	65		0.00E+00	-4575.557	-1698.055	Unlimited	0.0%	2.855	8.6E+05	0.0%
TANDEM AXLES/ DUAL WHEELS (TAD)										
10	5		0.00E+00	1.164	0.020	Unlimited	0.0%	3.883	5.5E+15	0.0%
20	10		0.00E+00	1.164	0.039	Unlimited	0.0%	3.883	5.5E+15	0.0%
30	15		0.00E+00	1.164	0.057	Unlimited	0.0%	3.883	5.5E+15	0.0%
40	20		0.00E+00	1.164	0.074	Unlimited	0.0%	3.883	2.0E+08	0.0%
50	25		0.00E+00	1.164	0.092	Unlimited	0.0%	3.883	1.8E+07	0.0%
60	30		0.00E+00	1.164	0.109	Unlimited	0.0%	3.883	4.8E+06	0.0%
70	35		0.00E+00	1.164	0.126	Unlimited	0.0%	3.883	1.8E+06	0.0%
80	40		0.00E+00	1.164	0.143	Unlimited	0.0%	3.883	8.3E+05	0.0%
90	45		0.00E+00	1.164	0.159	Unlimited	0.0%	3.883	4.2E+05	0.0%
100	50		0.00E+00	1.164	0.176	Unlimited	0.0%	3.883	2.3E+05	0.0%
110	55		0.00E+00	1.164	0.192	Unlimited	0.0%	3.883	1.4E+05	0.0%
120	60		0.00E+00	1.164	0.209	Unlimited	0.0%	3.883	8.4E+04	0.0%
130	65		0.00E+00	1.164	0.225	Unlimited	0.0%	3.883	5.3E+04	0.0%
140	70		0.00E+00	1.164	0.241	Unlimited	0.0%	3.883	3.5E+04	0.0%
150	75		0.00E+00	1.164	0.258	Unlimited	0.0%	3.883	2.4E+04	0.0%
160	80		0.00E+00	1.164	0.274	Unlimited	0.0%	3.883	1.6E+04	0.0%
170	85		0.00E+00	1.164	0.290	Unlimited	0.0%	3.883	1.2E+04	0.0%
180	90		0.00E+00	1.164	0.306	Unlimited	0.0%	3.883	8.3E+03	0.0%
190	95		0.00E+00	1.164	0.322	Unlimited	0.0%	3.883	6.0E+03	0.0%
200	100		0.00E+00	1.164	0.338	Unlimited	0.0%	3.883	4.5E+03	0.0%
210	105		0.00E+00	1.164	0.353	Unlimited	0.0%	3.883	3.3E+03	0.0%
220	110		0.00E+00	1.164	0.369	Unlimited	0.0%	3.883	2.5E+03	0.0%
230	115		0.00E+00	1.164	0.385	Unlimited	0.0%	3.883	1.9E+03	0.0%
TRI - AXLES/ DUAL WHEELS (TRD)										
10	5		0.00E+00	0.917	0.011	Unlimited	0.0%	2.930	5.5E+15	0.0%
20	10		0.00E+00	0.917	0.021	Unlimited	0.0%	2.930	5.5E+15	0.0%
30	15		0.00E+00	0.917	0.031	Unlimited	0.0%	2.930	5.5E+15	0.0%
40	20		0.00E+00	0.917	0.040	Unlimited	0.0%	2.930	5.5E+15	0.0%
50	25		0.00E+00	0.917	0.049	Unlimited	0.0%	2.930	5.5E+15	0.0%
60	30		0.00E+00	0.917	0.059	Unlimited	0.0%	2.930	5.5E+15	0.0%
70	35		0.00E+00	0.917	0.068	Unlimited	0.0%	2.930	5.5E+15	0.0%
80	40		0.00E+00	0.917	0.077	Unlimited	0.0%	2.930	5.5E+15	0.0%
90	45		0.00E+00	0.917	0.086	Unlimited	0.0%	2.930	5.5E+15	0.0%
100	50		0.00E+00	0.917	0.095	Unlimited	0.0%	2.930	5.5E+15	0.0%
110	55		0.00E+00	0.917	0.104	Unlimited	0.0%	2.930	5.5E+15	0.0%
120	60		0.00E+00	0.917	0.112	Unlimited	0.0%	2.930	5.5E+15	0.0%
130	65		0.00E+00	0.917	0.121	Unlimited	0.0%	2.930	5.5E+15	0.0%
140	70		0.00E+00	0.917	0.130	Unlimited	0.0%	2.930	5.5E+15	0.0%
150	75		0.00E+00	0.917	0.139	Unlimited	0.0%	2.930	5.5E+15	0.0%
160	80		0.00E+00	0.917	0.147	Unlimited	0.0%	2.930	2.0E+10	0.0%
170	85		0.00E+00	0.917	0.156	Unlimited	0.0%	2.930	6.1E+08	0.0%
180	90		0.00E+00	0.917	0.164	Unlimited	0.0%	2.930	1.9E+08	0.0%
190	95		0.00E+00	0.917	0.173	Unlimited	0.0%	2.930	9.1E+07	0.0%
200	100		0.00E+00	0.917	0.182	Unlimited	0.0%	2.930	5.1E+07	0.0%
210	105		0.00E+00	0.917	0.190	Unlimited	0.0%	2.930	3.2E+07	0.0%
220	110		0.00E+00	0.917	0.199	Unlimited	0.0%	2.930	2.1E+07	0.0%
230	115		0.00E+00	0.917	0.207	Unlimited	0.0%	2.930	1.5E+07	0.0%
240	120		0.00E+00	0.917	0.216	Unlimited	0.0%	2.930	1.1E+07	0.0%
250	125		0.00E+00	0.917	0.224	Unlimited	0.0%	2.930	8.1E+06	0.0%
260	130		0.00E+00	0.917	0.232	Unlimited	0.0%	2.930	6.1E+06	0.0%
						Total Fatigue	**0%**		Total Erosion %	**86%**

Result
Accepted

Rigid Pavement Design

Calculation of Concrete Pavement Thickness

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

University Hospital To Broadbeach, 30 yr

Design Details

CRC/Dowelled Joints:	Yes		
Concrete Shoulders:	No		
Design Period:	30	Years	
Design Traffic:	1.20E+07	CV Axle Groups	
TRIAL BASE THICKNESS	185	mm	
	Accepted		
Total Fatigue	0%		
Total Erosion %	52%		

Characteristic (28 Day)		
Compressive Strength f'c	36 MPa	
Flexural Strength f'_{cf}	4.5 MPa	Clause 9.3.3
Subgrade CBR	10.4 %	
Subbase Thickness & Type	125 mm LMC	Table 9.1
Subbase Stiffness	5000 MPa	Table 6.6
Effective CBR	75 %	Figure 9.1
Load Safety Factor:	1	Clause 9.3.6
Project Design Reliability	0.95	Table 9.2

Equivalent Erosion and Stress Factors

	SS	SD	TAD	TRD
% of Each Axle Group	100%			

Table A7.4.3

Load	Load Distribution (%) SS	SD	TAD	TRD
10				
20				
30				
40				
50				
60	33.33			
70				
80	66.67			
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				
190				
200				
210				
220				
230				
240				
250				
260				
	100	0	0	0

Fatigue Table 9.4

Coefficient	Without concrete shoulders SS	SD	TAD	TRD
a	0.118	0.56	0.219	0.089
b	125.4	184.4	399.6	336.4
c	-0.2396	-0.6663	-0.3742	-0.134
d	26969	44405	-38	-10007
e	0.0896	0.2254	0.168	0.083
f	0.19	19.75	-71.09	-83.14
g	-352174	-942585	681381	1215750
h	-0.0104	-0.0248	-0.0218	-0.012
I	-1.2536	-46657	3.6501	5.2724
j	-1709	-4082	2003	4400

Erosion with Dowelled or CRC bases Table 9.6

Coefficient	Without concrete shoulders SS	SD	TAD	TRD
a	0.072	0.643	1.41	2.089
b	679.9	684.5	498.9	351.3
c	-0.0789	-0.0576	-0.168	-0.3343
d	-58342	-58371	-3943	-25576
e	0.0179	0.0128	0.0322	0.0723
f	6.7	4.61	13.8	29.58
g	2139330	2131390	1437580	923081
h	-0.0021	-0.0017	-0.0044	-0.0086
I	-0.5199	-0.2056	-0.038	-1.6301
j	-187	-185	-697	-1327

Fatigue and Erosion Analysis

Axle Load (kN)	Design Load/Tyre (kN)	Proportion of Loads %	Expected Repetitions	Fatigue Analysis Se	Sr	Allowable Repetitions (N_f)	Fatigue (%)	Erosion Analysis F_3	Allowable Repetitions (N_e)	Damage (%)
SINGLE AXLES/ SINGLE WHEELS (SS)										
10	5		0.00E+00	0.989	0.063	Unlimited	0.0%	2.285	5.5E+15	0.0%
20	10		0.00E+00	0.989	0.121	Unlimited	0.0%	2.285	5.5E+15	0.0%
30	15		0.00E+00	0.989	0.178	Unlimited	0.0%	2.285	5.5E+15	0.0%
40	20		0.00E+00	0.989	0.233	Unlimited	0.0%	2.285	5.5E+15	0.0%
50	25		0.00E+00	0.989	0.287	Unlimited	0.0%	2.285	5.5E+15	0.0%
60	30	33.3333333	3.99E+06	0.989	0.341	Unlimited	0.0%	2.285	5.07E+08	0.8%
70	35		0.00E+00	0.989	0.394	Unlimited	0.0%	2.285	5.2E+07	0.0%
80	40	66.6666667	7.98E+06	0.989	0.446	Unlimited	0.0%	2.285	1.57E+07	50.7%
90	45		0.00E+00	0.989	0.499	8.2E+05	0.0%	2.285	6.7E+06	0.0%
100	50		0.00E+00	0.989	0.551	1.2E+05	0.0%	2.285	3.3E+06	0.0%
110	55		0.00E+00	0.989	0.602	2.9E+04	0.0%	2.285	1.8E+06	0.0%
120	60		0.00E+00	0.989	0.653	7.0E+03	0.0%	2.285	1.1E+06	0.0%
130	65		0.00E+00	0.989	0.704	1.7E+03	0.0%	2.285	6.9E+05	0.0%
SINGLE AXLES/ DUAL WHEELS (SD)										
10	5		0.00E+00	-4699.205	-156.468	Unlimited	0.0%	2.891	5.5E+15	0.0%
20	10		0.00E+00	-4699.205	-300.188	Unlimited	0.0%	2.891	5.5E+15	0.0%
30	15		0.00E+00	-4699.205	-439.460	Unlimited	0.0%	2.891	5.5E+15	0.0%
40	20		0.00E+00	-4699.205	-575.919	Unlimited	0.0%	2.891	5.5E+15	0.0%
50	25		0.00E+00	-4699.205	-710.325	Unlimited	0.0%	2.891	5.5E+15	0.0%
60	30		0.00E+00	-4699.205	-843.116	Unlimited	0.0%	2.891	4.6E+08	0.0%
70	35		0.00E+00	-4699.205	-974.580	Unlimited	0.0%	2.891	4.9E+07	0.0%
80	40		0.00E+00	-4699.205	-1104.918	Unlimited	0.0%	2.891	1.5E+07	0.0%
90	45		0.00E+00	-4699.205	-1234.279	Unlimited	0.0%	2.891	6.5E+06	0.0%
100	50		0.00E+00	-4699.205	-1362.779	Unlimited	0.0%	2.891	3.2E+06	0.0%
110	55		0.00E+00	-4699.205	-1490.509	Unlimited	0.0%	2.891	1.8E+06	0.0%
120	60		0.00E+00	-4699.205	-1617.543	Unlimited	0.0%	2.891	1.1E+06	0.0%
130	65		0.00E+00	-4699.205	-1743.942	Unlimited	0.0%	2.891	6.7E+05	0.0%
TANDEM AXLES/ DUAL WHEELS (TAD)										
10	5		0.00E+00	1.208	0.021	Unlimited	0.0%	3.970	5.5E+15	0.0%
20	10		0.00E+00	1.208	0.040	Unlimited	0.0%	3.970	5.5E+15	0.0%
30	15		0.00E+00	1.208	0.059	Unlimited	0.0%	3.970	5.5E+15	0.0%
40	20		0.00E+00	1.208	0.077	Unlimited	0.0%	3.970	5.5E+07	0.0%
50	25		0.00E+00	1.208	0.095	Unlimited	0.0%	3.970	8.5E+06	0.0%
60	30		0.00E+00	1.208	0.113	Unlimited	0.0%	3.970	2.5E+06	0.0%
70	35		0.00E+00	1.208	0.131	Unlimited	0.0%	3.970	1.0E+06	0.0%
80	40		0.00E+00	1.208	0.148	Unlimited	0.0%	3.970	4.7E+05	0.0%
90	45		0.00E+00	1.208	0.165	Unlimited	0.0%	3.970	2.4E+05	0.0%
100	50		0.00E+00	1.208	0.183	Unlimited	0.0%	3.970	1.3E+05	0.0%
110	55		0.00E+00	1.208	0.200	Unlimited	0.0%	3.970	7.8E+04	0.0%
120	60		0.00E+00	1.208	0.217	Unlimited	0.0%	3.970	4.8E+04	0.0%
130	65		0.00E+00	1.208	0.234	Unlimited	0.0%	3.970	3.0E+04	0.0%
140	70		0.00E+00	1.208	0.251	Unlimited	0.0%	3.970	2.0E+04	0.0%
150	75		0.00E+00	1.208	0.267	Unlimited	0.0%	3.970	1.3E+04	0.0%
160	80		0.00E+00	1.208	0.284	Unlimited	0.0%	3.970	9.2E+03	0.0%
170	85		0.00E+00	1.208	0.301	Unlimited	0.0%	3.970	6.5E+03	0.0%
180	90		0.00E+00	1.208	0.317	Unlimited	0.0%	3.970	4.6E+03	0.0%
190	95		0.00E+00	1.208	0.334	Unlimited	0.0%	3.970	3.4E+03	0.0%
200	100		0.00E+00	1.208	0.350	Unlimited	0.0%	3.970	2.5E+03	0.0%
210	105		0.00E+00	1.208	0.367	Unlimited	0.0%	3.970	1.8E+03	0.0%
220	110		0.00E+00	1.208	0.383	Unlimited	0.0%	3.970	1.4E+03	0.0%
230	115		0.00E+00	1.208	0.400	Unlimited	0.0%	3.970	1.1E+03	0.0%
TRI - AXLES/ DUAL WHEELS (TRD)										
10	5		0.00E+00	0.956	0.011	Unlimited	0.0%	2.957	5.5E+15	0.0%
20	10		0.00E+00	0.956	0.022	Unlimited	0.0%	2.957	5.5E+15	0.0%
30	15		0.00E+00	0.956	0.032	Unlimited	0.0%	2.957	5.5E+15	0.0%
40	20		0.00E+00	0.956	0.042	Unlimited	0.0%	2.957	5.5E+15	0.0%
50	25		0.00E+00	0.956	0.051	Unlimited	0.0%	2.957	5.5E+15	0.0%
60	30		0.00E+00	0.956	0.061	Unlimited	0.0%	2.957	5.5E+15	0.0%
70	35		0.00E+00	0.956	0.071	Unlimited	0.0%	2.957	5.5E+15	0.0%
80	40		0.00E+00	0.956	0.080	Unlimited	0.0%	2.957	5.5E+15	0.0%
90	45		0.00E+00	0.956	0.089	Unlimited	0.0%	2.957	5.5E+15	0.0%
100	50		0.00E+00	0.956	0.099	Unlimited	0.0%	2.957	5.5E+15	0.0%
110	55		0.00E+00	0.956	0.108	Unlimited	0.0%	2.957	5.5E+15	0.0%
120	60		0.00E+00	0.956	0.117	Unlimited	0.0%	2.957	5.5E+15	0.0%
130	65		0.00E+00	0.956	0.126	Unlimited	0.0%	2.957	5.5E+15	0.0%
140	70		0.00E+00	0.956	0.135	Unlimited	0.0%	2.957	5.5E+15	0.0%
150	75		0.00E+00	0.956	0.144	Unlimited	0.0%	2.957	5.5E+15	0.0%
160	80		0.00E+00	0.956	0.154	Unlimited	0.0%	2.957	1.6E+09	0.0%
170	85		0.00E+00	0.956	0.163	Unlimited	0.0%	2.957	3.0E+08	0.0%
180	90		0.00E+00	0.956	0.171	Unlimited	0.0%	2.957	1.2E+08	0.0%
190	95		0.00E+00	0.956	0.180	Unlimited	0.0%	2.957	6.3E+07	0.0%
200	100		0.00E+00	0.956	0.189	Unlimited	0.0%	2.957	3.8E+07	0.0%
210	105		0.00E+00	0.956	0.198	Unlimited	0.0%	2.957	2.4E+07	0.0%
220	110		0.00E+00	0.956	0.207	Unlimited	0.0%	2.957	1.6E+07	0.0%
230	115		0.00E+00	0.956	0.216	Unlimited	0.0%	2.957	1.2E+07	0.0%
240	120		0.00E+00	0.956	0.225	Unlimited	0.0%	2.957	8.6E+06	0.0%
250	125		0.00E+00	0.956	0.234	Unlimited	0.0%	2.957	6.5E+06	0.0%
260	130		0.00E+00	0.956	0.242	Unlimited	0.0%	2.957	5.0E+06	0.0%

Total Fatigue **0%** Total Erosion % **52%**

Result
Accepted

Rigid Pavement Design

Calculation of Concrete Pavement Thickness

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

University Hospital To Broadbeach, 50 yr

Design Details

CRC/Dowelled Joints:	Yes			
Concrete Shoulders:	No			
Design Period:	50	Years		
Design Traffic:	2.78E+07	CV Axle Groups		
TRIAL BASE THICKNESS	**190**	mm		
	Accepted			
Total Fatigue	0%			
Total Erosion %	91%			

Characteristic (28 Day)

Compressive Strength f'c	36 MPa	
Flexural Strength f'_{cf}	4.5 MPa	Clause 9.3.3
Subgrade CBR	10.4 %	
Subbase Thickness & Type	125 mm LMC	Table 9.1
Subbase Stiffness	5000 MPa	Table 6.6
Effective CBR	75 %	Figure 9.1
Load Safety Factor:	1	Clause 9.3.6
Project Design Reliability	0.95	Table 9.2

Equivalent Erosion and Stress Factors

	SS	SD	TAD	TRD	
% of Each Axle Group	100%				Table A7.4.3

	Load Distribution (%)				
Load	SS	SD	TAD	TRD	
10					
20					
30					
40					
50					
60	28.56				
70					
80	71.44				
90					
100					
110					
120					
130					
140					
150					
160					
170					
180					
190					
200					
210					
220					
230					
240					
250					
260					
	100	0	0	0	

Fatigue — Table 9.4

Coefficient	Without concrete shoulders			
	SS	SD	TAD	TRD
a	0.118	0.56	0.219	0.089
b	125.4	184.4	399.6	336.4
c	-0.2396	-0.6663	-0.3742	-0.134
d	26969	44405	-38	-10007
e	0.0896	0.2254	0.168	0.083
f	0.19	19.75	-71.09	-83.14
g	-352174	-942585	681381	1215750
h	-0.0104	-0.0248	-0.0218	-0.012
I	-1.2536	-46657	3.6501	5.2724
j	-1709	-4082	2003	4400

Erosion with Dowelled or CRC bases — Table 9.6

Coefficient	Without concrete shoulders			
	SS	SD	TAD	TRD
a	0.072	0.643	1.41	2.089
b	679.9	684.5	498.9	351.3
c	-0.0789	-0.0576	-0.168	-0.3343
d	-58342	-58371	-3943	-25576
e	0.0179	0.0128	0.0322	0.0723
f	6.7	4.61	13.8	29.58
g	2139330	2131390	1437580	923081
h	-0.0021	-0.0017	-0.0044	-0.0086
I	-0.5199	-0.2056	-0.038	-1.6301
j	-187	-185	-697	-1327

Fatigue and Erosion Analysis

Axle Load (kN)	Design Load/Tyre (kN)	Proportion of Loads %	Expected Repetitions	Fatigue Analysis Se	Sr	Allowable Repetitions (N_f)	Fatigue (%)	Erosion Analysis F_3	Allowable Repetitions (N_e)	Damage (%)
SINGLE AXLES/ SINGLE WHEELS (SS)										
10	5		0.00E+00	0.949	0.061	Unlimited	0.0%	2.249	5.5E+15	0.0%
20	10		0.00E+00	0.949	0.116	Unlimited	0.0%	2.249	5.5E+15	0.0%
30	15		0.00E+00	0.949	0.170	Unlimited	0.0%	2.249	5.5E+15	0.0%
40	20		0.00E+00	0.949	0.223	Unlimited	0.0%	2.249	5.5E+15	0.0%
50	25		0.00E+00	0.949	0.275	Unlimited	0.0%	2.249	5.5E+15	0.0%
60	30	28.56	7.94E+06	0.949	0.327	Unlimited	0.0%	2.249	1.93E+09	0.4%
70	35		0.00E+00	0.949	0.378	Unlimited	0.0%	2.249	8.1E+07	0.0%
80	40	71.44	1.99E+07	0.949	0.428	Unlimited	0.0%	2.249	2.20E+07	90.4%
90	45		0.00E+00	0.949	0.478	2.7E+06	0.0%	2.249	8.9E+06	0.0%
100	50		0.00E+00	0.949	0.528	2.4E+05	0.0%	2.249	4.3E+06	0.0%
110	55		0.00E+00	0.949	0.578	5.8E+04	0.0%	2.249	2.4E+06	0.0%
120	60		0.00E+00	0.949	0.627	1.5E+04	0.0%	2.249	1.4E+06	0.0%
130	65		0.00E+00	0.949	0.676	3.8E+03	0.0%	2.249	8.8E+05	0.0%
SINGLE AXLES/ DUAL WHEELS (SD)										
10	5		0.00E+00	-4575.557	-152.351	Unlimited	0.0%	2.855	5.5E+15	0.0%
20	10		0.00E+00	-4575.557	-292.289	Unlimited	0.0%	2.855	5.5E+15	0.0%
30	15		0.00E+00	-4575.557	-427.897	Unlimited	0.0%	2.855	5.5E+15	0.0%
40	20		0.00E+00	-4575.557	-560.766	Unlimited	0.0%	2.855	5.5E+15	0.0%
50	25		0.00E+00	-4575.557	-691.635	Unlimited	0.0%	2.855	5.5E+15	0.0%
60	30		0.00E+00	-4575.557	-820.932	Unlimited	0.0%	2.855	1.6E+09	0.0%
70	35		0.00E+00	-4575.557	-948.936	Unlimited	0.0%	2.855	7.7E+07	0.0%
80	40		0.00E+00	-4575.557	-1075.845	Unlimited	0.0%	2.855	2.1E+07	0.0%
90	45		0.00E+00	-4575.557	-1201.802	Unlimited	0.0%	2.855	8.6E+06	0.0%
100	50		0.00E+00	-4575.557	-1326.921	Unlimited	0.0%	2.855	4.2E+06	0.0%
110	55		0.00E+00	-4575.557	-1451.290	Unlimited	0.0%	2.855	2.3E+06	0.0%
120	60		0.00E+00	-4575.557	-1574.981	Unlimited	0.0%	2.855	1.4E+06	0.0%
130	65		0.00E+00	-4575.557	-1698.055	Unlimited	0.0%	2.855	8.6E+05	0.0%
TANDEM AXLES/ DUAL WHEELS (TAD)										
10	5		0.00E+00	1.164	0.020	Unlimited	0.0%	3.883	5.5E+15	0.0%
20	10		0.00E+00	1.164	0.039	Unlimited	0.0%	3.883	5.5E+15	0.0%
30	15		0.00E+00	1.164	0.057	Unlimited	0.0%	3.883	5.5E+15	0.0%
40	20		0.00E+00	1.164	0.074	Unlimited	0.0%	3.883	2.0E+08	0.0%
50	25		0.00E+00	1.164	0.092	Unlimited	0.0%	3.883	1.8E+07	0.0%
60	30		0.00E+00	1.164	0.109	Unlimited	0.0%	3.883	4.8E+06	0.0%
70	35		0.00E+00	1.164	0.126	Unlimited	0.0%	3.883	1.8E+06	0.0%
80	40		0.00E+00	1.164	0.143	Unlimited	0.0%	3.883	8.3E+05	0.0%
90	45		0.00E+00	1.164	0.159	Unlimited	0.0%	3.883	4.2E+05	0.0%
100	50		0.00E+00	1.164	0.176	Unlimited	0.0%	3.883	2.3E+05	0.0%
110	55		0.00E+00	1.164	0.192	Unlimited	0.0%	3.883	1.4E+05	0.0%
120	60		0.00E+00	1.164	0.209	Unlimited	0.0%	3.883	8.4E+04	0.0%
130	65		0.00E+00	1.164	0.225	Unlimited	0.0%	3.883	5.3E+04	0.0%
140	70		0.00E+00	1.164	0.241	Unlimited	0.0%	3.883	3.5E+04	0.0%
150	75		0.00E+00	1.164	0.258	Unlimited	0.0%	3.883	2.4E+04	0.0%
160	80		0.00E+00	1.164	0.274	Unlimited	0.0%	3.883	1.6E+04	0.0%
170	85		0.00E+00	1.164	0.290	Unlimited	0.0%	3.883	1.2E+04	0.0%
180	90		0.00E+00	1.164	0.306	Unlimited	0.0%	3.883	8.3E+03	0.0%
190	95		0.00E+00	1.164	0.322	Unlimited	0.0%	3.883	6.0E+03	0.0%
200	100		0.00E+00	1.164	0.338	Unlimited	0.0%	3.883	4.5E+03	0.0%
210	105		0.00E+00	1.164	0.353	Unlimited	0.0%	3.883	3.3E+03	0.0%
220	110		0.00E+00	1.164	0.369	Unlimited	0.0%	3.883	2.5E+03	0.0%
230	115		0.00E+00	1.164	0.385	Unlimited	0.0%	3.883	1.9E+03	0.0%
TRI - AXLES/ DUAL WHEELS (TRD)										
10	5		0.00E+00	0.917	0.011	Unlimited	0.0%	2.930	5.5E+15	0.0%
20	10		0.00E+00	0.917	0.021	Unlimited	0.0%	2.930	5.5E+15	0.0%
30	15		0.00E+00	0.917	0.031	Unlimited	0.0%	2.930	5.5E+15	0.0%
40	20		0.00E+00	0.917	0.040	Unlimited	0.0%	2.930	5.5E+15	0.0%
50	25		0.00E+00	0.917	0.049	Unlimited	0.0%	2.930	5.5E+15	0.0%
60	30		0.00E+00	0.917	0.059	Unlimited	0.0%	2.930	5.5E+15	0.0%
70	35		0.00E+00	0.917	0.068	Unlimited	0.0%	2.930	5.5E+15	0.0%
80	40		0.00E+00	0.917	0.077	Unlimited	0.0%	2.930	5.5E+15	0.0%
90	45		0.00E+00	0.917	0.086	Unlimited	0.0%	2.930	5.5E+15	0.0%
100	50		0.00E+00	0.917	0.095	Unlimited	0.0%	2.930	5.5E+15	0.0%
110	55		0.00E+00	0.917	0.104	Unlimited	0.0%	2.930	5.5E+15	0.0%
120	60		0.00E+00	0.917	0.112	Unlimited	0.0%	2.930	5.5E+15	0.0%
130	65		0.00E+00	0.917	0.121	Unlimited	0.0%	2.930	5.5E+15	0.0%
140	70		0.00E+00	0.917	0.130	Unlimited	0.0%	2.930	5.5E+15	0.0%
150	75		0.00E+00	0.917	0.139	Unlimited	0.0%	2.930	5.5E+15	0.0%
160	80		0.00E+00	0.917	0.147	Unlimited	0.0%	2.930	2.0E+10	0.0%
170	85		0.00E+00	0.917	0.156	Unlimited	0.0%	2.930	6.1E+08	0.0%
180	90		0.00E+00	0.917	0.164	Unlimited	0.0%	2.930	1.9E+08	0.0%
190	95		0.00E+00	0.917	0.173	Unlimited	0.0%	2.930	9.1E+07	0.0%
200	100		0.00E+00	0.917	0.182	Unlimited	0.0%	2.930	5.1E+07	0.0%
210	105		0.00E+00	0.917	0.190	Unlimited	0.0%	2.930	3.2E+07	0.0%
220	110		0.00E+00	0.917	0.199	Unlimited	0.0%	2.930	2.1E+07	0.0%
230	115		0.00E+00	0.917	0.207	Unlimited	0.0%	2.930	1.5E+07	0.0%
240	120		0.00E+00	0.917	0.216	Unlimited	0.0%	2.930	1.1E+07	0.0%
250	125		0.00E+00	0.917	0.224	Unlimited	0.0%	2.930	8.1E+06	0.0%
260	130		0.00E+00	0.917	0.232	Unlimited	0.0%	2.930	6.1E+06	0.0%

Total Fatigue **0%** Total Erosion % **91%**

Result
Accepted

Rigid Pavement Design

Calculation of Concrete Reinforcement

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

Helensvale to University Hospital, 30 yr

Reinforcement in Jointed Reinforced Pavements

Material Properties

Reinforcement Details			Concrete Details		
Bar Dia	**A_b**		f_c	36	MPa
8	50		f_{cf}	4.5	MPa
12	113		f_{ct}	2.7	MPa
16	201				
Fy	500	MPa			

Reinforcement

m	1.5		Table 9.10
L	7.40	*m*	
r	2400	kg/m^3	
g	9.81	m/s^2	
D	0.180	*m*	
f_s	300	*MPa*	
A_s	**157**	mm^2/m	Eqn. 9.6

N 8 @ 320 mm centres > SL82 Mesh

Dowels

db 28 *mm* @ ***300 mm centres*** Cl 9.4.6

Reinforcement in Continuously Reinforced Concrete Pavements

Material Properties

Reinforcement Details			Concrete Details		
Bar Dia	**A_b**		f_c	36	MPa
12	113		f_{cf}	4.5	MPa
16	201		f_{ct}	2.7	MPa
20	314				
Fy	500	MPa			

Transverse Reinforcement

m	1.5		Table 9.10
L	7.40	*m*	
r	2400	kg/m^3	
g	9.81	m/s^2	
D	0.180	*m*	
f_s	300	*MPa*	
A_s	**157**	mm^2/m	Eqn. 9.6

N 12 @ 720 mm centres

Longitudinal Reinforcement

d_b	16	*mm*	Radius	8	mm
e_s	250	me			
e_t	300	me			
W	0.2	*mm*			
p	**1.10%**				Eqn. 9.7

73 x N 16 @ 200 mm centres OK
2 Layers, e.g. top & bottom

Critical Reinforcement Check

f_{ct}	2.7	MPa	
m	1.5		
f_{sy}	500	MPa	
m	7.5		
p_{crit}	**0.56%**		Eqn. 9.9

37 x N 16 @ 200 mm centres

Theoretical Crack Spacing

f_{ct}	2.7	MPa	
m	7.5		
p	0.0110		
u	125	m^{-1}	
f_b	5.4	MPa	
e_s	250	me	
e_t	300	me	
E_c	33000	MPa	
L_{cr}	0.770	m	Eqn. 9.10

Within optimum range

Rigid Pavement Design

Calculation of Concrete Reinforcement

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

Helensvale to University Hospital, 50 yr

Reinforcement in Jointed Reinforced Pavements

Material Properties

Reinforcement Details			Concrete Details		
Bar Dia	A_b		f_c	36	MPa
8	50		f_{cf}	4.5	MPa
12	113		f_{ct}	2.7	MPa
16	201				
F_y	500	MPa			

Reinforcement

m	1.5		Table 9.10
L	7.40	m	
r	2400	kg/m^3	
g	9.81	m/s^2	
D	0.190	m	
f_s	300	MPa	
A_s	**166**	mm^2/m	Eqn. 9.6

N 8 @ 300 mm centres > SL82 Mesh

Dowels

db 28 *mm* @ ***300 mm centres*** Cl 9.4.6

Reinforcement in Continuously Reinforced Concrete Pavements

Material Properties

Reinforcement Details			Concrete Details		
Bar Dia	A_b		f_c	36	MPa
12	113		f_{cf}	4.5	MPa
16	201		f_{ct}	2.7	MPa
20	314				
F_y	500	MPa			

Transverse Reinforcement

m	1.5		Table 9.10
L	7.40	m	
r	2400	kg/m^3	
g	9.81	m/s^2	
D	0.190	m	
f_s	300	MPa	
A_s	**166**	mm^2/m	Eqn. 9.6

N 12 @ 680 mm centres

Longitudinal Reinforcement

d_b	16	*mm*	Radius	8	mm
e_s	250	me			
e_t	300	me			
W	0.2	*mm*			
p	**1.10%**				Eqn. 9.7

77 x N 16 @ 190 mm centres OK
2 Layers, e.g. top & bottom

Critical Reinforcement Check

f_{ct}	2.7	MPa	
m	1.5		
f_{sy}	500	MPa	
m	7.5		
p_{crit}	**0.56%**		Eqn. 9.9

39 x N 16 @ 190 mm centres

Theoretical Crack Spacing

f_{ct}	2.7	MPa	
m	7.5		
p	0.0110		
u	125	m^{-1}	
f_b	5.4	MPa	
e_s	250	me	
e_t	300	me	
E_c	33000	MPa	
L_{cr}	0.770	m	Eqn. 9.10

Within optimum range

Rigid Pavement Design

Calculation of Concrete Reinforcement

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

University Hospital To Broadbeach, 30 yr

Reinforcement in Jointed Reinforced Pavements

Material Properties

Reinforcement Details			Concrete Details		
Bar Dia	**A_b**		**f_c**	36	MPa
8	50		**f_{cf}**	4.5	MPa
12	113		**f_{ct}**	2.7	MPa
16	201				
Fy	500	MPa			

Reinforcement

				Table 9.10
m	1.5			
L	7.40	*m*		
r	2400	*kg/m³*		
g	9.81	*m/s²*		
D	0.185	*m*		
f_s	300	*MPa*		
A_s	**161**	*mm²/m*		Eqn. 9.6
N	***8***	***@***	***310*** ***mm centres***	***>*** **SL82 Mesh**

Dowels

db	**28**	*mm*	*@*	***300***	***mm centres***	Cl 9.4.6

Reinforcement in Continuously Reinforced Concrete Pavements

Material Properties

Reinforcement Details			Concrete Details		
Bar Dia	**A_b**		**f_c**	36	MPa
12	113		**f_{cf}**	4.5	MPa
16	201		**f_{ct}**	2.7	MPa
20	314				
Fy	500	MPa			

Transverse Reinforcement

				Table 9.10
m	1.5			
L	7.40	*m*		
r	2400	*kg/m³*		
g	9.81	*m/s²*		
D	0.185	*m*		
f_s	300	*MPa*		
A_s	**161**	*mm²/m*		Eqn. 9.6
N	***12***	***@***	***700*** ***mm centres***	

Longitudinal Reinforcement

d_b	16	*mm*	Radius	8	mm
e_s	250	me			
e_t	300	me			
W	0.2	*mm*			
p	**1.10%**				Eqn. 9.7
75	***x N 16***	***@***	***200***	***mm centres***	***OK***
			2	***Layers, e.g. top & bottom***	

Critical Reinforcement Check

f_{ct}	2.7	MPa		
m	1.5			
f_{sy}	500	MPa		
m	7.5			
p_{crit}	**0.56%**			Eqn. 9.9
38	***x N 16***	***@***	***200***	***mm centres***

Theoretical Crack Spacing

f_{ct}	2.7	MPa		
m	7.5			
p	0.0110			
u	125	m^{-1}		
f_b	5.4	MPa		
e_s	250	me		
e_t	300	me		
E_c	33000	MPa		
L_{cr}	0.770	m	***Within optimum range***	Eqn. 9.10

Rigid Pavement Design

Calculation of Concrete Reinforcement

Date: 18 April 2008 Project: Gold Coast Rapid Transit Job No: 41/16445 Engineer: R Pearson

Concept Design for BRT Pavement

Location

University Hospital To Broadbeach, 50 yr

Reinforcement in Jointed Reinforced Pavements

Material Properties

Reinforcement Details		Concrete Details	
Bar Dia	**A_b**	f_c	36 MPa
8	50	f_{cf}	4.5 MPa
12	113	f_{ct}	2.7 MPa
16	201		
Fy	500 MPa		

Reinforcement

m	1.5		Table 9.10
L	7.40 *m*		
r	2400 *kg/m³*		
g	9.81 *m/s²*		
D	0.190 *m*		
f_s	300 *MPa*		
A_s	**166** *mm²/m*		Eqn. 9.6

N 8 @ 300 mm centres > SL82 Mesh

Dowels

db 28 *mm* **@ *300 mm centres*** Cl 9.4.6

Reinforcement in Continuously Reinforced Concrete Pavements

Material Properties

Reinforcement Details		Concrete Details	
Bar Dia	**Ab**	f_c	36 MPa
12	113	f_{cf}	4.5 MPa
16	201	f_{ct}	2.7 MPa
20	314		
Fy	500 MPa		

Transverse Reinforcement

m	1.5		Table 9.10
L	7.40 *m*		
r	2400 *kg/m³*		
g	9.81 *m/s²*		
D	0.190 *m*		
f_s	300 *MPa*		
A_s	**166** *mm²/m*		Eqn. 9.6

N 12 @ 680 mm centres

Longitudinal Reinforcement

d_b	16 *mm*	Radius 8 mm	
e_s	250 me		
e_t	300 me		
W	0.2 *mm*		
p	**1.10%**		Eqn. 9.7

77 x N 16 @ 190 mm centres OK
2 Layers, e.g. top & bottom

Critical Reinforcement Check

f_{ct}	2.7 MPa		
m	1.5		
f_{sy}	500 MPa		
m	7.5		
p_{crit}	**0.56%**		Eqn. 9.9

39 x N 16 @ 190 mm centres

Theoretical Crack Spacing

f_{ct}	2.7 MPa		
m	7.5		
p	0.0110		
u	125 m^{-1}		
f_b	5.4 MPa		
e_s	250 me		
e_t	300 me		
E_c	33000 MPa		
L_{cr}	0.770 m	***Within optimum range***	Eqn. 9.10

Appendix E

Generic Copy of MRSS.01.001 and MRSS.01.003

MRSS.01.001

Supplementary Specification

Checking Subgrade

Capping Layer

Drainage Layer

Controlled Subgrade

Working Platform

Temporary Pavement

Verge

May 2006

Project Specific

Queensland Department of Main Roads

© The State of Queensland, Queensland Department of Main Roads

Contents

Page

1 GENERAL 1

1.1 SCOPE 1
1.2 DEFINITION OF TERMS AND SYMBOLS 1
1.2.1 General 1
1.2.2 Definitions 1
1.3 REFERENCES 4
1.4 STANDARD TEST METHODS 5

2 TESTING OF IN-SITU MATERIAL AND CHECK TESTING AND ASSESSMENT OF LOWER SUBGRADE DESIGN CBR 5

2.1 GENERAL 5
2.2 TESTS 5
2.3 ASSESSMENT AND SELECTION OF LOWER SUBGRADE DESIGN CALIFORNIA BEARING RATIO (CBR) 6
2.4 REPORTING 7

3 VERGE 7

3.1 GENERAL 7
3.2 REQUIREMENTS 7

4 WORKING PLATFORM 8

4.1 GENERAL 8
4.2 CONTRACTOR'S DESIGN REQUIREMENTS 8
4.3 IN-SERVICE REQUIREMENTS 9
4.4 CONTRIBUTION OF WORKING PLATFORM TO PAVEMENT DESIGN 9

5 CAPPING LAYER; DRAINAGE LAYER; CONTROLLED SUBGRADE; COMBINED LAYERS 10

5.1 CAPPING LAYER 10
5.2 DRAINAGE LAYER 10
5.3 CONTROLLED SUBGRADE 10
5.4 COMBINED LAYERS 11
5.5 MATERIALS 13
5.5.1 Controlled Fill Materials 13
5.5.2 Treated Materials 13
5.5.3 Drainage Materials 14

6 CUTTING IN ROCK 15

7 TEMPORARY PAVEMENTS 15

7.1 GENERAL 15
7.2 DESIGN, CONSTRUCTION, MAINTENANCE AND REMOVAL 16
7.3 REQUIREMENTS 16
7.3.1 General, Pavement Surface and Structural Minimum Requirements 16
7.3.2 Functional Requirements 17
7.3.3 Pavement Design 18

8 TOLERANCES 18

8.1 GENERAL 18

© The State of Queensland, Queensland Department of Main Roads

8.2 TOLERANCES 18

9 QUALITY 19

9.1 GENERAL 19
9.2 AUDIT 19
9.3 HOMOGENEOUS LOTS 19
9.4 INSITU UNTREATED SUBGRADE 20
9.5 CONTROLLED FILL, DRAINAGE LAYER 21
9.6 STABILISATION 21
9.6.1 In-situ Stabilised Materials 21
9.6.2 Plant Mix Stabilised Materials 21
9.7 GEOMETRICS: ALL MATERIALS 22
9.8 WORKING PLATFORM 22
9.9 VERGE 22
9.10 COMPACTION STANDARD: ALL MATERIALS 23
9.11 HOMOGENEITY 23

10 ADMINISTRATION 23

10.1 WORK ITEMS 23
10.2 WORK OPERATIONS 24
10.2.1 Introduction 24
10.2.2 Testing of In-situ Subgrade 24
10.2.3 Testing of Lower Subgrade to Determine Design CBR (Activities from testing the in-situ subgrade may contribute to this) 24
10.2.4 Testing for Lime Demand and Soluble Sulphate 24
10.2.5 Treatment in Rock Cuttings 25
10.2.6 Drainage Layer 25
10.2.7 Controlled Fill 26
10.2.8 Working Platform 26
10.2.9 Verge 26
10.2.10 Temporary Pavements 27
10.3 MEASUREMENT FOR PAYMENT 27

11 ADDENDUM 28

11.1 SUB-ITEMS (IF ANY) 28
11.2 PROJECT SPECIFIC REQUIREMENTS (IF ANY) 28

1 General

1.1 Scope

This specification sets out the requirements for:

a) Checking In-situ Subgrade;

b) Checking Design CBR on Lower Subgrade;

c) Capping Layer;

d) Controlled Subgrade;

e) Working Platform;

f) Drainage Layer

g) Verge; and,

h) Temporary Pavement.

These requirements are additional to, and have precedence over MRS 11.04 requirements for earthworks.

This specification shall be read in conjunction with all other contract documents, in particular MRS 11.01 *Introduction to Standard Specifications*, MRS 11.04 *General Earthworks*, MRS 11.07, MRS 11.05 and MRS 11.08, MRS 11.50 *Specific Quality System Requirements* and the Drawings.

1.2 Definition of Terms and Symbols

1.2.1 General

The terms and symbols in this specification shall be as defined in Table 1.2-1, the Notes to Table 1.2-1 and in the MRS specifications.

1.2.2 Definitions

Table 1.2-1 Terminology

Term	Description
Capping Layer	A layer that provides cover over an in-situ material that has a soaked CBR of less than 3.0 % but not less than 1.0 %.
Controlled Fill	Fill material with a low water induced volume change potential in accordance with Clause 9, which may be placed as part of the Controlled Subgrade.
Controlled Subgrade	A thickness of controlled material beneath the lowest pavement layer intended to reduce water induced volume change if there are in-situ materials that have potential for water-induced volume change.
Drainage Layer	A layer that intercepts water and/or breaks capillary rise.
Functional Requirements	Requirements related to a standard of service for the user of the Pavement and not other aspects of the pavement such as strength, durability, cost, life etc. Examples include: roughness, grade, cross-fall, rutting, surface defects, texture depth, skid resistance, delineation, visibility.
Lower Subgrade	The semi-infinite layer used in pavement design, located beneath the lowest of the following: a) Working Platform, or

© The State of Queensland, Queensland Department of Main Roads

Term	Description
	b) the lowest pavement layer if a Working Platform does not exist; or, c) the Drainage Layer except where there is a Capping Layer component in which case it is at the top of the Capping Layer component; or, d) the lowest Controlled Subgrade layer where a treatment to satisfy the controlled subgrade requirements has occurred, except where there is a Capping Layer component in which case it is at the top of the Capping Layer component. e) On embankments, lowest fill material within a depth of 2 m below the lowest pavement layer. Where a Capping Layer is provided it shall be considered to be part of the Lower Subgrade. The top of Lower Subgrade starts is the top of the Capping Layer.
In-situ Untreated Subgrade	In-situ subgrade material at the location, horizontal and vertical, where the characteristics of the subgrade are to be determined to assess: a) the need for one or more of the following elements: Capping Layer, Controlled Subgrade; Drainage Layer and/or Combined Capping-Drainage Layer; and, b) Lower Subgrade design CBR and swell.
Pavement	The portion of the road, including shoulders, placed above the Subgrade, which supports and forms a running surface for vehicular traffic and comprises material complying with a QDMR standard specification and/or supplementary specification for pavements such as MRS 11.05, MRS 11.08 (not MRS 11.07), MRS 11.30, MRS 11.39, MRS 11.40, MRSS.01.003 (Main Roads Supplementary Specification for asphalt). The Pavement does not include the Working Platform, Controlled Subgrade layer, Capping Layer, Drainage Layer, Combined Capping-Drainage Layer or Rock Cutting Treatment layer.
Pavement Safety	Characteristics of the pavement including but not limited to: surface type, surface texture, skid resistance, surface drainage, cross-fall, delineation, sight distance, guide posts, lighting and guardrail.
Temporary Pavement	Any pavement constructed for the purpose of carrying traffic for a short period (maximum 2 years) while the Pavement intended for normal use is under construction, reconstruction and/or rehabilitation. It is not designed for, intended for and cannot be used for any further use as a pavement structure (material components can be reused if recycled and utilised within a Pavement Design).
Settlement	A lowering of the height of the subgrade resulting from loading, including traffic, pavement and embankment, and including creep, shear and/or reduction in volume.
Subgrade	The surface immediately beneath the lowest Pavement Layer.
Treated Material	Material treated with lime and/or cement in accordance with Clause 9.
MRPDS	Queensland Department of Main Roads Pavement Design System. See definition in Notes to Table 1.2-1 (A) below.

© The State of Queensland, Queensland Department of Main Roads

Term	Description
Water Induced Volume Change	Change in the volume of the subgrade material due to a change in water content (See Note to Table 1.2-1 (B) below for soil classification).
Weighted Plasticity Index (WPI)	The product of the Plasticity Index and percentage passing the AS 0.425 mm sieve
Working Platform	A layer that provides: • improved access for construction traffic; • a platform for the construction of the Pavement layers; • protection to the underlying materials. The Working Platform shall conform to the requirements of Clause 4 of this document.

Notes to Table 1.2-1

(A) Queensland Department of Main Roads Pavement Design System (MRPDS)

The Queensland Department of Main Roads Pavement Design System (MRPDS) has been calibrated for performance as a complete integrated system[1] that includes the following documents:

a) Queensland Transport Pavement Design Manual (including 2004 and 2005 amendments);

b) Queensland Department of Main Roads Specifications (Standard and Supplementary);

c) Queensland Department of Main Roads Standard Drawings;

d) Queensland Department of Main Roads Standard Test Methods;

e) Queensland Department of Main Roads Quality requirements:

When applying the Queensland Department of Main Roads Pavement Design System, unless specifically stated otherwise:

a) Input parameters must be those that are stipulated in the Queensland Department of Main Roads Pavement Design System described above. In particular, moduli, fatigue and Poisson's ratio values must be those stipulated in the above documents and values from other sources, including test results not specifically allowed and/or other pavement documents, cannot be used.

b) Performance of products, components and materials used directly and indirectly in the MRPDS are based on conformance to the requirements in the documents described above.

Queensland Department of Main Roads Pavement Documents and Systems have been developed over many years so as to provide a Queensland network solution within varying parameters particular to Queensland including:

- A priority to provide
  - Ø all weather connections; and/or,

[1] For example, because test procedures and transfer factors do not yet adequately represent real in-service conditions, the pavement layer moduli are based on a combination of historical values that are derived from field performance as well as specific test results.

© The State of Queensland, Queensland Department of Main Roads

Ø an adequate level of service over the whole network;

rather than long service lives, low intervention levels or low risk solutions.

- Need to service a very large state with low population and traffic densities in many areas that necessitates low standards and higher risk solutions.
- Frequent inability to access materials that match first world standards and/or expectations.
- A risk profile that favoured lower initial standards, increased intervention and/or rehabilitation[2].
- Budget constraints.
- A project delivery system that had a fixed contract interface[3] between the owner and contractor for construction only. Planning and design was carried out internally or by skilled hired contractors / consultants[4].

The Queensland Department of Main Roads Pavement Design System is not directly suited for any purpose other than for use within their historic context as described above. In particular they cannot be used for:

a) Activities other than directly for the Queensland Department of Main Roads;

b) Design for any Legal Entity other than the Queensland Government;

c) Design for projects that have expectations and/or needs that may differ from the Queensland Department of Main Roads expectations and/or needs including but not limited to:

i) performance requirements;

ii) levels of risk;

iii) financial arrangements including initial and intervention costs;

iv) industry arrangements.

Where used within Queensland Department of Main Roads for roads in Queensland in an infrastructure delivery model that includes Functional Requirements, achievement of the Functional Requirements has to include additional requirements to those in the Queensland Department of Main Roads Pavement Design System.

1.3 References

Table 1.3-1 contains a list of the standard specifications referred to or required for the purposes of this specification.

Table 1.3-1 Standard Specification

[2] With the historic low traffic volumes, pavement intervention and/or rehabilitation costs were relatively low hence interventions and/or rehabilitations were a frequently preferred option due to lower whole-of-life cost and/or greater certainty about the overall solution due to exposure of the initial construction to actual loadings in the actual environment.

[3] The fixed contract interface was administered by an independent superintendent checking compliance with plans, drawings, specifications, test methods and quality control systems established and fixed prior to the contract. Variation from this involved re-negotiation of the contract involving new documents and costing for the changes.

[4] Skilled hired contractors / consultants required briefing, control, management and continuous involvement in decisions as issues arose. All this process was performed by internal trained, knowledgeable and experienced staff using the Main Roads manuals as a guide.

© The State of Queensland, Queensland Department of Main Roads

Specification Number	Specification
MRS 11.01	Introduction to Standard Specifications
MRS 11.03	Drainage, Retaining Structures and Protective Treatments
MRS 11.04	General Earthworks
MRS 11.05	Unbound Pavements
MRS 11.07	In Situ Stabilised Pavements
MRS 11.08	Plant Mixed Stabilised Pavements
MRS 11.39	Lean Mix Concrete Sub-base for Pavements
MRS 11.40	Concrete Base in Pavements
MRS 11.50	Specific Quality System Requirements

1.4 Standard Test Methods

Standard test methods are referenced within the standard specifications that are listed in Table 1.3-1.

2 Testing of In-situ Material and Check Testing and Assessment of Lower Subgrade Design CBR

2.1 General

The Contractor shall not proceed with any work below the level of the bottom of the Working Platform and shall not place the Working Platform or Pavement Layers until the tests, assessments and pavement design checks have been carried out in accordance with this document.

Initial testing shall be carried out to determine the characteristics of the in-situ untreated subgrade material to asses the need for any one or more of the following elements:

a) Capping Layer,

b) Drainage Layer; and / or

c) Controlled Subgrade.

The above testing shall be carried out to provide a 90% level of confidence (90% of the in-situ properties shall be above a minimum specified standard or below a maximum specified standard).

Additional testing may be required to assess the Lower Subgrade design CBR when the level of the Lower Subgrade has been established

Hold Point

Reference to the term ‘rock’ in this specification is only for the purposes of testing and/or for determination of the treatment to be applied to cuttings and not for the purposes of either determining the type of excavation and/or defining payment in the contract.

2.2 Tests

Samples shall be selected consistent with the testing frequency in the Addendum. Each sample shall be tested for:

a) Plastic Limit;

© The State of Queensland, Queensland Department of Main Roads

b) Liquid Limit;

c) Percent passing the AS 0.425 mm sieve;

d) Weighted Plasticity Index (WPI), which is the Plastic Limit multiplied by the percent passing the AS 0.425 mm sieve;

e) In-situ California Bearing Ratio (CBR), determined from dynamic cone penetrometer testing;

f) 4-day laboratory soaked California Bearing Ratio (CBR) and 10-day soaked CBR for the swell test and/or where high water contents are anticipated both at 98% standard density and optimum moisture content and 4.5 kg surcharge.

g) Lime Demand Testing

Where any lime treatment is to occur the Contractor shall also test the material to be treated to determine lime reaction and demand in accordance with Method No Q133.

h) Sulphate Content

Where cementitious treatment is to occur, the Contractor shall also test the material to be treated to determine the sulphate content in accordance with AS 1289.4.2.1 'Soil chemical tests- Determination of the sulphate content of a natural soil and the sulphate content of the groundwater- Normal method'. The soluble sulphate content shall not exceed 0.2%.

2.3 Assessment and Selection of Lower Subgrade Design California Bearing Ratio (CBR)

The Lower Subgrade design CBR determined at the planning or design phase shall be re-assessed prior to any subgrade treatment and the placement of the Working Platform or pavement. The pavement design shall be adjusted if necessary.

The methodology for determining the design values is as follows:

a) The in-situ untreated subgrade must be sectionalised. Considerations in section selection include:

i) Topographical features including hills, valleys, etc.

ii) Pavement location, horizontally and vertically; horizontal and vertical (cut, side cut, fill);

iii) Geological profile;

iv) Influence and/or presence of water; and

v) Consistency of lower subgrade soil type.

b) For a particular section, the statistical analysis detailed in the Queensland Transport Pavement Design Manual (including 2004 and 2005 amendments) Appendix B Clause 4 is to be applied separately to the 4-day soaked CBR test results and the in-situ CBR values (from dynamic cone penetrometer testing) for subgrade material in that section. The Lower Subgrade CBR to be used in pavement design is to be the lower of these values for each section. The representative CBR for the section shall be determined from the laboratory 4 -day soaked CBR or in-situ CBR (cone penetrometer) whichever is the lower result. A 90% level of confidence (90 % of results are greater that the representative CBR) shall apply for the determination of the representative CBR from each set of results.

c) Where the insitu subgrade design CBR is greater than or equal to 1% and less than 3 %, a Capping Layer shall be provided. If a Drainage Layer is not required or if the required thickness of Drainage Layer is less than required Capping Layer thickness, the top of the Capping Layer is the top of Lower Subgrade. If a Drainage Layer is required and the

© The State of Queensland, Queensland Department of Main Roads

required thickness equals or exceeds the Controlled Subgrade thickness, the top of the Drainage Layer is the top of Lower Subgrade. Where a Capping Layer is required, the design CBR for the Lower Subgrade shall be 3%.

d) Where the in-situ subgrade design CBR < 1 %, a separate analysis shall be carried out to determine in-situ treatment.

e) Where different design CBRs are determined in sections across (right angle to the centre-line) the lower subgrade, the lowest design value shall be used unless additional subgrade treatment is carried out to raise the lower of the CBRs.

f) Notwithstanding the above, the maximum Lower Subgrade design CBR shall be 15 %, except for subgrades in rock cutting treated with cement stabilised materials (Clause 6) in which case the maximum Lower Subgrade design CBR shall be 20%

2.4 Reporting

The results of the testing required by this document shall be available within 10 working days of exposure of the subgrade and prior to any subgrade treatment or placement of the Working Platform, or Pavement if there is not Working Platform.

Hold Point

The results shall be used to review the subgrade treatments and pavement design.

The Contractor shall include sufficient time for testing and assessment and the reprogramming and construction of the works if required but this shall be not less than 20 working days.

3 Verge

3.1 General

In addition to the requirements of MRS 11.04, the verge material shall meet the requirements given in Table 3.2-1.

3.2 Requirements

Table 3.2-1 Verge

Property	Limit	Value
WPI	maximum	1200
WPI	minimum	300
Liquid Limit	maximum	40
Plasticity Index	maximum	14
	minimum	4
Swell (At MDD and OMC and after 10 days soaking)	maximum	1.5%
Permeability	maximum	5×10^{-9} m/sec
California Bearing Ratio (At MDD and OMC and after 4 days soaking)	minimum	10
Grading:		
AS Sieve Size 19.0 mm	Percent passing	100
AS Sieve Size 9.50 mm	Percent passing	40 - 100
AS Sieve Size 2.36 mm	Percent passing	20 - 100

© The State of Queensland, Queensland Department of Main Roads

Property	Limit	Value
AS Sieve Size 0.425 mm	Percent passing	10 - 80
AS Sieve Size 0.075 mm	Percent passing	10 - 30
Characteristic Compaction Standard (Standard Compaction)	Relative Dry Density	100 %

4 Working Platform

4.1 General

A Working Platform of 150 mm minimum thickness shall be located below the lowest Pavement layer. (The working Platform is not a Pavement layer for the in-service structure).

The design, construction and maintenance of the Working Platform are the responsibility of the Contractor but shall include the specified in-service requirements given in Clause 4.3 below. The in-service requirements are for the sole purpose of providing a satisfactory substrate layer for the full service life of the pavement.

4.2 Contractor's Design Requirements

The Working Platform shall be designed by the Contractor to meet the minimum in-service requirements and the particular requirements of the project including, but not limited to, the following considerations:

a) The characteristics of the underlying subgrade materials;

b) The environment including, but not limited to, the rainfall, temperature, surface and sub-surface water conditions including location of the water table, surface sources of water and drainage, sub-surface sources of water and drainage;

c) The Contractor's construction traffic and equipment the Contractor intends to use for construction of the Pavement and other works;

d) The full operating life of the Working Platform including, but not limited to:

   i) Actual period during which the Working Platform will be required to provide an access for construction traffic;

   ii) Actual periods during which the Working Platform will be required to provide a platform for construction traffic and equipment; and

   iii) Actual periods during which it is not in use and prior to the construction of the overlying pavement;

e) Providing protection to the underlying layers including protection from water and stress;

f) Providing a platform for the construction of the overlying pavement with sufficient stiffness to enable the placement and compaction of the Pavement layers in accordance with their specified requirements;

g) Suitability for the Contractor's construction program;

h) Meeting in-service requirements as specified in Clauses 4.3.

As part of the planning and/or design of the Pavement and earthworks, the height of the top and bottom of the Working Platform shall be specified based on a Working Platform thickness of 150 mm. If the contractor requires a Working Platform thicker than 150 mm, this can be achieved by:

a) Where there are no other subgrade treatments;

© The State of Queensland, Queensland Department of Main Roads

Increasing the thickness of the Working Platform and lowering the Lower Subgrade to accommodate the increased thickness.

b) Where there are other subgrade treatments refer to Clause 5.4.

4.3 In-service Requirements

The Working Platform shall include the following minimum requirements that are necessary for the functioning of this layer when it becomes part of the subgrade for the operating service life of the Pavement structure:

The Working Platform shall be constructed using a material of a standard not less than Type 1.2 as specified in MRS 11.05, stabilised in accordance with MRS 11.07 or MRS 11.08 and comply with the following additional requirements:

a) A minimum 2.0 % cement added;

b) A minimum UCS of 1 MPa and a maximum UCS of 2 MPa at 7 days

c) A maximum WPI of 1200 for the untreated material;

d) Placed and maintained at a degree of saturation of not greater than 75% (as determined in accordance with Clause 10.2.6 of MRS 11.05);

e) At least 150 mm (compacted) thickness;

f) AMCO primed and (10 mm Class 170) sealed so that surface is sealed and safe and adequate for the Contractor's operations.

g) The surface of the Working Platform shall be maintained with a geometric tolerance of ±15 mm of the specified height and a maximum deviation from a 3 m straight edge of 8 mm at all points on the surface and the seal shall remain intact and waterproof.

The above requirements are a minimum only for the purpose of providing a layer beneath the final pavement and are not sufficient for a Working Platform subject to construction traffic and a construction platform for the pavement layers.

4.4 Contribution of Working Platform to Pavement Design

The Working Platform that, as a minimum, complies with the in-service requirements of this specification shall be considered to contribute to the pavement design as follows regardless of any additional quality implemented by the contractor but any additional thickness may be incorporated into the overall Pavement Design:

a) As a granular material, with the actual thickness of the Working Platform, and a CBR as calculated by the specified design system up to a maximum CBR of 15%;

b) In accordance with Queensland Transport Pavement Design Manual (including 2004 and 2005 amendments).

The Contractor shall demonstrate by testing and analysis carried out prior to placement of the first pavement layer that the Contractor's Working Platform will have at least the specified design in-service characteristics in Clause 4.3 after being used by construction traffic and immediately before being covered by the pavement. This testing and analysis shall include at least the following:

a) A review of the Contractor's pavement design and all quality records including the original test results;

b) FWD Deflection testing and analysis every 250 m in each wheel path of the final pavement. The FWD testing is to be used to identify general stiffness and any need for further investigation in a particular location;

c) Sampling and testing of materials as relevant for all the QDMR specification properties for that material type at least every 500 m and at locations of lowest strength as identified

© The State of Queensland, Queensland Department of Main Roads

by FWD analysis and assessment for compliance with the relevant specified requirements;

d) Insitu CBR determined from dynamic cone penetrometer testing and assessment for compliance with the requirement for a minimum CBR of 15%.

5 Capping Layer; Drainage Layer; Controlled Subgrade; Combined Layers

5.1 Capping Layer

Where the in-situ untreated subgrade has a design CBR < 3.0 % but ≥1.0%, a Capping Layer shall be provided. A specific assessment is required if the in-situ untreated subgrade has a design CBR less than 1%.

Capping layer thickness requirements are as per Table 5.1-1. Materials shall be per Clause 5.5.

Table 5.1-1 Capping Layer Thickness

In-situ Subgrade Design CBR	Capping Layer Thickness: minimum
≥ 2.5 % to < 3.0 %;	150 mm
≥ 2.0 % to < 2.5 %;	200 mm
≥ 1.5 % to < 2.0 %;	300 mm
≥ 1.0 % to < 1.5 %;	400 mm

5.2 Drainage Layer

Where there are water or potential water related issues, a Drainage Layer shall be provided. Materials to be used are given in Clause 5.5.

Where the material on which the Drainage Layer is placed has a CBR > 1.0% at the time of construction, determined by in-situ cone penetrometer testing, the drainage layer shall consist of a geotextile wrapped 300 mm thick rock fill.

Where the material on which the drainage layer is placed has a CBR of < 1.0% at the time of construction a specific assessment of rock fill properties and thickness is required.

5.3 Controlled Subgrade

A Controlled Subgrade shall be established over any in-situ untreated subgrade with a swell of > 0.5%.

Where the potential swell of the in-situ subgrade material is:

a) Swell greater than or equal to 7.0%

A Geotechnical assessment must be carried out and the specified requirements of the geotechnical Assessment applied; or,

b) Swell greater 0.5% and less than 7%

Controlled Subgrade requirements should be determined by a Geotechnical assessment and the specified requirements of the Geotechnical Assessment applied. If a Geotechnical assessment is not carried out, the thickness shall be as per Table 5.3-1 shall apply. Materials to be used are given in Clause 5.5.

Table 5.3-1 Controlled Subgrade Thickness

In-situ Subgrade Swell %	Controlled Subgrade Thickness, mm

© The State of Queensland, Queensland Department of Main Roads

≥ 7.0%	Geotechnical Assessment
≥ 5.0% to <7.0%	1000
≥ 2.5% to < 5.0 %	600
≥ 0.5% to < 2.5 %	150

5.4 Combined Layers

There may be the need for one or more subgrade treatments, as detailed in the Clauses in this specification, and in some cases one treatment can perform the function of another and need not be duplicated.

A summary of applicability, to be read in conjunction with the definition of the treatment and the application instructions below, is given in Table 5.4-1.

Table 5.4-1 Subgrade Treatment Guide (Always a Working Platform)

In-situ Conditions / ***Treatment***	**Applicability (Required if Black)**							
In-situ subgrade CBR	≥ 3.0 %				< 3.0 %[1]			
Capping Layer					■	■	■	■
Water Exposure[2]	no		Yes		No		yes	
Drainage Layer			■	■			■	■
Swell %	< 0.5	≥ 0.5	< 0.5	≥ 0.5	< 0.5	≥ 0.5	< 0.5	≥ 0.5
Controlled Subgrade		■		■		■		■

Notes;

1) For CBR less than 1.0% a Capping Layer is required but its composition and thickness is subject to a specific assessment.
2) Water Exposure is water that can affect the pavement and/or the Working Platform, Capping Layer and/or Controlled Subgrade due to flow from an internal and/or external source and/or soil suction affects from a high water table.

Combined treatments shall be applied as follows:

a) Capping Layer only is required

   i) Place Working Platform on top of Capping Layer.

      If the Contractor wishes to increase the thickness of the Working Platform, as per Clause 4, above the specified minimum in-service thickness, the top and bottom levels of the Capping Layer must be lowered to retain the required Capping Layer thickness.

b) Drainage Layer only is required

   i) Place Working Platform on top of Drainage Layer.

      If the Contractor wishes to increase the thickness of the Working Platform, as per Clause 4, above the specified minimum in-service thickness, top and bottom levels of the Drainage Layer must be lowered to retain the required Drainage Layer thickness.

c) Both Capping and Drainage Layers are required

i) Where the Capping Layer thickness is greater than the Drainage Layer thickness:

- increase the thickness of the Drainage Layer to satisfy the required Capping Layer thickness; and/or,
- place a Controlled Fill and/or a Treated Material on the Drainage Layer to make up the required Capping Layer thickness.

If the Contractor wishes to increase the thickness of the Working Platform, as per Clause 4, above the specified minimum in-service thickness, top and bottom levels of the layer determined from the above must be lowered to retain the required Layer thickness.

ii) Where the Capping Layer thickness is less than or equal to the Drainage Layer thickness, no additional material is required and the required Drainage Layer thickness applies.

If the Contractor wishes to increase the thickness of the Working Platform above the specified minimum in-service thickness, top and bottom levels of the Drainage Layer must be lowered to retain the required Drainage Layer thickness

For purpose of pavement thickness design, the Lower Subgrade is the top of the Drainage Layer. The Lower Subgrade design CBR shall be 3%.

d) Both Controlled Subgrade and Capping Layer are required

i) Where the Working Platform thickness (selected by the Contractor or minimum specified) and Capping Layer thickness equals or exceed the required Controlled Subgrade thickness, no additional material is required.

ii) Where the Working Platform thickness (selected by the Contractor or minimum specified) and Capping Layer thickness is less than the required Controlled Subgrade thickness, increase thickness of Working Platform and/or add Controlled Fill or Treated Material to make up required Controlled Subgrade thickness as appropriate.

e) Both Controlled Subgrade and Drainage Layer are required

i) Where the Working Platform thickness (selected by the Contractor or minimum specified) and Drainage Layer thickness equals or exceeds the required Controlled Subgrade thickness, no additional material is required.

ii) Where the Working Platform thickness (selected by the Contractor or minimum specified) and Drainage Layer thickness is less than the required Controlled Subgrade thickness, increase thickness of Working Platform and/or Drainage Layer and/or add Controlled Fill or Treated Material to make up required Controlled Subgrade thickness as appropriate.

f) Controlled Subgrade, Capping Layer and Drainage Layer are required

i) Where the required Capping Layer thickness is greater than the Drainage Layer thickness (note from (e) that the overall Capping Layer thickness applies):

- if the Working Platform thickness (selected by the Contractor or minimum specified) and Capping Layer thickness equals or exceeds the required Controlled Subgrade thickness, no additional material is required.
- if the Working Platform thickness (selected by the Contractor or minimum specified) and Capping Layer thickness is less than the required Controlled Subgrade thickness, increase the thickness of the Working Platform and/or add Controlled Fill or Treated material to make up required Controlled Subgrade thickness as appropriate.

ii) Where the required Capping Layer thickness is less than or equal to the Drainage Layer thickness (note from (e) that the Drainage Layer thickness applies):

© The State of Queensland, Queensland Department of Main Roads

- if the Working Platform thickness (selected by the Contractor or minimum specified) and Drainage Layer thickness equals or exceeds the required Controlled Subgrade thickness, no additional material is required.
- if the Working Platform thickness (selected by the Contractor or minimum specified) and Drainage Layer thickness is less than the required Controlled Subgrade thickness, increase the thickness of the Working Platform, Drainage Layer and/or add Controlled Fill or Treated material to make up required Controlled Subgrade thickness as appropriate.

5.5 Materials

5.5.1 Controlled Fill Materials

Where Controlled Fill Material is required and used, the material shall comply with the following:

a) General Fill Material - Class B as specified in MRS 11.04; and,

b) Additional requirements as specified in Table 5.5-1 below.

Table 5.5-1 Controlled Fill Material Requirements

Property	Component Depth[1] below the Working Platform	
	≤ 150 mm	> 150 mm
Laboratory CBR[2]	Minimum 8%	Minimum 8%
Maximum aggregate size	75 mm	75 mm
WPI	< 1200	< 2200
Swell[3]	≤ 0.5%	≤2.5%
Passing 0.075 mm	4 – 30 % inclusive	4 – 30 % inclusive
PI	> 4	> 4

Notes:

1) Thickness of Controlled Subgrade is specified in Clause 5.3. This Table provides the material properties of the Controlled Fill components, if required, of the specified Controlled Subgrade thickness

2) Tested at maximum dry density, optimum moisture content, 4.5 kg surcharge and 10 day soaked CBR. Material may be chosen with a maximum CBR up to 15.0 % along with the associated influence on overall design if this is considered to provide a better complete design solution.

3) Tested at optimum moisture content, maximum standard density, 10 day soaked CBR and 4.5 kg surcharge.

5.5.2 Treated Materials

5.5.2.1 Lime Modification

Lime modification may be employed provided that the material to be treated has the following characteristics:

a) plasticity index > 30;

b) percentage passing 0.075 mm sieve > 25 %; and,

c) lime reacts as determined by Test Method Q133;

d) soluble sulphate does not exceed 0.2%;

e) the material can be worked with a 275 ± 25 Brake Horse Power purpose-built stabilising machine with assistance by prior ripping with a grader utilising rear-mounted rippers; and,

f) material to be treated has a maximum aggregate size of 75 mm.

Where the material complies with the above, stabilise with the amount of lime determined from the following, whichever is the greater:

a) to satisfy the lime demand requirements (Test Method Q133);

b) not less than 3% by mass of lime; or,

c) to achieve a minimum UCS of 1 MPa in 14 day

Treatment is to be carried out with a purpose built minimum 275 ± 25 Brake Horse Power purpose-built stabilising machine with assistance by prior ripping with a grader utilising rear-mounted rippers in accordance with MRS 11.07 and at least three passes of the stabilization machine, as follows:

a) Pass 1 with no additive;

b) Pass 2 with half the additive followed by a two day delay; and,

c) Pass 3 with the remaining additive.

5.5.2.2 Cement Modification

Cement modification may be employed provided that the material to be treated has the following characteristics:

a) Plasticity index ≤ 10;

b) Percentage passing the 0.075 mm sieve ≤ 25;

c) Maximum aggregate size is 75 mm;

d) In-situ material can be treated with a 275 ± 25 Brake Horse Power purpose-built stabilising machine with assistance by prior ripping with a grader utilising rear-mounted rippers

Where the in-situ material does not comply with the above but has PI ≤ 30 and percentage passing the 0.075 mm sieve ≤ 25 % it can be stabilised with lime as per clause 5.2.3 and then stabilised with cement.

In-situ stabilization is to be with a minimum 275 ± 25 Brake Horse Power purpose-built stabilising machine with assistance by prior ripping with a grader utilising rear-mounted rippers and in accordance with MRS 11.07 using a cementitious blend of cement and 25 % fly ash to achieve a 7 day UCS of between 1 and 2 MPa but not less than 1.0 % of additive.

Plant mix stabilization is to be in accordance with MRS 11.08 utilising a minimum Type 2.5 material in accordance with MRS 11.05 to achieve a 7 day UCS of between 1 and 2 MPa but not less than 1.0 % of additive.

5.5.3 Drainage Materials

The drainage materials for the Drainage Layer shall consist of a geotextile wrapped (top, bottom and all sides) layer of 300 mm thick high permeability aggregate.

The geotextile shall be non-woven in accordance with MRS 11.03 Clause 31.6 and shall be placed at the bottom of the excavation and wrapped around and over the Drainage Layer.

The drainage material shall consist of the following:

a) a gap-graded crushed rock with a minimum permeability of 1000 µm/s;

b) a minimum 4-day soaked CBR (OMC:MDD) of 30%;

© The State of Queensland, Queensland Department of Main Roads

c) a grading as per Table 5.5-2;

d) 10 % Fines Value > 100 kN;

e) Wet/Dry strength variation < 30%;

f) Degradation Factor > 50;

g) The drainage blanket material must not contain clay fines or silt.

h) The drainage blanket material must be placed and spread in such a way as to avoid segregation and to ensure that it is not contaminated with foreign materials.

Table 5.5-2 Drainage Layer: Particle Size Distribution

Sieve Size mm	125	19.0	1.18	0.075
Percent Passing by Mass	100	0 - 15	0 - 5	< 0.5%

6 Cutting in Rock

Cutting involving the excavation of a rock floor requires excavation to a tolerance of ± 75 mm and backfilling with an average 200 mm cement stabilised material.

The stabilised backfill material shall be at least a Type 2.4 pavement material in accordance with MRS 11.05, stabilised with cementitious blend (25 percent fly ash) to achieve a 7 day UCS between 1 and 2 MPa and constructed in accordance with MRS 11.08. It shall be primed with an AMCOO prime and sealed with Class 170 bitumen and 10 mm cover aggregate. The surface tolerance shall be ±15 mm.

7 Temporary Pavements

7.1 General

Temporary pavements are those with a maximum life of 2 years and are used for such applications as sidetracks and temporary structures on new, reconstructed and/or rehabilitated works.

Temporary pavements in accordance with this supplementary specification are not intended for, not designed for and must not be used for:

a) Traffic other than general public road traffic;

b) Haul roads;

c) Any other purpose after its primary design use, including but not limited to a local street, service road or access road. Its materials can be recycled for use in another pavement structure at that or another location provided the design is in accordance with unless it the Queensland Department of Main Roads Design System or Temporary Pavements;

d) Any life longer than 2 years.

Drainage Layer and Controlled Subgrade treatment requirements do not apply to Temporary Pavements except where they are required to achieve the functional requirements specified in Clause 9.3.2. Capping Layer requirements also apply to Temporary Pavements.

Pavements that are required for any other purpose than temporary pavements in accordance with the above requirements must be designed as a normal pavement in accordance with the Queensland Department of Main Roads Design System.

Materials used in Temporary Pavement may be recycles into other structures including pavements if appropriate and in accordance with the relevant design requirements and specifications.

© The State of Queensland, Queensland Department of Main Roads

7.2 Design, Construction, Maintenance and Removal

The Contractor shall design, construct, maintain and, on termination of the use of the temporary pavements, remove all temporary pavements and associated temporary infrastructure such as drainage, signs, guideposts etc. The Contractor shall meet all associated costs including design, testing and delivery of test results, supply of materials and equipment, construction, monitoring, maintenance as required, and removal.

Pavement design and construction shall be in accordance with the current Queensland Department of Main Roads Design System except as provided in Clause 7.1 and within the constraints of Clause 7.3.

7.3 Requirements

7.3.1 General, Pavement Surface and Structural Minimum Requirements

Table 7.3-1 General Minimum Requirements

Item	Requirement
Lane width	Min 3.5 m
Shoulder width	Outer shoulder: minimum 3.0 m Inner Shoulder: minimum 1.0 m for 4 lanes or greater (2 lanes each way)
Cross-fall	3.0 % minimum
Horizontal and vertical alignment	Minimum for 100 km/hr design speed unless specified otherwise in the Addendum
Flood Immunity	Minimum Q50 unless specified otherwise in the Addendum
Design traffic loading	Determined by the contractor for the service life of the temporary pavement.
Lane availability	Unless specified otherwise in the Addendum, 2 lanes to be available in each direction, at all times except for the maximum delays due to servicing as specified below. Monday to Friday 7.0 am to 9 am and 4.30 pm to 6.0 pm: 0 minutes 9.0 am to 4.30 pm, 6.0 pm to 10.0 pm: 15 minutes 10.0 pm to 7.0 am: 30 minutes with two days warning by signs otherwise 15 minutes. Saturday 8.0 am to 9 am : 0 minutes; 9.0 am to 5.0 pm: 15 minutes 5.0 pm to 8.0 am: 30 minutes with two days warning by signs otherwise 15 minutes. Sunday 8.0 am to 10.0 pm: 15 minutes 10.0 pm to 8.0 am: 30 minutes with two days warning by signs otherwise 15 minutes
Delineation and	Queensland Manual of Uniform Traffic Control Requirements, standard

traffic control	specifications and drawings, and the Contractor's site safety plan.
Road furniture including signs, delineation, fencing etc.	Queensland Department of Main Roads specifications and manuals.

Table 7.3-2 Pavement Surface and Structure: Minimum Requirements

Situation	Rural		Urban
	AADT < 5,000	AADT ≥ 5,000	All AADT
	Pavement Surface		
Water film thickness and/or high rainfall is an issue or posted speed ≥ 80 km/h	Two Coat bitumen seal	Open Graded Asphalt over min. 40 mm size 14 mm asphalt	Open Graded Asphalt over min. 40 mm size 14 mm asphalt
Posted speeds of < 80 km/h and water film thickness and/or high rainfall is not an issue	Two Coat bitumen seal	Minimum 50 mm Size 14 mm asphalt	Minimum 50 mm Size 14 mm asphalt
	Pavement Structure		
Where rain is likely during construction	Cement stabilised min. 2 MPa: Pre-crack only	Cement stabilised min. 2 MPa: Pre-crack only	Cement stabilised min. 2 MPa: Pre-crack only
Where rain is unlikely during construction	Unbound Granular	Cement stabilised min. 2 MPa: Pre-crack only	Cement stabilised min. 2 MPa: Pre-crack only
General	The above may be replaced by full depth asphalt, with the relevant asphalt surface from the above table, in accordance with the Queensland Department of Main Roads Pavement Design System. The minimum cover thickness over stabilised layers to minimize reflective cracking shall not apply to Temporary Pavements.		
Asphalt Surfaces	All asphalt surfaces shall have a 14 mm cover aggregate seal and prime beneath the surface asphalt.		

The pavement shall not be opened to traffic until the pavement surface has complied with Main Roads Pavement Safety requirements and policy. A check independent of and in addition to any other quality system requirement shall be carried out for: cross-fall, surface texture, skid resistance, superelevation and transitions, water film thickness, signage and delineation.

All asphalt shall comply with the requirements of Supplementary Specification MRSS 11.01.003.

7.3.2 Functional Requirements

The pavement shall comply with the functional requirements of Table 7.3-3 below.

Notwithstanding the specified conformance testing to be carried out by the Contractor given in Table 9.3-3, audit testing may be carried out by the Principal at any time.

Table 7.3-3 Functional Requirements

Functional Requirement	Test Method	Test Frequency	Limit
		All within one week after initial construction and then repeated within the periods given below that are the maximum period from the previous assessment	
Roughness	QDMR QC 708	3 months	max. 60
Rutting		3 months	max. 10 mm
Texture	QDMR QC 705	3 months	min. 0.7 mm
Cracking		3 months	Max. 5 m > 1 mm
Potholing		3 months	max. 20 mm diam. and/or 10 mm deep
Ravelling		3 months	< 5 %
Loose stones		3 months	zero
Flushing		3 months	< 5 %
Water ponding		3 months	zero

7.3.3 Pavement Design

Any temporary pavement design shall be independently reviewed at least 10 working days before construction commences.

Hold Point

8 Tolerances

8.1 General

Notwithstanding the requirements in any standard specification, the tolerances in Table 8.2-1 shall apply so that the actual height of the top of any layer shall be within the primary tolerance of the specified height.

8.2 Tolerances

Table 8.2-1 Construction Tolerances Assumed in Design

Layer/ Location	Primary tolerance (applied to the height of any point on the surface of the layer)
All asphalt layers	± 10 mm
All concrete layers (including lean mix concrete)	± 10 mm
All cementitiously stabilised layers	± 15 mm

© The State of Queensland, Queensland Department of Main Roads

Working platform	± 10 mm
Drainage Layer	± 15 mm
Controlled Fill	± 15 mm
Controlled Subgrade	± 15 mm
Capping Layers	± 15 mm
Lower Subgrade	± 15 mm
Insitu Subgrade Level	± 15 mm

9 Quality

9.1 General

The requirements below represent an absolute minimum testing program. The Contractor remains responsible for performing sufficient tests and inspections to ensure that the lot complies with all the standards and requirements of the specifications.

There are two levels of minimum testing frequencies given below. The Reduced Level shall apply after no non-conformances have been detected in two consecutive lots. As stated above, these are absolute minimum levels and the Contractor should be testing more frequently where necessary (particularly at the commencement of new activities).

Where a Contractor is operating at the Reduced Level and a non-conformance occurs for any standard or requirement for a lot, the Contractor shall immediately go back to the Normal Level of testing until no non-conformances have been detected in two consecutive lots.

9.2 Audit

An independent audit, employed and funded by the owner, shall be carried out at intervals of no less than 2 months and involving no less than 20% of the Contractor's records and no less than 10% parallel complete testing, all selected randomly.

9.3 Homogeneous Lots

This specification is based on the use of lots, which are homogeneous (in the context of the specification requirements), identifiable quantities defined in forms such as:

a) length, e.g. linear metres

b) area, e.g. square metres

c) volume, e.g. cubic metres

d) mass, e.g. tonnes

e) units of manufacture, such as batches, etc.

f) of items \and material types identified by name and specification requirements such as:

g) controlled subgrade

h) in situ stabilisation

i) lime

j) fly ash

from which samples are taken and about which decisions are made on the basis of such processes as:

a) tests

b) inspections

© The State of Queensland, Queensland Department of Main Roads

c) test procedures

d) observations

e) auditing

Lot sizes are given in this Addendum.

The minimum and/or maximum lot sizes and/or testing frequencies given in this Addendum are not sufficient to check the lot for homogeneity. The Contractor should check for homogeneity on a regular basis but not less than the frequency given in this Addendum. The lot can be audited for homogeneity at any time.

Homogeneity can be assessed by utilisation of the specification requirements for the particular item or material and by:

a) conducting a statistically significant number of tests, at least 30; and/or

b) subdividing the initially chosen lot in any number and size of smaller lots and testing each smaller lot as required, and in accordance with the minimum testing frequencies given in this Addendum.

9.4 Insitu Untreated Subgrade

Lot Size

Homogenous sections with:

a) a maximum length of 1000 m; and,

b) a minimum of one lot per roundabout and minimum of one lot per intersection.

Test Frequency

Location	Property	Test Frequency	
		Normal	Reduced
All sections	Tests as per Clause 2 of this specification, except California Bearing Ratio	five 60 kg samples	five 60 kg samples
All sections	Tests as per Clause 2 of this specification, California Bearing Ratio	two 60 kg samples	two 60 kg samples
All sections	Test as per Clause 2 of this specification, Lime Demand Testing	sample required for Test Method Q133	sample required for Test Method Q133
All sections	Tests as per Clause 2 of this specification, except California Bearing Ratio	See Note 1 below.	

Note 1

In addition to the tests specified in Clause 9.4 and where the material in the in-situ subgrade is other than rock, the Contractor shall determine the in-situ CBR of the top 500 mm of the in-situ untreated Subgrade with a dynamic cone penetrometer (minimum three tests). The lots tested are to be selected so that they are homogeneous, and shall be no longer than 1000 m

© The State of Queensland, Queensland Department of Main Roads

in chainage, with a minimum of one per roundabout and one per intersection and the same lot boundaries as in Clause 2.2.

9.5 Controlled Fill, Drainage Layer

Lot Size

Homogenous sections no longer than 500 m, with a minimum of one lot per roundabout and minimum of one lot per intersection for in-situ material or every 1000 tonnes for imported material.

Test Frequency

Location	Property	Test Frequency	
		Normal	Reduced
In-situ	All specified properties	1 of each / 100 m	1 of each / 500 m
Imported	All specified properties	1 of each/ 10 tonne	1 of each/ 20 tonne

9.6 Stabilisation

9.6.1 In-situ Stabilised Materials

Lot Size

1,000.00 m^2

Test Frequency

Property	Test Frequency per Lot	
	Normal	Reduced
Material properties	5	1
Constructed Thickness	10	2
Additive Content	5	2

9.6.2 Plant Mix Stabilised Materials

Lot Size

20.00 m^3

Test Frequency

Property	Test Frequency per Lot	
	Normal	Reduced
Material properties	3	1
Constructed thickness (??)	3	2
Additive Content	2	2

© The State of Queensland, Queensland Department of Main Roads

9.7 Geometrics: All Materials

Lot Size

Continuous

Test Frequency

Property	Test Frequency	
	Normal	Reduced
Horizontal Dimensions		
Vertical, Height Control		
Height	All grid points[1]	all grid points[1]
Straight-edge		
Crossfall	1 per 10 metre	1 per 20 metre

Note 1: Unless specified otherwise, at least each lane and shoulder centre line, LHS and RHS at 25 metre intervals

9.8 Working Platform

Lot Size

300 m^3 maximum

Testing Frequency

Property	Test Frequency per Lot	
	Normal	Reduced
Material properties	3	1
Constructed thickness ??	3	2
Additive Content	2	1

9.9 Verge

Lot Size

500 m^3 maximum

Testing Frequency

Property	Test Frequency per Lot	
	Normal	Reduced
Material properties	3	1
Constructed thickness???	3	1

© The State of Queensland, Queensland Department of Main Roads

9.10 Compaction Standard: All Materials

Lot Size

A continuous single layer produced in a continuous operation in one day.

Test Frequency

Property	Test Frequency	
	Normal	Reduced
Compaction in Lots using Nuclear Gauge	1 per 200 m^3 with a minimum of 10	1 per 300 m^3 with a minimum of 10
Compaction in Lots, Sand Replacement	1 per 400 m^3 with a minimum of 7	1 per 600 m^3 with a minimum of 7

9.11 Homogeneity

Homogeneity shall be checked for every 60th lot.

10 Administration

10.1 Work Items

Measurement for payment clauses are in the referenced specifications except for:

a) the testing of the In-situ Subgrade, Lower Subgrade?? and Controlled Fill??; and

b) references to work operations in Clause 11.2

The work items covered by this specification are listed in Table 11.1-1.

Allan I think these work items need to be edited. Lower subgrade is a term we use for pavement design purposes it is not physical entity. Similarly for Controlled Subgrade. Should the work items be changed to 'Controlled Fill", "Capping Layer", "Stabilised Subgrade" etc

Table 10.1-1 Work Items

Item Number	Description	Specification	Unit
	Testing of In-situ Subgrade	herein	set of tests as per Clause 2
	Testing of Drainage Layers??	herein	set of tests as per Clause 2
	Testing of Capping Layers??	herein	set of tests as per Clause 2
	Testing for Lime Demand and Soluble Sulphate	herein	test as per Clause 2
	Treatment of Rock Cutting	herein	m^3
	Drainage Layer	herein	m^3
	Controlled Fill	herein	m^3
	Capping Layer	herein	m^3

© The State of Queensland, Queensland Department of Main Roads

	Working Platform	herein	m^2
	Verge Material	MRS 11.04 and herein	m^3
	Temporary Pavements	herein	m^2

10.2 Work Operations

10.2.1 Introduction

Work operations common to all work items are given in MRS 11.01. Work operations specific to the work items covered by this specification are given in Clause 1.2.3.

All work items are to be completed in accordance with:

a) this supplementary specification; and

b) other specifications as identified in this supplementary specification.

10.2.2 Testing of In-situ Subgrade

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Provision of all labour and equipment;

b) Provision, calibration and maintenance of laboratory facilities.

c) Sampling, testing and quality assurance requirements as per the sampling and testing requirements;

d) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified.

10.2.3 Testing of Lower Subgrade to Determine Design CBR (Activities from testing the in-situ subgrade may contribute to this)

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Provision of all labour and equipment;

b) Provision, calibration and maintenance of laboratory facilities;

c) Sampling, testing and quality assurance requirements as per the sampling and testing requirements;

d) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified.

10.2.4 Testing for Lime Demand and Soluble Sulphate

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Provision of all labour and equipment;

b) Provision, calibration and maintenance of laboratory facilities;

c) Sampling, testing and quality assurance requirements as per the sampling and testing requirements;

d) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified.

© The State of Queensland, Queensland Department of Main Roads

10.2.5 Treatment in Rock Cuttings

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Loosening in situ material;

b) Excavating, loading, hauling and unloading loosened material;

c) Any additional stockpiling, reloading, hauling and unloading of excavated material as required to deliver the material to its final point of placement;

d) Disposing or otherwise using excavated material;

e) Compacting material at the bottom of excavations;

f) Supply, delivery and placement of all materials;

g) Stabilization;

h) Provision of all materials, labour and equipment;

i) Trimming;

j) Priming and sealing;

k) Provision, calibration and maintenance of laboratory facilities;

l) Sampling, testing and quality assurance requirements as per the sampling and testing;

m) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified; and,

n) Additional work as required complying with the requirements of this supplementary specification.

10.2.6 Drainage Layer

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Loosening in situ material;

b) Excavating, loading, hauling and unloading loosened material;

c) Any additional stockpiling, reloading, hauling and unloading of excavated material as required to deliver the material to its final point of placement;

d) Disposing or otherwise using excavated material;

e) Compacting material at the bottom of excavations;

f) Supply, delivery and placement of all materials;

g) Stabilization if selected;

h) Provision of all materials, labour and equipment;

i) Trimming;

j) Provision, calibration and maintenance of laboratory facilities;

k) Sampling, testing and quality assurance requirements as per the sampling and testing;

l) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified.

m) Finishing batters; and,

n) Additional work as required complying with the requirements of this supplementary specification.

© The State of Queensland, Queensland Department of Main Roads

10.2.7 Controlled Fill

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Loosening in situ material;

b) Excavating, loading, hauling and unloading loosened material;

c) Any additional stockpiling, reloading, hauling and unloading of excavated material as required to deliver the material to its final point of placement;

d) Disposing or otherwise using excavated material;

e) Compacting material at the bottom of excavations;

f) Supply, delivery and placement of all materials;

g) Stabilization if selected;

h) Provision of all materials, labour and equipment;

i) Trimming;

j) Provision, calibration and maintenance of laboratory facilities;

k) Sampling, testing and quality assurance requirements as per the sampling and testing;

l) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified.

m) Finishing batters; and,

n) Additional work as required complying with the requirements of this supplementary specification.

10.2.8 Working Platform

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Design, construction, monitoring, and maintenance such that the Working Platform meets all performance requirements detailed in this specification;

b) Provision of all materials, labour and equipment;

c) Stabilization;

d) Provision, calibration and maintenance of laboratory facilities;

e) Sampling, testing and quality assurance requirements as per the sampling and testing requirements;

f) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified;

g) Delivery of performance requirements.

10.2.9 Verge

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Excavation (where required) including loading, hauling and disposal of excavated materials;

b) Supplying and placing controlled verge material from stockpiles and/or borrow areas on or off site as required;

c) Spreading, compacting and finishing verge material;

© The State of Queensland, Queensland Department of Main Roads

d) Provision of all materials, labour and equipment;

e) Provision, calibration and maintenance of laboratory facilities;

f) Sampling, testing and quality assurance requirements as per the sampling and testing requirements;

g) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified.

h) Finishing batters; and,

i) Additional work as required to comply with the requirements of this supplementary specification.

10.2.10 Temporary Pavements

The Contractor is responsible for all costs associated with carrying out the Works including the following:

a) Design, construction, monitoring, maintenance and removal of temporary pavements (including drainage) such that they meet all performance requirements;

b) Provision of all materials, labour and equipment;

c) Stabilization

d) Provision, calibration and maintenance of laboratory facilities;

e) Sampling, testing and quality assurance requirements as per the sampling and testing requirements;

f) Delivery of the results of all tests and inspections, including monitoring testing, within the time specified;

g) Maintenance of performance requirements.

10.3 Measurement for Payment

Measurement for payment is on the basis of the completion of each set of tests as defined in Clause 2.

© The State of Queensland, Queensland Department of Main Roads

11 ADDENDUM

Supplementary Specification MRSS.01.001

Specific Contract Requirements

Project Name: _____

11.1 Sub-Items (if any)

Sub-item Number	Description	General Location	Unit

11.2 Project Specific Requirements (if any)

© The State of Queensland, Queensland Department of Main Roads

MRSS.01.003

Supplementary Specification Heavy Duty Asphalt

February 2006

Queensland Department of Main Roads

© The State of Queensland, Queensland Department of Main Roads

Contents

Page

1 GENERAL 1

1.1 SCOPE 1
1.2 DEFINITION OF TERMS 1
1.2.1 General 1
1.3 GENERAL REQUIREMENTS FOR ASPHALT 2
1.3.1 Introduction 2
1.3.2 Water 2
1.3.3 Trafficking 2

2 OPEN GRADED ASPHALT 3

2.1 GENERAL 3
2.1.1 Specification 3
2.1.2 Application 3
2.1.3 Associated Requirements 3
2.2 ASPHALT PROPERTIES 3
2.2.1 General 3
2.2.2 Binder 3
2.2.3 Aggregate 4
2.2.4 Particle Coating 4
2.3 ASPHALT MANUFACTURE AND PLACEMENT 4
2.4 SURFACE EVENNESS 4

3 DENSE GRADED ASPHALT: SIZE 14 MM 4

3.1 GENERAL 4
3.1.1 Specification 4
3.1.2 Application 4
3.1.3 Associated Requirements 5
3.2 MIX NOMINAL SIZE AND DESIGNATION 5
3.3 BINDER 5
3.4 AGGREGATES 5
3.5 ASPHALT PROPERTIES 5
3.5.1 General 5
3.5.2 Air Voids 5
3.5.3 Binder Film Thickness 5
3.5.4 Particle Coating 5
3.5.5 Laboratory Compaction 5
3.5.6 Marshall Stability 5
3.5.7 Air Voids at Maximum Cycles 5
3.5.8 Stripping 6
3.5.9 Dynamic Creep 6
3.5.10 Resilient Modulus 6
3.5.11 Wheel Tracking 6

4 BASE ASPHALT LAYER 6

4.1 GENERAL 6
4.1.1 Specification 6
4.1.2 Application 6
4.1.3 Associated Requirements 6
4.2 MIX NOMINAL SIZE AND DESIGNATION 6
4.3 BINDER 7
4.4 AGGREGATES 7
4.5 ASPHALT PROPERTIES 7
4.5.1 General 7
4.5.2 Air Voids 7

© The State of Queensland, Queensland Department of Main Roads

4.5.3 Binder Film Thickness *7*
4.5.4 Particle Coating *7*
4.5.5 Marshall Stability *7*
4.5.6 Air Voids at Maximum Cycles *7*
4.5.7 Stripping *7*
4.5.8 Resilient Modulus *7*
4.5.9 Wheel Tracking *7*

5 BINDER **8**

5.1 SBS POLYMER MODIFIED 8
5.1.1 General *8*
5.1.2 Mixing Requirements *8*
5.1.3 Properties *8*
5.1.4 Sampling and Testing *8*
5.1.5 Transport and Storage *9*

6 AGGREGATES AND FILLER **9**

6.1 COARSE AGGREGATE 9
6.2 FINE AGGREGATE 10
6.3 COMBINED AGGREGATE 10
6.4 FILLER 10

7 CONSTRUCTION PROCESS REQUIREMENTS **11**

7.1 COLD PLANING 11
7.1.1 Removal of Material *11*
7.1.2 Surface Texture *11*
7.1.3 Thickness of Replacement Asphalt *11*
7.2 TEXTURING OF EXISTING SURFACE 11
7.2.1 General *11*
7.2.2 Self-Propelled Machine Texturing *11*
7.2.3 Hand-Operated Machine Texturing *12*
7.2.4 Retexturing *12*
7.2.5 Removal of Loose Material *12*
7.2.6 Damaged Surfaces *12*
7.3 JOINING NEW WORK TO EXISTING WORK 12
7.4 EXISTING STRUCTURES 12
7.5 TACK COATING 12
7.6 LAYING OF ASPHALT 13
7.6.1 Laying Requirements *13*
7.6.2 Plant Requirements *13*
7.7 SURFACE CONDITION 13
7.8 CONSTRUCTION LAYER THICKNESS LIMITS 14
7.8.1 Compaction of Asphalt with a Polymer Modified Binder *14*
7.9 JOINTS 14
7.9.1 General *14*
7.9.2 Longitudinal Joints *15*
7.9.3 Transverse Joints *16*
7.9.4 Compaction Standard, Joints *16*
7.10 PAVEMENT CLEANLINESS 16
7.11 MAINTENANCE OF THE SUBGRADE AND/OR THE PAVEMENT COURSES 16

8 QUALITY **17**

8.1 CHARTS 17
8.2 LOT SIZES AND TESTING FREQUENCIES 17
8.2.1 General *17*
8.2.2 Homogeneous Lots *18*
8.2.3 Coarse Aggregate *18*
8.2.4 Fine Aggregate, Source Rock from a Quarry Source *19*

© The State of Queensland, Queensland Department of Main Roads

8.2.5 Fine Aggregate, All Sources *19*
8.2.6 Combined Filler *20*
8.2.7 Production Asphalt *20*
8.2.8 Binder *21*
8.2.9 Placed Asphalt Geometrics *22*
8.2.10 Compaction Standard *22*
8.2.11 Homogeneity *23*

9 ADMINISTRATION **23**

9.1 ITEMS 23
9.2 WORK OPERATIONS 23

10 ADDENDUM **1**

10.1 SUB-ITEMS 1
10.2 DETAILS 1
10.2.1 Tack Coat *1*
10.2.2 Surface Preparation *1*
10.2.3 Paver Level Control *1*
10.2.4 Corrector Course *2*
10.2.5 Height or Thickness Control *2*

© The State of Queensland, Queensland Department of Main Roads

1 General

1.1 Scope

This supplementary specification covers all the asphalt to be used in Queensland Department of Main Roads (QDMR) Heavy Duty Pavement Design in accordance with the 2005 amendments to the Queensland Transport Pavement Design Manual. The asphalt includes:

a) Open graded asphalt, with the modified requirements in this supplementary specification;

b) DG14 asphalt, with the modified description and the modified requirements in this supplementary specification; and,

c) DG20 asphalt, with the modified description and the modified requirements in this supplementary specification.

Stone Mastic Asphalt is not included in Heavy Duty Pavement Design.

This specification has been developed for QDMR purposes and intents including but not limited to:

a) Level of risk adopted by QDMR;

b) Integration with the QDMR design systems, other specifications, drawings and test methods;

c) QDMR Quality assurance systems; and,

d) Subject to the use of and compliance with the conditions and context of the Queensland Department of Main Roads Pavement Design System as defined in the Definition of Terms in this document.

The development of this specification has been based on QDMR experience and provides the best performance for the particular need based on this experience. It does not directly provide any performance or functional requirements or outcomes including but not limited to fatigue, stripping, rutting, oxidation, skid resistance, texture depth and permeability. Provision and maintenance of these requirements require specific project design and controls and in-service monitoring and treatment including but not limited to drainage, cross-fall, speed restriction (temporary or permanent), texturing and/or application of high friction aggregate.

This specification, or any part of this specification, has not been developed for, and is not suitable for, any other purpose.

1.2 Definition of Terms

1.2.1 General

The terms in this specification shall be as defined in Table 1.3-1, MRSS.01.001: Supplementary Specification; Checking Subgrade, Capping Layer, Drainage Layer, Controlled Subgrade, Working Platform, Temporary Pavement, Verge and in the MRS specifications, with possible conflict of definition being resolved in accordance with the provisions of MRS11.01.

Table 1.2-1 Definition of Terms

Term	Definition
Weighted Plasticity Index	The product of the Plasticity Index and percentage passing the AS 0.425 mm sieve

© The State of Queensland, Queensland Department of Main Roads

Term	Definition
(WPI)	

1.3 General Requirements for Asphalt

1.3.1 Introduction

These general requirements apply to all asphalt types.

The locations of the types of asphalt specified in this supplementary specification are shown on the Drawings for the Works.

This specification does not cover any aspect of asphalt placed on concrete. Where asphalt is to be placed on concrete, additional requirements to provide an adequate bond between the asphalt and the concrete are required. This specification does not include these additional requirements.

1.3.2 Water

Water shall not be applied to asphalt for any purpose, including cooling except that it may be added directly to roller tyres for cooling of those tyres with a minimum amount of water falling onto the asphalt.

1.3.3 Trafficking

1.3.3.1 Structural Requirements

The asphalt pavement shall not be trafficked, unless the requirements in the next paragraph are approved by the Superintendent, until the final surface layer has been placed except for construction traffic required for the placement of asphalt or a tack coat or a seal at the immediate area of placement and 500 m either side of that area. Until the seal beneath the surface course has been placed, no asphalt shall be uncovered for more than 5 calendar days.

Traffic may use the lower layers of a pavement provided:

a) Design calculations using the load spectrum for the traffic that is to be applied, termed the design construction traffic load intensity, are carried out to determine the additional layer thicknesses required to ensure there is no loss to the original design life;

b) Any increase in surface height is acceptable;

c) The design is checked and approved by the Superintendent;

d) The additional thicknesses are incorporated at no additional cost and any other resulting work (including lowering the subgrade and/or changing drainage and/or regrading the surface) is carried out at no additional cost;

e) Traffic use is continuously monitored and the design construction traffic load intensity is not exceeded. Use to the lower layers shall cease immediately when the design construction load intensity is reached.

f) The pavement layer is protected from the ingress of water by at least a polymer modified seal, as specified below except that the spray rate shall not be a minimum of 1.5 litres per m^2 but shall be determined to suite the need, with 14 mm a cover aggregate.

A seal shall be provided immediately beneath all final surface layers, including but not limited to:

- Open graded asphalt;
- Dense graded asphalt.

© The State of Queensland, Queensland Department of Main Roads

The seal shall comprise:

a) An S20E polymer modified binder or an S10E polymer modified binder in the colder period of the year;

b) Size 14 mm cover aggregate;

c) A spray rate to accommodate the traffic that will use the seal, the aggregate size and the nature of the underlying layer, but not less than 1.0 litres per m^2.

d) A maximum of 2.0 % cutting oil unless the asphalt surfacing is delayed by a minimum of 3 months.

1.3.3.2 Safety Requirements

The pavement shall not be opened to traffic until the pavement surface has complied with Main Roads pavement surface safety requirements and policy. A check independent of and in addition to any other quality system requirement shall be carried out for: cross-fall, surface texture, skid resistance, superelevation and transitions, water film thickness, signage and delineation.

2 Open Graded Asphalt

2.1 General

2.1.1 Specification

Open graded asphalt shall comply with specification MRS11.34 and the overriding and additional requirements of this supplementary specification.

2.1.2 Application

Open graded asphalt shall be used as the surface course except in areas of high shear including, but not limited to: curves, roundabouts, gradients and intersections.

2.1.3 Associated Requirements

A seal must be placed beneath the open graded asphalt as specified in the general requirements.

Open graded asphalt may have a relatively short life and will need to be milled and replaced at regular intervals.

The voids in open graded asphalt will gradually be filled during service. Open graded asphalt requires regular cleaning to maintain its original characteristics.

2.2 Asphalt Properties

2.2.1 General

The following changes and additions to the requirements of specification MRS11.34 shall apply:

2.2.2 Binder

The binder shall be a styrene butadiene styrene (SBS) A15E polymer modified binder complying with the requirements of Austroads Technical Report AP-T41/06, Specification Framework for Polymer Modified Binders and Multigrade Bitumens (2006), and Clause 5 of this supplementary specification. The target binder contents, air voids and binder film thicknesses shall be as per Table 2.2-1.

Table 2.2-1 Open Graded Asphalt: Target Mix Binder Limits

Property	Unit	Limit	OG10	OG14

© The State of Queensland, Queensland Department of Main Roads

Effective Binder Volume	%	Minimum	9.0	8.0
Free Binder Volume	%	Minimum	6.5	5.5
Binder Film Thickness	µm	Minimum	15.0	15.0
Air Voids	%	Minimum Maximum	12.0 17.0	12.0 17.0
Abrasion Loss	%	Maximum	30	30
Binder Drainage	%	Maximum	0.3	0.3

2.2.3 Aggregate

The aggregate shall comply with requirements of specification MRS11.34 as modified in Clause 6 of this supplementary specification.

2.2.4 Particle Coating

When tested in accordance with AS 2891.11, the degree of particle coating shall not be less than 99%.

2.3 Asphalt Manufacture and Placement

The maximum mixing temperature for asphalt containing SBS polymer modified binder shall be 175°C.

The surfacing layer shall be placed only when the pavement temperature is above 15°C. It shall not be placed during rain nor on a surface that has any moisture present. An emulsion tack coat shall be used at all times except where the seal has been placed on the same day. The spray rate shall be adjusted to suit the age and texture of the underlying surface.

2.4 Surface Evenness

The road roughness count rate of the asphalt surfacing shall be not more than 40 counts per kilometre when tested in accordance with Test Method Q708.

3 Dense Graded Asphalt: Size 14 mm (HS14)

3.1 General

3.1.1 Specification

Size 14 mm dense graded asphalt shall comply with specification MRS11.30 and the overriding and additional requirements of this supplementary specification.

3.1.2 Application

Size 14 mm dense graded asphalt is used:

a) As a binder layer (The layer immediately beneath the surfacing layer and a seal) in heavy-duty (deep strength or full depth asphalt) asphalt pavements.

b) As the layer immediately beneath an open graded asphalt and a seal in all cases including asphalt surfaced unbound granular pavements.

c) As a surfacing layer in areas of high shear or areas of high potential for rutting. At the time of publication of this supplementary specification, there was evidence that the current size 14 mm polymer modified dense graded asphalt is in the pessimistic voids range that allows the entry and possible retention of water. This is one of the factors that can cause stripping in asphalt. Consequently, if polymer modified size 14 mm asphalt is

© The State of Queensland, Queensland Department of Main Roads

used as a surface course, stripping could occur and the asphalt may have to be replaced at regular intervals.

3.1.3 Associated Requirements

When placed over older work, the existing surface must be textured in accordance with this specification.

When used as a surface layer, an adequate seal must be placed beneath the dense graded asphalt.

3.2 Mix Nominal Size and Designation

The mix which shall be used for the Works shall be polymer modified DG14HS (high strength) mix.

3.3 Binder

Binder to be used in an asphalt binder layer shall be styrene butadiene styrene (SBS) A15E polymer modified binder complying with the requirements of Austroads Technical Report AP-T41/06, Specification Framework for Polymer Modified Binders and Multigrade Bitumens (2006), and Clause 5 of this supplementary specification.

3.4 Aggregates

In addition to the aggregate requirements of specification MRS11.30, the requirements of Clause 6 apply.

3.5 Asphalt Properties

3.5.1 General

The following changes and additions to the requirements of specification MRS11.30 shall apply:

3.5.2 Air Voids

The target mix air voids shall be 4.5+/-0.5%.

3.5.3 Binder Film Thickness

The binder film thickness for the target mix shall not be less than 8.0 µm and for any tolerance mix shall not be less than 6.0 µm when tested in accordance with Test Method Q317.

3.5.4 Particle Coating

When tested in accordance with AS 2891.11, the degree of particle coating shall not be less than 99%.

3.5.5 Laboratory Compaction

The laboratory compaction standard shall be 75 blows Marshall (hand compaction).

3.5.6 Marshall Stability

The minimum Marshall stability shall be 11 kN.

3.5.7 Air Voids at Maximum Cycles

Three target mix test specimens shall be assessed for air voids, using gyratory compaction at 250 cycles in accordance with AS 2891.2.2. The air void content of each test specimen shall be determined in accordance with Test Methods Q306C, Q307A and Q311. At 250 cycles of gyratory compaction, the average air voids shall not be less than 2.5%.

© The State of Queensland, Queensland Department of Main Roads

3.5.8 Stripping

When tested in accordance with Test Method Q315, the tensile strength ratio shall not be less than 80%.

3.5.9 Dynamic Creep

For any asphalt with a polymer modified binder, dynamic creep testing in accordance with AS 2891.12.1 shall be carried out on asphalt at the target grading, with target binder content, 5+/- 0.5% air voids and with the binder to be used on the Works.

High strength asphalt shall exceed 90,000 pulses to 2% plastic strain and medium strength asphalt shall exceed 50,000 pulses to 2% plastic strain.

3.5.10 Resilient Modulus

The resilient modulus of the target mix shall be determined in accordance with AS 2891.2.1, AS 2891.2.2 (120 cycles) and AS 2891.13.1.

3.5.11 Wheel Tracking

Wheel tracking testing shall be carried out in accordance with the requirements of Q319 and Q320, using the Queensland Department of Main Roads wheel tracking tester on asphalt at the target grading, target binder content and target air voids, and with the binder to be used in the Works. The test conditions shall be as follows:

a) Temperature: 60^{o}C

b) Wheel load: 700 N

c) Wheel width: 50 mm

d) Wheel diameter: 200 mm

Slope assessment shall be by linear regression of the data between 2000 and 5000 cycles.

The asphalt shall have a maximum value of 0.07 mm/kilocycle.

4 Base Asphalt Layer

4.1 General

4.1.1 Specification

The asphalt base layer shall consist of dense graded asphalt complying with specification MRS11.30 and the overriding and additional requirements of this supplementary specification.

4.1.2 Application

Size 20 mm high modulus dense graded asphalt shall be used as a base layer in heavy-duty pavements (deep strength or full depth asphalt).

4.1.3 Associated Requirements

A binder layer, a seal and a surfacing layer or a seal and size 14 mm dense graded asphalt, shall always cover the high modulus base layer.

4.2 Mix Nominal Size and Designation

The 20 mm nominal size mix shall be used for these Works and shall be designated as DG20HM 600 (when using Class 600 bitumen) and DG20HM 320 (when using Class 320 bitumen).

© The State of Queensland, Queensland Department of Main Roads

4.3 Binder

Binder to be used in the DG20HM asphalt shall be Class 600 bitumen or Class 320 bitumen, complying with the requirements of MRS11.17.

4.4 Aggregates

In addition to the aggregate requirements of specification MRS11.30, the requirements of Clause 6 also apply.

4.5 Asphalt Properties

4.5.1 General

The following changes and additions to the requirements of specification MRS11.30 shall apply:

4.5.2 Air Voids

The target mix air voids shall be 4.5+/-0.5%.

4.5.3 Binder Film Thickness

The binder film thickness for the target mix shall not be less than 8.0 µm and for any tolerance mix shall not be less than 6.0 µm when tested in accordance with Test Method Q317.

4.5.4 Particle Coating

When tested in accordance with AS 2891.11, the degree of particle coating shall not be less than 99%.

4.5.5 Marshall Stability

The minimum Marshall stability shall be 7.5 kN.

4.5.6 Air Voids at Maximum Cycles

Three target mix test specimens shall be assessed for air voids, using gyratory compaction at 250 cycles in accordance with AS 2891.2.2. The air void content of each test specimen shall be determined in accordance with Q306C, Q307A and Q311. At 250 cycles of gyratory compaction, the average air voids shall not be less than 2.5%.

4.5.7 Stripping

When tested in accordance with Q315, the tensile strength ratio shall not be less than 80%.

4.5.8 Resilient Modulus

The resilient modulus of the target mix shall be not less than 5000 MPa as determined in accordance with AS 2891.2.1, AS 2891.2.2 (120 cycles) and AS 2891.13.1.

4.5.9 Wheel Tracking

Wheel tracking testing shall be carried out in accordance with the requirements of Test Methods Q319 and Q320, using the Queensland Department of Main Roads wheel tracking tester on asphalt at the target grading, target binder content and target air voids. The test conditions shall be as follows:

a) Temperature: 60^{o}C

b) Wheel load: 700 N

c) Wheel width: 50 mm

d) Wheel diameter: 200 mm

© The State of Queensland, Queensland Department of Main Roads

Slope assessment shall be by linear regression of the data between 2000 and 5000 cycles.

The asphalt shall have a maximum value of 0.2 mm/kilocycle.

5 Binder

5.1 SBS Polymer Modified

5.1.1 General

The Contractor shall formulate the polymer modified binder and also utilise the necessary mixing, handling, storing and, if necessary, remixing requirements to achieve the properties specified in Clause 5.1.3.

5.1.2 Mixing Requirements

5.1.3 Properties

The polymer modified binder for use in asphalt shall be a grade A15E complying with the requirements of Austroads Technical Report AP-T41/06, Specification Framework for Polymer Modified Binders and Multigrade Bitumens (2006), except that all specification limits are absolute and not subject to any negotiation and/or agreement as stated in some areas of AP-T41/06.

The polymer modified binder for use in seals shall be a grade S20E or a grade S10E for use in the colder period of the year complying with the requirements of Austroads Technical Report AP-T41/06, Specification Framework for Polymer Modified Binders and Multigrade Bitumens (2006), except that all specification limits are absolute and not subject to any negotiation and/or agreement as stated in some areas of AP-T41/06..

SBS polymer modified binder shall also be tested for segregation in accordance with Q345, and shall comply with the requirements of Table 5.1-1.

Table 5.1-1 Segregation Limits

Property	Test Method	Unit	Maximum Difference
Softening Point	Q334	^{o}C	7
Polymer Content	QT.STM 25	%	2.5

5.1.4 Sampling and Testing

Samples of polymer modified binder shall be sampled from the bottom of the storage tank after each delivered load and immediately prior to its incorporation into the production asphalt and then tested. The samples shall be taken at regular intervals, from the bottom of the storage tank. Sample size shall be a minimum of one litre.

As a minimum requirement, each sample shall be tested for softening point and torsional recovery and viscosity at 165 ^{o}C. One in three samples shall be randomly selected and tested for consistency at 60^{o}C and elastic recovery at 60^{o}C; and one in ten samples shall be randomly selected and tested for segregation as specified in Clause 5.1.3.

Additionally, from each delivery, two samples each of 2 litres shall be taken and labelled with the date, time, project and tanker registration. Each sample shall be signed by the Contractor and the superintendent's representative. One sample shall be held by the Contractor and one sample shall be forwarded to the Queensland Department of Main Roads laboratory at 35 Butterfield St. Herston for storage for at least 5 years. These samples are available for testing the properties of the binder.

© The State of Queensland, Queensland Department of Main Roads

5.1.5 Transport and Storage

The manufacturer of the polymer modified binder shall detail instructions for the transport and/or storage of the polymer modified binder to ensure that the property requirements of Clause 5.1.3 are achieved by the polymer modified binder used in the asphalt. These instructions shall be consistent with the polymer manufacturer's requirements, shall form part of the Contractor's quality plan and shall cover at least the following:

a) Circulation during transport and storage;

b) Remixing immediately prior to use;

c) Transport and/or storage limits related to binder temperature and time;

d) Transport and/or storage and/or circulation equipment requirements.

6 Aggregates and Filler

6.1 Coarse Aggregate

The modified and additional requirements for coarse aggregate are as given in Table 6.1-1 and 6.1-2.

Table 6.1-1 Modified Coarse Aggregate Requirements

Property	Test Method	Source Material Group					
		Acid Igneous	Inter-mediate Igneous	Basic Igneous	Meta-morphic	Sedi-mentary Duricrust	Natural Gravel
Ten Percent Fines Value (Wet) (kN) minimum	Q205B	130	140	150	140	130	130
Wet/Dry Strength Variation (%) maximum	Q205C	40	35	30	35	40	40
Degradation Factor minimum	Q208B	40	45	50	45	-	-
Crushed Particles (%) minimum	Q215	80	80	80	80	80	80

Flakiness Index (%) maximum	Q201A	25	25	25	25	25	25

Note: Greenstone may be used if it has a wet/dry strength variation of up to 50% provided it has a minimum 10% fines value of 210kN.

Table 6.1-2 Additional Coarse Aggregate Requirements

Property	Test Method	Unit	Limit	Value
Water Absorption	Q214B	percent	maximum	2
Finer than 0.075 mm Sieve	Q103A	percent	maximum	2[1]
Polished Aggregate Friction Value[2] All trafficked layers[3]	Q203	no.	minimum	48
Polished Aggregate Friction Value[2] All layers other than a trafficked layer[3].	Q203	no.	minimum	46
Weak Particles	Q217	percent	maximum	1

Notes

1: A maximum value of 25% shall apply where the clay index of the controlled filler is not greater than 18.

2: All aggregate shall be tested. Where aggregates are combined all the individual aggregate components shall be tested. and shall comply with the specified requirement.

3: For this specification requirement a trafficked layer includes any layer subject to any traffic other than construction traffic under the control of the constructor and subject to a maximum speed limit of 60 km per hour.

6.2 Fine Aggregate

The source rock for the fine aggregate shall comply with the requirements of the coarse aggregate.

6.3 Combined Aggregate

For the purpose of this project and notwithstanding the requirements of MRS 11.30, when tested in accordance with Q124, the combined coarse and fine aggregate (excluding added filler) shall have a sand equivalent value not less than 40.

6.4 Filler

Notwithstanding the requirements for filler in MRS11.30, when tested in accordance with Q129, the combined filler shall have a clay index value not greater than 2.2.

Hydrated lime must be included in all asphalt mixes and shall comprise 1.5% to 2% of the combined grading. It shall comply with the requirements of AS 1672.1.

© The State of Queensland, Queensland Department of Main Roads

7 Construction Process Requirements

7.1 Cold Planing

7.1.1 Removal of Material

The areas to be planed as shown on the Drawings shall be planed to the lines indicated thereon and to the specified depths or levels, using the approved planing equipment. The surface produced by planing shall be swept free of all loose material.

All removed and swept material shall be disposed of as given in the Addendum MRSS.01.003.

The use of heating equipment to soften the existing surface to facilitate removal shall not be permitted.

7.1.2 Surface Texture

The surface produced by the planing equipment shall have a coarse texture which is suitable for bonding to the new asphalt.

Areas of the existing surface which are damaged by the planing equipment or are a result of planing at a depth in excess of that specified shall be repaired by the Contractor at no additional cost to the Principal before the end of the work session in which the damage occurred, and to the satisfaction of the Superintendent.

7.1.3 Thickness of Replacement Asphalt

Where the replacement asphalt mix is to be placed to a nominal thickness, the depth of the planing at the edges of the planed area shall not be less than that shown on the Drawings.

The depth of planing at any point in the planed area shall be such that the minimum thicknesses shown on the Drawings are achieved in conjunction with the surface finish and smoothness requirements specified.

Any area of planing which is planed to a depth greater than 10 mm in excess of that required shall be reinstated to the required level with asphalt, at no additional cost to the Principal.

Asphalt required for reinstatement and for the course being placed in the planed area shall be placed in one layer unless otherwise determined by the Superintendent.

7.2 Texturing of Existing Surface

7.2.1 General

The areas to be textured as shown on the Drawings shall be treated as described below, using a self-propelled machine, to increase the average surface texture depth of the existing surface.

Heating of the existing surface to facilitate texturing by softening the surface shall not be permitted.

7.2.2 Self-Propelled Machine Texturing

The treatment shall produce scoops not less than 10 mm wide and not less than 100 mm long with an average depth of between 5 mm and 10 mm. A cold-milling machine with teeth attached to a rotating drum or equipment with a similar effect shall be used. If the equipment is fitted with cutting teeth, all cutting teeth shall be uniformly worn so as to produce scoops of uniform depth in accordance with the texture pattern shown on the Drawings. Cutting teeth shall be maintained in uniform condition and alignment.

The equipment shall be operated in whatever direction or directions are necessary to produce the specified texture.

© The State of Queensland, Queensland Department of Main Roads

The treatment shall result in 100% of the surface being treated by the machine.

7.2.3 Hand-Operated Machine Texturing

Any areas of the surface unable to be textured by the machine texturing equipment used generally, because of minor surface irregularities or any other reason, shall be treated using hand-operated powered equipment to provide the texture specified for self-propelled machine texturing.

7.2.4 Retexturing

Any areas of textured pavement in which more than 5% of a 3m x 3m area is inadequately textured shall be retextured using the hand-operated texturing machine.

7.2.5 Removal of Loose Material

On completion of texturing, the surface shall be swept free of all loose material. Particular attention shall be given to cleaning the cutting residue from the scoops in the textured surface. All the removed and swept material shall be disposed of as given in the Addendum MRSS.01.003.

7.2.6 Damaged Surfaces

Areas of the existing surface which are damaged by the texturing equipment as a result of texturing at a depth in excess of that specified above shall be repaired by the Contractor at no additional cost to the Principal before the end of the work session in which the damage occurred, and to the satisfaction of the Superintendent.

7.3 Joining New Work to Existing Work

Existing asphalt pavements shall be cut back to provide the following:

a) a vertical face at the joint line against which the new asphalt is to be placed;

b) a longitudinal taper such that the minimum layer thickness is as specified in Clause 7.8.

7.4 Existing Structures

Asphalt shall be compacted and neatly finished adjacent to existing structures.

Where the specified heights and/or widths etc. of the asphalt conflict with the dimensions and/or locations of any existing structures, the Superintendent shall be advised and the Superintendent shall instruct the Contractor on what alternative action, if any, is required.

7.5 Tack Coating

Tack coating of existing surfaces on or against which the asphalt is to be laid shall be carried out as follows:

a) After surface preparation and at a safe time prior to placing the asphalt, the surface shall be uniformly covered with a fine sprayed coat of bituminous emulsion, complying with the requirements of AS 1160, at the application rate given in Clause 2.1 of Addendum MRSS.01.003. The bituminous emulsion shall be allowed to break prior to laying the asphalt.

b) Warming of the bituminous emulsion to not more than 45^{o}C and/or dilution with water which will not affect the emulsion, at a rate of up to a maximum of 2 parts water to 1 part emulsion, may be undertaken in order to facilitate spraying.

c) Vehicles employed to spray the bituminous emulsion shall be in good mechanical order and shall be fitted with a spray bar.

d) Hand spraying shall be carried out only in areas where it is impractical to employ a spray bar.

© The State of Queensland, Queensland Department of Main Roads

e) Protective boards and/or covers shall be employed as necessary to prevent overspray beyond the surfaces to be tack coated.

f) Any pools of bituminous emulsion which may form in depressions or surface irregularities shall be broomed out over the adjacent areas with brooms or rubber squeegees before the emulsion breaks.

If the pavement structure consists of a number of layers of asphalt and if the elapsed time between the construction of the pavement layers does not exceed one day, tack coating of the surfaces between the layers shall be carried out only if the Superintendent so directs.

The joint surface shall, however, be cleaned of any loose or other deleterious material prior to the subsequent overlay of asphalt.

7.6 Laying of Asphalt

7.6.1 Laying Requirements

Unless specified otherwise elsewhere in the Contract Documents, self-propelled mechanical pavers shall be employed to lay the asphalt. Hand spreading of the asphalt shall be confined to specific operations.

7.6.2 Plant Requirements

For each working asphalt paver, the Contractor shall supply the following:

a) vibrating steel-wheeled roller (except for open graded asphalt where a static roller shall be provided);

b) medium pneumatic-tyred roller (except for open graded asphalt); and/or

c) heavy pneumatic-tyred roller (except for open graded asphalt).

All details of the plant and equipment to be used on the Works shall be supplied with the tender.

All plant and equipment shall be adequately maintained. In particular, oil and fuel spills and/or leakages shall be prevented.

Mechanical pavers shall be capable of laying at least 100 tonnes per hour.

7.7 Surface Condition

The surface on which the asphalt is to be placed shall be essentially dry and free of any surface water.

Asphalt shall not be placed during periods of heavy or continuous rain or when rain is imminent.

All asphalt shall be laid on an existing sealed surface, either an asphalt surfacing or a bitumen seal. This specification excludes the placement of asphalt on a concrete surface.

The surface of the pavement shall be thoroughly swept using a rotary broom to remove any loose material or other deleterious material which may be present. Any deleterious material which still adheres to the surface after sweeping shall be removed by other means.

A suction broom shall be used in association with any milling operation.

In addition to and following mechanical sweeping:

a) any areas of oil or fuel spillage shall be cleaned with detergent, flushed with clean water and allowed to dry prior to application of the tack coat; and,

b) any cracks, joints or holes in the pavement shall be rectified.

© The State of Queensland, Queensland Department of Main Roads

Frames for manhole covers, gully gratings, kerbs and other structures shall have the joint surfaces cleaned free of any extraneous material.

For polymer modified asphalt, the existing surface shall consist of either an asphalt or a cover aggregate with a nominal size of 16 mm or greater. All existing asphalt surfaces which are older than one year which are to be overlaid shall be textured over the whole surface with a purpose-built asphalt milling machine. The treatment shall produce intermittent scoops not less than 10 mm wide and not less than 100 mm long, with an average depth of between 5 mm and 10 mm.

Polymer modified asphalt shall be placed when the existing pavement temperature is above 15^{o}C.

7.8 Construction Layer Thickness Limits

The as-constructed thickness of any placed and compacted layer shall be within the limits given in Table 11 of MRS11.30 and MRS11.34 as appropriate.

These limits are related to constructability requirements and not structural thickness and/or geometric requirements. The Contractor shall plan the laying operations so that the combinations of individual layers placed comply with the geometric requirements of Clause 10.3.2 and Table 15 of MRS11.30.

7.8.1 Compaction of Asphalt with a Polymer Modified Binder

The maximum asphalt mixing temperature for asphalt containing SBS polymer modified binder shall be 175^{o}C.

Polymer modified asphalt shall be placed only when the pavement temperature is above 15^{o}C. It shall not be placed during rain nor on a surface that has any moisture present. An emulsion tack coat shall be used if the delay between the placing of the particular layer and the layer beneath exceeds three days.

The maximum asphalt laying temperature for asphalt containing SBS polymer modified binder shall be 165^{o}C.

Polymer modified asphalt covered by this specification may be more difficult to compact than asphalt with Class 320 bitumen. The Contractor shall take action to ensure that additional equipment and/or controls are provided to guarantee the specified compaction standard. These additional requirements shall include at least the following:

a) Delivery and Placement

Where necessary, additional control on the delivery and placement of the asphalt to ensure that the temperature range necessary for compaction is maintained during the compaction phase.

b) Compaction

Where necessary, larger and/or additional compaction equipment to increase the compactive effort and/or ensure that compaction occurs while the asphalt is sufficiently hot.

7.9 Joints

7.9.1 General

The laying program shall be such as to keep the number of joints, transverse and longitudinal, to a minimum.

Joints shall be provided as follows:

a) Longitudinally: if the width of the pavement is such that more than one paving run is necessary.

© The State of Queensland, Queensland Department of Main Roads

b) Transversely: after the completion of a day's paving operations or where a delay in the paving operation allows the previously laid asphalt to cool below the minimum rolling temperatures specified in MRS11.30, and elsewhere if a break in a longitudinal run is permitted by the Superintendent.

7.9.2 Longitudinal Joints

7.9.2.1 Hot Joints

Where job planning and weather conditions permit the placement of a lane before the temperature of the edge of the preceding lane has dropped below 100°C, the joint may be treated as a hot joint.

Hot longitudinal joints shall be constructed by the use of one of the following:

a) using two spreaders operating 'in echelon'; or,

b) by leaving a 150 mm wide strip of asphalt mix unrolled along the free edge of each lane until after the adjoining lane has been placed.

The unrolled strip of asphalt mix shall be compacted simultaneously with the material in the adjoining lane. Rolling shall commence before the temperature of the asphalt along the edge of the first-placed lane has fallen below 100°C. After placing the adjacent lane, the initial pass with the rollers shall overlap the previously placed lane by at least 0.5 m.

7.9.2.2 Warm Joints

Where job planning and weather conditions permit the placement of the adjoining lane before the temperature in the edge of the lane being placed has dropped below 65°C, the joint may be treated as a warm joint.

The full width of the lane being placed shall be rolled with the breakdown roller.

When rolling along a free edge, the roller shall not overhang the edge by more than 100 mm. The edge of the lane shall be formed while hot to a straight, tight face at approximately 45°C to the vertical, using steel lutes or similar equipment.

Pneumatic-tyred rolling shall proceed along the lane to within 50 to 70 mm of the edge, but not to the extent that collapse or rollover of the edge occurs.

After placing the adjacent lane, the initial passes with the pneumatic-tyred roller shall overlap the previously placed lane by at least 0.5 m.

7.9.2.3 Cold Joints

Where a hot or warm longitudinal joint is not feasible, or not permitted due to weather conditions, the full width of the lane being placed shall be rolled with the breakdown roller.

a) When rolling along a free edge, the breakdown rollers should not overhang the edge by more than 100 mm. Pneumatic-tyred rolling shall be carried right to the edge of the lane such that the outer tyre of the roller overlaps the edge by approximately 25 mm.

b) Before placing the adjoining lane, the edge shall be checked transversely with a straight-edge to determine the extent of any loss of shape (rolled-over edge). The edge shall be cut back with a cutting wheel or other approved means a minimum distance of 50 mm to remove all segregated and out-of-shape material and to expose a clean straight vertical face for the full depth of the layer. Cutting with a diamond saw will not be permitted.

The edge face shall be sprayed with a uniform thin coat of bituminous emulsion in accordance with MRS11.30 before placing the adjoining asphalt. Waste material from cutting back of cold joints shall be replaced by the Contractor at no cost to the Principal.

© The State of Queensland, Queensland Department of Main Roads

7.9.3 Transverse Joints

Transverse joints shall be at right angles to the direction of placing and shall be cut to a straight vertical face for the full depth of the course.

Before making transverse joints, areas at the end of the run which are rough or too low shall be determined by checking longitudinally with a straight-edge and removed. The joint shall be cut using a cutting wheel and the cut material removed and discarded. Cutting using a diamond saw will not be permitted. Material wasted as a result of cutting back to form a transverse joint shall be replaced by the Contractor at no cost to the Principal.

The face of the joint shall be sprayed uniformly with a double coat of bituminous emulsion before placing the asphalt in the adjoining lane.

The joint shall be made using the mechanical spreader positioned on the joint such that the hot asphalt is spread against the face of the joint for the full width of the lane and to the required predetermined uncompacted thickness.

In the breakdown rolling of the transverse joint, the roller shall operate parallel with the transverse joint overlapping approximately 50 mm to 100 mm onto the freshly placed material and shall apply not more than two passes. Each successive pass shall overlap a small distance onto the fresh material until the full width of the roller bears on the fresh material. Breakdown rolling shall then continue as normal.

The asphalt in the completed joint shall conform to the required density, surface smoothness and levels specified herein.

In multiple layer work, the joints in successive layers shall be offset at least 100 mm, except for longitudinal joints on a crowned pavement.

7.9.4 Compaction Standard, Joints

All individual test results on joints shall have a minimum compaction standard of 90% relative compaction (not characteristic value).

7.10 Pavement Cleanliness

The Contractor shall clean the surface of all pavements in areas where work is undertaken under the Contract, or which are used to haul materials for use in the Contract, prior to the pavements being opened for use in such a way that the pavements are free from all loose material.

The pavements shall be swept, blown or vacuumed clean by mechanical brooms, suction sweepers, hand brooming and other means, so that the cleanliness requirement is met at least 15 minutes before the pavement is due to be opened for use by traffic.

The pavements will be inspected by the Superintendent at the time when cleaning operations are nearly complete. The Contractor shall accompany the Superintendent during this inspection and shall immediately undertake additional cleaning operations in areas identified by the Superintendent as not complying with the cleanliness requirement, using methods that will ensure rapid cleaning to the standard specified, before the time when traffic movements are due to commence.

The Contractor shall be fully responsible for ensuring that the pavements meet the cleanliness requirement prior to opening to traffic use.

7.11 Maintenance of the Subgrade and/or the Pavement Courses

The Contractor shall be responsible for maintaining the existing subgrade or the existing pavement courses and the pavement courses constructed under this Contract, in a condition which complies with the relevant specification, from the time when the Contractor takes possession of the Site until the Date of Completion.

© The State of Queensland, Queensland Department of Main Roads

8 Quality

8.1 Charts

The manufacture and placement of asphalt and all its constituent materials shall be administered on the basis of lots (see MRS11.01 and MRS11.50), which shall be clearly identified and recorded.

For materials tested at the point of manufacture, test certificates shall be obtained and held on site.

Compliance testing of all other materials, including all aggregates, shall be carried out on lots at the batching site. However, if the aggregate manufacturer has third-party quality assurance, compliance testing may be carried out at the point of manufacture.

All quality assurance records (including test results) shall be maintained on a computer system which shall also include the capacity to summarise, graph and carry out statistical calculations on the data.

In addition to the tests specified in this specification, charts shall be maintained for at least the following:

a) Combined Aggregate

   i) 10% fines value/wet

   ii) percent passing the sieve one below the sieve with 100% passing

   iii) percent passing the AS 2.36 mm sieve

   iv) percent passing the AS 0.075 mm sieve

   v) bulk density

b) Asphalt Manufacture

   i) maximum density

   ii) binder content

c) Asphalt Placement

   i) characteristic value of relative compaction.

The charts shall include the following:

a) the actual results with the specified tolerances;

b) a five-point running mean with limits set at 0.7 tolerances;

c) a five-point running range (highest from the lowest).

8.2 Lot Sizes and Testing Frequencies

8.2.1 General

The requirements in this clause represent an absolute minimum testing program. The Contractor remains responsible for performing sufficient tests and inspections to ensure that the lot complies with all the standards and requirements of the specifications.

There are two levels of minimum testing frequencies given below. The Reduced Level shall apply after no non-conformances have been detected in two consecutive lots. As stated above, these are absolute minimum levels and the Contractor should be testing more frequently where necessary (particularly at the commencement of new activities).

Where a Contractor is operating at the Reduced Level and a nonconformance occurs for any standard or requirement for a lot, the Contractor shall immediately go back to the

© The State of Queensland, Queensland Department of Main Roads

Normal Level of testing until no non-conformances have been detected in two consecutive lots.

8.2.2 Homogeneous Lots

This specification is based on the use of lots, which are homogeneous (in the context of the specification requirements), identifiable quantities defined in forms such as:

a) length, e.g. linear metres

b) area, e.g. square metres

c) volume, e.g. cubic metres

d) mass, e.g. tonnes

e) units of manufacture, such as batches, etc.

of items and material types identified by name and specification requirements such as:

i) aggregate

ii) sand

iii) binder such as bitumen

iv) filler such as fly ash

v) class and nominal size of asphalt

from which samples are taken and about which decisions are made on the basis of such processes as:

A) tests

B) inspections

C) test procedures

D) observations

E) auditing

The minimum and/or maximum lot sizes and/or testing frequencies given in this specification are not sufficient to check the lot for homogeneity. The Contractor should check for homogeneity on a regular basis but not less than the frequency given in Clause 8.2.11. The lot can be audited for homogeneity at any time.

Homogeneity can be assessed by utilisation of the specification requirements for the particular item or material and by:

a) conducting a statistically significant number of tests, at least 30; or

b) subdividing the initially chosen lot in any number and size of smaller lots and testing each smaller lot as required, and in accordance with the minimum testing frequencies given in this Addendum.

8.2.3 Coarse Aggregate

Lot Size

5,000.00 tonnes of combined aggregate (each component is combined in the approved mix proportions prior to the test)

Testing Frequency

Property	Test Frequency	
	Normal	Reduced

Ten Percent Fines Value (wet) (standard test)	1	1
Ten Percent Fines Value (wet) (size)	1 per 10 lots	1 per 20 lots
Wet/Dry Variation (standard test) Wet/Dry Variation (size)	1 1 per 10 lots	1 1 per 20 lots
Crushed Faces	3	1
Flakiness Index	3	1
Water Absorption	1	1
Degradation Factor	1	1
Weak Particles	2	1
Polished Aggregate Friction Value	3	1
Material Finer than 0.075 mm	2	1

8.2.4 Fine Aggregate, Source Rock from a Quarry Source

Lot Size

10,000.00 tonnes

Testing Frequency

	Test Frequency	
Property	**Normal**	**Reduced**
Ten Percent Fines Value (wet)	1	1
Wet/Dry Variation	1	1
Washington Degradation	1	1
Polished Aggregate Friction Value	1	1
Water Absorption	1	1

8.2.5 Fine Aggregate, All Sources

Lot Size

5,000.00 tonnes of combined aggregate (each component is combined in the approved mix proportions prior to the test)

Testing Frequency

	Test Frequency per Lot	
Property	**Normal**	**Reduced**
Clay Index	3	1
Plasticity Index	3	1

© The State of Queensland, Queensland Department of Main Roads

8.2.6 Combined Filler

Lot Size

Every 3,000.00 tonnes of production asphalt

Testing Frequency

	Test Frequency	
Property	**Normal**	**Reduced**
Voids in the Compacted Filler	2	1 every second lot

8.2.7 Production Asphalt

8.2.7.1 Manufacture

The manufacture of asphalt, including the metering of all materials, mixing times, plant calibration and maintenance, storage, maintenance of temperature etc. shall be continuously monitored by a party independent of the manufacturer.

8.2.7.2 Grading, Binder Content, Maximum Density and Particle Coating

Lot Size

As per specifications MRS11.30 and MRS11.34

Testing Frequency

	Test Frequency per Lot	
Property	**Normal**	**Reduced**
Grading	2	2
Binder Content	2	2
Binder Film Thickness	2	2
Maximum Density	2	2
Particle Coating	1	1 per 10 lots
Constituent Material components relative to the approved mix (source and percentage in the production mix)	1 per 5 lots	1 per 10 lots

8.2.7.3 Complete Characterisation

Lot Size

15,000.00 tonnes or once for each type of asphalt on the project where the total amount of asphalt is less than 15,000.00 tonnes.

Test Frequency

© The State of Queensland, Queensland Department of Main Roads

	Test Frequency per Lot	
Property	**Normal**	**Reduced**
Marshall Stability	1	1
Marshall Flow	1	1
Stripping	1	1
Air Voids at Maximum Cycles	1	1
Wheel Tracking (one test for reporting purposed only)	1	1
Modulus	1	1
Air Voids	1	1
Voids in the Mineral Aggregate	1	1
Binder Film Thickness	1	1
Grading	1	1
Binder Content	1	1

8.2.8 Binder

Lot Size

The lot size for the testing below shall be a discrete quantity of material in a storage tank. After each delivery the material in the storage tank is considered to be a new lot.

Additionally, from each delivery two 2 litre samples shall be taken and labelled with the date, time, project and tanker registration. Each sample shall be signed by the contractor and the Superintendent's representative. One sample shall be held by the contractor and one sample shall be forwarded to the Queensland Department of Main Roads laboratory at 35 Butterfield St. Herston for storage for at least 5 years. These samples are available for testing to check the properties of the binder.

Test Frequency

	Test Frequency per Lot	
Property	**Normal**	**Reduced**
Bitumen		
Viscosity at 60°C	1 per 4 lots	1 per 20 lots
Polymer Modified Binder[1]		
Consistency at 60°C	1 per 3 lots	1 per 5 lots
Elastic Recovery at 60°C	1 per 3 lots	1 per 5 lots
Viscosity at 165°C	1	1
Torsional Recovery	1	1

© The State of Queensland, Queensland Department of Main Roads

Segregation	1	1
Softening Point	1	1

8.2.9 Placed Asphalt Geometrics

Lot Size

Continuous

Testing Frequency

	Test Frequency	
Property	**Normal**	**Reduced**
Horizontal Dimensions	1 per 50 m	1 per 200 m
Vertical, Height Control		
Height	all grid points[1]	all grid points[1]
Thickness (probing)	20 per day	10 per day
Thickness (coring)	10 on the day defined in note 2	10 on the day defined in note 2
Vertical, Thickness Control		
Thickness (probing)	1 per 10 metres	1 per 20 metres
Thickness (coring)	10 on the day defined in note 2	10 on the day defined in note 2
Straight-edge		
Longitudinal	2 per joint	2 per joint
Crossfall	1 per 10 metre	1 per 20 metre
Surface Evenness	continuous per lane	continuous per lane

Notes:

1 Unless specified otherwise, at least each lane and shoulder centre line, LHS and RHS at every 25 metre intervals

2 Includes the first day of any new work and also the day on which nuclear gauge calibration occurs

8.2.10 Compaction Standard

Lot Size

A continuous single layer produced in a continuous operation in one day

Testing Frequency

	Test Frequency	
Property	**Normal**	**Reduced**
Compaction in Lots other than Joints using Nuclear Gauge	1 per 200 m^2 with a minimum of 10	1 per 200 m^2 with a minimum of 10

© The State of Queensland, Queensland Department of Main Roads

Compaction in Lots other than Joints using Coring	1 per 400 m^2 with a minimum of 7	1 per 400 m^2 with a minimum of 7
Compaction in Joint Lots using Coring: Longitudinal	1 per joint	1 per 10 joints
Compaction in Joint Lots using Nuclear Gauge: Longitudinal	1 per 500 linear metres	1 per 1000 linear metres
Compaction in Joint Lots using Nuclear Gauge: Transverse	2 per joint	1 per joint

8.2.11 Homogeneity

Homogeneity shall be checked for every 30th lot.

9 Administration

9.1 Items

The items are as per Table 1.3-1 and the work operations, measurement for payment and all other requirements, except for the modifications and additional requirements contained in this supplementary specification, are as per the standard specification referenced from within this supplementary specification. Item numbers are to be determined to suit the particular project and in accordance with the Main Roads item numbering system.

Table 9.1-1 Work Items

Item Number	Description	Specification Reference	Unit of Measurement
	Preparation of the Existing Surface (Dense Graded Asphalt)	MRS11.30	m^2
	Preparation of the Existing Surface (Open Graded Asphalt)	MRS11.34	m^2
	Tack Coat (Dense Graded Asphalt)	MRS11.30	litre
	Tack Coat (Open Graded Asphalt)	MRS11.34	litre
	Open Graded Asphalt Surfacing, OG14 mix	MRS11.34 and MRSS.01.003	tonne
	Dense Graded Asphalt Pavement, DG14HS mix	MRS11.30 and MRSS.01.003	tonne
	Dense Graded Asphalt Pavement, DG20HM mix	MRS11.30 and MRSS.01.003	tonne

9.2 Work Operations

In addition to the work operations in each of the referenced standard specifications, the following shall also apply:

a) Provision, calibration and maintenance of laboratory facilities;

b) Sampling, testing and quality assurance requirements;

© The State of Queensland, Queensland Department of Main Roads

c) Delivery of the results of all tests and inspections, including monitoring testing, within five working days of the specified time for the test or inspection; and,

d) Removal and disposal of any non-conforming material or product, or any material or product not utilised for a reduced level of service and replacement with conforming material or product.

© The State of Queensland, Queensland Department of Main Roads

10 ADDENDUM

Supplementary Specification MRSS.01.003
Specific Contract Requirements

Contract Number:

10.1 Sub-Items

Sub-item Number	Description	Specification Reference	Binder Type	General Location

10.2 Details

10.2.1 Tack Coat

The tack coat shall be sprayed at a rate to suit the surface but shall be between 0.05 and 0.2 litres/m^2 of residual bitumen.

10.2.2 Surface Preparation

10.2.2.1 Cold Planing or Texturing

10.2.2.2 Preparation of Existing Surface

10.2.3 Paver Level Control

Unless stated otherwise, all asphalt layers are to be controlled by C initially followed by D where adequate.

Method Code:	Description
A	Paver self-leveling action only
B	Manual control in conjunction with finisher's self-leveling action
C	Automatic control actuated by a fixed reference line
D	Automatic control actuated by a matching shoe
E	Automatic control actuated by a computerised layer thickness device

© The State of Queensland, Queensland Department of Main Roads

G Other

10.2.4 Corrector Course

10.2.5 Height or Thickness Control

Height control shall be used for all asphalt on this project.

© The State of Queensland, Queensland Department of Main Roads

GHD Pty Ltd ABN 39 008 488 373

201 Charlotte Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com.au

© GHD Pty Ltd 2008

This document is and shall remain the property of GHD Pty Ltd. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	R Blumson, R Pearson	C Taylor		M Hellmuth		9/5/08
1	Multiple	C O'Brien		M Hellmuth		19/06/08