Building Code Clause(s) **B1, B2**

PRODUCER STATEMENT – PS1 – DESIGN

(Guidance notes on the use of this form are printed on page 2)

ISSUED BY: **Airey Consultants Ltd** **(ACL ref. 12204 ~ 01)**
(Design Firm)

TO: **Progeni Ltd.**
(Owner/Developer)

TO BE SUPPLIED TO: **Porirua City Council**
(Building Consent Authority)

IN RESPECT OF: **Concrete accessways**
(Description of Building Work)

AT: **Exploration Way, Porirua**
(Address)

.... **LOT**....................... **DP** .... **SO** ....

We have been engaged by the owner/developer referred to above to provide **Structural design of concrete accessway** services in respect of the requirements of
(Extent of Engagement)

Clause(s) **B1, B2** of the Building Code for
All ☐ or Part only ☒ (as specified in the attachment to this statement), of the proposed building work.

The design carried out by us has been prepared in accordance with:

☒ Compliance Documents issued by the Ministry of Business, Innovation & Employment **B1/VM1, B2/AS1** or
(verification method / acceptable solution)

☒ Alternative solution as per the attached schedule **NZS4404, Austroads Pavement Design, TNZ Bridge Manual**

The proposed building work covered by this producer statement is described on the drawings titled **Progeni Ltd., Exploration Way, Porirua: Proposed Concrete accessway**

and numbered **ACL # 12204 - 01: S01, S02, B01**

;
together with the specification, and other documents set out in the schedule attached to this statement.
On behalf of the Design Firm, and subject to:
(i) Site verification of the following design assumptions **CBR ≥ 7.0**
(ii) All proprietary products meeting their performance specification requirements;

I **believe on reasonable grounds** that a) the building, if constructed in accordance with the drawings, specifications, and other documents provided or listed in the attached schedule, will comply with the relevant provisions of the Building Code and that b), the persons who have undertaken the design have the necessary competency to do so. I also recommend the following level of construction monitoring/observation:
☐CM1 ☐CM2 ☒CM3 ☐CM4 ☐CM5 (Engineering Categories) or ☐ as per agreement with owner/developer (Architectural)

I, **Roger James Twiname** am: ☒CPEng **71526** #
(Name of Design Professional)

☐Reg Arch .#

I am a Member of : ☒ IPENZ ☐NZIA and hold the following qualifications **BE, MIPENZ, CPEng (NZ, IntPE (NZ)**
The Design Firm issuing this statement holds a current policy of Professional Indemnity Insurance no less than $200,000*.
The Design Firm is a member of ACENZ: ☒

SIGNED BY **R J Twiname**............ ON BEHALF OF **Airey Consultants Ltd.** ....
(Design Firm)

Date **12 February 2016** (signature)..

Note: This statement shall only be relied upon by the Building Consent Authority named above. Liability under this statement accrues to the Design Firm only. The total maximum amount of damages payable arising from this statement and all other statements provided to the Building Consent Authority in relation to this building work, whether in contract, tort or otherwise (including negligence), is limited to the sum of $200,000.*

AIREY CONSULTANTS LTD.

ACENZ

Engineering Calculations

for

Proposed Concrete Accessway

at

Exploration Way

Porirua

Client: ***Progeni Ltd.***

Job No: **12204 ~ 01**

Date: **January 2016**

Design Engineer:
Roger Twiname
CPEng(NZ), IntPE(NZ)
BE, MIPENZ

Contacts:
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R J TWINAME
BE, MIPENZ (Civil, Structural)
CPEng ID No. 71526
AIREY CONSULTANTS LTD
10/02 /2016

BRIDGING SLAB DESIGN:

- Design for 85% HN Loading to TNZ BRIDGE MANUAL (APP. D) ie: 0.85 x 120 kN axle & 3.5 kN/m²
  = 102 kN (10.4 T)

ULS LOADS: (TABLE D.2)

1A: 1.10 DL + 1.84 (LL x I) (governs)

2A = 1.20 DL + 1.20 (LL x I)
(2B & 2C sim)

$I = 1.30$ (Fig 3.2)

- PAVEMENT IS TYP 5.7m WIDE
- PIPES ARE AT DEPTHS ~ 1.0m, 1.1m, 1.5m & 1.7m COVER
- " " " APPROX. 1.8 → 2.0m APART.
- CLEARANCE TO PIPES = 1.0m

⇒ BRIDGE SPAN ≃ 4.5m MIN.
" " ≃ 6.0m EFFECTIVE

- BY INSPECTION, DESIGN FOR SINGLE 120 kN AXLE AT MIDSPAN (CRITICAL FOR FLEXURE)

- FOR SHEAR, WILL GOVERN SLAB THICKNESS.

$v_{max} = 0.2 f'_c$ or 8MPa

$\phi = 0.75$

$f'_c = 30$MPa ⇒ $v_{max} = 6$MPa

$V^* \le \phi V_n$

$V_n = v_n A_{cv}$ $A_{cv} = b_w d$

$P^* = 1.84 \times 102 \times 1.3$
$= 244$kN

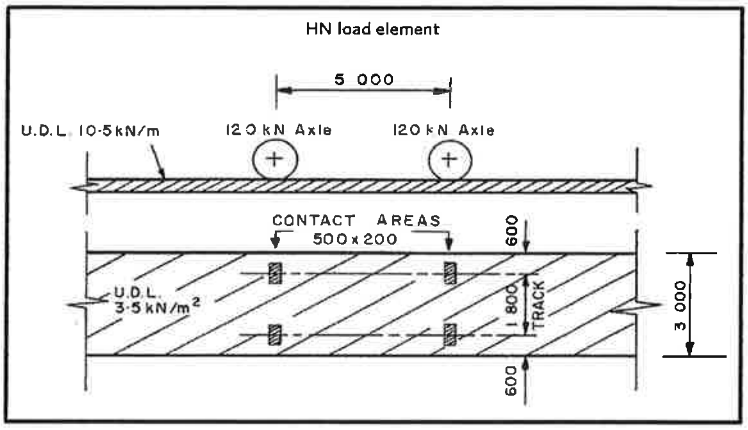
$v_c = 0.17 k_a \sqrt{f'_c}$ for $d \le 200$mm
$= 0.17 \times 1.0 \sqrt{30} = 0.931$ MPa

BR02

Consulting Civil and Structural Engineers	Client:	Progeni Ltd.	Sheet No:
Pukekohe Takapuna Howick Queenstown	Job:	Exploration Way Whitby	Job No:
	Calc's By:	Roger T	Date: 03-Feb-16

Concrete Pavement design for 85%HN traffic loading:
(Ref. NZ Transport Agency Bridge Manual, Appendix D)

HN Axle load =	**120.0**	kN
85% HN =	**102.0**	kN
axle spacing =	5.0	m
wheel track spacing =	1.8	m
contact areas =	500.0	mm wide
=	200.0	mm deep
UDL Live load =	3.50	kPa
85% HN UDL =	**2.975**	kPa
UDL load width =	3.00	m



UDL Load cases: (applicable)

Primary Normal: (Self weight and Traffic combinations only)

Load case: 1A	DL	LL x I	
Load Factors	1.10	1.84	(Ref. Table D.2)
UDL	**5.28**	**8.37**	[kPa]
Wheel loads		**244.0**	[kN]

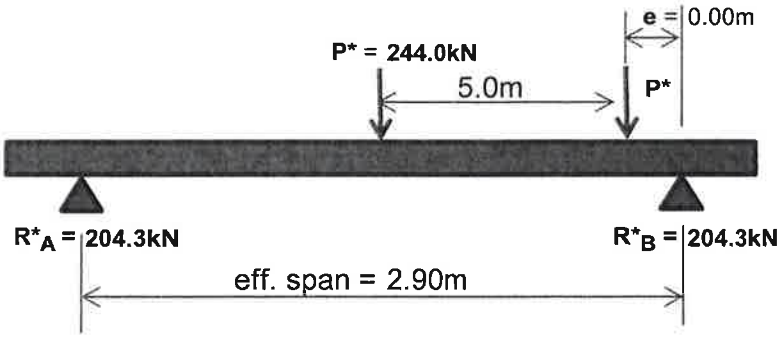
where: Impact Factor, **I** = **1.30** (Ref. Fig 3.2)

Slab design: (single span)

Overall slab thickness, **D** =	**200**	mm
Slab self weight, **DL**, G_s =	4.80	kPa
Topping thickness, **t** =	**0**	mm
Density of topping, γ_t =	**0.0**	kN/m^3
Topping weight, **DL**, G_T =	0.00	kPa
⇒ **Total DL** =	**4.80**	kPa
Effective width of slab, **W** =	**6.00**	m
Effective slab span, **L** =	**2.90**	m

B203

Case 1: Axle load at centre



effective w^*_{UDL} = 9.47 kN/m

P^*_Q = 244.0 kN

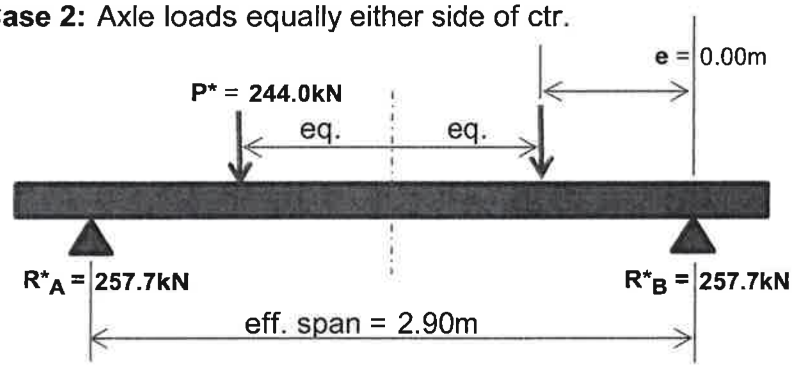
M^*_{max} = **39.43** kNm/m

R^*_A = 204.35 kN

R^*_B = **204.35** kN

V^*_A = **34.06** kN/m

Case 2: Axle loads equally either side of ctr.



effective w^*_{UDL} = 9.47 kN/m

P^*_Q = 244.0 kN

M^*_{max} = **9.95** kNm/m

R^* = **257.71** kN

V^*_A = **42.95** kN/m

⇒ **Maximum design M^*_{max}** = **39.43** kNm/m

⇒ **Maximum design V^*_{max}** = **42.95** kN/m

BNOY

Reinforced slab capacity:

Nominal compressive strength, f'_c = **30.0** MPa
Elastic Modulus: $E_c = 3320\sqrt{f'_c} + 6900$
design E_c = **25,084** MPa

reinforcing grade, f_y = **500** MPa
E_s = 2.00E+05 MPa

Reinforcing:

bar size, d_b =	**16**	mm		
Overall slab depth, **D** =	200	mm		
bottom cover =	**50**	mm		
effective depth, **d** =	142	mm (to centroid of tens. reinf)		
s_{max} = 2D =	300	mm	≤ 300	(9.3.8.3)
bar ctrs, **s** =	**275**	mm		**OK**
⇒	**HD16 - 275**			
Steel area, A_s =	731.1	mm²/m		
slab width, **b** =	1,000	mm/m		
ρ =	0.0051			
β = 0.85 **0.75 ρ_b** =	0.0296			**OK**

For one-way slabs:

(Eq. 9 -1) Min. steel area, $A_s = \sqrt{f'_c} / (4 f_y).b_w.d$

=	389	mm²/m		**OK**
≥ 1.4 b_w d / f_y =	**398**	mm²/m	governs	

balanced strain check:
(strength)

a = $A_s f_y$ / (0.85 f'c b)

=	**14.3**	mm
⇒ **c** =	**16.9**	mm
⇒ **jd** =	134.00	mm
C =	365.6	kN

ε_c = 0.003 $c_b = d\ \varepsilon_c / (\varepsilon_c + \varepsilon_y)$

=	77.5	mm	
0.75 c_b =	58.1	mm	**OK**

Flexural Strength: **Applied ultimate moment, M* =** **39.43** kNm/m

ϕ_b = **0.85**

Dependable flexural strength: **ϕM_n** = **41.90** kNm/m **OK**

NB: with 75 B/C, HD16-200
ϕM_n = 45.78 kN ok

BR05

Shear - slabs: (9.3.9.3)

Maximum ultimate shear, V^* = 42.95 kN/m

ϕ_s = **0.75**

V_n = 57.27 kN/m

⇒ v_n = **0.40** MPa

$v_b = (0.07+10\,\rho_w)\sqrt{f'c}$

= 0.67 MPa

need not be less than: $v_{c,min.} = 0.08\sqrt{f'_c}$ = 0.44 MPa

and no more than: $v_{c,max.} = 0.2\sqrt{f'_c}$ = 1.10 MPa

⇒ v_b = **0.67** MPa

k_a = **1.00**

k_d = **1.00**

$v_c = k_a k_d v_b$ (Eq. 9-5)

= **0.67** MPa

max. v_n = 0.2f'c or 8.0MPa

= 6.00 MPa **OK**

v_n = 0.606 v_c

Shear strength, $\phi V_n = \phi_s v_c b_w d$

⇒ ϕV_n = **70.87** kN/m **OK**

Transverse reinforcing:

(8.8.1) $A_{s,min}$ = (0.7/fy).Ag $\geq 0.0014\,A_g$

= **280** mm^2/m

s_{max} = 2D = 300 mm ≤ 300 (9.3.8.3)

bar size, d_b = **12** mm

bar ctrs, **s** = **300** mm **OK**

Steel area, A_s = 377 mm^2/m **OK**

⇒ **HD12 - 300 transverse**

AIREY CONSULTANTS LTD. Consulting Civil and Structural Engineers

Pukekohe Takapuna Howick Queenstown

CLIENT:		SHEET No.: 06
JOB:		JOB No.:
CALCS. BY:	PHONE:	DATE:

GROUND BEAMS: $L \simeq 5.7m + 2x$

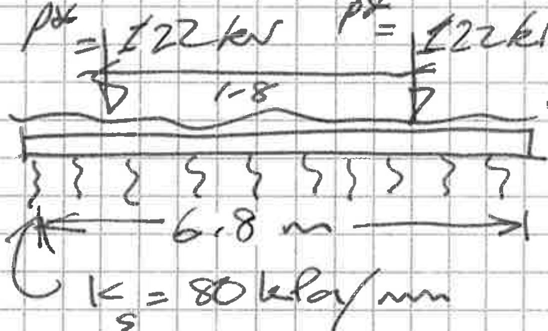
$V^* = 42.95 kN/m$

$q_{dep} = 150 kPa \Rightarrow$ min width $= \left(\frac{43}{150}\right) = 0.29m$ OK

$< 0.40m$

ie: 400 w beam OK

Check beam reinf.:



$K_s = 80 kPa/mm$

$w^*(UDL) = 1.1G + 1.84 L_u \times I$

$P^* = 244/2 = 122 kN$

$= 1.1 \times 5.52 \times 5.75 + 1.84 \times \frac{3.5 \times 5.75}{5.7} \times 1.3$

$\doteq 43.34 kN/m$ $\Rightarrow$ Tot $R^* = 43.34 \times 5.7 + 244 = 491 k$

P^* may be taken over 500mm

$\Rightarrow w^* = 144 kN/m$ locally

$\times 0.4 w = 32 kN/m/mm$

$s = 0.4 = 12.8 kN/mm$

$\Rightarrow K_s = \frac{12.8 \times 10^3 kN/m}{@ 400 crs.}$

Try 400x400 BEAM

$\Rightarrow M^*_{max} = 53.3 kNm$

$d \simeq 400 - 75 - 10 \Rightarrow A_s \simeq 423 mm^2$
$= 315$

$= 3HD16$

$\frac{491 kN}{150 kPa}$

$= 3.27 m^2$ min

$\div 400 mm = 8.18 m$

$\Rightarrow$

3HD16 T&B $\Rightarrow \phi M_n = 76.96 kNm$ OK

$V^*_{max} = 80.74 kN$

HRG-150 $\Rightarrow \phi V_n = 105.5 kN$ OK

(see s/sheet over)

B207

AIREY CONSULTANTS LTD. Consulting Civil and Structural Engineers	Client:	Progeni Ltd.	Sheet No:
	Job:	Exploration Way Whitby	Job No:
Pukekohe Takapuna Howick Queenstown	Calc's By:	Roger T	Date: 25-Jan-16

Edition: 12.08.15

Reinforced concrete member capacities:

Material Type = concrete

Nominal compressive strength, $\mathbf{f'_c}$ = 30.0 MPa

Elastic Modulus: $E_c = 3320 \sqrt{f'_c} + 6900$

design E_c = 25,084 MPa

reinforcing grade, f_y = 500 MPa

E_s = 2.00E+05 MPa

member type B (**B** = beam, **S** = slab)

Reinforcing:

for slabs:

effective depth, **d** = 0 mm (to centroid of tens. Reinf)

bar size, d_b = 0 mm

ctrs, **s** = 0 mm

A_s = 0.0 mm^2/m

for beams:

Layer	d_b (mm)	No.	A_s	d (mm)	α_a	L_{db} (mm)
L1	16	3	603.2	315	1.00	730
L2			0.0		1.00	
L3			0.0		1.00	
L4			0.0		1.00	

total steel area, A_s = 603 mm^2 (tension)

effective **d** = 315.0 mm

width, **b** = 400 mm

o/a depth/thickness, **D** = 400 mm

effective depth, **d** = 315.0 mm (to centroid of tens. reinf.)

design steel area, A_s = 603.2 mm^2 or mm^2/m

ρ = 0.0048

$\beta = 0.85$ **0.75** ρ_b = 0.0177

BR08

For beams and one-way slabs:

Min. steel area, $\mathbf{A_s = \sqrt{f'_c} / (4 f_y).b_w.d}$ (Eq. 9 -1)

= **345** mm^2

balanced strain check: $a = A_s f_y / (0.85 f'c\ b)$

(strength) = **29.6** mm

⇒ **c =** **34.8** mm

⇒ **jd =** 300.22 mm

C = 301.6 kN

$c_b = d\ \varepsilon_c / (\varepsilon_c + \varepsilon_y)$ ε_c = **0.0030**

= 171.8 mm

0.75 c_b = 128.9 mm **OK**

Flexural Strength: **Applied ultimate moment, M* =** **53.3** kNm

ϕ_b = **0.85**

Dependable flexural strength: ϕM_n = **76.96** kNm **OK**

BR09

shear - beams:

Maximum ultimate shear, V^* = 80.7 kN

V_n = 107.7 kN ϕ_s = 0.75

⇒ v_n = **0.85** MPa

$v_b = (0.07+10\,\rho_w)\sqrt{f'c}$ (9.3.9.4)

= 0.65 MPa

need not be less than: $v_{c,min.} = 0.08\sqrt{f'_c}$ = 0.44 MPa

and no more than: $v_{c,max.} = 0.2\sqrt{f'_c}$ = 1.10 MPa

for masonry: v_m = 0.00 MPa

⇒ v_b = **0.65** MPa

k_d = 1.00 $v_c = k_d\,k_a\,v_b$ (Eq. 9-5)

k_a = 1.000 = **0.65** MPa

max. v_n = 0.2f'c or 8.0MPa (9.3.9.3.3)

= 6.00 MPa OK

shear reinforcing :

Stirrup yield strength, f_{yt} = 500 MPa

s = d/4 if $V_s > 0.33\sqrt{f'_c}\,b_w\,d$ = 227.74 kN (9.3.9.4.12,(d))

⇒ s_{max} = d/2 = 157.5 mm

s = 150 mm OK

$A_{v,min} = (1/16)\sqrt{f'_c}\,b_w\,s\,/f_{yt}$ = 41 mm² (Eq. 9-10) OK

required A_v = 41 mm²

stirrup dia. = 6 mm

No. legs = 2

A_v = 57 mm² OK

V_s = 59.38 kN

use : **2 leg HR6 - 150**

Shear strength, $\phi V_n = \phi_s\,(A_v\,f_{yt}\,d\,/\,s + v_c\,b_w\,d)$

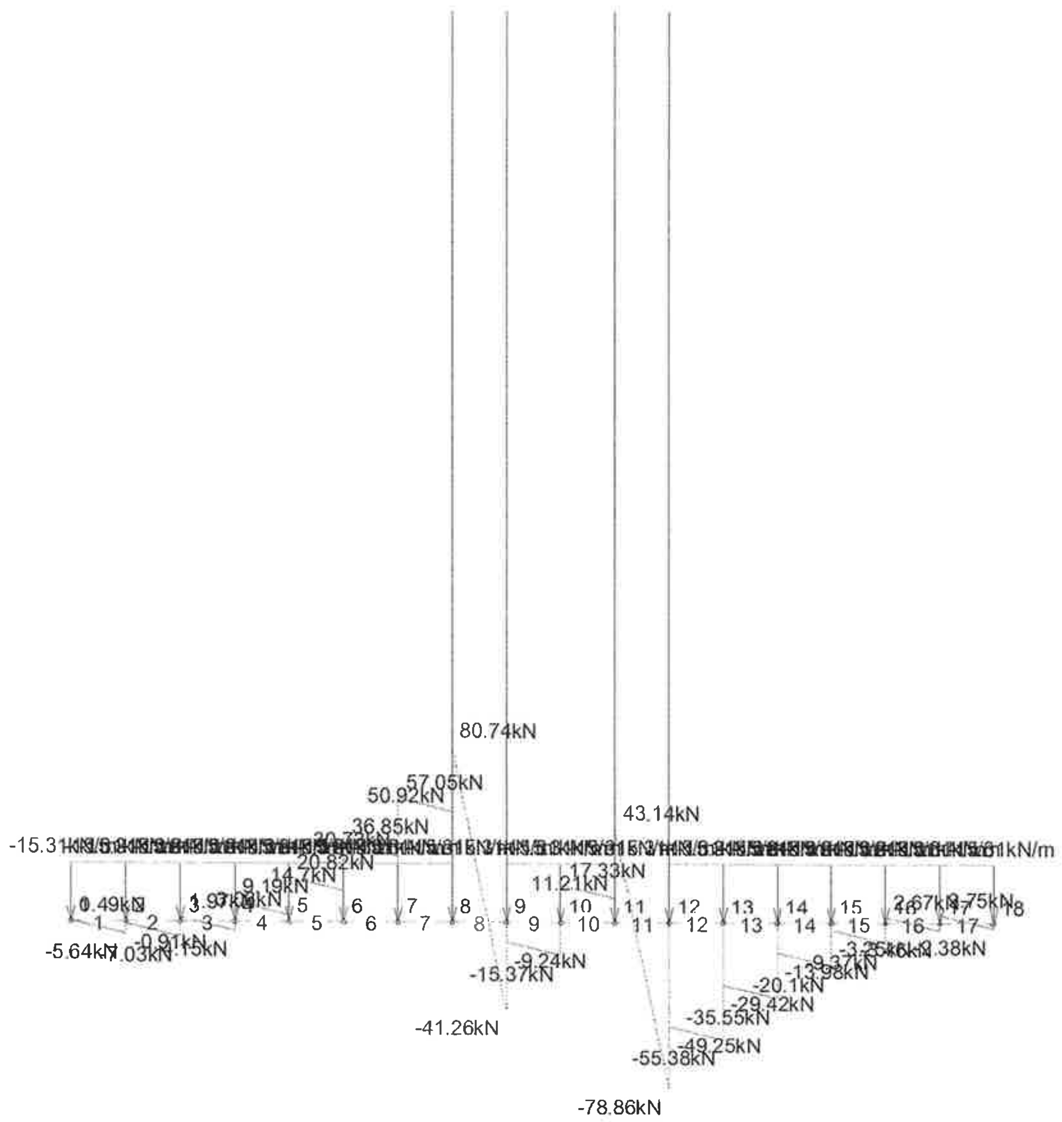
= **105.54** kN OK

SPACE GASS 11.06 - AIREY CONSULTANTS LTD

25 Jan 2016, 4:13 pm

All load cases:

■ 1



Materials:
■ 1 CONCRETE-32

Sections:
■ 1 400x400BM

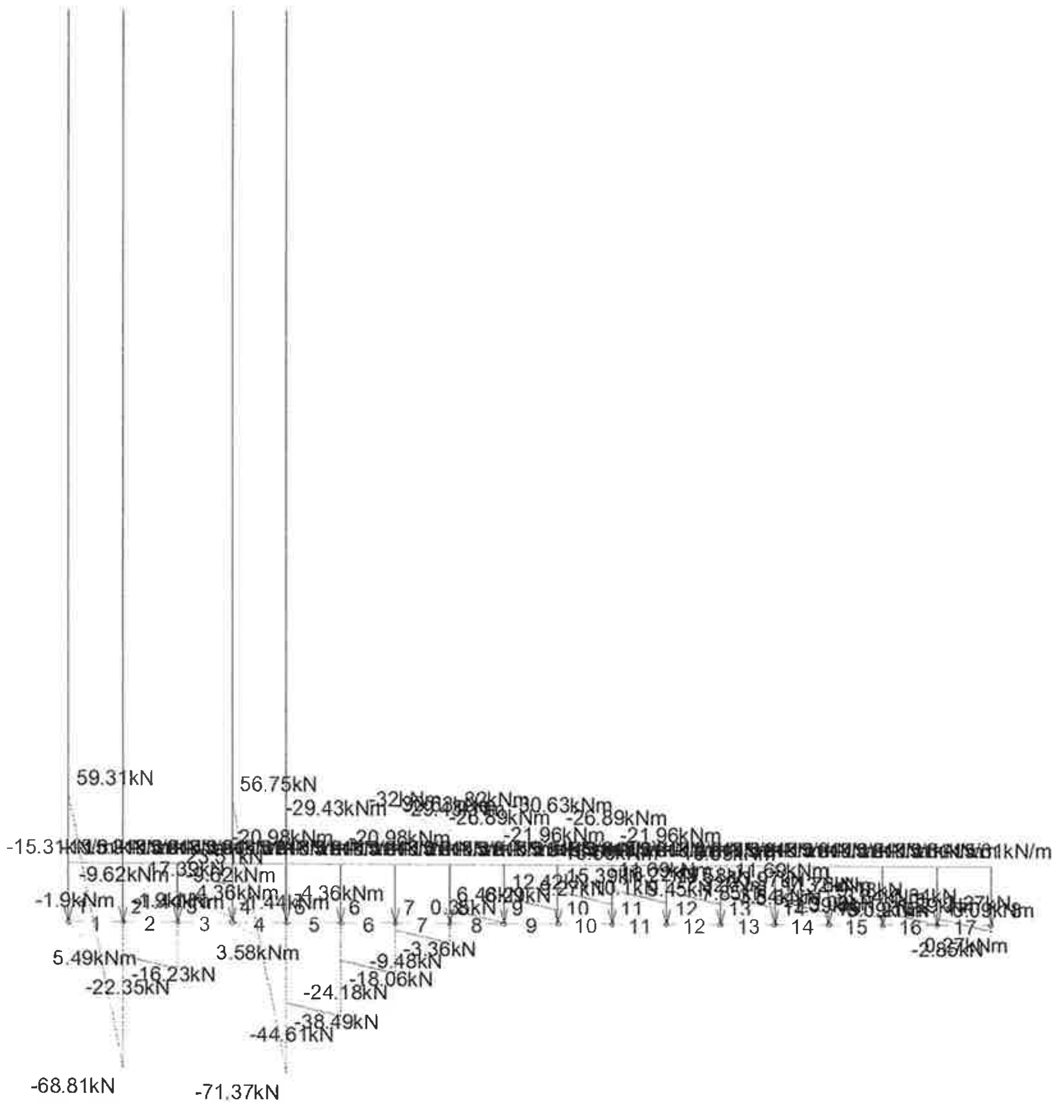
BR10

Job: Unnamed
Units - Len: m, Sec: mm, Mat: MPa, Dens: T/m^3, Temp: Celsius, Force: kN, Mom: kNm, Mass: T, Acc: g's, Trans: mm, Stress: MPa
Scales - Frame: 1:56, Load: 2, Disp: None, Moment: None, Shear: 3.6, Axial: None, Torsion: None

SPACE GASS 11.06 - AIREY CONSULTANTS LTD

25 Jan 2016, 4:17 pm

Load cases:
2



Materials:
1 CONCRETE-32

Sections:
1 400x400BM

BR11

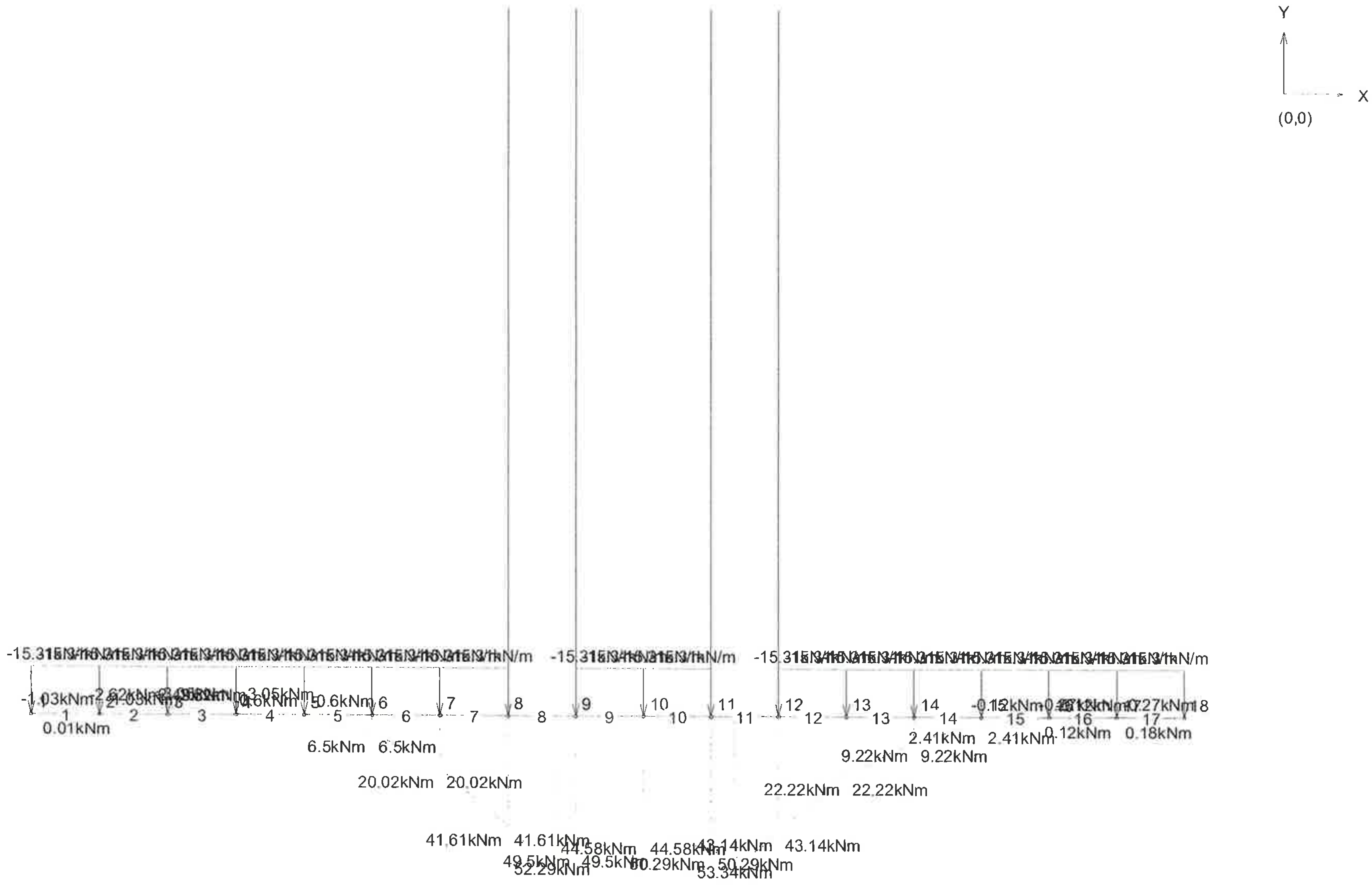
Job: Unnamed
Units - Len: m, Sec: mm, Mat: MPa, Dens: T/m^3, Temp: Celsius, Force: kN, Mom: kNm, Mass: T, Acc: g's, Trans: mm, Stress: MPa
Scales - Frame: 1:56, Load: 2, Disp: None, Moment: 2.3, Shear: 3.6, Axial: None, Torsion: None

SPACE GASS 11.06 - AIREY CONSULTANTS LTD

25 Jan 2016, 4:09 pm

All load cases:

■ 1



Materials:
■ 1 CONCRETE-32

Sections:
■ 1 400x400BM

BR12

Job: Unnamed
Units - Len: m, Sec: mm, Mat: MPa, Dens: T/m^3, Temp: Celsius, Force: kN, Mom: kNm, Mass: T, Acc: g's, Trans: mm, Stress: MPa
Scales - Frame: 1:36, Load: 2, Disp: None, Moment: 2.3, Shear: None, Axial: None, Torsion: None

SPACE GASS 11.06 - AIREY CONSULTANTS LTD
Job: Z:\Jobs 0000-9999\1000 Airey Consultants\16 Community Projects\Auckland Harbour Bridge\Skypath NorthRamp\SGUJ0001
Designer: Date: Monday, January 25, 2016 4:14 PM Page: 1

BR13

ANALYSIS STATUS REPORT

Job name ...... Unnamed
Location ...... Z:\Jobs 0000-9999\1000 Airey Consultants\16 Community Proje...

Length units	m
Section property units	mm
Material strength units	MPa
Mass density units	T/m^3
Temperature units	Celsius
Force units	kN
Moment units	kNm
Mass units	T
Acceleration units	g's
Translation units	mm
Stress units	MPa

Nodes	18	(32765)
Members	17	(32765)
Plates	0	(32765)
Restrained nodes	18	(32765)
Nodes with spring restraints	18	(32765)
Section properties	1	(5000)
Material properties	1	(999)
Constrained nodes	0	(32765)
Member offsets	0	(32765)
Node loads	0	(250000)
Prescribed node displacements	0	(250000)
Member concentrated loads	0	(250000)
Member distributed forces	17	(250000)
Member distributed torsions	0	(250000)
Thermal loads	0	(250000)
Member prestress loads	0	(250000)
Plate pressure loads	0	(250000)
Self weight load cases	0	(10000)
Combination load cases	0	(10000)
Load cases with titles	0	(10000)
Lumped masses	0	(250000)
Spectral load cases	0	(10000)
Static analysis	Y	
Dynamic analysis	N	
Response analysis	N	
Buckling analysis	N	
Ill-conditioned	N	
Non-linear convergence	Y	
Frontwidth	12	
Total degrees of freedom	104	
Static load cases	1	(10000)
Mass load cases	0	(10000)

NODE COORDINATES (m)

Node	X Coord	Y Coord	Z Coord
1	0.000	0.000	0.000
2	0.400	0.000	0.000
3	0.800	0.000	0.000
4	1.200	0.000	0.000
5	1.600	0.000	0.000
6	2.000	0.000	0.000
7	2.400	0.000	0.000
8	2.800	0.000	0.000
9	3.200	0.000	0.000
10	3.600	0.000	0.000
11	4.000	0.000	0.000
12	4.400	0.000	0.000
13	4.800	0.000	0.000
14	5.200	0.000	0.000
15	5.600	0.000	0.000
16	6.000	0.000	0.000
17	6.400	0.000	0.000
18	6.800	0.000	0.000

MEMBER DATA (deg,kNm/rad,m)
(F=Fixed, R=Released) (*=Cable length)

Memb	Dir Angle	Dir Node	Dir Axis	Memb Type	Node A	Node B	Sect	Mat	Node A Fixity	Node B Fixity	Length
1	0.00			Norm	1	2	1	1	FFFFFF	FFFFFF	0.400
2	0.00			Norm	2	3	1	1	FFFFFF	FFFFFF	0.400
3	0.00			Norm	3	4	1	1	FFFFFF	FFFFFF	0.400
4	0.00			Norm	4	5	1	1	FFFFFF	FFFFFF	0.400
5	0.00			Norm	5	6	1	1	FFFFFF	FFFFFF	0.400
6	0.00			Norm	6	7	1	1	FFFFFF	FFFFFF	0.400
7	0.00			Norm	7	8	1	1	FFFFFF	FFFFFF	0.400
8	0.00			Norm	8	9	1	1	FFFFFF	FFFFFF	0.400
9	0.00			Norm	9	10	1	1	FFFFFF	FFFFFF	0.400
10	0.00			Norm	10	11	1	1	FFFFFF	FFFFFF	0.400
11	0.00			Norm	11	12	1	1	FFFFFF	FFFFFF	0.400
12	0.00			Norm	12	13	1	1	FFFFFF	FFFFFF	0.400
13	0.00			Norm	13	14	1	1	FFFFFF	FFFFFF	0.400
14	0.00			Norm	14	15	1	1	FFFFFF	FFFFFF	0.400
15	0.00			Norm	15	16	1	1	FFFFFF	FFFFFF	0.400
16	0.00			Norm	16	17	1	1	FFFFFF	FFFFFF	0.400
17	0.00			Norm	17	18	1	1	FFFFFF	FFFFFF	0.400

NODE RESTRAINTS (kN/m,kNm/rad)
(F=Fixed, R=Released, S=Spring, *=General)

Node	Rest Code	X Axial Stiffness	Y Axial Stiffness	Z Axial Stiffness	X Rotation Stiffness	Y Rotation Stiffness	Z Rotation Stiffness
1	FSFFRR		12800.000				
2	RSRRRR		12800.000				
3	RSRRRR		12800.000				
4	RSRRRR		12800.000				
5	RSRRRR		12800.000				
6	RSRRRR		12800.000				
7	RSRRRR		12800.000				
8	RSRRRR		12800.000				
9	RSRRRR		12800.000				
10	RSRRRR		12800.000				
11	RSRRRR		12800.000				
12	RSRRRR		12800.000				
13	RSRRRR		12800.000				
14	RSRRRR		12800.000				
15	RSRRRR		12800.000				
16	RSRRRR		12800.000				
17	RSRRRR		12800.000				
18	RSFRRR		12800.000				

SECTION PROPERTIES (mm,mm^2,mm^4,deg)

Sect	Name	Mark	Shape	Source
1	400x400BM	S1	Solid square	User

Sect	Area of Section	Torsion Constant	Y-Axis Mom of In	Z-Axis Mom of In	Y-Axis Shr Area	Z-Axis Shr Area	Princ Angle
1	1.6000E+05	3.5994E+09	2.1333E+09	2.1333E+09	Infinite	Infinite	0.00

Sect	Shape	Trans	Mir	Rotate	D	Bt/Bb	Btw/Bbw	Tt/Tb	Tw/Rr
1	Solid square	No	No	0.00	400.00	0.00	0.00	0.00	0.00
						0.00	0.00	0.00	0.00

MATERIAL PROPERTIES (MPa,T/m^3,strain/degC)

Matl	Material Name	Young's Modulus	Poisson's Ratio	Mass Density	Coeff of Expansion	Concrete Strength
1	CONCRETE-32	3.1000E+04	0.20	2.5000E+00	1.000E-05	32.00

BR14

SPACE GASS 11.06 - AIREY CONSULTANTS LTD
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Designer: Date: Monday, January 25, 2016 4:14 PM Page: 2

MEMBER DISTRIBUTED FORCES (m, kN/m)

Load Case	Memb	Sub Load	Axes Sys	Start Position	Finish Position	X Start/ Finish	Y Start/ Finish	Z Start/ Finish
1	1	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	2	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	3	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	4	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	5	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	6	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	7	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	8	2	GI	0.000%	100.000%	0.000 0.000	-305.000 -305.000	0.000 0.000
	9	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	10	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	11	2	GI	0.000%	100.000%	0.000 0.000	-305.000 -305.000	0.000 0.000
	12	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	13	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	14	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	15	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	16	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000
	17	1	GI	0.000%	100.000%	0.000 0.000	-15.310 -15.310	0.000 0.000

NODE DISPLACEMENTS (mm, rad)

Load case 1 (Linear):

Node	X-Axis Transl'n	Y-Axis Transl'n	Z-Axis Transl'n	X-Axis Rotation	Y-Axis Rotation	Z-Axis Rotation
1	0.000	-0.038	0.000	0.000	0.000	-0.001
2	0.000	-0.370	0.000	0.000	0.000	-0.001
3	0.000	-0.703	0.000	0.000	0.000	-0.001
4	0.000	-1.042	0.000	0.000	0.000	-0.001
5	0.000	-1.387	0.000	0.000	0.000	-0.001
6	0.000	-1.731	0.000	0.000	0.000	-0.001
7	0.000	-2.056	0.000	0.000	0.000	-0.001
8	0.000	-2.329	0.000	0.000	0.000	-0.001
9	0.000	-2.502	0.000	0.000	0.000	0.000
10	0.000	-2.554	0.000	0.000	0.000	0.000
11	0.000	-2.495	0.000	0.000	0.000	0.000
12	0.000	-2.313	0.000	0.000	0.000	0.001
13	0.000	-2.028	0.000	0.000	0.000	0.001
14	0.000	-1.685	0.000	0.000	0.000	0.001
15	0.000	-1.317	0.000	0.000	0.000	0.001
16	0.000	-0.940	0.000	0.000	0.000	0.001
17	0.000	-0.563	0.000	0.000	0.000	0.001
18	0.000	-0.186	0.000	0.000	0.000	0.001

MEMBER FORCES AND MOMENTS (kN, kNm)

Load case 1 (Linear):

Memb	Node	Axial Force	Y-Axis Shear	Z-Axis Shear	X-Axis Torsion	Y-Axis Moment	Z-Axis Moment
1	1	0.000	0.487	0.000	0.000	0.000	0.000
	2	0.000	-5.637	0.000	0.000	0.000	-1.030
2	2	0.000	-0.907	0.000	0.000	0.000	-1.030
	3	0.000	-7.031	0.000	0.000	0.000	-2.618
3	3	0.000	1.971	0.000	0.000	0.000	-2.618
	4	0.000	-4.153	0.000	0.000	0.000	-3.054
4	4	0.000	9.188	0.000	0.000	0.000	-3.054
	5	0.000	3.064	0.000	0.000	0.000	-0.604
5	5	0.000	20.820	0.000	0.000	0.000	-0.604
	6	0.000	14.696	0.000	0.000	0.000	6.500
6	6	0.000	36.853	0.000	0.000	0.000	6.500
	7	0.000	30.729	0.000	0.000	0.000	20.016
7	7	0.000	57.047	0.000	0.000	0.000	20.016
	8	0.000	50.923	0.000	0.000	0.000	41.610
8	8	0.000	80.735	0.000	0.000	0.000	41.610
	9	0.000	-41.265	0.000	0.000	0.000	49.504
9	9	0.000	-9.244	0.000	0.000	0.000	49.504
	10	0.000	-15.368	0.000	0.000	0.000	44.582
10	10	0.000	17.330	0.000	0.000	0.000	44.582
	11	0.000	11.206	0.000	0.000	0.000	50.289
11	11	0.000	43.138	0.000	0.000	0.000	50.289
	12	0.000	-78.862	0.000	0.000	0.000	43.144
12	12	0.000	-49.253	0.000	0.000	0.000	43.144
	13	0.000	-55.377	0.000	0.000	0.000	22.218
13	13	0.000	-29.421	0.000	0.000	0.000	22.218
	14	0.000	-35.545	0.000	0.000	0.000	9.225
14	14	0.000	-13.978	0.000	0.000	0.000	9.225
	15	0.000	-20.102	0.000	0.000	0.000	2.409
15	15	0.000	-3.249	0.000	0.000	0.000	2.409
	16	0.000	-9.373	0.000	0.000	0.000	-0.116
16	16	0.000	2.665	0.000	0.000	0.000	-0.116
	17	0.000	-3.459	0.000	0.000	0.000	-0.274
17	17	0.000	3.748	0.000	0.000	0.000	-0.274
	18	0.000	-2.376	0.000	0.000	0.000	0.000

NODE REACTIONS (kN, kNm)

Load case 1 (Linear):

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
1	0.000	0.487	0.000	0.000	0.000	0.000
2	0.000	4.730	0.000	0.000	0.000	0.000
3	0.000	9.001	0.000	0.000	0.000	0.000
4	0.000	13.342	0.000	0.000	0.000	0.000
5	0.000	17.755	0.000	0.000	0.000	0.000
6	0.000	22.157	0.000	0.000	0.000	0.000
7	0.000	26.318	0.000	0.000	0.000	0.000
8	0.000	29.812	0.000	0.000	0.000	0.000
9	0.000	32.021	0.000	0.000	0.000	0.000
10	0.000	32.698	0.000	0.000	0.000	0.000
11	0.000	31.932	0.000	0.000	0.000	0.000

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
12	0.000	29.609	0.000	0.000	0.000	0.000
13	0.000	25.956	0.000	0.000	0.000	0.000
14	0.000	21.567	0.000	0.000	0.000	0.000
15	0.000	16.854	0.000	0.000	0.000	0.000
16	0.000	12.038	0.000	0.000	0.000	0.000
17	0.000	7.207	0.000	0.000	0.000	0.000
18	0.000	2.376	0.000	0.000	0.000	0.000
Load	0.000	-335.860	0.000	0.000	0.000	0.000
Reac	0.000	335.860	0.000	0.000	0.000	0.000
Equil	0.000E+00	0.000E+00	0.000E+00			
Resid	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.215E-12

BILL OF MATERIALS (m,m^2,T)

Memb	Sect	Qty	Section Name	Unit Length	Total Length	Unit Mass	Total Mass
1	1	17	400x400BM	0.400	6.800	0.160	2.720

Total mass = 2.720
Centre of gravity = 3.400,0.000,0.000

BR15

$\Rightarrow A_{cv, min} = \frac{325 \times 10^3}{0.931} = 350 \times 10^3 \ mm^2/m$

$(b = 5700)$

$\Rightarrow d \simeq \frac{350 \times 10^3}{5700} = 61.2 mm$

– try 300 mm slab $t = 0.3m \rightarrow G = 7.2 kPa$

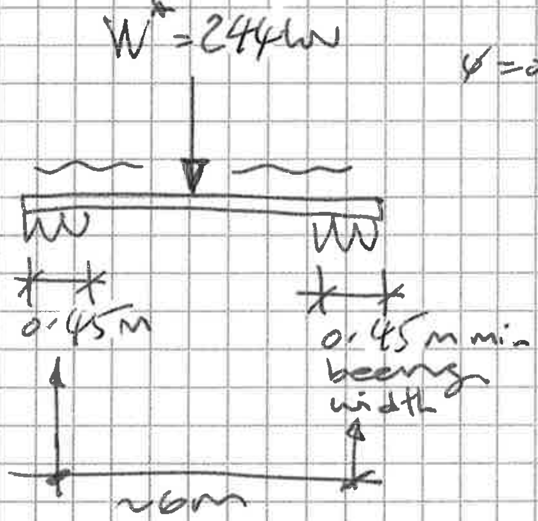
$\Rightarrow 1.10 G = 7.92 kPa$

$\Rightarrow V^*_G \simeq 7.92 \times 6.0 \times 5.7 / 2 = 135 kN$

tot $R^* = V^* \simeq 244 + 135$

$\Rightarrow V^* = 379 kN$

$\phi = 0.75 \Rightarrow V_n = 505 kN$



$q_{dep} = 150 kPa$ (100 kPa allow. CBR ≃ 7)

$\Rightarrow A_b = 2.53 m^2$

$\div 5.7 = 0.45 m$

$A_{cv, min} = \frac{505 \times 10^3}{0.931}$

$= 542 \times 10^3 mm^2$

$\div 5700 \Rightarrow d_{min} = 95 mm$

$V_b = (0.07 + 10 \rho_w) \sqrt{f'_c} \leq 0.2 \sqrt{f'_c}$

$= 1.095 MPa$

$M^*_{max} \simeq 244 \times \frac{6.0}{4} + 180 \times 6.0/8$

$= 501 kNm$

$\div 88 kNm/m$

– try 200 thick slab

$G = 4.8 kPa$

$1.10 G = 5.28 kPa$

$W^*_G = 180 kN$

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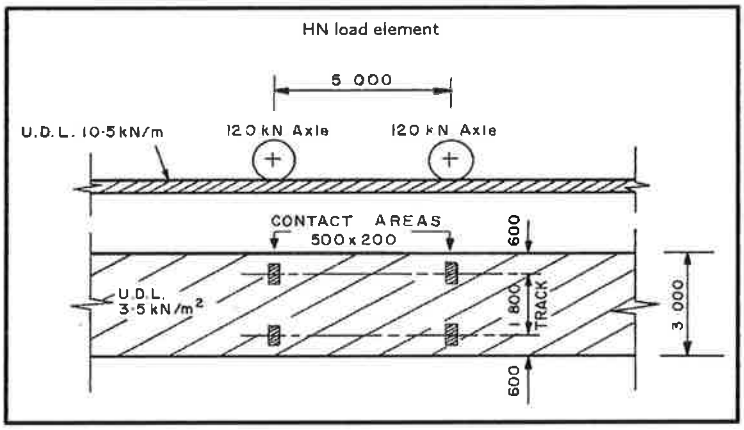
	Job:	Exploration Way Whitby	Job No:
Pukekohe Takapuna Howick Queenstown	Calc's By:	Roger T	Date: 03-Feb-16

Concrete Pavement design for 85%HN traffic loading:
(Ref. NZ Transport Agency Bridge Manual, Appendix D)

HN Axle load =	**120.0**	kN
85% HN =	**102.0**	kN
axle spacing =	5.0	m
wheel track spacing =	1.8	m
contact areas =	500.0	mm wide
=	200.0	mm deep
UDL Live load =	3.50	kPa
85% HN UDL =	**2.975**	kPa
UDL load width =	3.00	m



UDL Load cases: (applicable)

Primary Normal: (Self weight and Traffic combinations only)

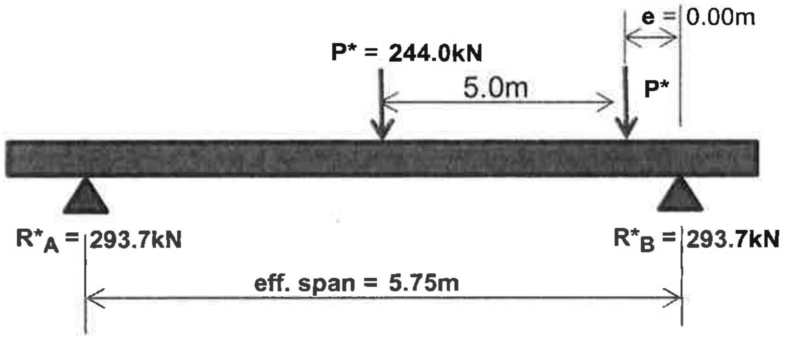
Load case: 1A	DL	LL x I	
Load Factors	1.10	1.84	(Ref. Table D.2)
UDL	**6.072**	**8.37**	[kPa]
Wheel loads		**244.0**	[kN]

where: Impact Factor, **I** = **1.30** (Ref. Fig 3.2)

Slab design: (single span)

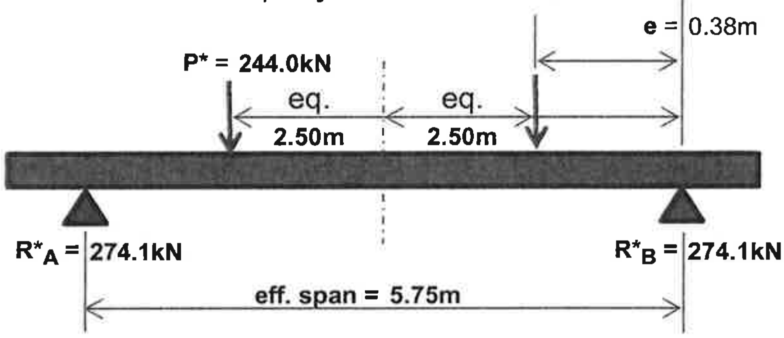
Overall slab thickness, **D** =	**230**	mm
Slab self weight, **DL,** G_s =	5.52	kPa
Topping thickness, **t** =	**0**	mm
Density of topping, γ_t =	**0.0**	kN/m³
Topping weight, **DL,** G_T =	0.00	kPa
⇒ **Total DL =**	**5.52**	kPa
Effective width of slab, **W** =	**5.70**	m
Clear span, L_c =	**5.40**	m
⇒ Effective slab span, L_e =	**5.75**	m (betweeen CL of supports)

Case 1: Axle load at centre



effective w^*_{UDL} =	10.48	kN/m
P^*_Q =	244.0	kN
M^*_{max} =	**104.84**	kNm/m
R^*_A =	293.71	kN
R^*_B =	**293.71**	kN
V^*_A =	**51.53**	kN/m

Case 2: Axle loads equally either side of ctr.



effective w^*_{UDL} =	10.48	kN/m
P^*_Q =	244.0	kN
M^*_{max} =	**59.36**	kNm/m
R^* =	**274.11**	kN
V^*_A =	**48.09**	kN/m

⇒ **Maximum design M^*_{max}** = **104.84** kNm/m

⇒ **Maximum design V^*_{max}** = **51.53** kN/m

BR19

Reinforced slab capacity:

	Nominal compressive strength, f'_c =	**30.0**	MPa		
Elastic Modulus:	$E_c = 3320 \sqrt{f'_c} + 6900$				
	design E_c =	**25,084**	MPa		
	reinforcing grade, f_y =	**500**	MPa		
	E_s =	2.00E+05	MPa		
Reinforcing:	bar size, d_b =	**16**	mm		
	Overall slab depth, **D** =	**230**	mm		
	bottom cover =	**75**	mm		
	effective depth, **d** =	147	mm (to centroid of tens. reinf)		
	s_{max} = 2D =	300	mm	≤ 300	(9.3.8.3)
	bar ctrs, **s** =	**100**	mm		**OK**
	⇒	**HD16 - 100**			
	Steel area, A_s =	2,010.6	mm^2/m		
	slab width, **b** =	1,000	mm/m		
	ρ =	0.0137			
β = 0.85	**0.75** ρ_b =	0.0296			**OK**

For one-way slabs:

(Eq. 9 -1)	Min. steel area, $A_s = \sqrt{f'_c} / (4 f_y) . b_w . d$				
	=	403	mm^2/m		**OK**
	$\geq 1.4\, b_w\, d / f_y$ =	**412**	mm^2/m	governs	

balanced strain check:	**a** = $A_s f_y / (0.85 f'c\, b)$			
(strength)	=	**39.4**	mm	
⇒	**c** =	**46.4**	mm	
	⇒ **jd** =	139.00	mm	
	C =	1005.3	kN	
ε_c = 0.003	$c_b = d\, \varepsilon_c / (\varepsilon_c + \varepsilon_y)$			
	=	80.2	mm	
	0.75 c_b =	**60.1**	mm	**OK**

Flexural Strength:	**Applied ultimate moment, M* =**	**104.84**	kNm/m	
	ϕ_b =	**0.85**		
Dependable flexural strength:	ϕM_n =	**108.77**	kNm/m	**OK**

Reinforced slab capacity:

BR20

Nominal compressive strength, f'_c = 30.0 MPa

Elastic Modulus: $E_c = 3320 \sqrt{f'_c} + 6900$

design E_c = **25,084** MPa

reinforcing grade, f_y = 500 MPa

E_s = 2.00E+05 MPa

Reinforcing:

bar size, d_b = 16 mm

Overall slab depth, **D** = **230** mm (ON DPM)

bottom cover = 50 mm

effective depth, **d** = 172 mm (to centroid of tens. reinf)

$s_{max} = 2D$ = 300 mm ≤ 300 (9.3.8.3)

bar ctrs, **s** = 125 mm **OK**

⇒ **HD16 - 125** (ALT.)

Steel area, A_s = 1,608.5 mm^2/m

slab width, **b** = 1,000 mm/m

ρ = 0.0094

$\beta = 0.85$ **0.75 ρ_b =** 0.0296 **OK**

For one-way slabs:

(Eq. 9 -1) Min. steel area, $A_s = \sqrt{f'_c} / (4 f_y).b_w.d$

= 471 mm^2/m **OK**

$\geq 1.4\, b_w\, d / f_y$ = **482** mm^2/m governs

balanced strain check:

(strength)

a = $A_s f_y / (0.85 f'c\, b)$

= **31.5** mm

⇒ **c =** **37.1** mm

⇒ **jd =** 164.00 mm

C = 804.2 kN

$\varepsilon_c = 0.003$ $c_b = d\, \varepsilon_c / (\varepsilon_c + \varepsilon_y)$

= 93.8 mm

0.75 c_b = **70.4** mm **OK**

Flexural Strength: **Applied ultimate moment, M* =** **104.84** kNm/m

ϕ_b = **0.85**

Dependable flexural strength: **ϕM_n =** **106.80** kNm/m **OK**

BR21

Shear - slabs: (9.3.9.3)

Maximum ultimate shear, V^* = **51.53** kN/m

ϕ_s = **0.75**

V_n = 68.70 kN/m

⇒ v_n = **0.47** MPa

$v_b = (0.07+10\,\rho_w)\sqrt{f'c}$

= 1.13 MPa

need not be less than: $v_{c,min.} = 0.08\sqrt{f'_c}$ = 0.44 MPa

and no more than: $v_{c,max.} = 0.2\sqrt{f'_c}$ = 1.10 MPa

⇒ v_b = **1.10** MPa

k_a = **1.00**

k_d = **1.00**

$v_c = k_a k_d v_b$ (Eq. 9-5)

= **1.10** MPa

max. v_n = 0.2f'c or 8.0MPa

= 6.00 MPa **OK**

v_n = 0.427 v_c

Shear strength, $\phi V_n = \phi_s v_c b_w d$

⇒ ϕV_n = **120.77** kN/m **OK**

Transverse reinforcing:

(8.8.1) $A_{s,min} = (0.7/fy).Ag$ $\geq 0.0014\,A_g$

= **322** mm²/m

s_{max} = 2D = 300 mm ≤ 300 (9.3.8.3)

bar size, d_b = **12** mm

bar ctrs, **s** = **300** mm **OK**

Steel area, A_s = 377 mm²/m **OK**

⇒ **HD12 - 300 transverse**

End supports:

dependable bearing capacity, ϕq_b = **150** kPa

maximum V^* = 51.53 kN/m (at supports)

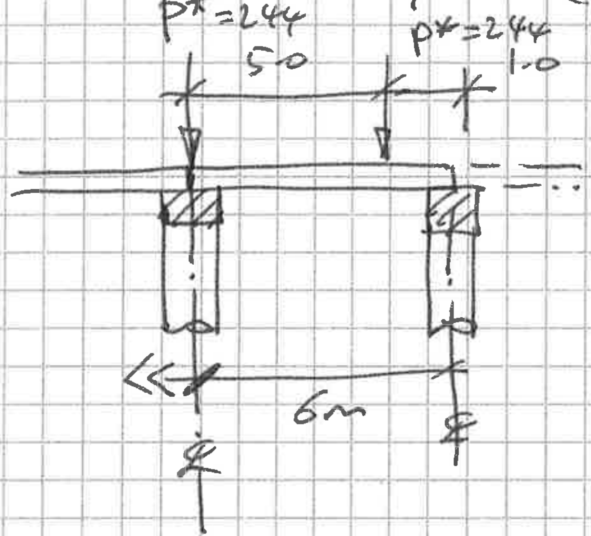
⇒ minimum bearing width, w_b = 0.344 m

⇒ Overall slab length L_o = **6.10** m

BEAMS

- max trib span = 6m (slab span)
- allow 4m max width (min ≃ 3m)

G slab (230 thick) ≃ 5.52 kPa



1.1G = 6.07 kPa
×6 = 36.42 kN/m

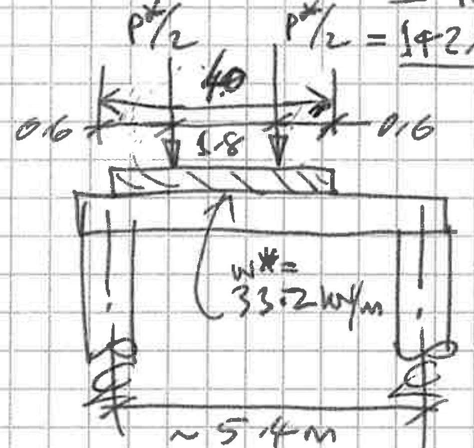
P* = (1.84 × 102 × 1.3)
= 244 kN

⇒ P*eff on beams (max.)

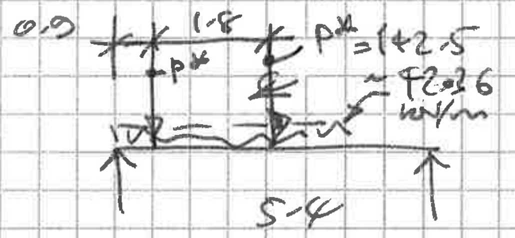
= 244 + 244 × 1.0/6
= 285 kN (eff.) (max.)

- max beam span ≃ 5.4m

P*/2 P*/2 = 142.5 kN (eff.)



- assume one load central:

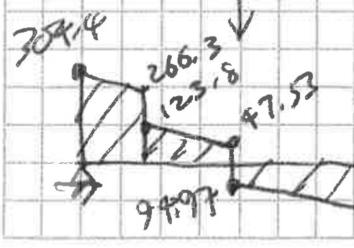


(will be, by inspection, critical load case)

Try 500W × 450D BEAM
G = 5.4 kN/m
1.1G = 5.94 " "

tot w* ≃ 42.36 kN/m

M*max @V* = 0 initially ⇒ M* ≃ 142.5 × 5.4/4 + (142.5 × 0.9 × 4.5)/5.4 × (2.7/4.5)
+ 42.36 × 5.4²/8
= 411 kNm



SHEAR [kN]

V*max ≃ 142.5/2 + 142.5 × 4.5/5.4 + 42.36 × 5.4/2
= 304.4 kN

AIREY CONSULTANTS LTD. Consulting Civil and Structural Engineers	Client:	Progeni Ltd.	Sheet No: 23
Pukekohe Takapuna Howick Queenstown	Job:	Exploration Way Whitby	Job No:
	Calc's By:	Roger T	Date: 05-Feb-16

Edition: **12.08.15**

Reinforced concrete member capacities:

Material Type = concrete
Nominal compressive strength, $\mathbf{f'_c}$ = **30.0** MPa

Elastic modulus, $\mathbf{E_c}$ = $3320 \sqrt{f'_c} + 6900$
⇒ design $\mathbf{E_c}$ = **25,084** MPa

Reinforcing grade, $\mathbf{f_y}$ = **500** MPa
Young's modulus, $\mathbf{E_s}$ = 2.00E+05 MPa

Reinforcing:

Layer	d_b (mm)	No.	A_s	d (mm)	α_a	L_{db} (mm)
L1	25	4	1963	552.5	1.00	1141
L2			0	0.0	1.00	
L3			0	0.0	1.00	
L4			0	0.0	1.00	

(tension)

total steel area, $\mathbf{A_s}$ = **1,963** mm^2

Effective width, **b** = **450** mm
o/a depth/thickness, **D** = **575** mm
bottom cover to stirrups, $\mathbf{c_b}$ = **75** mm
Effective depth, **d** = 552.5 mm (to centroid of tens. reinf.)
design steel area, $\mathbf{A_s}$ = 1,963 mm^2
ρ = 0.0079
$\beta = 0.85$ **0.75** ρ_b = 0.0177

balanced strain check: (strength)

a = $A_s f_y / (0.85 f'c\, b)$
= **85.6** mm
⇒ **c =** **100.7** mm
⇒ **jd =** 509.72 mm
C = 981.7 kN
$\mathbf{c_b} = d\, \varepsilon_c / (\varepsilon_c + \varepsilon_y)$ ε_c = **0.0030**
= 301.4 mm
0.75 $\mathbf{c_b}$ = 226.0 mm   **OK**

Flexural Strength:

Applied ultimate moment, M* = **411.0** kNm

ϕ_b = **0.85**

Dependable flexural strength: $\phi \mathbf{M_n}$ = **425.36** kNm   **OK**

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Shear - beams:

	Maximum ultimate shear, V^* =	**304.40**	kN	
	ϕ_s =	**0.75**		
	V_n =	405.87	kN	
⇒	v_n =	**1.63**	MPa	
	$v_b = (0.07+10\,\rho_w)\sqrt{f'c}$			(9.3.9.4)
	=	0.82	MPa	
need not be less than:	$v_{c,min.} = 0.08\sqrt{f'_c}$ =	0.44	MPa	
and no more than:	$v_{c,max.} = 0.2\sqrt{f'_c}$ =	1.10	MPa	
for masonry:	v_m =	**0.00**	MPa	
⇒	v_b =	**0.82**	MPa	
k_d = **1.00**	$v_c = k_d\,k_a\,v_b$			(Eq. 9-5)
k_a = **1.000**	=	**0.82**	MPa	
	max. v_n = 0.2f'c or 8.0MPa			
	=	6.00	MPa	OK

Shear reinforcing :

v_n = 2.00 v_c

therefore shear reinforcing is required

Stirrup yield strength, f_{yt} =	**300**	MPa		
s = d/4 if $V_s > 0.33\sqrt{f'_c}\,b_w\,d$ =	449.39	kN		(9.3.9.4.12,(d))
⇒ s_{max} = **d/2 =**	276.3	mm		
s =	**250**	mm		OK
$A_{v,min} = (1/16)\sqrt{f'_c}\,b_w\,s/f_{yt}$ =	128	mm^2	(Eq. 9-10)	OK
required A_v =	306	mm^2		
stirrup dia. =	**10**	mm		
No. legs =	**4**			
A_v =	314	mm^2		OK
V_s =	208.3	kN		
use :	**4 leg R10 - 250**			

Shear strength, $\phi V_n = \phi_s\,(A_v\,f_{yt}\,d\,/\,s + v_c\,b_w\,d)$

= **359.1** kN OK

For $R^* = 304$ kN, min bearing area $= \frac{304}{150}$

$= 2.03 m^2$
$\doteq 1.45$ m.sq.

or $\approx 2.0m \times 1.0m$

or// using piles:

– try 450 ∅ piles $\phi R_u = \pi \times 150 \times 0.45^2 / 4$
$= 23.8$ kN

skin friction, $\phi R_u = \frac{150}{6} = 25$ kPa

$\Rightarrow D_{min} = \frac{304 - 23.8}{25}$

$= 11.20m$!! NG.

with 2m × 1m ftgs:

$M^* = (150 \times 1.0) \times \left(\frac{2.0}{2}\right)^2 / 2 = 75$ kNm
$= 75$ kNm/m

assume $d = 300m \Rightarrow d_c \doteq 300 - 75 - 10$
$= 215$

$A_s = 872 mm^2/m$

$= 5$ HD16 $A_s = 1005 mm^2$

$\Rightarrow \phi M_n = 85.5$ kNm/m ok

Shear: $V^* = 304/2 = 152$ kN

$v_n < 0.2 f'_c = 4$ MPa
< 8 MPa ok

$\Rightarrow v_n = \frac{152 \times 10^3}{0.75 \times 1000 \times 215} = 0.99$ MPa

$\rho_w = 4.67 \times 10^{-3}$

$f'_c = 20$

$v_c = (0.07 + 10\rho_w)\sqrt{f'_c}$
$= 0.117\sqrt{f'_c}$ $(\le 0.2\sqrt{f'_c})$ ✓
$= 0.523$ MPa $(= 0.89$ MPa$)$ ✓

$0.2\sqrt{f'_c} = 0.89$ MPa

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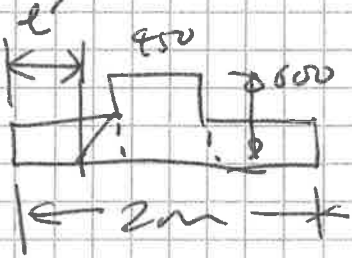
for $d = 215$ $l' = \left(\frac{2000 - 450}{2}\right) - 215 = 560\,mm$



$\Rightarrow V^*_l = 0.560 \times 1.0 \times 150\,kPa$

$= 84\,kN$

$\Rightarrow v_n = 0.52\,MPa$

$- \; v_c = 0.523\,MPa$ ie. OK

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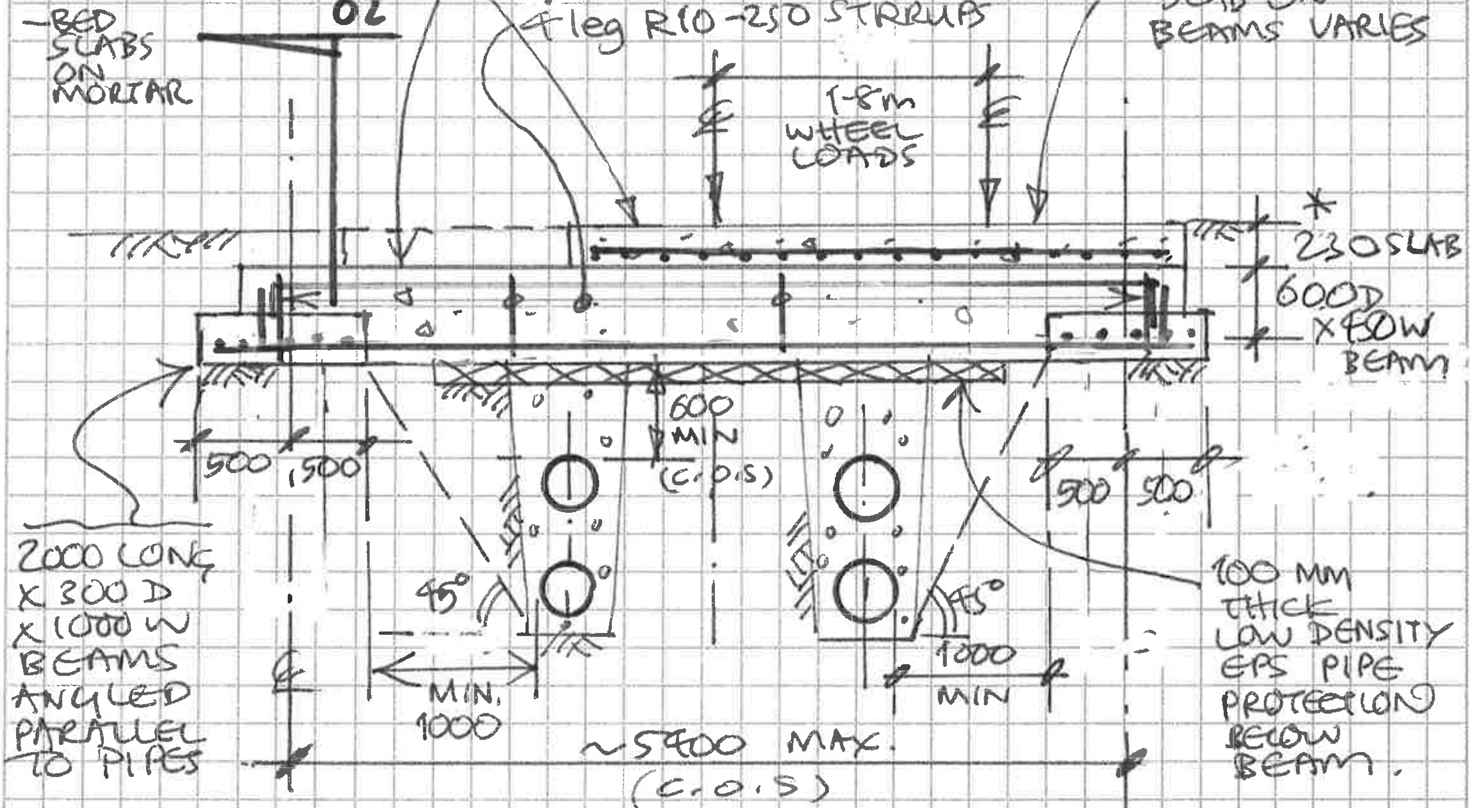
*
- 230 THICK x 30MPa SLAB
  HD16 - 100, 75 B/COV. (NO DPM.) (BEND ENDS 200)
  OR HD16 - 125, 50 B/COV
  ON DPM
- HD12-300
  TRANSVERSE,
  BEND ENDS 150
- BED SLABS ON MORTAR

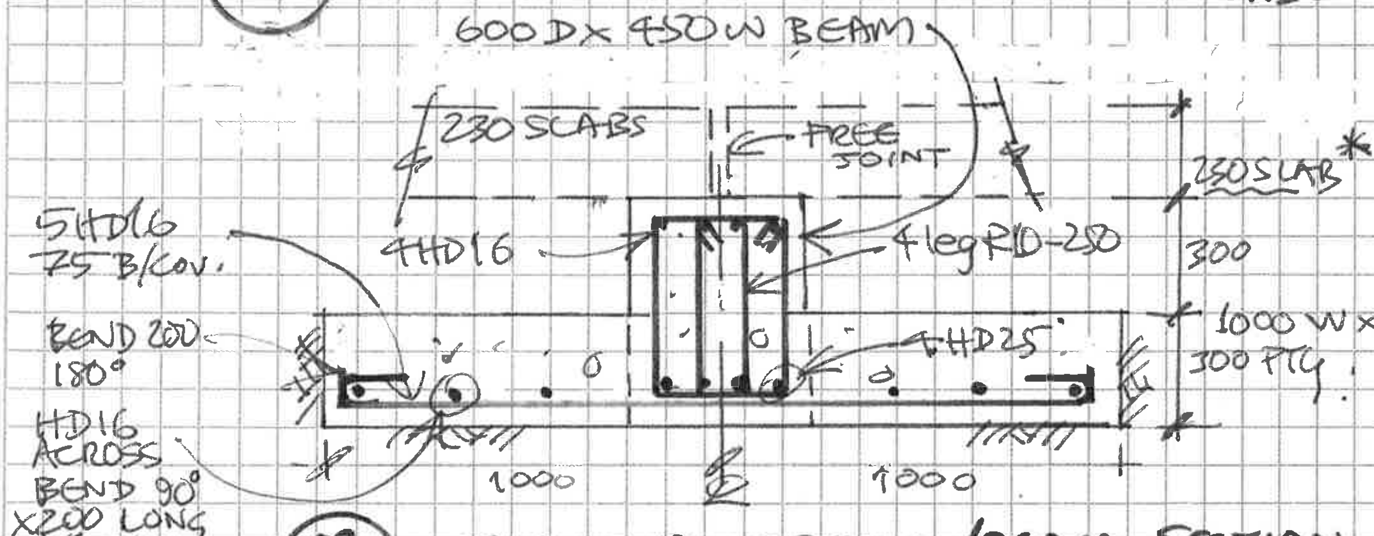
600D x 450W x 20MPa
CONC. BEAMS
4 HD25 BTM 75 B/COV.
4 HD16 TOP
4 leg R10-250 STIRRUPS

NOTE:
POSITION OF SLAB ON BEAMS VARIES



(02) TYP. SECTION AT BEAMS

~1:50



(03) TYP. END DETAILS / BEAM SECTION

~1:20

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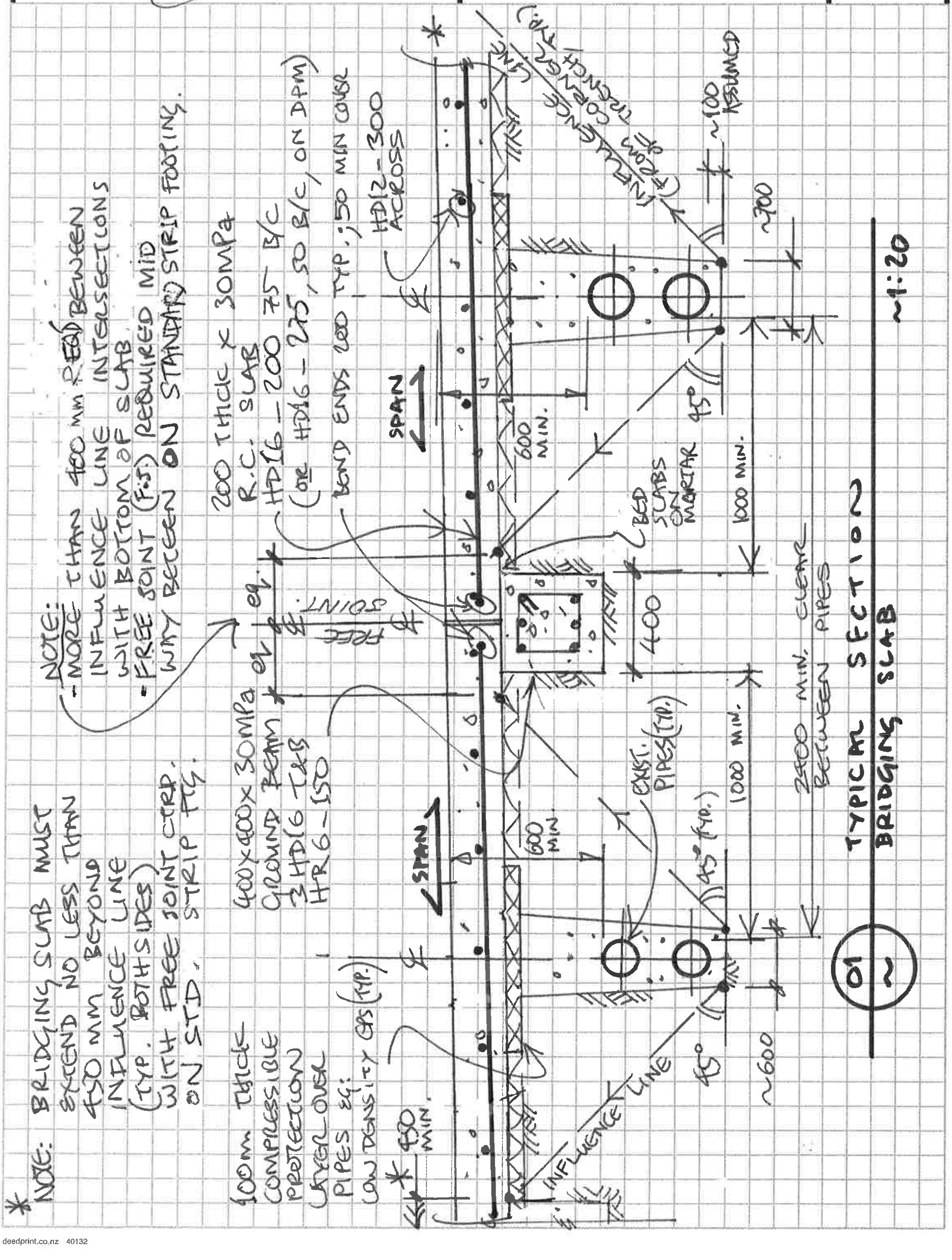

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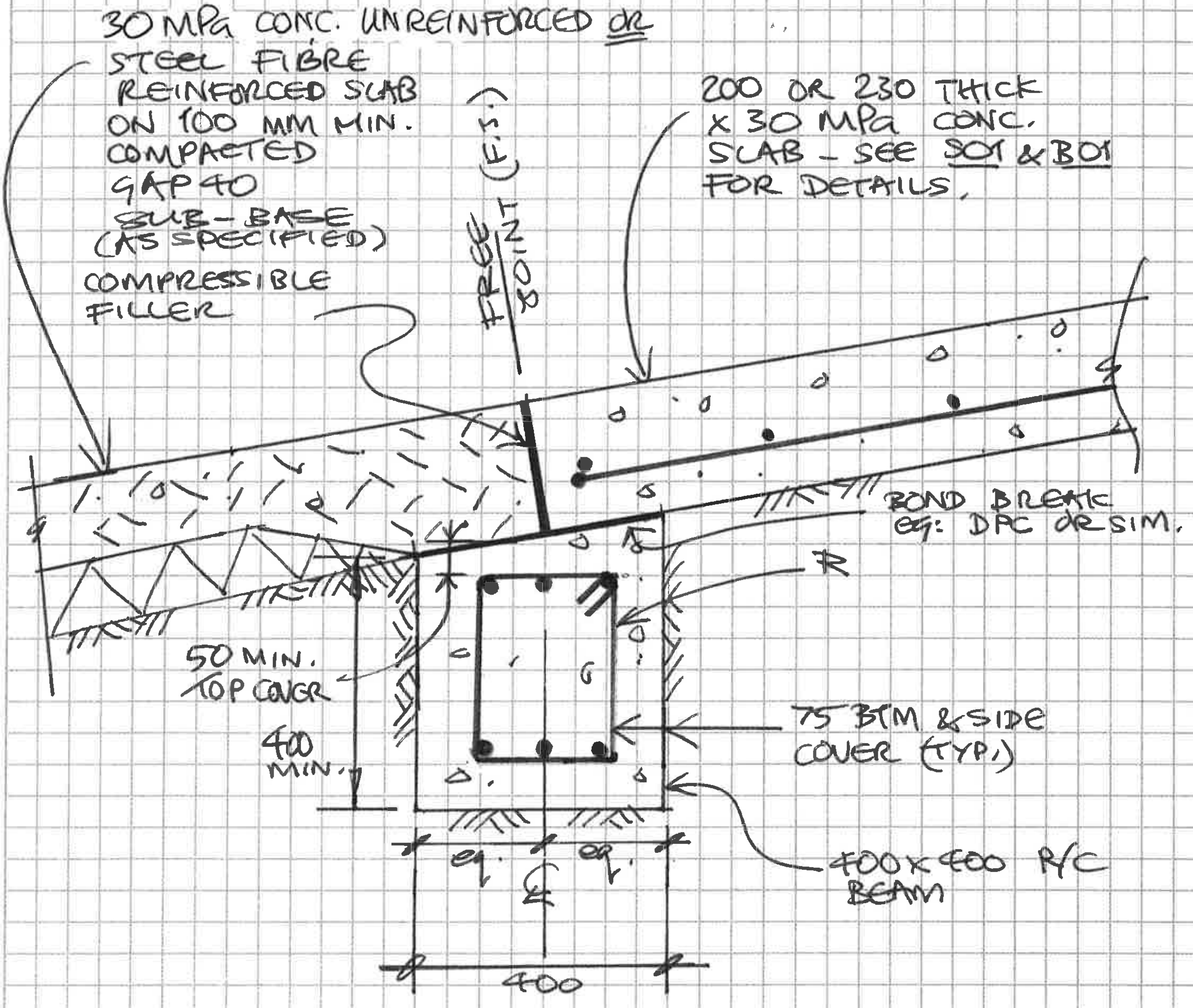
		JOB: EXPLORATION WAY	JOB No.: 12204-1
Pukekohe Takapuna Howick Queenstown		CALCS. BY: R.T PHONE:	DATE: JAN'16



02 ~ TYPICAL SLAB DETAILS

~1:10

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	JOB: EXPLORATION WAY.	JOB No.: 12204-1
	CALCS. BY: PHONE:	DATE: JAN '16

Pavement options summary:

- max load limit = 85% HN
  = 102 kN

- for subgrade CBR = 7%
- using unbound sub-base,
  eff. CBR = CBR = 7%
- using min. sub-base thickness = 100mm

A/ ⇒ 170 mm x 30MPa conc.
on 100 mm un-bound sub-base
(OR 160 thick on 100 mm bound sub-base)

B/ OR 145mm thick x 30MPa
Steel fibre reinf conc.
on 100 mm un-bound sub-base

C/ OR 135mm thick x 30MPa conc slab
steel fibre reinforced
on 100mm thick bound sub-base
(5% by mass cement content)

Reinforcing:

- steel fibre content = to Dramix reqs.
- min. 28 day flexural strength = 5.5MPa
- undowelled contraction joints
  @ 4m centres max.
  or dowelled with joints @ 5m ctrs max.
  or reinforced with joints @ 8m ctrs max.
- dowels, where used per AUSTROADS REQS.

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TABLE 9.4 APPROPRIATE DOWEL DIAMETERS

SLAB THICKNESS (h) (mm)	DOWEL DIAMETER* (mm)
$125 < h \le 140$	20
$140 < h \le 160$	24
$160 < h \le 190$	28
$190 < h \le 220$	33
$220 < h \le 250$	36

*AS 2338 Preferred dimensions of wrought metal products

- DOWEL BARS . GR. 250 x 450 mm LONG ROUND BARS @ 300 CTRS CENTRALLY PLACED
- DEBOND ONE SIDE OF JOINT.

TABLE 9.5 VALUES OF COEFFICIENT OF FRICTION

Coefficient of Friction	Bond-breaking system
1.0	A bituminous sprayed seal applied to the sub-base surface
1.5	A thin coat of wax debonding agent applied to the sub-base surface
2.0	A chlorinated rubber curing compound applied to the sub-base surface or use of an asphalt sub-base

A pro-forma to assist with design calculations is provided in Appendix I.

9.4.3 Minimum Base Thickness

Irrespective of the base thicknesses determined in accordance with this procedure, the minimum allowable thickness of concrete base to be trafficked by commercial vehicles should be

(i) 150 mm; except for

(ii) steel-fibre reinforced concrete where the minimum thickness of base should be not less than 125 mm.

These minimum thicknesses of concrete base also apply to asphalt surfaced rigid pavements.

9.4.4 Example of the Use of the Design Procedure

An example thickness design of a rigid pavement is given in Appendix I.

9.4.5 Example Design Charts

Example design charts for rigid pavements are presented in Figures 9.7 to 9.10. These charts have been determined using axle load distributions considered to be typical of rural and urban highways in Eastern Australia assuming a 28 day concrete flexural strength of 4.25 MPa (deemed equivalent to a compressive strength of 32 MPa). The load distributions and associated percentages of axle types on which the charts are based are given in Appendix I.

It is emphasised that the use of these example charts is limited by the similarity between the traffic loadings in Appendix I and those expected on the pavement being designed.

9.4.6 Provision of Dowels and Tie Bars

The thickness design procedure provides for the option of dowelled or undowelled contraction joints, as well as the option of adopting concrete shoulders (defined in Section 9.3.5).

9.4.6.1 Dowels

Dowel bars are to be plain steel bars of Grade 250R and 450 mm long. Dowels should be straight with one end free from burrs. Appropriate dowel diameters are given in Table 9.4.

Dowels at a spacing of 300 mm should be installed at transverse contraction joints where applicable. Dowels must be securely held parallel to each other, to the road centreline and to the centreline of the surface of the finished pavement. More than half of the smooth end of the dowel should be coated with a debonding agent to ensure lack of bond to the concrete on that side of the joint.

9.4.6.2 Tie Bars

Tie bars prevent separation of the pavement at longitudinal joints, allowing warping or curling to occur without excessive restraint.

Ties are to be 12 mm diameter Grade 400Y deformed steel bars, one metre long, placed centrally in the joint at spacings determined from Figure 9.11. A coefficient of friction of 1.5 (between base and sub-base) is assumed in Figure 9.11. Table 9.5 gives indicative values of the coefficient of friction for different bond-breaking systems. For a coefficient of friction of 1.0 an increase of 33% in the spacing given in Figure 9.11 is required and a coefficient of 2.0 requires a 33% reduction in the spacing derived from Figure 9.11.

Rigid Pavement Design:

(To Austroads)

Pavemnent Type =	**JU**	**Jointed, Undowelled**
Measured subgrade **CBR** =	**7.0**	%
Sub-base type =	**UB**	**Unbound**
Sub-base thickness =	**100**	mm
Design CBR =	**7.0**	% (Fig 9.2)

OPTION 'A'

Design traffic:

Axle group loads:

Axle config.	single single	single dual	tandem dual	triaxle dual
Load (kN)	**53**	**80**	**135**	**181**

Design Period = **25** years (20 - 40yrs

Design number of heavy axles, C_{ag} = C_d x 365 x GF

= **3.65E+04** EDA's

where: No. of lots served = **40**

Vehicles per day per lot = **10**

= 400 vpd

% HCV = **1.0** %

⇒ Design no. HCV's/day, C_d = **4**

where: Growth rate = **0** %

⇒ **GF** = **25.0** (Table 7.2)

Flexural strength:

Nominal concrete strength, f'c = **30.0** MPa (30 MPa m

Concrete flexural strength, f_{cf} = **0.75√f'c** (Eq. 6.5.1)

= **4.11** MPa

Steel fibre reinforced concrete = **No**

Steel fibre reinforced concrete, f^r = 5.0 - 5.5 MPa

⇒ use Design f_r = **4.11** MPa **NG**

Type = **Rural**

Shoulders = **No**

Dowelled = **No** (as above)

Load safety factor, L_{SF} = **1.0** (9.3.6)

Trial base thickness, t = **170** mm

Equivalent stress: (Table 9.2)

	CBR	SS	SD	TAD	TRD
design CBR =	7.0	1.399	2.254	1.903	1.417
Stress ratio factors =		0.340	0.548	0.463	0.345

Erosion factors: (Table 9.2) Undowelled

	CBR	SS	SD	TAD	TRD
design CBR =	7.0	2.631	3.354	3.371	1.703
Erosion factors =		2.631	3.354	3.371	1.703

Type SS:	Rural	Single axle, single wheels		SRF = 0.34		EF = 2.631	
Prop. of axle grp. =	0.35			Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	5.0	3.19	4.08E+02	unlimited	0.00	unlimited	0.00
20	10.0	7.00	8.94E+02	unlimited	0.00	unlimited	0.00
30	15.0	9.24	1.18E+03	unlimited	0.00	unlimited	0.00
40	20.0	28.74	3.67E+03	unlimited	0.00	5.88E+07	0.01
50	25.0	32.19	4.11E+03	1.49E+07	0.03	1.45E+07	0.03
60	30.0	13.40	1.71E+03	1.26E+06	0.14	4.63E+06	0.04
70	35.0	4.65	5.94E+02	1.06E+05	0.56	1.76E+06	0.03
80	40.0	1.21	1.55E+02	8.93E+03	1.73	7.62E+05	0.02
90	45.0	0.25	3.19E+01	7.54E+02	4.24	3.64E+05	0.01
102	51.0	0.08	1.02E+01	3.88E+01	26.36	1.66E+05	0.01
110	55.0	0.06	7.67E+00	5.36E+00	142.93	1.04E+05	0.01
	(65kN max.)				**175.98**		**0.15**
				at 102kN Σ =	**33%**		

Type SD: Rural Single axle, dual wheels							
Prop. of axle grp. = 0.12				SRF = 0.548		EF = 3.354	
				Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	2.5	7.91	3.46E+02	unlimited	0.00	unlimited	0.00
20	5.0	14.13	6.19E+02	unlimited	0.00	unlimited	0.00
30	7.5	12.43	5.44E+02	unlimited	0.00	unlimited	0.00
40	10.0	12.14	5.32E+02	unlimited	0.00	unlimited	0.00
50	12.5	11.26	4.93E+02	unlimited	0.00	unlimited	0.00
60	15.0	10.16	4.45E+02	unlimited	0.00	unlimited	0.00
70	17.5	9.09	3.98E+02	unlimited	0.00	unlimited	0.00
80	20.0	8.70	3.81E+02	unlimited	0.00	5.88E+07	0.00
90	22.5	6.66	2.92E+02	unlimited	0.00	2.81E+07	0.00
102	25.5	4.08	1.79E+02	unlimited	0.00	1.28E+07	0.00
110	27.5	1.98	8.67E+01	unlimited	0.00	7.99E+06	0.00
120	30.0	0.88	3.85E+01	unlimited	0.00	4.63E+06	0.00
130	32.5	0.41	1.80E+01	3.09E-05	58152333.81	2.80E+06	0.00
140	35.0	0.18	7.88E+00	8.66E-24	##########	1.76E+06	0.00
	(65kN max.)				##########		**0.01**

TypeTAD:	Rural	Tandem axle, dual wheels		SRF = 0.463		EF = 3.371	
Prop. of axle grp. =		0.32		Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	1.3	0.37	4.32E+01	unlimited	0.00	unlimited	0.00
20	2.5	0.56	6.54E+01	unlimited	0.00	unlimited	0.00
30	3.8	1.34	1.57E+02	unlimited	0.00	unlimited	0.00
40	5.0	3.39	3.96E+02	unlimited	0.00	unlimited	0.00
50	6.3	5.19	6.06E+02	unlimited	0.00	unlimited	0.00
60	7.5	5.10	5.96E+02	unlimited	0.00	unlimited	0.00
70	8.8	4.80	5.61E+02	unlimited	0.00	unlimited	0.00
80	10.0	4.78	5.58E+02	unlimited	0.00	unlimited	0.00
90	11.3	5.23	6.11E+02	unlimited	0.00	unlimited	0.00
102	12.8	6.15	7.18E+02	unlimited	0.00	unlimited	0.00
110	13.8	7.21	8.42E+02	unlimited	0.00	unlimited	0.00
120	15.0	8.06	9.41E+02	unlimited	0.00	unlimited	0.00
130	16.3	8.88	1.04E+03	unlimited	0.00	unlimited	0.00
140	17.5	9.01	1.05E+03	unlimited	0.00	unlimited	0.00
150	18.8	8.28	9.67E+02	unlimited	0.00	8.84E+07	0.00
160	20.0	6.82	7.97E+02	unlimited	0.00	5.90E+07	0.00
170	21.3	5.28	6.17E+02	unlimited	0.00	4.03E+07	0.00
180	22.5	3.72	4.34E+02	unlimited	0.00	2.82E+07	0.00
190	23.8	2.53	2.96E+02	unlimited	0.00	2.01E+07	0.00
200	25.0	1.58	1.85E+02	unlimited	0.00	1.46E+07	0.00
210	26.3	0.86	1.00E+02	unlimited	0.00	1.07E+07	0.00
220	27.5	0.42	4.91E+01	unlimited	0.00	8.01E+06	0.00
230	28.8	0.23	2.69E+01	unlimited	0.00	6.06E+06	0.00
240	30.0	0.13	1.52E+01	unlimited	0.00	4.64E+06	0.00
250	31.3	0.06	7.01E+00	1.02E+01	68.95	3.60E+06	0.00
	(65kN max.)				**68.95**		**0.01**

TypeTRD: Rural	Triaxles, dual wheels			SRF = 0.345		EF = 1.703	
Prop. of axle grp. =	0.21			Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	0.8	0.20	1.53E+01	unlimited	0.00	unlimited	0.00
20	1.7	0.55	4.22E+01	unlimited	0.00	unlimited	0.00
30	2.5	1.56	1.20E+02	unlimited	0.00	unlimited	0.00
40	3.3	6.80	5.21E+02	unlimited	0.00	unlimited	0.00
50	4.2	15.95	1.22E+03	unlimited	0.00	unlimited	0.00
60	5.0	12.50	9.58E+02	unlimited	0.00	unlimited	0.00
70	5.8	8.47	6.49E+02	unlimited	0.00	unlimited	0.00
80	6.7	6.18	4.74E+02	unlimited	0.00	unlimited	0.00
90	7.5	3.45	2.64E+02	unlimited	0.00	unlimited	0.00
102	8.5	2.88	2.21E+02	unlimited	0.00	unlimited	0.00
110	9.2	2.40	1.84E+02	unlimited	0.00	unlimited	0.00
120	10.0	3.07	2.35E+02	unlimited	0.00	unlimited	0.00
130	10.8	2.87	2.20E+02	unlimited	0.00	unlimited	0.00
140	11.7	2.71	2.08E+02	unlimited	0.00	unlimited	0.00
150	12.5	3.06	2.35E+02	unlimited	0.00	unlimited	0.00
160	13.3	3.51	2.69E+02	unlimited	0.00	unlimited	0.00
170	14.2	3.91	3.00E+02	unlimited	0.00	unlimited	0.00
180	15.0	4.58	3.51E+02	unlimited	0.00	unlimited	0.00
190	15.8	4.26	3.27E+02	unlimited	0.00	unlimited	0.00
200	16.7	3.78	2.90E+02	unlimited	0.00	unlimited	0.00
210	17.5	2.95	2.26E+02	unlimited	0.00	unlimited	0.00
220	18.3	1.83	1.40E+02	unlimited	0.00	unlimited	0.00
230	19.2	0.86	6.59E+01	unlimited	0.00	7.71E+07	0.00
240	20.0	0.73	5.60E+01	unlimited	0.00	5.90E+07	0.00
250	20.8	0.38	2.91E+01	unlimited	0.00	4.57E+07	0.00
260	21.7	0.19	1.46E+01	unlimited	0.00	3.57E+07	0.00
270	22.5	0.14	1.07E+01	unlimited	0.00	2.82E+07	0.00
280	23.3	0.06	4.60E+00	unlimited	0.00	2.24E+07	0.00
290	24.2	0.05	3.83E+00	unlimited	0.00	1.80E+07	0.00
300	25.0	0.06	4.60E+00	unlimited	0.00	1.46E+07	0.00
310	25.8	0.02	1.53E+00	unlimited	0.00	1.19E+07	0.00
320	26.7	0.03	2.30E+00	unlimited	0.00	9.72E+06	0.00
330	27.5	0.02	1.53E+00	1.15E+01	13.33	8.01E+06	0.00
	(65kN max.)				**13.33**		**0.00**

Rigid Pavement Design:

(To Austroads)

Pavemnent Type = **JU** **Jointed, Undowelled**

Measured subgrade **CBR** = **7.0** %

Sub-base type = **UB** **Unbound**

Sub-base thickness = **100** mm

Design CBR = **7.0** % (Fig 9.2)

OPTION 'B'

Design traffic:

Axle group loads:

Axle config.	single single	single dual	tandem dual	triaxle dual
Load (kN)	**53**	**80**	**135**	**181**

Design Period = **25** years (20 - 40yrs

Design number of heavy axles, C_{ag} = C_d x 365 x GF

= **3.65E+04** EDA's

where: No. of lots served = **40**

Vehicles per day per lot = **10**

= 400 vpd

% HCV = **1.0** %

⇒ Design no. HCV's/day, C_d = **4**

where: Growth rate = **0** %

⇒ **GF** = **25.0** (Table 7.2)

Flexural strength:

Nominal concrete strength, **f'c** = **30.0** MPa (30 MPa m

Concrete flexural strength, f_{cf} = **0.75√f'c** (Eq. 6.5.1)

= **4.11** MPa

Steel fibre reinforced concrete = **Yes**

Steel fibre reinforced concrete, f^r = 5.0 - 5.5 MPa

⇒ use Design f_r = **5.00** MPa

Type = **Rural**

Shoulders = **No**

Dowelled = **No** (as above)

Load safety factor, L_{SF} = **1.0** (9.3.6)

Trial base thickness, t = **145** mm

Equivalent stress: (Table 9.2)

	CBR	SS	SD	TAD	TRD
design CBR =	7.0	1.734	2.757	2.265	1.685
Stress ratio factors =		**0.347**	**0.551**	**0.453**	**0.337**

Erosion factors: (Table 9.2) Undowelled

	CBR	SS	SD	TAD	TRD
design CBR =	7.0	2.824	3.507	3.516	1.950
Erosion factors =		**2.824**	**3.507**	**3.516**	**1.950**

Type SS:	**Rural**	**Single axle, single wheels**			**SRF = 0.347**		**EF = 2.824**
Prop. of axle grp. =		**0.35**		**Fatigue**		**Erosion**	
axle load [kN]	**design load** [kN]	**Prop. of load** [%]	**exp. reps**	**allow. reps**	**fatigue** %	**allow. reps**	**Damage** %
10	5.0	3.19	4.08E+02	unlimited	0.00	unlimited	0.00
20	10.0	7.00	8.94E+02	unlimited	0.00	unlimited	0.00
30	15.0	9.24	1.18E+03	unlimited	0.00	8.96E+07	0.00
40	20.0	28.74	3.67E+03	unlimited	0.00	1.48E+07	0.02
50	25.0	32.19	4.11E+03	1.10E+07	0.04	3.64E+06	0.11
60	30.0	13.40	1.71E+03	8.75E+05	0.20	1.16E+06	0.15
70	35.0	4.65	5.94E+02	6.97E+04	0.85	4.42E+05	0.13
80	40.0	1.21	1.55E+02	5.55E+03	2.79	1.91E+05	0.08
90	45.0	0.25	3.19E+01	4.41E+02	7.23	9.15E+04	0.03
102	51.0	0.08	1.02E+01	2.12E+01	48.24	4.17E+04	0.02
110	55.0	0.06	7.67E+00	2.80E+00	274.01	2.60E+04	0.03
	(65kN max.)				**333.36**		**0.59**
				at 102kN Σ =	**59%**		

Type SD: Rural Single axle, dual wheels							
Prop. of axle grp. = 0.12				SRF = 0.551		EF = 3.507	
				Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	2.5	7.91	3.46E+02	unlimited	0.00	unlimited	0.00
20	5.0	14.13	6.19E+02	unlimited	0.00	unlimited	0.00
30	7.5	12.43	5.44E+02	unlimited	0.00	unlimited	0.00
40	10.0	12.14	5.32E+02	unlimited	0.00	unlimited	0.00
50	12.5	11.26	4.93E+02	unlimited	0.00	unlimited	0.00
60	15.0	10.16	4.45E+02	unlimited	0.00	8.96E+07	0.00
70	17.5	9.09	3.98E+02	unlimited	0.00	3.41E+07	0.00
80	20.0	8.70	3.81E+02	unlimited	0.00	1.48E+07	0.00
90	22.5	6.66	2.92E+02	unlimited	0.00	7.06E+06	0.00
102	25.5	4.08	1.79E+02	unlimited	0.00	3.22E+06	0.01
110	27.5	1.98	8.67E+01	unlimited	0.00	2.01E+06	0.00
120	30.0	0.88	3.85E+01	unlimited	0.00	1.16E+06	0.00
130	32.5	0.41	1.80E+01	1.27E-06	###########	7.04E+05	0.00
140	35.0	0.18	7.88E+00	2.81E-25	###########	4.42E+05	0.00
	(65kN max.)				###########		**0.03**

TypeTAD:	Rural	Tandem axle, dual wheels		SRF = 0.453		EF = 3.516	
Prop. of axle grp. =	0.32			Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	1.3	0.37	4.32E+01	unlimited	0.00	unlimited	0.00
20	2.5	0.56	6.54E+01	unlimited	0.00	unlimited	0.00
30	3.8	1.34	1.57E+02	unlimited	0.00	unlimited	0.00
40	5.0	3.39	3.96E+02	unlimited	0.00	unlimited	0.00
50	6.3	5.19	6.06E+02	unlimited	0.00	unlimited	0.00
60	7.5	5.10	5.96E+02	unlimited	0.00	unlimited	0.00
70	8.8	4.80	5.61E+02	unlimited	0.00	unlimited	0.00
80	10.0	4.78	5.58E+02	unlimited	0.00	unlimited	0.00
90	11.3	5.23	6.11E+02	unlimited	0.00	unlimited	0.00
102	12.8	6.15	7.18E+02	unlimited	0.00	unlimited	0.00
110	13.8	7.21	8.42E+02	unlimited	0.00	unlimited	0.00
120	15.0	8.06	9.41E+02	unlimited	0.00	9.00E+07	0.00
130	16.3	8.88	1.04E+03	unlimited	0.00	5.45E+07	0.00
140	17.5	9.01	1.05E+03	unlimited	0.00	3.42E+07	0.00
150	18.8	8.28	9.67E+02	unlimited	0.00	2.22E+07	0.00
160	20.0	6.82	7.97E+02	unlimited	0.00	1.48E+07	0.01
170	21.3	5.28	6.17E+02	unlimited	0.00	1.01E+07	0.01
180	22.5	3.72	4.34E+02	unlimited	0.00	7.08E+06	0.01
190	23.8	2.53	2.96E+02	unlimited	0.00	5.04E+06	0.01
200	25.0	1.58	1.85E+02	unlimited	0.00	3.66E+06	0.01
210	26.3	0.86	1.00E+02	unlimited	0.00	2.69E+06	0.00
220	27.5	0.42	4.91E+01	unlimited	0.00	2.01E+06	0.00
230	28.8	0.23	2.69E+01	unlimited	0.00	1.52E+06	0.00
240	30.0	0.13	1.52E+01	unlimited	0.00	1.17E+06	0.00
250	31.3	0.06	7.01E+00	1.02E+01	68.95	9.03E+05	0.00
	(65kN max.)				**68.95**		**0.05**

TypeTRD: Rural	Triaxles, dual wheels			SRF = 0.337		EF = 1.95	
Prop. of axle grp. = 0.21				Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	0.8	0.20	1.53E+01	unlimited	0.00	unlimited	0.00
20	1.7	0.55	4.22E+01	unlimited	0.00	unlimited	0.00
30	2.5	1.56	1.20E+02	unlimited	0.00	unlimited	0.00
40	3.3	6.80	5.21E+02	unlimited	0.00	unlimited	0.00
50	4.2	15.95	1.22E+03	unlimited	0.00	unlimited	0.00
60	5.0	12.50	9.58E+02	unlimited	0.00	unlimited	0.00
70	5.8	8.47	6.49E+02	unlimited	0.00	unlimited	0.00
80	6.7	6.18	4.74E+02	unlimited	0.00	unlimited	0.00
90	7.5	3.45	2.64E+02	unlimited	0.00	unlimited	0.00
102	8.5	2.88	2.21E+02	unlimited	0.00	unlimited	0.00
110	9.2	2.40	1.84E+02	unlimited	0.00	unlimited	0.00
120	10.0	3.07	2.35E+02	unlimited	0.00	unlimited	0.00
130	10.8	2.87	2.20E+02	unlimited	0.00	unlimited	0.00
140	11.7	2.71	2.08E+02	unlimited	0.00	unlimited	0.00
150	12.5	3.06	2.35E+02	unlimited	0.00	unlimited	0.00
160	13.3	3.51	2.69E+02	unlimited	0.00	unlimited	0.00
170	14.2	3.91	3.00E+02	unlimited	0.00	unlimited	0.00
180	15.0	4.58	3.51E+02	unlimited	0.00	9.00E+07	0.00
190	15.8	4.26	3.27E+02	unlimited	0.00	6.41E+07	0.00
200	16.7	3.78	2.90E+02	unlimited	0.00	4.65E+07	0.00
210	17.5	2.95	2.26E+02	unlimited	0.00	3.42E+07	0.00
220	18.3	1.83	1.40E+02	unlimited	0.00	2.56E+07	0.00
230	19.2	0.86	6.59E+01	unlimited	0.00	1.93E+07	0.00
240	20.0	0.73	5.60E+01	unlimited	0.00	1.48E+07	0.00
250	20.8	0.38	2.91E+01	unlimited	0.00	1.15E+07	0.00
260	21.7	0.19	1.46E+01	unlimited	0.00	8.97E+06	0.00
270	22.5	0.14	1.07E+01	unlimited	0.00	7.08E+06	0.00
280	23.3	0.06	4.60E+00	unlimited	0.00	5.64E+06	0.00
290	24.2	0.05	3.83E+00	unlimited	0.00	4.52E+06	0.00
300	25.0	0.06	4.60E+00	unlimited	0.00	3.66E+06	0.00
310	25.8	0.02	1.53E+00	unlimited	0.00	2.98E+06	0.00
320	26.7	0.03	2.30E+00	unlimited	0.00	2.44E+06	0.00
330	27.5	0.02	1.53E+00	1.15E+01	13.33	2.01E+06	0.00
	(65kN max.)				**13.33**		**0.00**

Rigid Pavement Design:

(To Austroads)

Pavemnent Type =	JU		**Jointed, Undowelled**
Measured subgrade **CBR** =	7.0	%	
Sub-base type =	B		**Bound**
Sub-base thickness =	100	mm	
Design CBR =	18.5	% (Fig 9.2)	

OPTION 'C'

Design traffic:

Axle group loads:

Axle config.	single single	single dual	tandem dual	triaxle dual
Load (kN)	53	80	135	181

Design Period = 25 years (20 - 40yrs)

Design number of heavy axles, C_{ag} = C_d x 365 x GF

= 3.65E+04 EDA's

where: No. of lots served = 40

Vehicles per day per lot = 10

= 400 vpd

% HCV = 1.0 %

⇒ Design no. HCV's/day, C_d = 4

where: Growth rate = 0 %

⇒ GF = 25.0 (Table 7.2)

Flexural strength:

Nominal concrete strength, f'c = 30.0 MPa (30 MPa m

Concrete flexural strength, f_{cf} = 0.75√f'c (Eq. 6.5.1)

= 4.11 MPa

Steel fibre reinforced concrete = Yes

Steel fibre reinforced concrete, f^r = 5.0 - 5.5 MPa

⇒ use Design f_r = 5.00 MPa

Type = Rural

Shoulders = No

Dowelled = No (as above)

Load safety factor, L_{SF} = 1.0 (9.3.6)

Trial base thickness, t = 135 mm

Equivalent stress: (Table 9.2)

	CBR	SS	SD	TAD	TRD
design CBR =	**18.5**	1.745	2.674	2.113	1.638
Stress ratio factors =		**0.349**	**0.535**	**0.423**	**0.328**

Erosion factors: (Table 9.2) Undowelled

	CBR	SS	SD	TAD	TRD
design CBR =	**18.5**	2.904	3.476	3.520	4.211
Erosion factors =		**2.904**	**3.476**	**3.520**	**4.211**

Type SS: Rural Single axle, single wheels **SRF = 0.349** **EF = 2.904**

Prop. of axle grp. = 0.35

				Fatigue		Erosion	
axle load [kN]	**design load** [kN]	**Prop. of load** [%]	**exp. reps**	**allow. reps**	**fatigue** %	**allow. reps**	**Damage** %
10	5.0	3.19	4.08E+02	unlimited	0.00	unlimited	0.00
20	10.0	7.00	8.94E+02	unlimited	0.00	unlimited	0.00
30	15.0	9.24	1.18E+03	unlimited	0.00	5.06E+07	0.00
40	20.0	28.74	3.67E+03	unlimited	0.00	8.33E+06	0.04
50	25.0	32.19	4.11E+03	1.01E+07	0.04	2.06E+06	0.20
60	30.0	13.40	1.71E+03	7.90E+05	0.22	6.55E+05	0.26
70	35.0	4.65	5.94E+02	6.18E+04	0.96	2.49E+05	0.24
80	40.0	1.21	1.55E+02	4.84E+03	3.19	1.08E+05	0.14
90	45.0	0.25	3.19E+01	3.79E+02	8.43	5.16E+04	0.06
* **102**	51.0	0.08	1.02E+01	1.78E+01	57.32	2.35E+04	0.04
110	55.0	0.06	7.67E+00	2.32E+00	329.87	1.47E+04	0.05
	(65kN max.)				**400.02**		**1.05**
				at 102kN Σ =	**70%**		

*85% HN LIMIT = 102 kN

Type SD: Rural Single axle, dual wheels							
Prop. of axle grp. = 0.12				SRF = 0.535		EF = 3.476	
				Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	2.5	7.91	3.46E+02	unlimited	0.00	unlimited	0.00
20	5.0	14.13	6.19E+02	unlimited	0.00	unlimited	0.00
30	7.5	12.43	5.44E+02	unlimited	0.00	unlimited	0.00
40	10.0	12.14	5.32E+02	unlimited	0.00	unlimited	0.00
50	12.5	11.26	4.93E+02	unlimited	0.00	unlimited	0.00
60	15.0	10.16	4.45E+02	unlimited	0.00	5.06E+07	0.00
70	17.5	9.09	3.98E+02	unlimited	0.00	1.92E+07	0.00
80	20.0	8.70	3.81E+02	unlimited	0.00	8.33E+06	0.00
90	22.5	6.66	2.92E+02	unlimited	0.00	3.98E+06	0.01
102	25.5	4.08	1.79E+02	unlimited	0.00	1.82E+06	0.01
110	27.5	1.98	8.67E+01	unlimited	0.00	1.13E+06	0.01
120	30.0	0.88	3.85E+01	unlimited	0.00	6.55E+05	0.01
130	32.5	0.41	1.80E+01	3.23E+01	55.62	3.97E+05	0.00
140	35.0	0.18	7.88E+00	2.54E-17	##########	2.49E+05	0.00
	(65kN max.)				##########		0.05

TypeTAD:	Rural	Tandem axle, dual wheels		SRF = 0.423		EF = 3.52	
Prop. of axle grp. =		0.32		Fatigue		Erosion	
axle load [kN]	design load [kN]	Prop. of load [%]	exp. reps	allow. reps	fatigue %	allow. reps	Damage %
10	1.3	0.37	4.32E+01	unlimited	0.00	unlimited	0.00
20	2.5	0.56	6.54E+01	unlimited	0.00	unlimited	0.00
30	3.8	1.34	1.57E+02	unlimited	0.00	unlimited	0.00
40	5.0	3.39	3.96E+02	unlimited	0.00	unlimited	0.00
50	6.3	5.19	6.06E+02	unlimited	0.00	unlimited	0.00
60	7.5	5.10	5.96E+02	unlimited	0.00	unlimited	0.00
70	8.8	4.80	5.61E+02	unlimited	0.00	unlimited	0.00
80	10.0	4.78	5.58E+02	unlimited	0.00	unlimited	0.00
90	11.3	5.23	6.11E+02	unlimited	0.00	unlimited	0.00
102	12.8	6.15	7.18E+02	unlimited	0.00	unlimited	0.00
110	13.8	7.21	8.42E+02	unlimited	0.00	8.75E+07	0.00
120	15.0	8.06	9.41E+02	unlimited	0.00	5.07E+07	0.00
130	16.3	8.88	1.04E+03	unlimited	0.00	3.07E+07	0.00
140	17.5	9.01	1.05E+03	unlimited	0.00	1.93E+07	0.01
150	18.8	8.28	9.67E+02	unlimited	0.00	1.25E+07	0.01
160	20.0	6.82	7.97E+02	unlimited	0.00	8.35E+06	0.01
170	21.3	5.28	6.17E+02	unlimited	0.00	5.71E+06	0.01
180	22.5	3.72	4.34E+02	unlimited	0.00	3.99E+06	0.01
190	23.8	2.53	2.96E+02	unlimited	0.00	2.84E+06	0.01
200	25.0	1.58	1.85E+02	unlimited	0.00	2.06E+06	0.01
210	26.3	0.86	1.00E+02	unlimited	0.00	1.52E+06	0.01
220	27.5	0.42	4.91E+01	unlimited	0.00	1.13E+06	0.00
230	28.8	0.23	2.69E+01	unlimited	0.00	8.59E+05	0.00
240	30.0	0.13	1.52E+01	unlimited	0.00	6.58E+05	0.00
250	31.3	0.06	7.01E+00	1.02E+01	68.95	5.09E+05	0.00
	(65kN max.)				**68.95**		**0.09**

TypeTRD:	**Rural**	**Triaxles, dual wheels**			**SRF = 0.328**	**EF = 4.211**	
Prop. of axle grp. =		**0.21**		**Fatigue**		**Erosion**	
axle load [kN]	**design load** [kN]	**Prop. of load** [%]	**exp. reps**	**allow. reps**	**fatigue** %	**allow. reps**	**Damage** %
10	0.8	0.20	1.53E+01	unlimited	0.00	unlimited	0.00
20	1.7	0.55	4.22E+01	unlimited	0.00	unlimited	0.00
30	2.5	1.56	1.20E+02	unlimited	0.00	unlimited	0.00
40	3.3	6.80	5.21E+02	unlimited	0.00	unlimited	0.00
50	4.2	15.95	1.22E+03	unlimited	0.00	unlimited	0.00
60	5.0	12.50	9.58E+02	unlimited	0.00	unlimited	0.00
70	5.8	8.47	6.49E+02	unlimited	0.00	unlimited	0.00
80	6.7	6.18	4.74E+02	unlimited	0.00	unlimited	0.00
90	7.5	3.45	2.64E+02	unlimited	0.00	unlimited	0.00
102	8.5	2.88	2.21E+02	unlimited	0.00	unlimited	0.00
110	9.2	2.40	1.84E+02	unlimited	0.00	unlimited	0.00
120	10.0	3.07	2.35E+02	unlimited	0.00	unlimited	0.00
130	10.8	2.87	2.20E+02	unlimited	0.00	unlimited	0.00
140	11.7	2.71	2.08E+02	unlimited	0.00	unlimited	0.00
150	12.5	3.06	2.35E+02	unlimited	0.00	unlimited	0.00
160	13.3	3.51	2.69E+02	unlimited	0.00	unlimited	0.00
170	14.2	3.91	3.00E+02	unlimited	0.00	7.26E+07	0.00
180	15.0	4.58	3.51E+02	unlimited	0.00	5.07E+07	0.00
190	15.8	4.26	3.27E+02	unlimited	0.00	3.61E+07	0.00
200	16.7	3.78	2.90E+02	unlimited	0.00	2.62E+07	0.00
210	17.5	2.95	2.26E+02	unlimited	0.00	1.93E+07	0.00
220	18.3	1.83	1.40E+02	unlimited	0.00	1.44E+07	0.00
230	19.2	0.86	6.59E+01	unlimited	0.00	1.09E+07	0.00
240	20.0	0.73	5.60E+01	unlimited	0.00	8.35E+06	0.00
250	20.8	0.38	2.91E+01	unlimited	0.00	6.47E+06	0.00
260	21.7	0.19	1.46E+01	unlimited	0.00	5.06E+06	0.00
270	22.5	0.14	1.07E+01	unlimited	0.00	3.99E+06	0.00
280	23.3	0.06	4.60E+00	unlimited	0.00	3.18E+06	0.00
290	24.2	0.05	3.83E+00	unlimited	0.00	2.55E+06	0.00
300	25.0	0.06	4.60E+00	unlimited	0.00	2.06E+06	0.00
310	25.8	0.02	1.53E+00	unlimited	0.00	1.68E+06	0.00
320	26.7	0.03	2.30E+00	unlimited	0.00	1.38E+06	0.00
330	27.5	0.02	1.53E+00	1.15E+01	13.33	1.13E+06	0.00
	(65kN max.)				**13.33**		**0.01**