Project Details

Customer	NOURYON INDUSTRIAL CHEMICALS B.V.	**Project No.**	NR1038
Project Title	Brine Field Project - Haaksbergen	**Calc No.**	1.333.473
Calculation Title	Loading Unloading Slab	**Phase/CTR**	Execute
Elec File Location	NR1038/C.05/0038		

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
A	31-May-21	5.	5.								

Calculation Objective

The objective of this calculation report is to present calculation for Loading Unloading slab for Execute phase of the Project.

Calculation Method

Calculation is presented by using simple explanatory template.

Assumptions

The assumptions are presented in Calculation report.

Software Used

Title: Staad.Pro Connect Edition. **Version:** V22 update 5 **Validation: (Y / N / N/A)**

References

NR1038/C.07/0001 - Design Criteria

Conclusions

Refer section 5.0

Related to a Safety Critical System? **No** Status of Supplier Data used **N/A**

HOLDS

None

A	31-May-21	Issue for Building Permit	5.1.2.e	5.1.2.e	5.1.2.e
Rev	**Date**	**Description**	**By**	**Checked**	**Approved**

This Calculation represents the work of Worley performed to recognized engineering principles and practices appropriate for the terms of reference provided by Worley contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither Worley, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.

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Please check boxes for all applicable items checked or mark as "N/A" if not appropriate:

Calculations:

Originator	Checker	
☒	☒	Calculation number assigned and registered (refer to project numbering system or Document Number Standard (MS-DP-STD-0009 for format).
☒	☒	All required information on Cover Sheet provided
☒	☒	Revision history box complete and signed. (Typed names (minimum of first initial and surname e.g. A. Wood) of Originator, Checker, Approver to be initialed beside at sign-off) (Dates in standard format (DD-MMM-YY))
☒	☒	Table of Contents.
☒	☒	Appropriate stamp for preliminary issues.
☒	☒	Source of input data stated (with revision number and date if relevant).
☒	☒	Customer's requirements included/addressed.
☒	☒	Approach used is appropriate for problem being solved.
☒	☒	Method clear and easy to follow.
☒	☒	Input data correct.
☒	☒	Calculation is arithmetically correct, OR software previously verified and reference to verification checked.
☒	☒	Calculation result within expected limits.
☒	☒	Calculation tolerances stated if significant.
☒	☒	Units used as required by customer. Unit conversions correctly performed.
☒	☒	Appropriate cross-references.
☒	☒	Sketches included and clearly labeled, where required.
☒	☒	Appendices included and referenced, as required.
☒	☒	Considered design reviews, HAZOP actions, Customer input, safety and environmental issues, etc.

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Please check boxes for all applicable items checked or mark as "N/A" if not appropriate:

☒	☒	Safety in Design (SID) and Sustainable Design are addressed. Refer relevant SID Discipline Standard.
☒	☒	Conclusions and recommendations are appropriate.

Checking records:

☒	☒	Checked and annotated copy of calculation filed (use "Doc Check Print" stamp).
☒	☒	Corrections made as required and calculation dated and signed on cover sheet by checker.
☒	☒	Alternative method calculation and/or representative check performed and filed, as required.

Revisions:

☒	☒	Changes clouded, tracked or highlighted.
☒	☒	Revision history block updated.
☒	☒	Calculation re-checked if required.

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1. INTRODUCTION

1.1 General

The overall scope of the Haaksbergen Brinefield comprises a range of greenfield installations. The general layout scope of work is divided into the following main areas:

Pump station plot
Well pads & above ground
Works at Ganzebos
Transport trenches
Hengelo works

Site Location

The new Pump House as part of the Haaksbergen (HKS) Brine Field Project is being executed north of the town of Haaksbergen in the Netherlands. It concerns a triangular plot on the “Stepelerveld” industrial park to the west of the company Uzin UTz Nederland.

To the North of Pump House is located the degasser/Blanketing Oil tank pit along with the Loading/Unloading Slab.

To the north & west of the new Pump House, the new drilling sites will be developed in phases. For this project, 7 so-called well pads (drilling locations) will be included (numbers 1 to 7).

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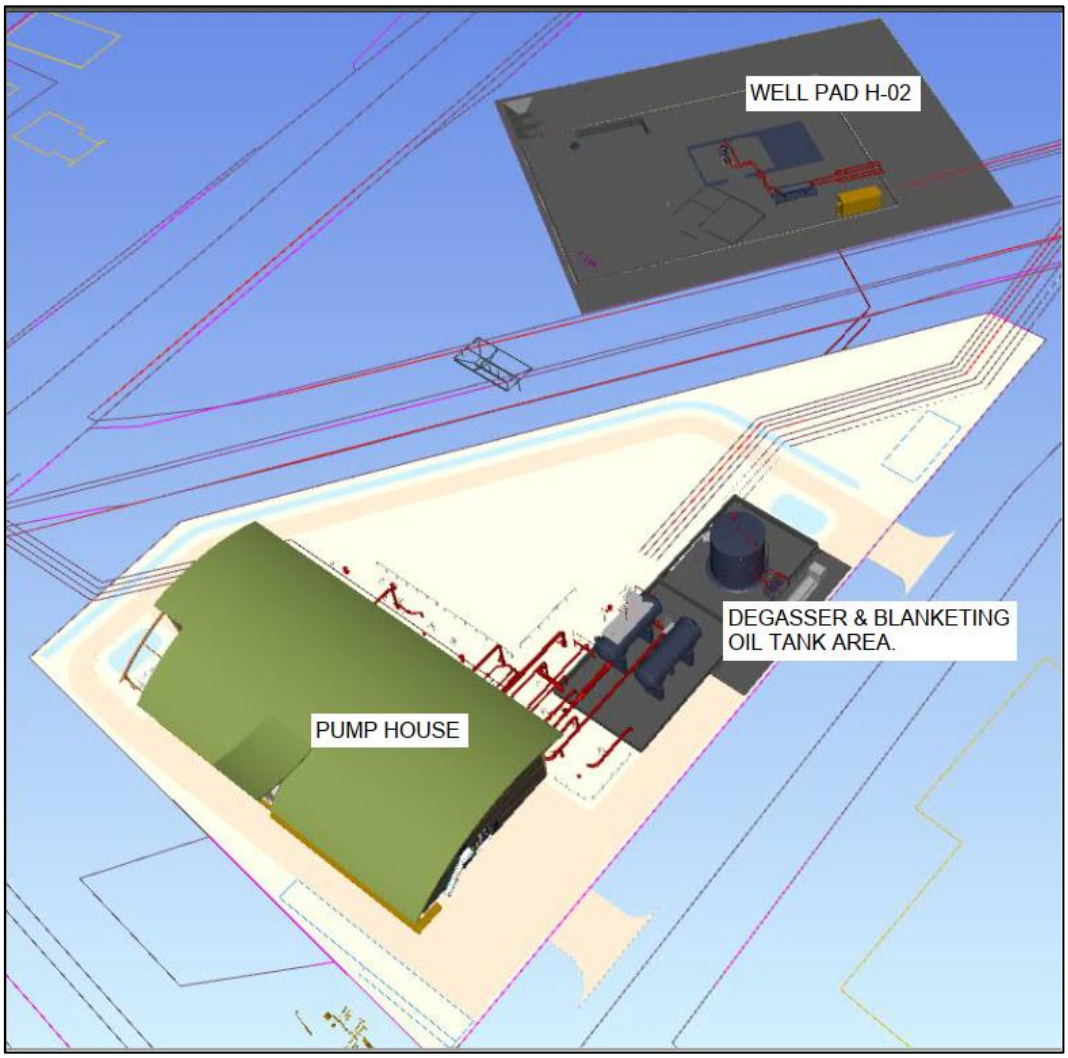

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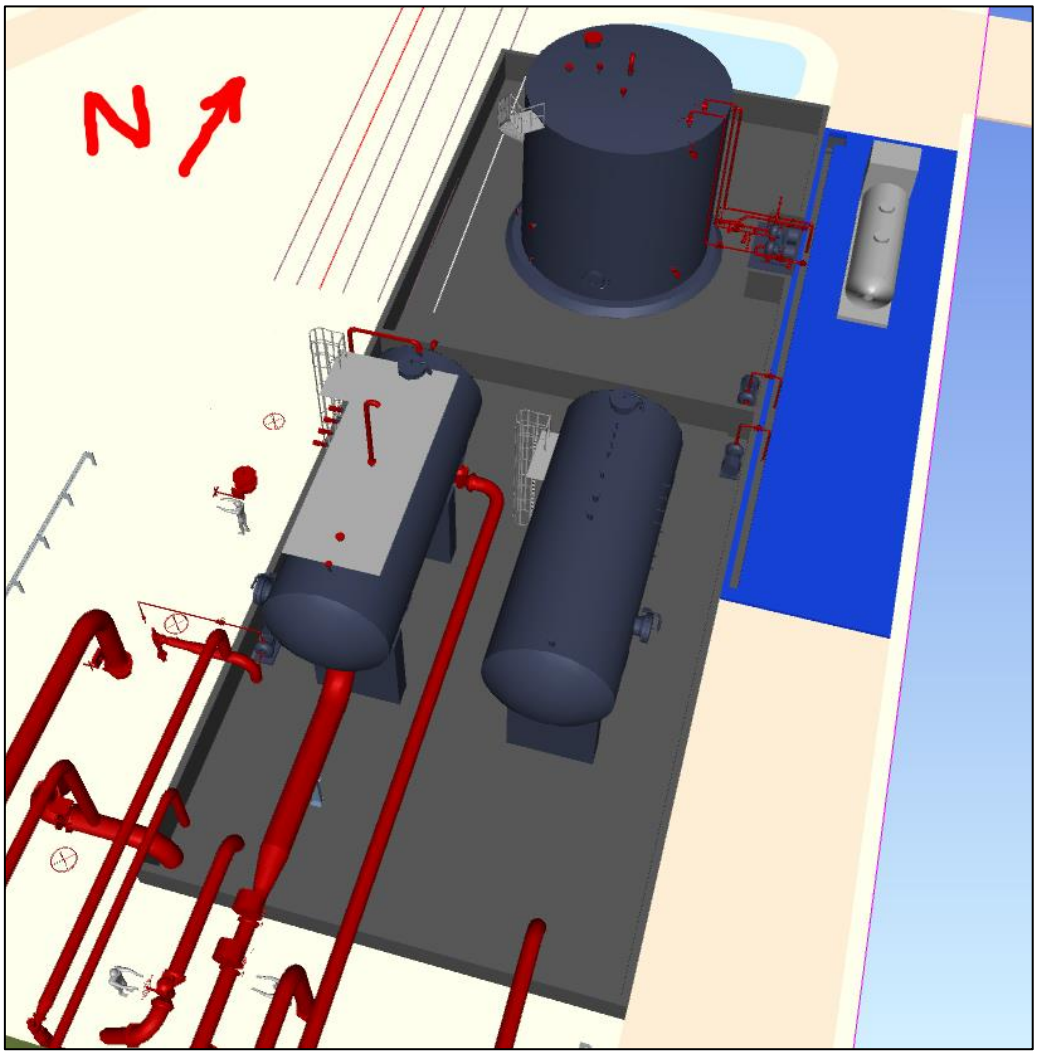
1.2 Loading Unloading Slab

This report consists of Loading calculations and design checks for a Loading and Unloading Slab highlighted in blue, beside Degasser pit & Blanketing Oil Tank pit.
The plan dimensions of the Slab are
Length - 26.7 m (Along North South)
Width - 6.0 m (Along East West)
Thickness - 0.7 m (As determined in this report)



2. DESIGN DATA

REFERENCE DOCUMENTS

VN-77421-5, Rev 1	Geotechnisch Onderzoek, dated 9th April 2021.
VN-77421-1, Rev 1	Grondwatermonetoring, dated 18th January 2021.

DESIGN DATA FOR CONCRETE

Concrete grade	C30/37
Reinforcement	B500B (minimum yield stress = 500 N/mm^2)
Environmental class	XC4 Carbonation induced corrosion XD2 Cloride induced corrosion XS1 Cloride induced corrosion from sea water XF3 Freez & Thow attack XA2 Chemical Attack
Concrete cover	50 mm
Allowable crack width	max. 0.2 mm
Density concrete	ρ = 25 kN/m^3
Construction Class	S4

CALCULATION METHOD

Linear elastic analysis of member forces according first order effect.

DESIGN WORKING LIFE

Working life category	4
Design working life	50 years
Consequence class	CC3
Reliability class	RC3

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CODES AND OTHER REGULATIONS

American Standards

ACI 360R	Design of Slabs on Grade
ACI 302.1R	Guide for Concrete Floor and Slab Construction
ACI 224.3R	Joints in Concrete Construction

Nouryon Standards

2.176.109 Rev B	Technical Requirements for designing concrete structures
1.761.916 Rev D	Loading and deformations for the calculations of Building Structures

ASSUMPTION LIST

1. Factor of Safety = 2.5 (Load factor 1.65 x Dynamic impact factor 1.5)
2. Coefficient of Subgrade reaction k = 14000 kN/m^3 (50 pci)

Typical values of modulus of subgrade reaction

The typical values of modulus of subgrade reaction of different types of soils are given below;

Soil description	Modulus of subgrade reaction (kN/m^2/m)
Humus soil or peat	5000 – 15000
Recent embankment	10000 – 20000
Fine or slightly compacted soil	15000 – 30000
Well compacted sand	50000 – 100000

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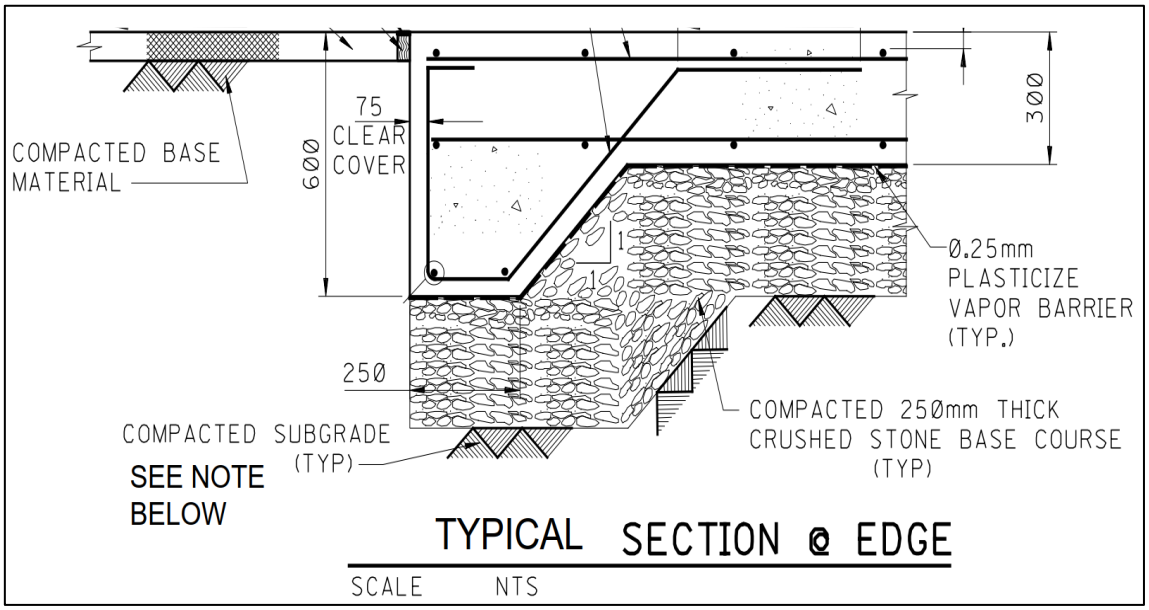
2.1 Cross-section details

A Slab thickness of 300 mm is adopted with thickening at the edges and application of Compacted Subgrade and Crushed Stone Base Course.

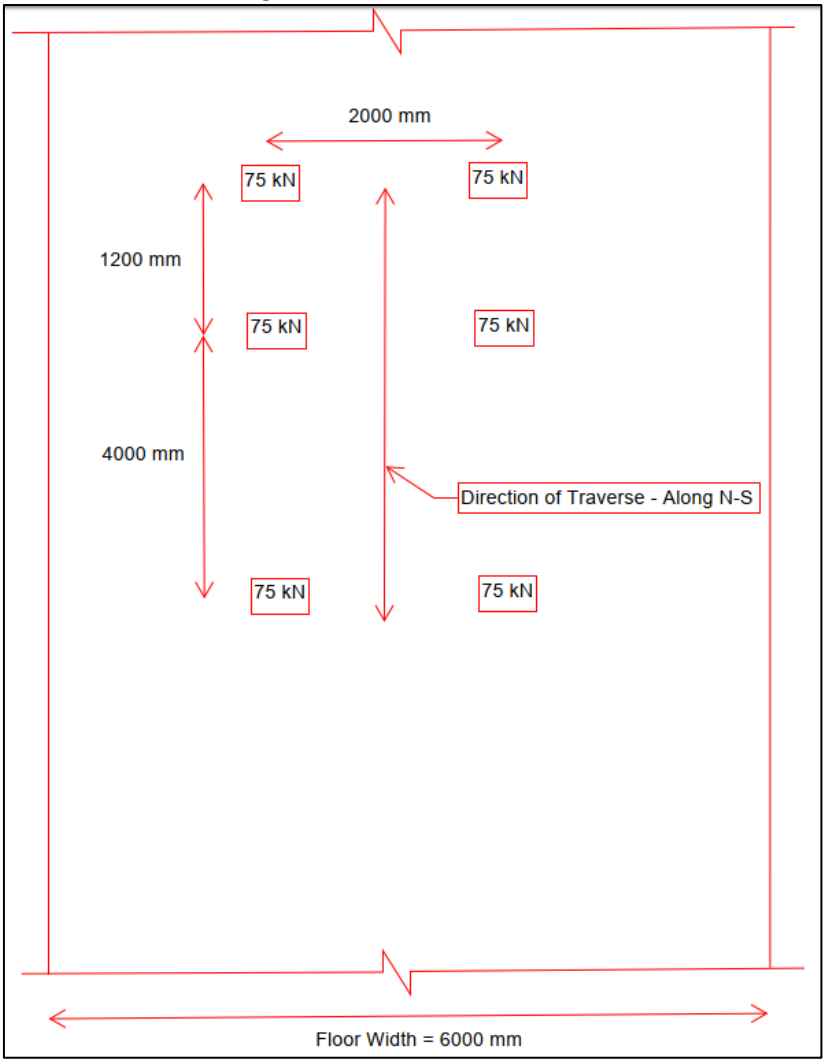


Note: Contractor to ensure that the subgrade & subbase are well compacted and treated with soil improvement techniques to support a vehicular load of 45 MT.

3. LOADS

3.1 Traffic Load (QTL)

These consists of a set of Wheel loads as given below.



An impact factor (vertical) of 1.5 is considered for purpose of design
Area of contact = 0.4 m x 0.4 m.

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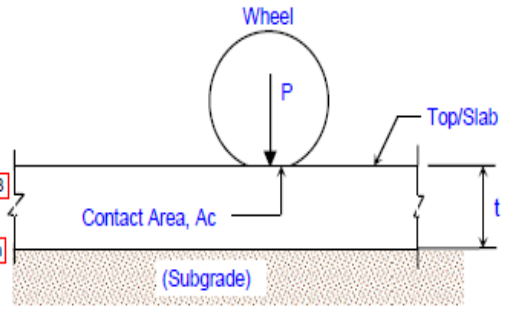
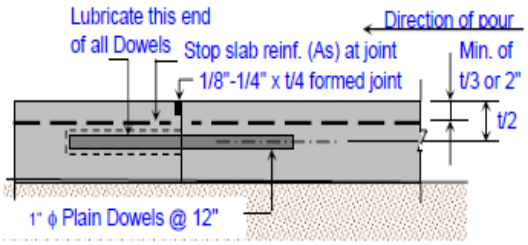
4. GRADE SLAB CALCULATION

Input Data:

Slab Thickness, t =	12.00	in.	300 mm
Concrete Strength, f 'c =	4000	psi	Approx 30 Mpa
Conc. Unit Weight, wc =	155	pcf	25 kN/m3
Reinforcing Yield, fy =	70000	psi	Approx 500 Mpa
Subgrade Modulus, k =	50	pci	Approx 14000 kN/m3
Concentrated Load, P =	16540	lbs.	75 kN
Contact Area, Ac =	248.00	in.^2	400 mm x 400 mm
Factor of Safety, FS =	2.50		
Dowel Bar Dia., db =	1.000	in.	25 mm
Dowel Bar Spacing, s =	12.00	in.	300 mm
Expansion Joint Width, z =	0.4700	in.	12 mm
Joint Spacing, L =	32.800	ft.	10 m
Temperature Range, ΔT =	20.00	deg.	
Increase for 2nd Wheel, i =	0	%	



Concrete Slab on Grade



Typical Construction Joint for Load Transfer

Results:

Check Slab Flexural Stress: (assuming unreinforced slab with interior load condition)

Effective Load Radius, a =	8.885	in.	225.7 mm	a = SQRT(Ac/π)
Modulus of Elasticity, Ec =	4027555	psi	27769 Mpa	= 33*wc^1.5*SQRT(f 'c)
Modulus of Rupture, MR =	569.21	psi	3.92 Mpa	MR = 9*SQRT(f 'c)
Cracking Moment, Mr =	13.66	ft-k/ft.	60.78 kN/m	MR*(12*t^2/6)/12000 (per 1' = 12" width)
Poisson's Ratio, μ =	0.15			μ = 0.15 (assumed for concrete)
Radius of Stiffness, Lr =	58.692	in.	1490 mm	Lr = (Ec*t^3/(12*(1-μ^2)*k))^0.25
Equivalent Radius, b =	8.341	in.	212 mm	b = SQRT(1.6*a^2+t^2)-0.675*t , for a < 1.724*t
1 Load: fb1(actual) =	161.90	psi	1.12 Mpa	fb1(actual) = 3*P*(1+μ)/(2*π*t^2)*(LN(Lr/b)+0.6159) (Ref. 1)
2 Loads: fb2(actual) =	N.A.	psi		fb2(actual) = N.A.
Fb(allow) =	227.68	psi	1.57 Mpa	Fb(allow) = MR/FS

Fb(allow) >= fb(actual), O.K.

Note: Effect of a 2nd load was not considered.

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Check Slab Bearing Stress: (assuming working stress) (Ref. 4)

fp(actual) = 66.69 psi (0.46 Mpa) fp(actual) = P/Ac

Fp(allow) = 2390.68 psi (16.48 Mpa) Fp(allow) = 4.2*MR **Fp(allow) >= fp(actual), O.K.**

Check Slab Punching Shear Stress: (assuming working stress) (Ref. 4)

bo = 62.992 in. (1600 mm) bo = 4*SQRT(Ac) (assumed shear perimeter)

fv(actual) = 12.42 psi (0.086 Mpa) fv(actual) = P/(t*(bo+4*t))

Fv(allow) = 153.69 psi (1.06 Mpa) Fv(allow) = 0.27*MR **Fv(allow) >= fv(actual), O.K.**

Shrinkage and Temperature Reinf.: (assuming subgrade drag method) (Ref. 3)

Friction Factor, F = 1.50 F = 1.5 (assumed friction factor between subgrade and slab)

Slab Weight, W = 155.00 psf (25 kN/m3) W = wc*(t/12)

Reinf. Allow. Stress, fs = 52500 psi (362 Mpa) fs = 0.75*fy

As = 0.073 in.^2/ft. (154 mm2/m) As = F*L*W/(2*fs)

(continued)

Slab Reinforcing: (assuming temperature method)

fr = 227.68 psi (1.57 Mpa) fr = MR/FS

fs = 52500 psi (362 Mpa) fs = 0.75*fy

a = 0.0000055 a = 5.5x10^(-6) (assumed thermal expansion coefficient)

Es = 29000000 psi (2.0e8 kN/m2) s = 29x10^6 (modulus of elasticity for steel)

As = 0.332 in.^2/ft. (703 mm2/m) As = fr*(12)*t/(2*(fs-ΔT*α*Es))

Provided Reinforcemnt (0.71) in^2. >= Required, O.K.

Slab Reinforcing: (assuming concrete-to-steel ratio method)

fr = 227.684 psi (1.57 Mpa) fr = MR/FS

fs = 52500 psi (362 Mpa) fs = 0.75*fy

As = 0.625 in.^2/ft. (1323 mm2/m) As = fr*(12)*t/fs

Provided Reinforcemnt (0.71) in^2. >= Required, O.K.

Reinforcing Bar Dia., db = 0.472 in.

Reinforcing Bar Spacing, s = 5.90 in.

12 mm diameter bar
150 mm spacing

Provided reinforcemnt in each layer & in each direction top & bottom = 0.356 in.^2/ft.

Total provided reinforcment in slab in each direction = 0.713 in.^2/ft.

Determine Estimated Crack Width:

Slab-base Frict. Adjust., C = 1.00 C = 1.0 (assumed value for no subbase)

Thermal Expansion, α = 0.0000055 in./in./deg α = 5.5x10^(-6) (assumed thermal expansion coefficient)

Shrinkage Coefficient, ε = 0.00035 in./in. ε = 3.5x10^(-4) (assumed coefficient of shrinkage)

Est. Crack Width, ΔL = 0.1811 in. (4.6 mm) ΔL = C*L*12*(α*ΔT+ε)

Provided Joint Width (0.47) in. >= Estimated, O.K.

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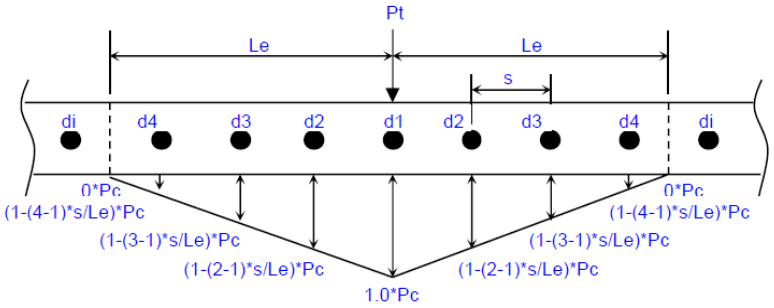
Check Bearing Stress on Dowels at Construction Joints with Load Transfer: (Ref. 2)



Assumed Load Transfer Distribution for Dowels at Construction Joint

L_e =	58.692	in. [1491 mm]	$L_e = 1.0*L_r$ = applicable dist. each side of critical dowel
Effective Dowels, N_e =	4.91	bars	$N_e = 1.0+2*\Sigma(1-d(n-1)*s/L_e)$ (where: n = dowel #)
Joint Load, P_t =	8270.00	lbs. [37.5 kN]	$P_t = 0.50*P$ (assumed load transferred across joint)
Critical Dowel Load, P_c =	1684.02	lbs. [76.4 kN]	$P_c = P_t/N_e$
Mod. of Dowel Suppt., k_c =	1500000	psi [1.03e7 kN/m2]	= 1.5x10^6 (assumed for concrete)
Mod. of Elasticity, E_b =	29000000	psi [2.08e7 kN/m2]	= 29x10^6 (assumed for steel dowels)
Inertia/Dowel Bar, I_b =	0.0491	in.^4 [20.43e3 mm3]	$\pi*d_b\text{^}4/64$
Relative Bar Stiffness, β =	0.716		$\beta = (k_c*d_b/(4*E_b*I_b))\text{^}(1/4)$
$f_{d(actual)}$ =	2819.16	psi [19.44 Mpa]	$f_{d(actual)} = k_c*(P_c*(2+\beta*z)/(4*\beta\text{^}3*E_b*I_b))$
$F_{d(allow)}$ =	4000.00	psi [27.57 Mpa]	$F_{d(allow)} = (4-d_b)/3*f'_c$ **Fd(allow) >= fd(actual), O.K.**

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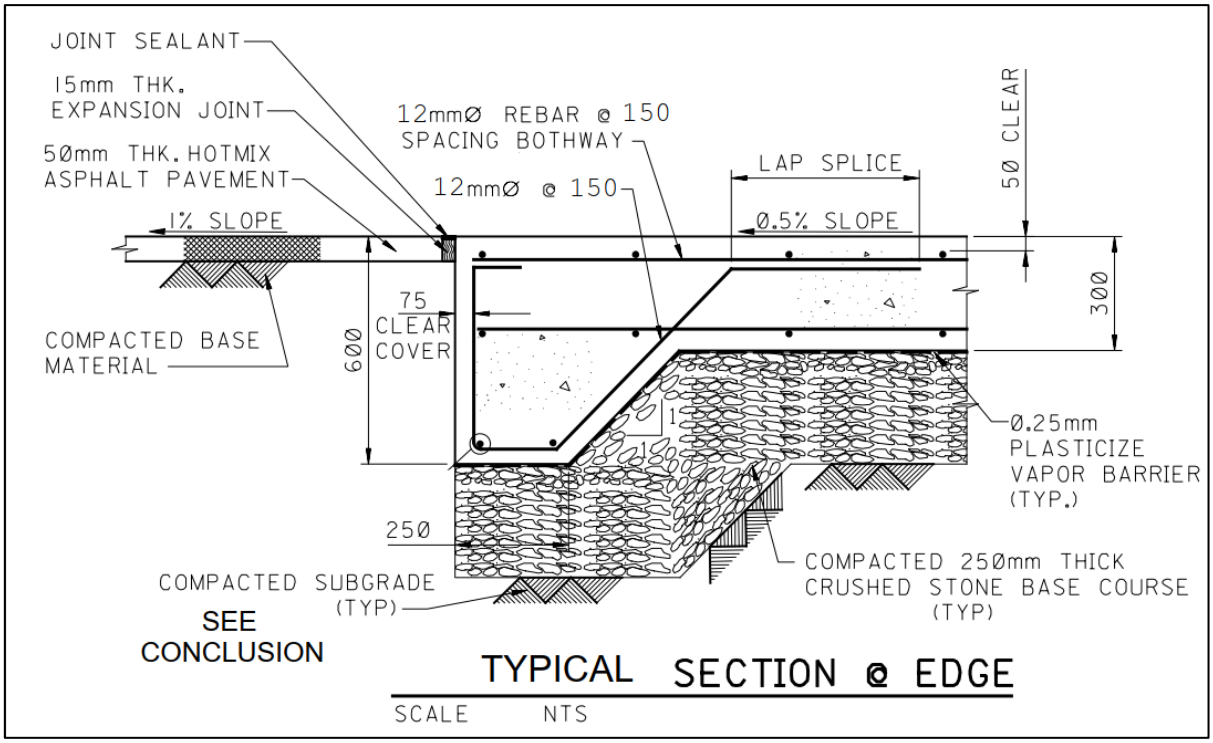
5. CONCLUSION & DETAILS

The Loading Unloading Slab is safe both in Serviceability and Strength criteria.
The subgrade must be checked for possible weak bearing material.

Contractor to ensure that the subgrade & subbase are well compacted and treated with soil improvement techniques to support a vehicular load of 45 MT.



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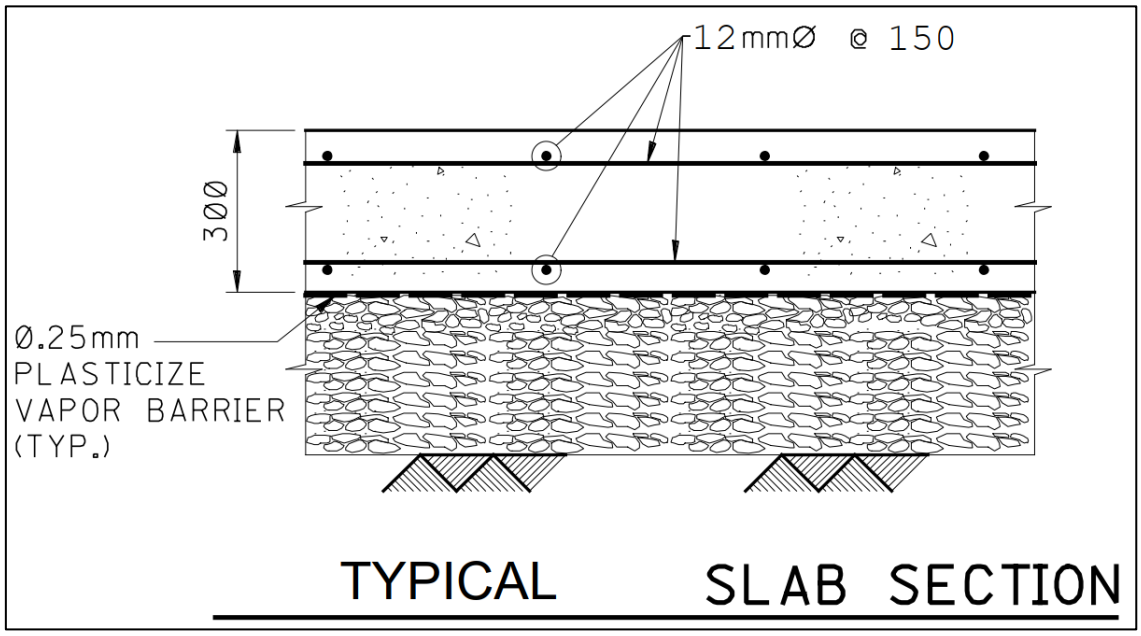

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