Aswathanarayana & Eswara LLP

Design Check of Steel Fibre Reinforced Concrete Grade Slab as per TR 34, 3rd Edition

Project: ***Amazon FC, Hyderabad***

Designed for: ***GMR***

Design case: ***69 kN point load due to racking, back to back***

Date: *October 28, 2016*

1. Input

1.1 Materials

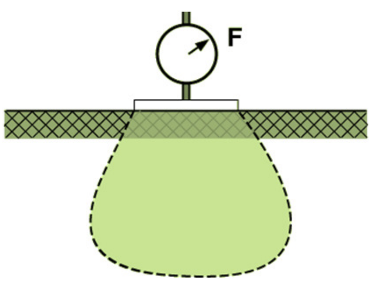
Concrete Characteristics

ConcreteCube Compressive Strength:	f_{cu} =	35	MPa	
Mean Axial Tensile Strength:	f_{ctm} =	2.8	MPa	
Characteristic Axial Tensile Strength	$f_{ctk(0.5)}$ =	2.0	MPa	(obtained from table 9.1)
Secant Modulus of Concrete:	E =	32000	N/mm^2	
Poisson Coefficient:	μ =	0.15		
Coefficient of Thermal Expansion:	α =	0.00001	/ ^{o}C	

Steel Fibre Characteristics

Fibre Name and Type:	Dramix Fibres, 60 mm long and 0.75 mm diameter			
Fibre Dosage:	D_F =	15	kg/m^3	As per manufacturer's spec
$R_{e,3}$ value:	$R_{e,3}$ =	0.4		

1.2 Sub-base



The sub-base constant k (modulus of reaction) is typically obtained from plate load tests.This 'k' value must be achieved below the grade slab before the casting of the slab.

The equivalent modulus of subgrade reaction 'k' to be achieved at site :-

k_s = 0.06 N/mm^3

1.3 Load & Material Factors

Static Load Factor of Safety	=	1.20
Dynamic Load Factor of Safety	=	1.60
Concrete Material Safety	=	1.50
Fibre Concrete Material Safety	=	1.50

1.4 Geometry

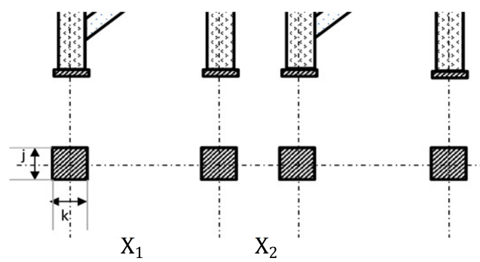
Slab Length	L	=	4500	mm
Slab Width	B	=	4500	mm
Trial Thickness	h	=	$\boxed{175}$	mm
Elastic Radius	*l*	=	702.6	mm

1.5 Design and Loading Parameters

Design Concrete Flexural Tensile Strength: $f_{ctd,fl} = f_{ctk(0.5)} \times (1+(200/h)^{0.5})/Y_m =$ 2.8 MPa

<u>Racking Loads:</u>

Post Load	P	=	69	kN/leg
Base Plate Size	j	=	180	mm
	k	=	125	mm
Leg Spacing	X_1		950	mm
	X_2		500	mm



<u>Forklift Loads:</u>

P = 33 kN

Wheel Contact Area Considerd = 70 mm x 100 mm

Equivalent Radius of Contact, a = 47.2 mm

All input values are as per typical data on forklift

2. Design

2.1 Post Loads

The design is carried out for the post loads as per the formulae detailed in TR-34, 3rd Edition. The four point loads due to back-to-back racking configuration of the post legs can act on the floor via a single point or a dual point load action.

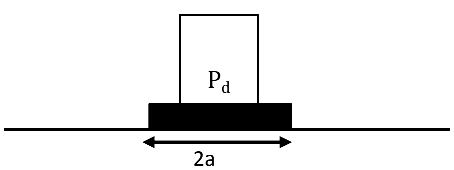
Radius of relative stiffness is given as:-

$$l = \sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}}$$

= 702.59 mm

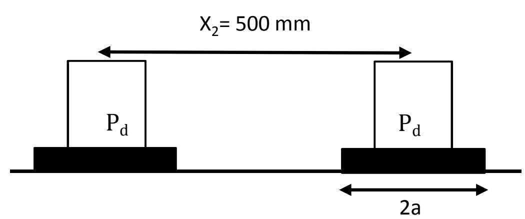
Single Point Load

P_d = 82.8 kN (factored)



Radius, a = $[(180 \times 125)/3.14]^{0.5}$
= 84.63 mm

Therefore, $\frac{a}{l} =$ 0.12

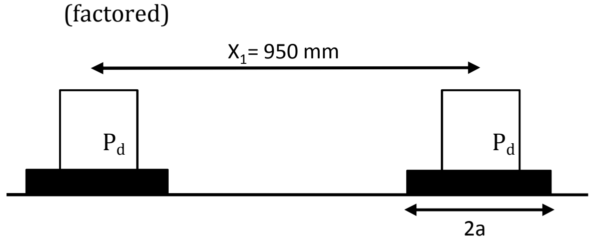


Radius, a = $[(180 \times 125 \times 2+375 \times 180)/3.14]^{0.5}$
= 189.23 mm

Therefore, $\frac{a}{l} =$ 0.27

Dual Point Loads

P_d = 82.8 kN (factored)



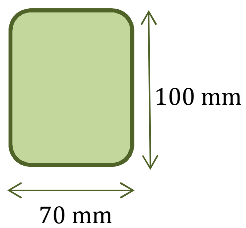
Radius, a = $[(180 \times 125)/3.14]^{0.5}$
= 84.63 mm

Therefore, $\frac{a}{l} =$ 0.12

2.2 Forklift Wheel Loads

Single Wheel Load is acting as per the configuration shown below:-

P_d = 52.8 kN (factored)



Radius of equivalent circle is given as :-

$$a = 47.20 \text{ mm}$$

Radius of relative stiffness is given as:-

$$l = \sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}}$$

$$= 702.59 \text{ mm}$$

Therefore, $\frac{a}{l} =$ 0.07

2.3 Section Capacities

Section Capacity of Plain Concrete = $M_n = \dfrac{f_{ctd,fl}h^2}{6}$ = 14.08 kNm/m

Dramix® SFRC Capacity at the bottom = $M_p = \dfrac{h^2}{6\gamma_m}\left(R_{e,3} \times f_{ctk,fl}\right)$

= 5.91 kNm/m

Cracked to Uncracked Moment Ratio = $\dfrac{M_p}{M_n} =$ 0.42 > 0.3, **Hence OK**
(Section9.4.2 of TR 34, 3rd Edition)

Load Transfer Across Formed Free Movement Joints

Load transfer across the edge of a formed free movement joint is taken as 15 %.

Therefore, ratio of load retained = $\aleph_{edge} =$ 0.85

Load transfer across the corner of two formed free movement jointsmay be taken as :-

= $(1 - 0.85 \times 0.85 \times 0.7)$ = 0.494

Therefore, ratio of load retained = (1 - 0.494) = $\aleph_{corner} =$ 0.506

Single Point Load Capacities

Internal Load: $\dfrac{a}{l} = 0$

$P = 2\pi\left(M_n + M_p\right)$ = 125.63 kN

Internal Load: $\dfrac{a}{l} \geq 0.2$

$$P = \frac{4\pi\left(M_n + M_p\right)}{\left[1 - \left(\frac{a}{3l}\right)\right]}$$ = 269.21 kN

For Post Load with,	$\dfrac{a}{l} =$ 0.12	, P =	212.10 kN	$> P_d$ =	83 kN	**SAFE, OK**
	$\dfrac{a}{l} =$ 0.27	, P =	318.99 kN	$> P_d$ =	166 kN	**SAFE, OK**
For Wheel Load with,	$\dfrac{a}{l} =$ 0.07	, P =	173.86 kN	$> P_d$ =	53 kN	**SAFE, OK**

Edge Load: $\frac{a}{l} = 0$

$$P = \frac{[\pi(M_n + M_p) + 4M_n]}{2}$$ = 59.57 kN

Edge Load: $\frac{a}{l} \geq 0.2$

$$P = \frac{[\pi(M_n + M_p) + 4M_n]}{\left[1 - \left(\frac{2a}{3l}\right)\right]}$$ = 137.47 kN

For Post Load with,	$\frac{a}{l} =$ 0.12	, P =	106.49	kN > $P_d ℵ_{edge}$ =	70	kN	**SAFE, OK**
	$\frac{a}{l} =$ 0.27	, P =	164.48	kN > $P_d ℵ_{edge}$ =	141	kN	**SAFE, OK**
For Wheel Load with,	$\frac{a}{l} =$ 0.07	, P =	85.74	kN > $P_d ℵ_{edge}$ =	45	kN	**SAFE, OK**

Corner Load: $\frac{a}{l} = 0$

$$P = 2M_n$$ = 28.16 kN

Corner Load: $\frac{a}{l} \geq 0.2$

$$P = \frac{4M_n}{\left[1 - \left(\frac{a}{l}\right)\right]}$$ = 70.41 kN

For Post Load with,	$\frac{a}{l} =$ 0.12	, P =	53.60	kN > $P_d ℵ_{corner}$ =	42	kN	**SAFE, OK**
	$\frac{a}{l} =$ 0.27	, P =	85.05	kN > $P_d ℵ_{corner}$ =	84	kN	**SAFE, OK**
For Wheel Load with,	$\frac{a}{l} =$ 0.07	, P =	40.83	kN > $P_d ℵ_{corner}$ =	27	kN	**SAFE, OK**

Dual Point Load Capacities

Internal Load: $\frac{a}{l} = 0$

$$P = \left[2\pi + \frac{1.8X_1}{l}\right](M_n + M_p) \quad = \quad 174.30 \quad kN$$

Internal Load: $\frac{a}{l} \geq 0.2$

$$P = \left[\frac{4\pi}{\left[1 - \left(\frac{a}{3l}\right)\right]} + \frac{1.8X_1}{\left(l - \frac{a}{2}\right)}\right](M_n + M_p) \quad = \quad 323.28 \quad kN$$

For Post Load with, $\frac{a}{l} =$ 0.12 , P = 264.03 kN $> P_d =$ 83 kN **SAFE, OK**

Edge Load: $\frac{a}{l} = 0$

P = 174.30 × 0.47 = 82.65 kN

Edge Load: $\frac{a}{l} \geq 0.2$

P = 323.28 × 0.51 = 165.08 kN

For Post Load with, $\frac{a}{l} =$ 0.12 , P = 132.29 kN $> P_d ℵ_{edge} =$ 54 kN **SAFE, OK**

After checking all the cases, the design is found SAFE for all the loading cases

2.4 Illustration