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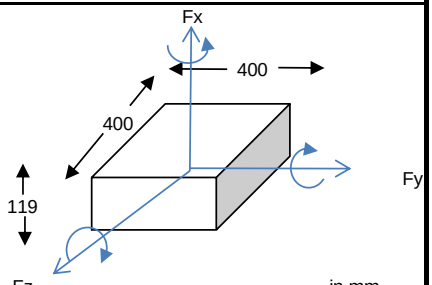
Laminated Elastomeric Bearing Calculation Based On EN 1337-3:2005 (TYPE - C)

Calculation sheet		**DATE -31/10/2021**		**Pages: 3**	ID :
Client	*M/s. NMDC*	**LOCATION**	**Size - 400 x 400 x 119mm**		
Project	*NMDC - THUMAYRIYAH ACCESS BRIDGE*	**Qty - 20nos**			

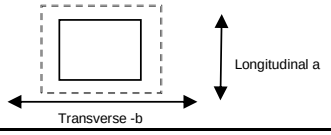
BEARING DIMENSIONS

a	Overall Width	mm	400.0	
b	Overall Length	mm	400.0	
c	Edge Cover of Elastomer	mm	6.0	
a_e	Effective Width	mm	388.0	
b_e	Effective Length	mm	388.0	
n_i	Number of inner Elastomer Layers		8.0	
t_i	Thickness of an inner Layer	mm	10.0	
n_o	No. of Outer Cover Layer		0.0	
t'	Thickness of outer Cover Layer -	mm	0.0	
n_r	No. of reinforcing plates		7.0	
t	Thickness of reinforcing plates	mm	2.7	
c_{hecker}	Thickness of Top plate	mm	10.0	
c_{hecker}	Thickness of Bottom plate combined	mm	10.0	
h_e	Actual thickness of Elastomer	mm	80.0	
h	Overall thickness of Bearing	mm	119	



ELASTOMER PROPERTIES

H	Nominal Hardness acc to EN 1337	IRHD	60.0
G_l	long term shear modulus	N/mm^2	0.90
G_s	short term shear modulus / dynamic	N/mm^2	0.90
E_b	bulk modulus	N/mm^2	2000.0
Cc	Compression Stiffness as per design	kN/mm	657.6



DESIGN CALCULATIONS

DESIGN LOADS			SLS	ULS	
Vertical Loads KN)	V_p	permanent	310	310	
	V_l	live /seismic	590	880	
	Vmin	minimum	165	165	
	V_d	design load = V_p + V_l	900	1190	<- Max Design Load
Horizontal Loads (KN)	H_{pb}	permanent // to length b - Transverse Force	0	0	
	H_{lb}	live /seismic //to length b - Transverse Force	20	12	<- Max Horizontal Transverse Force.
	H_{pa}	permanent // to width a - Longitudinal Force	0	0	
	H_{la}	live /seismic //to width a - Longitudinal Force	30	40	<- Max Horizontal Longitudinal Force.

DISPLACEMENTS & ROTATION			SLS	ULS	
Disp. in (mm)	δ pa	permanent disp // to width a - Longitudinal	6.0	9.0	
	δ pb	permanent disp // to length b - Transverse	0.0	0.0	
	δ pa	Live /reversible disp // to width a - Longitudinal	22.0	27.0	
	δ pb	Live /reversible disp // to length b - Transverse	20.0	12.0	
	α pa	Longitudinal permanent rotation	0.0004	0.0006	
	α pb	Transverse permanent rotation	0.0001	0.0002	
	α la	Longitudinal live/seismic rotation	0.0025	0.0033	
	α lb	Transverse live/seismic rotation	0.0006	0.0009	
	α ma	Longitudinal maximum rotation		**0.0039**	<- Max Longitudinal Rotation Value
	α mb	Transverse maximum rotation		**0.0011**	<- Max Transverse Rotational Value

SHAPE FACTOR		SLS	ULS	
S	Shape Factor	**9.700**	**9.700**	
A_1	Effective plan area (mm^2)	**150544**	**150544**	
lp	Force Free Parameter (mm)	**1552**	**1552**	

DISPLACEMENTS DUE TO LIVE LOAD		SLS	ULS	
Kd	dynamic stiffness (KN/mm)	**1.69**	**1.69**	<- Calculated Shear Stiffness Value
Ks	static shear stiffness(KN/mm)	**1.69**	**1.69**	
δ la	permanent disp // width a (mm) - Longitudinal - Horizontal Load	**6.00**	**9.00**	
δ lb	permanent disp // length b (mm) - Transverse - Horizontal Load	**0.00**	**0.00**	
δ la	live/seismic disp // width a (mm) - Longitudinal	**39.71**	**50.62**	
δ lb	live/seismic disp // length b (mm) - Transverse	**31.81**	**19.09**	

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DISPLACEMENT DUE TO SHEAR LOAD		SLS	ULS					
δ a	displacement in direction width - a (mm) - Longitudinal	**45.71**	**59.62**	<- Longitudinal Displacement due to Horizontal force				
δ b	displacement in direction length - b (mm) - Transverse	**31.81**	**19.09**	<- Transverse Displacement due to Horizontal force				
SHEAR STRAIN		SLS	ULS					
ε qa	Design load strain // width a - Longitudinal	**0.57**	**0.75**					
ε qb	Design load strain // length b - Transverse	**0.40**	**0.24**					
ε q	resultant shear strain	**0.70**	**0.80**					
ε pv	permissible value for shear strain	0.70	1.00					
CHECKS ε pv > ε q		PASS	PASS					**CHECK - 1**
DESIGN STRAIN DUE TO COMPRESSIVE LOAD		SLS	ULS					
Ar	reduced A1 (mm^2) area	**120465**	**120007**					
ε cl	Design Strain due to live load	**0.84**	**1.26**					
ε cp	Design Strain due to Permanent Load	**0.44**	**0.44**					
ε cd	Strain due to design load - long term G (only for ULS cal)		**1.70**					
DESIGN STRAIN DUE TO ANGULAR ROTATION		SLS	ULS					
ε al	Design Strain due to live load	**0.26**	**0.35**					
ε cp	Design Strain due to Permanent Load	**0.04**	**0.42**					
MAXIMUM DESIGN STRAIN - sum of strains		SLS	ULS					
K_{Ll}	type loading factor for live loads - Safety factor (1 or 1.5)	1.5						
K_{Lp}	type loading factor for all others - Safety factor	1.4						
K_L	type loading factor		1.0					
Ym	partial safety factor	1.40	1.00					
ε u	maximum permissible value	7.00	7.00					
ε t	sum of strains	**3.40**	**2.92**					
ε pv	Sum of all strain - permissible value as per En 1337-3 2005	5.0	7.00					
CHECK ε t < ε pv		PASS	PASS					**CHECK -2**
ROTATION LIMITATION		SLS	ULS					
K r	rotation factor	3.00	3.00					
z l	live load deflection of an individual inner layer (mm)	**0.11**	**0.17**					
z p	perm load deflection of an individual inner layer (mm)	**0.06**	**0.06**					
∑ z	total vertical deflection of bearing(mm)	**1.37**	**1.81**					
z min	Min vertical deflection of bearing required to allows rotation	**0.47**	**0.65**					
CHECK ∑ z > z min		PASS	PASS					**CHECK - 3**
FIXING OF BEARING		SLS	ULS					
σ m	average comp stress due to V d (N/mm2)	**7.47**	**9.92**					
σ cdmin	min comp stress due to min load (N/mm2)	**1.37**	**1.37**					
σ pv	permissible value	3.00	3.00					
μ ec	friction coefficient between concrete & checkered plates	0.5	0.5					
Ha	design horizontal load // to width a (kN) -Longitudinal	**77**	**101**					
Hb	design horizontal load // to length b (kN) - Transverse	**54**	**32**					
H	resultant horizontal force (kN)	**94**	**106**					
Hrc	resistance force due to μec (kN)	**155**	**155**					
CHECK σ m < 15,20 Mpa		PASS	PASS					**CHECK - 4**
CHECK Hrc > H (*Required only in case of Top/Bottom Checker plate*)		PASS	PASS					**CHECK - 5**
BUCKLING STABILITY		SLS	ULS					
σ d	average comp stress due to V d (N/mm2)	**7.47**	**9.92**					
σ pv	permissible value (this calculation uses long term G)	**28.23**	**28.23**					
CHECK σ pv > σ d		PASS	PASS					**CHECK - 6**
INTERNAL MS STEEL PLATE / SHIM THICKNESS		SLS	ULS					
fy	yield stress of the steel (N/mm^2)	**260**	**260**					
Kp	Stress correction factor	**1.3**	**1.3**					
Kh	induced tensile stresses factor	**1.0**	**1.0**					
Ym	partial safety factor	**1.3**	**1.3**					
t_{s1}	minimum thickness of steel plate (mm) Calculated	**1.0**	**1.3**					
t_{s2}	minimum thickness of steel plate (mm)	**2.0**	**2.0**					
t	Thickness of reinforcing plates (mm)	**2.7**	**2.7**					
CHECK t > ts1 and t > ts2		PASS	PASS					**CHECK - 7**

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5.3.3.7 FORCES, MOMENTS ACTING ON THE STRUCTURE		SLS	ULS
Rxy	Resultant of forces resisting the translatory movement in KN	**94.32**	**106.02**
Mb	Restoring Moment due to rotation about an axis through the centre of the bearing , // to length (b) in KN/mtr	**4.90**	**4.90**
Ma	Restoring Moment due to rotation about an axis through the centre of the bearing , // to width (a) in KN/mtr	**17.37**	**17.37**

Yellow columns - values to be entered