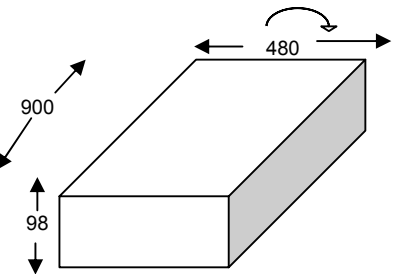


Laminated Elastomeric Bearings Calculation Based On prEN 1337-3:2004 V 6.0

Client **FREYSSINET - ETHAD TOWER EB** DATE **-08/02/2009**  
 Bearing 3 - P4PT3 - Permutation - QTY 1 No

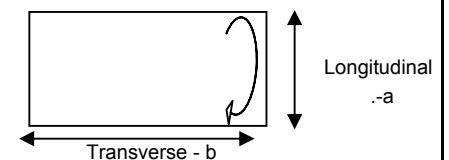
**BEARING DIMENSIONS**

a	Overall Width	mm	480.0
b	Overall Length	mm	900.0
c	Edge Cover of Elastomer	mm	4.0
a <sub>e</sub>	Effective Width	mm	472.0
b <sub>e</sub>	Effective Length	mm	892.0
n <sub>i</sub>	Number of inner Elastomer Layers		4.0
t <sub>i</sub>	Thickness of an inner Layer	mm	15.0
n <sub>o</sub>	No. of Outer Cover Layer		2.0
t'	Thickness of outer Cover Layer -	mm	3.8
n <sub>r</sub>	No. of reinforcing plates		5.0
t	Thickness of reinforcing plates	mm	6.1
h <sub>e</sub>	Actual thickness of Elastomer	mm	60.0
h	Overall thickness of Bearing	mm	98.0



**ELASTOMER PROPERTIES**

H	Norminal Hardness acc to EN 1337	IRHD	60.0
G <sub>l</sub>	long term shear modulus	N/mm <sup>2</sup>	0.90
G <sub>s</sub>	short term shear modulus / dynamic	N/mm <sup>2</sup>	1.80
E <sub>b</sub>	bulk modulus	N/mm <sup>2</sup>	2000.0
Cc	Compression Stiffness required as per design	kN/mm	800.0
Cs	Shear Stiffness required as per design	kN/mm	2.0



**DESIGN CALCULATIONS**

DESIGN LOADS			SLS	ULS				
Vertical KN	V <sub>p</sub>	permanent	3742	3742				
	V <sub>l</sub>	live /seismic	806	1783				
	V	design load effect = DD x 1.2 + LL x 1.6	5780	7343.2				
	V <sub>min</sub>	min design load	5780	7343.2				
Horizontal KN	H <sub>pb</sub>	permanent // to length b - Transverse Force	0	0				
	H <sub>lb</sub>	live /seismic //to length b - Transverse Force	0	0				
	H <sub>pa</sub>	permanent // to width a - Longitudinal Force	0	0				
	H <sub>la</sub>	live /seismic //to width a - Longitudinal Force	0	0				
	H <sub>vm</sub>	acting with V <sub>min</sub>	0	0				
DISPLACEMENTS & ROTATION			SLS	ULS				
Disp (mm)	δ <sub>pa</sub>	permanent disp // to width a - Longitudinal	0.0000	0.0000				
	δ <sub>pb</sub>	permanent disp // to length b - Transverse	0.0000	0.0000				
Rotations (rad)	α <sub>c</sub>	const tolerance	0.0010	0.0010				
	α <sub>pa</sub>	longitudinal perm rotation	0.0020	0.0020				
	α <sub>pb</sub>	transverse perm rotation	0.0010	0.0010				
	α' <sub>a</sub>	α <sub>pa</sub> + α <sub>c</sub>	0.0030	0.0030				
	α' <sub>b</sub>	α <sub>pb</sub> + α <sub>c</sub>	0.0020	0.0020				
	α <sub>la</sub>	logitudinal live/seismic rotation	0.0020	0.0020	→	Longitudinal Live + Sesmic rotation		
	α <sub>lb</sub>	transverse live/seismic rotation	0.0020	0.0020	→	Transverse Live + Sesmic rotation		
	α <sub>ma</sub>	logitudinal maximum rotation		0.0050				
	α <sub>mb</sub>	transverse maximum rotation		0.0040				
SHAPE FACTOR			SLS	ULS				
S	Shape Factor		10.289	10.289				
A <sub>1</sub>	Effective plan area (mm <sup>2</sup> )		421024	421024				
l <sub>p</sub>	Force Free Parameter (mm)		2728	2728				
LIVE LOAD DISPLACEMENTS			SLS	ULS				
K <sub>d</sub>	dynamic stiffness (KN/mm)		12.631	12.631				
K <sub>s</sub>	static shear stiffness(KN/mm)		6.32	6.32				
δ <sub>la</sub>	live/seismic disp // width a (mm) - Longitudinal		0.00	0.00				
δ <sub>lb</sub>	live/seismic disp // length b (mm) - Transverse		0.00	0.0				
DESIGN LOAD DISPLACEMENTS			SLS	ULS				
δ <sub>a</sub>	design load disp // width a (mm) - Longitudinal		0.0	0.0				
δ <sub>b</sub>	design load disp // length b (mm) - Transverse		0.0	0.0				
SHEAR STRAIN			SLS	ULS				
ε <sub>qa</sub>	Design load strain // width a - Longitudinal		0.00	0.00				
ε <sub>qb</sub>	Design load strain // length b - Transverse		0.00	0.00				
ε <sub>q</sub>	resultant shear strain		0.00	0.00				
ε <sub>pv</sub>	permissible value		0.7	2.0				
CHECKS ε <sub>pv</sub> > ε <sub>q</sub>			PASS	PASS				

<b>STRAIN DUE TO COMPRESSIVE LOAD</b>		SLS	ULS						
Ar	reduced A1 (mm <sup>2</sup> )	421024	421024						
ε cl	Strain due to live load	0.16	0.34						
ε cp	Strain due to Permanent Load	1.44	1.44						
ε cd	Strain due to design load - long term G		2.83						
<b>STRAIN DUE TO ANGULAR ROTATION</b>		SLS	ULS						
ε al	Strain due to live load	0.91	0.91						
ε cp	Strain due to Permanent Load	1.00	1.00						
<b>MAXIMUM DESIGN STRAIN</b>		SLS	ULS						
K <sub>Ll</sub>	type loading factor for live loads - Safety factor	1.0							
K <sub>Lp</sub>	type loading factor for all others - Safety factor	1.0							
K <sub>L</sub>	type loading factor		1.0						
Ym	partial safety factor	1.4	1.15						
ε u	maximum permissible value	7.0	7.0						
ε t	sum of strains	3.50	3.83						
ε pv	permissible value	5.0	6.09						
CHECK ε t < ε pv		PASS	PASS						
<b>ROTATION LIMITATION</b>		SLS	ULS						
K r	rotation factor	3.0	3.0						
z l	live load def of an individual inner layer (mm)	0.0	0.1						
z p	perm load def of an individual inner layer (mm)	0.3	0.3						
Σ z	total vertical deflection (mm)	2.1	2.7						
z min	min vertical def which allows rotation (mm)	1.98	1.98						
CHECK Σ z > z min		PASS	PASS						
<b>VERTICAL DEFLECTION LIMITATION</b>		SLS	ULS						
Σ z l	vertical deflection under live loads (mm)	0.18	-						
z Max	max vertical deflection under live load (mm)	1.01	-						
CHECK z max > Σ z l		PASS	-						
<b>FIXING OF BEARING</b>		SLS	ULS						
σ m	average comp stress due to V min (N/mm <sup>2</sup> )	13.73	17.44						
σ c d min	min comp stress due to perm load ( N/mm <sup>2</sup> )	8.89	8.89						
σ pv	permissible value	3.00	3.00						
μ er	friction coefficient between concrete and rubber	0.6	0.6						
μ ec	friction coefficient between concrete & checkered plates	0.5	0.5						
Ha	design horizontal load // to width a (kN) -Longitudinal	0	0						
Hb	design horizontal load // to length b (kN) - Transverse	0	0						
H	resultant horizontal force (kN)	0	0						
Hr	resistance force due to μ e (kN)	2245	2245						
Hrc	resistance force due to μ ec (kN)	1871	1871						
CHECK σ c d min > σ pv		PASS	PASS						
CHECK Hr > H		PASS	PASS						
CHECK Hrc > H ( Required only in case of Top/Bottom Checker plate )		PASS	PASS						
<b>BUCKLING STABILITY</b>		SLS	ULS						
σ d	average comp stress due to V min (N/mm <sup>2</sup> )	13.73	17.44						
σ pv	permissible value ( this calculation uses long term G )	48.56	48.56						
CHECK σ pv > σ d		PASS	PASS						
<b>STEEL PLATE THICKNESS</b>		SLS	ULS						
f <sub>y</sub>	yield stress of the steel ( N/mm <sup>2</sup> )	220	220						
K <sub>p</sub>	Stress correction factor	1.3	1.3						
K <sub>h</sub>	induced tensile stresses factor	1.3	1.3						
Y <sub>m</sub>	partial safety factor	1.5	1.5						
t <sub>s1</sub>	minimum thickness of steel plate (mm)	4.7	6.0						
t <sub>s2</sub>	minimum thickness of steel plate (mm)	2.0	2.0						
t	Thickness of reinforcing plates (mm)	6.1	6.1						
CHECK t > t <sub>s1</sub> and t > t <sub>s2</sub>		PASS	PASS						

SI No	Bearing Size		Elastomer Thickness	No of Elastomer	MS Shim Thickness	No of Shims	Cover Layer	Net Height
	Length	Width						
1	480	900	14	4	6	5	4	94
2	480	900	15	4	6	5	4	98
3	485	900	14	4	6	5	4	94
4	485	900	15	4	6	5	4	98
5	490	900	14	4	6	5	4	94
6	490	900	15	4	6	5	4	98
7	480	905	14	4	6	5	4	94
8	480	905	15	4	6	5	4	98
9	485	905	14	4	6	5	4	94
10	485	905	15	4	6	5	4	98
11	490	905	14	4	6	5	4	94
12	490	905	15	4	6	5	4	98
13	480	910	14	4	6	5	4	94
14	480	910	15	4	6	5	4	98
15	485	910	14	4	6	5	4	94
16	485	910	15	4	6	5	4	98
17	490	910	15	4	6	5	4	98
18	480	915	14	4	6	5	4	94
19	480	915	15	4	6	5	4	98
20	485	915	14	4	6	5	4	94
21	485	915	15	4	6	5	4	98
22	490	915	15	4	6	5	4	98
23	480	920	14	4	6	5	4	94
24	480	920	15	4	6	5	4	98
25	485	920	15	4	6	5	4	98
26	490	920	15	4	6	5	4	98
27	480	925	14	4	6	5	4	94
28	480	925	15	4	6	5	4	98
29	485	925	15	4	6	5	4	98
30	490	925	15	4	6	5	4	98
31	480	930	15	4	6	5	4	98
32	485	930	15	4	6	5	4	98
33	490	930	15	4	6	5	4	98
34	480	935	15	4	6	5	4	98
35	485	935	15	4	6	5	4	98
36	490	935	15	4	6	5	4	98
37	480	940	15	4	6	5	4	98
38	485	940	15	4	6	5	4	98
39	490	940	15	4	6	5	4	98
40	480	945	15	4	6	5	4	98
41	485	945	15	4	6	5	4	98
42	490	945	15	4	6	5	4	98
43	480	950	15	4	6	5	4	98
44	485	950	15	4	6	5	4	98
45	490	950	15	4	6	5	4	98
46	480	955	15	4	6	5	4	98
47	485	955	15	4	6	5	4	98
48	490	955	15	4	6	5	4	98
49	480	960	15	4	6	5	4	98
50	485	960	15	4	6	5	4	98
51	490	960	15	4	6	5	4	98
52	480	965	15	4	6	5	4	98
53	485	965	15	4	6	5	4	98
54	490	965	15	4	6	5	4	98
55	480	970	15	4	6	5	4	98
56	485	970	15	4	6	5	4	98
57	490	970	15	4	6	5	4	98
58	480	975	15	4	6	5	4	98
59	485	975	15	4	6	5	4	98
60	490	975	15	4	6	5	4	98
61	480	980	15	4	6	5	4	98
62	485	980	15	4	6	5	4	98
63	490	980	15	4	6	5	4	98
64	480	985	15	4	6	5	4	98

64	480	985	15	4	6	5	4	98
65	485	985	15	4	6	5	4	98
66	480	990	15	4	6	5	4	98
67	485	990	15	4	6	5	4	98
68	480	995	15	4	6	5	4	98
69	485	995	15	4	5	5	4	93
70	485	995	15	4	6	5	4	98
71	480	1000	15	4	6	5	4	98
		<b>Min</b>	<b>Max</b>					
	Width	<b>480</b>	<b>490</b>					
	Length	<b>900</b>	<b>1000</b>					
	No of layers	<b>3</b>	<b>4</b>					
	Thickness	<b>12</b>	<b>15</b>					
	Thickness of p	<b>5</b>	<b>6</b>					