Disc Bearing Specifications

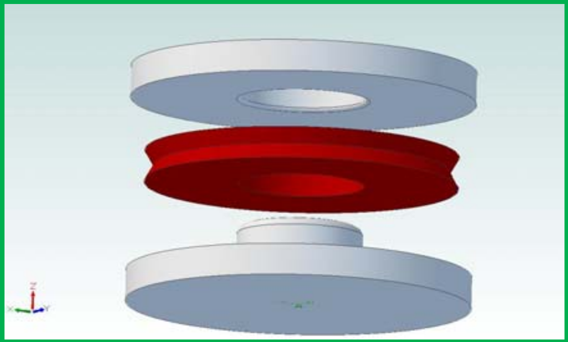
AASHTO T-2

~~Austin, TX July 2012~~

~~Columbus, OH   June 2014~~

~~Minneapolis, MN June 2016~~

Spokane, Washington June 2017



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Motivations for Disc Design Update

1. The disc **design methodology has not evolved** as other bearing types have.

2. Test, analysis, and field history support an increase in **allowables** that were first established 45 years ago.

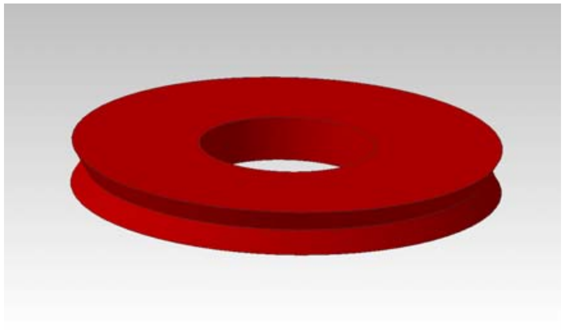
3. Short squat pads can accommodate **higher stresses** than tall pads.

4. Tall pads can accommodate **more strain** than short pads.

Current Limits

Design Section 14.7.8.3

- *"At the service limit state…deflection under total load does not exceed ten percent"*
- *"The average compressive stress on the disc does not exceed 5.0 ksi"*
- *150% load, no gapping at 0.020 radians*



S=2.00

Three main objectives of Method B are;

1. Relegate design changes to the neighborhood of 20% beyond that allowed by current specifications.
2. Recognize that short pads can accommodate high stresses and tall pads can accommodate high strains.
3. Prevent concurrent maximum allowable values of stress and strain.

3.4 Design Constraints Working Together

The Method B constraints work together to form design boundaries to ensure that limit states remain within the neighborhood of a 20% increase on current limits (Figure 3-4). Maximum stress and strain values cannot be reached simultaneously. Unlike Method A, Method B maximum allowable stresses and strains are dependent upon shape factor (Table 3-1).

Table 3-1: Limit comparisons

	Method A Service Limits		Method B Service Limits	
A.1	$\sigma_c \leq 5.00$ ksi	B.1	$\sigma_c \leq 7.00$ ksi	
A.2	$\varepsilon_c \leq 0.10$	B.2	$\varepsilon_c \leq 0.14$	
A.3	$\alpha_B \geq 0.0133$	B.3	$\sigma_c \cdot \varepsilon_c \leq 0.72$	
		B.4	$\varepsilon_c \leq 0.24/S$	*$\varepsilon_c = 0.10$ for $S > 2.4$* *(Se <= 0.24)*
		B.5	$\alpha_B \geq 0.015$	

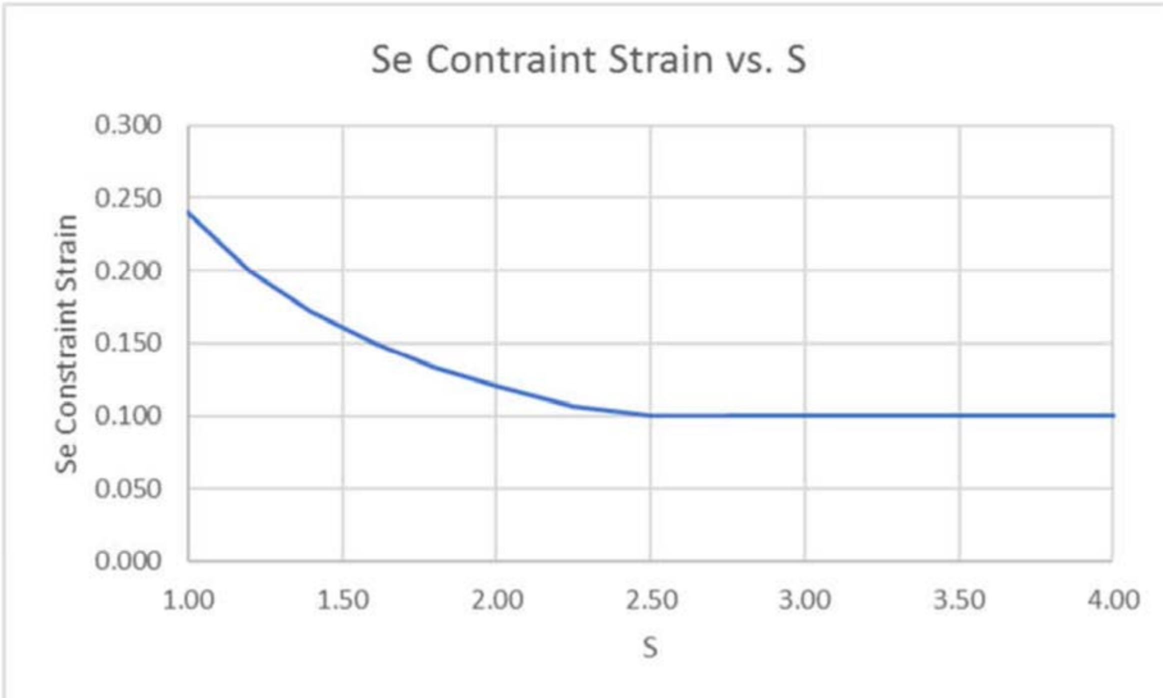


Figure 4-5: Se constraint strain

Se Constraint

AASHTO Section 14.7.5.3, Method B

$$\varepsilon_a = \frac{\sigma_S}{3GB_a S^2} \qquad \gamma_a = D_a \frac{\sigma_S}{GS} \qquad \gamma_a \le 3.0$$

Elastomeric bearings

$$S\varepsilon_a \le \frac{1}{B_a D_a} = 0.60$$

Disc bearings $S\varepsilon_c \le 0.24$

The Se constraint is similar to the AASHTO Method B limit on shear strain at the edge

The value of 0.24 is based on a 20% increase on current typical disc designs

Softer material

Table 3-2: Stress and strain limits for E = 5 ksi material designs

5.00	E									
S	**S_α**	**Se**	**Ec**	ε_α	ε_{Se}	$\varepsilon_\alpha/\varepsilon_c$	τ^*_{pc}	$\sigma_c\varepsilon_c$	σ_c	ε_c
1.00	1.12	0.140	11.80	0.034	0.240	0.24	0.177	0.231	1.651	0.140
1.20	1.35	0.168	14.57	0.040	0.200	0.29	0.203	0.286	2.040	0.140
1.40	1.57	0.196	17.38	0.047	0.171	0.34	0.225	0.341	2.433	0.140
1.60	1.80	0.224	20.13	0.054	0.150	0.38	0.243	0.395	2.819	0.140
1.80	2.02	0.240	22.77	0.061	0.133	0.45	0.246	0.405	3.036	0.133
2.00	2.24	0.240	25.24	0.067	0.120	0.56	0.232	0.363	3.029	0.120
2.25	2.52	0.240	28.07	0.076	0.107	0.71	0.215	0.319	2.994	0.107
2.50	2.81	0.250	30.61	0.084	0.100	0.84	0.208	0.306	3.061	0.100
2.75	3.09	0.275	32.86	0.093	0.100	0.93	0.214	0.329	3.286	0.100
3.00	3.37	0.300	34.85	0.101	0.100	1.01	0.217	0.348	3.485	0.100
3.50	3.93	0.350	38.14	0.118	0.100	1.18	0.223	0.381	3.814	0.100
4.00	4.49	0.400	40.72	0.135	0.100	1.35	0.227	0.407	4.072	0.100

Moderate durometer (e.g. 60D)

Table 3-3: Stress and strain limits for E = 10 ksi material designs

10.00	E									
S	S_{Ω}	Se	Ec	ε_{α}	ε_{Se}	$\varepsilon_{\alpha}/\varepsilon_{c}$	τ^{*}_{pc}	$\sigma_{c}\varepsilon_{c}$	σ_{c}	ε_{c}
1.00	1.12	0.140	23.59	0.034	0.240	0.24	0.177	0.462	3.303	0.140
1.20	1.35	0.168	29.14	0.040	0.200	0.29	0.203	0.571	4.079	0.140
1.40	1.57	0.196	34.75	0.047	0.171	0.34	0.225	0.681	4.866	0.140
1.60	1.80	0.224	40.26	0.054	0.150	0.40	0.233	0.720	5.384	0.134
1.80	2.02	0.240	45.53	0.061	0.133	0.48	0.232	0.720	5.726	0.126
2.00	2.24	0.240	50.48	0.067	0.120	0.56	0.231	0.720	6.029	0.119
2.25	2.52	0.240	56.14	0.076	0.107	0.71	0.215	0.639	5.989	0.107
2.50	2.81	0.250	61.22	0.084	0.100	0.84	0.208	0.612	6.122	0.100
2.75	3.09	0.275	65.72	0.093	0.100	0.93	0.214	0.657	6.572	0.100
3.00	3.37	0.300	69.69	0.101	0.100	1.01	0.217	0.697	6.969	0.100
3.50	3.93	0.350	76.29	0.118	0.100	1.28	0.205	0.642	7.000	0.092
4.00	4.49	0.400	81.44	0.135	0.100	1.57	0.195	0.602	7.000	0.086

Harder material

Table 3-4: Stress and strain limits for E = 20 ksi material designs

20.00	E									
S	S_α	Se	Ec	ε_α	ε_{Se}	$\varepsilon_\alpha/\varepsilon_c$	τ^*_{pc}	$\sigma_c\varepsilon_c$	σ_c	ε_c
1.00	1.12	0.140	47.18	0.034	0.240	0.27	0.156	0.720	5.828	0.124
1.20	1.35	0.168	58.27	0.040	0.200	0.36	0.161	0.720	6.477	0.111
1.40	1.57	0.196	69.51	0.047	0.171	0.47	0.162	0.705	7.000	0.101
1.60	1.80	0.224	80.53	0.054	0.150	0.62	0.151	0.608	7.000	0.087
1.80	2.02	0.240	91.07	0.061	0.133	0.79	0.142	0.538	7.000	0.077
2.00	2.24	0.240	100.96	0.067	0.120	0.97	0.134	0.485	7.000	0.069
2.25	2.52	0.240	112.29	0.076	0.107	1.22	0.126	0.436	7.000	0.062
2.50	2.81	0.250	122.43	0.084	0.100	1.47	0.119	0.400	7.000	0.057
2.75	3.09	0.275	131.43	0.093	0.100	1.74	0.114	0.373	7.000	0.053
3.00	3.37	0.300	139.38	0.101	0.100	2.01	0.109	0.352	7.000	0.050
3.50	3.93	0.350	152.58	0.118	0.100	2.57	0.102	0.321	7.000	0.046
4.00	4.49	0.400	162.88	0.135	0.100	3.13	0.097	0.301	7.000	0.043


DISC DESIGN - METHOD B

Proposed update to AASHTO Design Specifications Section 14.7.8 – Disc Bearings. Method B includes the influence of shape factor. Method B represents a 20% increase over current limits. Field history, analysis, and testing are used to support this increase.

Design Method for Polyurethane Load Bearing Discs

1. Notation
2. Specifications
3. Intro/Overview
4. Finite Element Analysis
5. Disc Elasticity (theory)
6. Testing
7. Examples

Method B

- The **design methodology has ~~not~~ evolved** as bearing types have. ✓
- Test, analysis, and field history support an increase in **allowables** that were established 45 years ago. ✓
- **Short squat pads** can accommodate **higher stresses** than tall pads. **Tall pads** can accommodate **more strain** than short pads. ✓
- Represents **20% increase** in material duress. ✓

  - Simple
  - Work in our range of experience

Acknowledgements

- RJ Watson, Inc
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  - Richard Vanderwedge, Justin Walker
- T2 Committee

Thank you