ASSOCIATED ENGINEERING

January 26, 2004
File: 012187

Brian Chow, M. Eng., P.Eng.
Senior Structures & Roads Engineer
Ministry of Forests
Resource Tenures and Engineering Branch
PO Box 9510 Stn Prov Govt
727 Fisgard Street
Victoria, B.C.
V8W 9C2

Associated Engineering (B.C.) Ltd.
Suite 300
4940 Canada Way
Burnaby, B.C.
Canada
V5G 4M5
Tel. 604.293.1411
Fax 604.291.6163
www.ae.ca

Re: DESIGN OF BEARINGS FOR TYPICAL STEEL GIRDER FORESTRY BRIDGES

Dear Mr. Chow:

Associated Engineering is pleased to submit a technical memorandum summarising our review of the design of plain natural rubber elastomeric bearing pads. In addition to suggesting that the Ministry adopt the methodology included in CAN/CSA-S6-00, we have included recommendations regarding the detailing of a typical bearing assemblies and the use of reinforced laminated bearing pads for spans exceeding 40 m.

If you have any further questions, please feel free to contact me at your convenience.

Respectfully submitted

ASSOCIATED ENGINEERING

Prepared by:

JHenley

Julien Henley, P.Eng.
Structural Engineer

Reviewed by:

D. I. Harvey, P. Eng.
Senior Structural Engineer

JH/mceb

MEMO	SEND TO	Brain Chow, P.Eng. British Columbia Ministry of Forests
ASSOCIATED ENGINEERING	FROM	ASSOCIATED ENGINEERING
	LOCATION: Burnaby	NAME: Julien Henley, P.Eng.

RE:	PROJECT NO.	FILE	DATE
		012187-000-003	January 26, 2004

SUBJECT
DESIGN OF PLAIN ELASTOMERIC BEARING PADS FOR STEEL GIRDER BRIDGES

Summary of bearing design in accordance with CAN/CSA-S6-00, AASHTO LRFD 1998 and BS-5400

The following briefly summarises the various design methods that could be adopted for the design of plain natural rubber elastomeric bearing pads. The limiting criteria are summarised in Table 1.

CAN/CSA-S6-00 Maximum allowable stress is limited to a function based the bearing pad shape factor to a maximum value of 7 MPa. Vertical strain is limited to 0.07 and no uplift is allowed when the bearing is subject to a rotational displacement.

AASHTO Maximum allowable stress is limited to 5.5 MPa. To accommodate rotational displacements without uplift, a minimum allowable stress is also defined based on the bearing pad shape factor and shear modulus of the elastomer.

BS-5400 Maximum allowable stress is limited to function based on the shape factor of the pad and the shear modulus of the elastomer. A typical allowable bearing stress is about 3 MPa. To accommodate rotational displacements without uplift, a minimum vertical deflection is defined.

To compare these methods, sample bearing designs were completed and the results summarised in Table 2. The designs all assumed 4.8 m wide composite concrete decks and 60 durometer plain rubber bearing pads. S6-00 SLS loads were assumed when considering designs based on BS-5400.

Table 1
Summary of Limiting Parameters

Parameter	CAN/CSA-S6-00	AASHTO LRFD 1998	BS5400
Shape Factor	$\frac{W \times L}{2 \times t \times (W+L)}$	$\frac{W \times L}{2 \times t \times (W+L)}$	$\frac{W \times L}{2 \times (1.8 \times t) \times (W+L)}$
Limiting SLS Stress (MPa)	$1.95 \times S - 3.6 \leq 7$ [2]	5.5	$G \times S \leq 5 \times G$
Vertical deflection	*0.07t*	N/A	N/A
Rotation[1]	No uplift	$f_s \geq 0.5GS \times \left(\frac{L}{t}\right)^2 \times \theta$	$\Delta \geq \frac{L\theta}{3}$

Note:
1. AASHTO requires the inclusion of an additional 0.005 rad to account for fabrication/installation irregularities
2. Numerical approximation of limits defined graphically in S6-00

Table 2
Sample Bearing Designs

Bridge	S6-00 (modified)	AASHTO LRFD (1998)	BS-5400
18 m L75	400 x 375 x 25	400 x 300 x 25	550 x 475 x 25
30 m L75	425 x 400 x 25	400 x 400 x 30	550 x 525 x 25
39 m L75	500 x 375 x 25	450 x 400 x 30	600 x 550 x 25
18 m L100	450 x 375 x 25	450 x 325 x 25	550 x 500 x 25
30 m L100	500 x 400 x 25	475 x 400 x 30	600 x 550 x 25
39 m L100	525 x 400 x 25	550 x 400 x 35	600 x 600 x 25
18 m L165	500 x 400 x 25	525 x 400 x 25	600 x 600 x 25
30 m L165	600 x 400 x 25	650 x 450 x 35	700 x 600 x 25
39 m L165	600 x 500 x 30	600 x 475 x 45	700 x 650 x 25

A review of the sample designs indicates the following:

- As span lengths increase there are greater live load rotational and translational displacement demands on the bearings. To accommodate these, the bearing pad thickness must be increased.

- Given the additional 0.005 rad rotational allowance that AASHTO specifies, bearings pads designed in accordance with AASHTO are typically thicker than those designed in accordance with S6-00.

- Bearings designed in accordance with BS-5400 are typically larger than those design in accordance with S6-00 or AASHTO given the very low allowable design stresses (typically 50% of those based on S6-00 and AASHTO).

- For the longer spans (> 39 m), the plain pads are very large when compared to typical flange widths. For these span lengths, it may be more appropriate to consider the use of reinforced laminated pads. These pads are typically smaller than plain rubber pads and able to resist higher vertical loads and displacement demands.

Proposed design methodolgy for plain elastomeric bearing pads

We propose the following methodology for the design of plain elastomeric bearing pads:

1. *Bearing design should be completed in accordance with CAN/CSA-S6-00.*

2. *When checking the rotational capacity of the bearings, only the live load rotation need be considered if the dead load rotations are accommodated in the construction methodology. The live load rotational demand can be estimated as*

$$\theta_{LL} = \frac{M_{ll} \times l}{3 \times E \times I}$$

where M_{ll} = *maximum factored live load moment*
l = *span length*

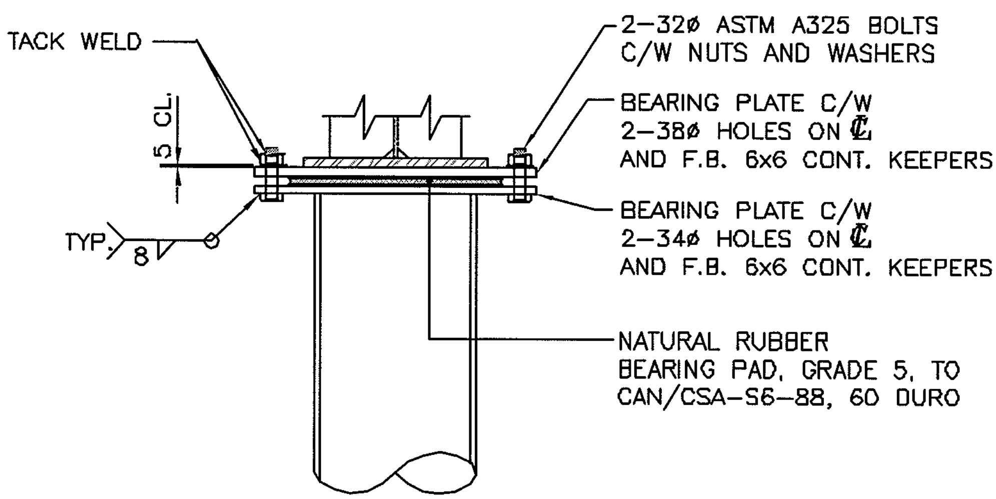
3. *Typically shear deformation need not be considered if the connection between the two bearing plates does not allow for a significant shear displacement (e.g. by use of anchor bolts for shear connection). If the bearing plates allow for a shear displacement, this deformation must be included in the bearing design.*

4. *Where spans exceed 40 m, reinforced laminated bearing pads should be used to accommodate the increased vertical loads and associated deformations.*

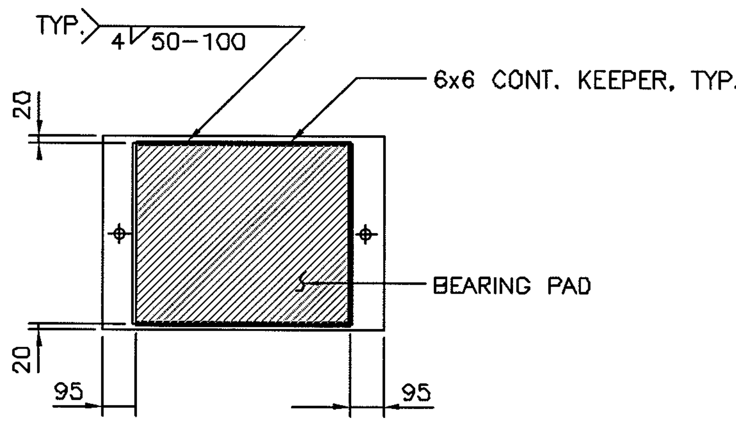
5. *Revise the standard bearing drawings to include continuous keepers on both the top and bottom bearing plates (as shown on the attached sketch) to help restrain the elastomeric pad.*

6. *Require that upon the completion of bridge installation, the bearings be inspected and if required, reset to relieve any unintended shear and rotational deformations that may have been applied during the construction of the bridge.*

AUTOCADD DRAWING No.



BEARING DETAIL



PLAN ON KEEPERS

DESIGN: JH	
CHECK: DIH	
DRAWN: JH	
DATE: JANUARY 2004	
SCALE:	
JOB No. 012187	
DWG. No. 2187-SK-1	△

MINISTRY OF FOREST

DETAILING OF PLAIN ELASTOMERIC BEARING PADS

ASSOCIATED ENGINEERING