okAgenda

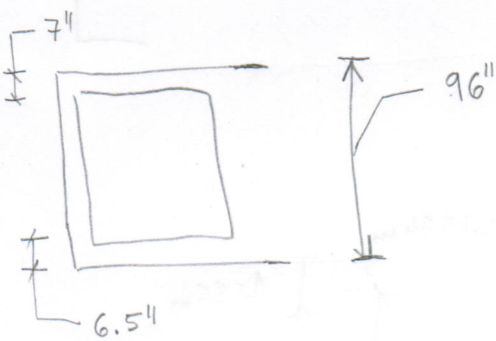
Subject: TEMPERATURE GRADIENT LOADING FOR BRIDGE MODELER OBJECTS

Subtask:

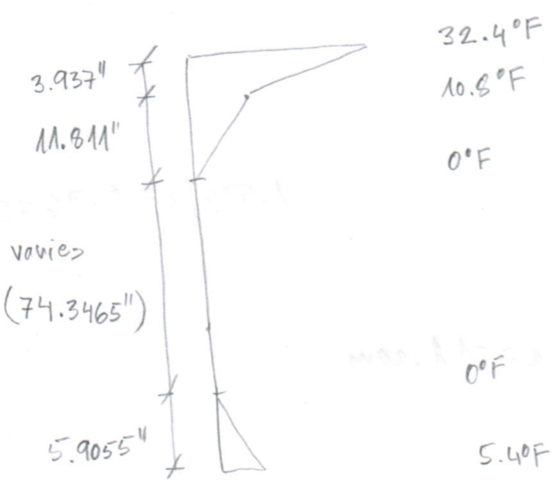
Prepared by: ok   Date: 7/21/2009

Sheet No. 1   of

[kip, in, F]



BOBJ2 > Load pattern „Temp" > Temperature gradient BTGL1



Σ =

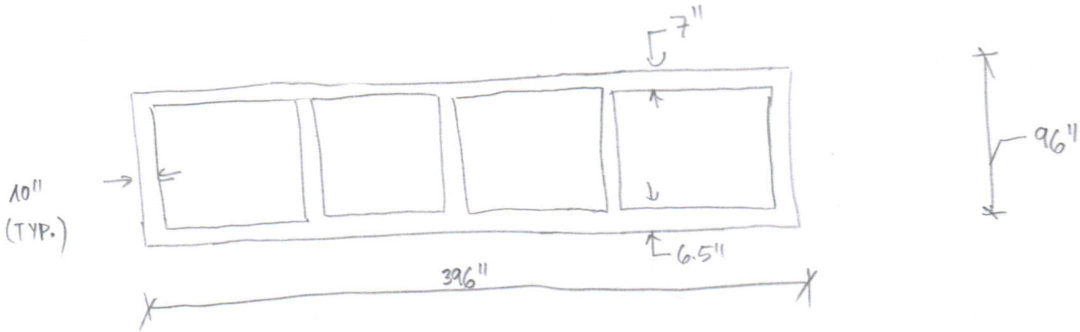
okAgenda

Subject:

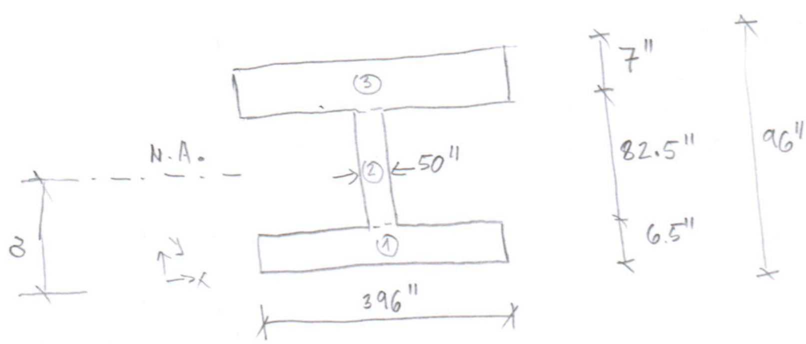
Subtask:

Prepared by: ok Date: 7/23/2009

Sheet No. 2 of



⇓ equivalent I-section (not to scale)



Determine a

	A	y_{cg}	$A y_{cg}$
①	2574 in^2 ✓	3.25"	8365.5
②	4125 in^2 ✓	47.75"	196968.75
③	2772 in^2 ✓	92.5"	256410
	Σ = 9471 in^2		Σ = 461744.25 in^3

$$a = \frac{\Sigma A y_{cg}}{\Sigma A} = 48.753484 \text{ in} \checkmark$$

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Subject:

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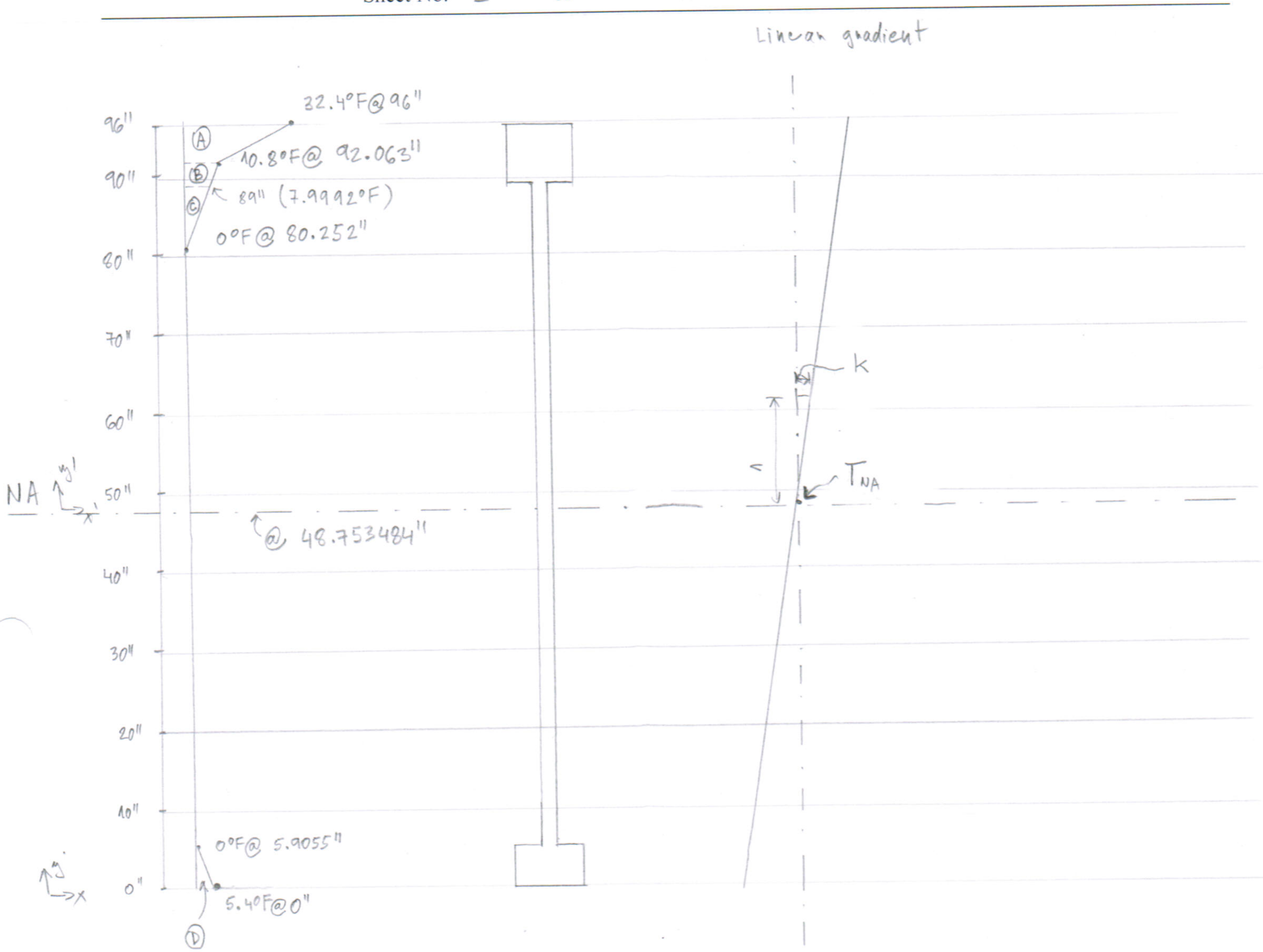
Sheet No. 3 of



okAgenda

Subject:
Subtask:
Prepared by: ok   Date: 7/23/2009
Sheet No. 4   of

			y_{bot}	y_{top}	Δy	section width	Integrated Temperature	y_{cg}
A	A_1	10.8°F □	92.063"	96"	3.937"	396"	16837.7616	94.0315"
	A_2	21.6°F △	92.063"	96"	3.937"	396"	16837.7616	94.687667"
B	B_1	7.9992°F □	89"	92.063"	3.063"	396"	9702.613642	90.5315"
	B_2	2.8008°F ▽	89"	92.063"	3.063"	396"	1698.612379	91.042"
C		7.9992°F ▽	80.252"	89"	8.748"	50"	1749.42504	86.084"
D		△ 5.4°F	0"	5.9055"	5.9055"	396"	6314.1606	1.9685"

Σ 53140.33486 (P)

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Subject:

Subtask:

Prepared by: ok   Date: 7/23/2009

Sheet No. 5   of

	arm to NA	Integrated Temperature Moment
A_1	45.278016"	762 380.439
A_2	45.934183"	773 428.823
B_1	41.778016"	405 335.948
B_2	42.288516"	71 831.797
C	37.330516"	65 306.939
D	-46.784984"	-295 407.903
		Σ 173 2896.043 (M3) (from Excel)

Refering to Figure on page 3 (Linear gradient), the following equations can be written (assuming $\alpha E = 1$):

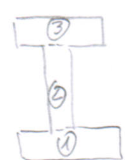
$$P = \int_A T(y')\, dA = \int_A (T_{NA} + k y')\, dA = T_{NA} A + k \int_A y'\, dA = T_{NA} A + k Q$$

$$M_3 = \int_A y' T(y')\, dA = \int_A y'(T_{NA} + k y')\, dA = \int_A T_{NA} y'\, dA + \int_A k y'^2\, dA =$$

$$= T_{NA} Q + k I$$

where Q is static moment of Area (zero about NA)

I is moment of inertia



$$\left(\begin{array}{cc|c} T_{NA} & k & \\ A & Q=0 & P \\ Q=0 & I & M_3 \end{array} \right)$$

$$T_{NA} = \frac{P}{A} = \frac{53140.33486}{9471} = 5.610847°F$$

$$k = \frac{M_3}{I} = \frac{1732896.043}{12998760} = 0.137159$$

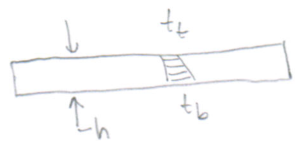
↑ from SAP2000 & verified by hand

top fiber temperature = 5.610847 + (96" − 48.753484")(0.137159) = 12.09°F

bottom fiber temperature = 5.610847 + (−48.753484")(0.137159) = −1.08°F

OK!

Determine fixed moments



$$\overline{M}_{ab} = \frac{EI}{h} \alpha (t_b - t_t) \qquad \overline{M}_{ba} = \frac{-EI}{h} \alpha (t_b - t_t)$$

$E = 3232.6008$ ksi

$I = 12{,}998{,}760$ in^4

$h = 96$ in

$t_t = 12.09$°F

$t_b = -1.08$°F

$\alpha = 0.000005556 \frac{1}{°F}$

$M = 32028.07$ kip-in $\frac{1 ft}{12 in}$ =

= 2669.005 kip-ft

(SAP2000 gives very similar value for single frame element and solid bridge model)