CALCULATION/PROBLEM COVER SHEET

Calculation/Problem No: M-04

Title: BASE ANGLE STIFFNESS

Client: TUGCO/CPSES Project: CABLE TRAY EVAL.

Job No: 0210-040

Design Input/References:

SEE SECTION 4.0 REFERENCES

Assumptions:

SEE SECTION 1.0 DESCRIPTION OF ANALYSIS

Method:

SEE SECTION 1.0 DESCRIPTION OF ANALYSIS

Remarks:

1. SEE SECTION 3.0 DISSCUSSION OF RESULTS/RECOMMENDATIONS
2. RESULTS OF THIS CALCULATION AFFECT IMPELL REPORT # 01-0210-1470, IMPELL CALCULATIONS B-01 AND B-02 (JOB NO. 0210-041).

REV. NO.	REVISION	APPROVED	DATE
[redacted]	ORIGINAL ISSUE	Calvin Yee Wong	1/31/86
[redacted]	REVISED TO INCORPORATE BASEPLATE II & ANALYSIS.	Calvin Yee Wong	3/21/86

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NOTE: THE FOLLOWING PAGES HAVE BEEN ADDED IN REV 1:

SEC. 1.0 PG's 8-10 OF 10
SEC. 2.0 PG's 16-23 OF 23
SEC 3.0 PG. 3 OF 3
SEC 4.0 PG 2 OF 2

THE FOLLOWING PAGES HAVE BEEN REVISED OR REPLACED IN REV 1:

SEC. 3.0 PG 2 OF 3 (REPLACED)
SEC 4.0 PG 1 OF 2 (REVISED)
SEC 2.0 PG. 4-7, 12, 13, OF 23 (REPLACED)
PG 11 OF 23 (REVISED)
SEC. 3.0 P. 1 OF 3 (REVISED)

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0	ELL	12-6-85	RJB	12-19-85			

1.0 DESCRIPTION OF ANALYSIS:

THE PURPOSE OF THIS CALCULATION IS TO DETERMINE THE RANGE OF STIFFNESS VALUES ASSOCIATED WITH BASE ANGLES. FOUR COMMONLY USED BASE ANGLE SIZES WERE EVALUATED:

1. L 6 x 6 x 3/4
2. L 6 x 6 x 3/8
3. L 6 x 4 x 3/4
5. L 5 x 5 x 3/4

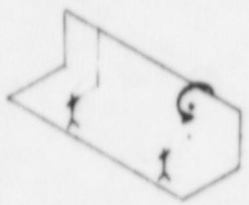
BOTH 2-BOLT AND 1-BOLT BASE ANGLE CONFIGURATIONS WERE EVALUATED. SINCE THE SUPPORT IS MODELED TO THE FACE OF THE FIXED LEG OF THE ANGLE, IT WAS DETERMINED THAT ONLY TWO OF THE SIX STIFFNESSES REQUIRED EVALUATION: (1) THE BENDING STIFFNESS ABOUT THE LONGITUDINAL AXIS OF THE ANGLE, AND (2) THE DIRECT PULLOUT STIFFNESS OF THE ANGLE. THE OTHER TWO TRANSLATIONAL STIFFNESSES AND TWO ROTATIONAL STIFFNESS ARE JUDGED TO BE RIGID, WITH EXCEPTION TO THE ROTATION ABOUT THE BOLT AXIS FOR THE 1-BOLT WHICH IS FREE.

THE PROGRAM BASEPLATE-II WAS USED TO EVALUATE THE BASE ANGLES. NINE LOAD CASES WERE RUN FOR EACH 2-BOLT ANGLE, AND FIVE CASES FOR EACH 1-BOLT. A DESCRIPTION OF EACH OF THE CASES ANALYZED FOLLOWS.

2-BOLT MODEL:

THE 2-BOLT MODELS FOR THE BASE ANGLES ARE ALL SIMILAR. THE BASE ANGLE LENGTH AND BOLT SPACINGS WERE CONSIDERED WITH VARYING DIMENSIONS THAT WERE COMMONLY USED. THE MOST COMMONLY USED ANCHOR BOLT IS THE 1¼" HILTI SUPER KWIK. THESE CONFIGURATIONS ARE REPRESENTATIVE OF THE BASE ANGLES REVIEWED TO DATE.

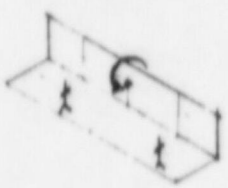
NINE LOAD CASES WERE EVALUATED FOR EACH OF THE FOUR BASE ANGLE SIZES:

1. 

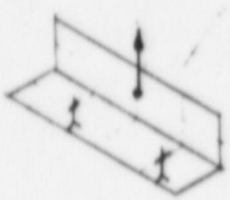
MOMENT LOADING ON FREE LEG AT BOLT LOCATION.

2. 

PULL-OUT LOAD ON FREE LEG AT BOLT LOCATION.

3. 

MOMENT LOADING ON FREE LEG MIDWAY BETWEEN BOLTS

4. 

PULL-OUT LOAD ON FREE LEG MIDWAY BETWEEN BOLTS

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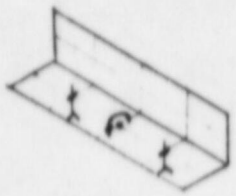
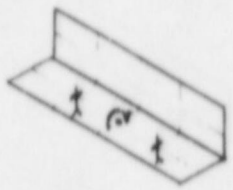
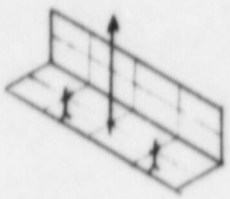
1	[illegible]	3-10-86	[illegible]	3-11-86	IMPELL CORPORATION	0210-040	2
0	ELC	12-4-85	[illegible]	12-4-85		CALC NO M-04	OF 10

5.  MOMENT LOADING ON FIXED LEG MIDWAY BETWEEN BOLTS

6.  MOMENT LOADING ON FIXED LEG MIDWAY BETWEEN BOLTS

7.  PULL-OUT LOAD ON FIXED LEG MIDWAY BETWEEN BOLTS

THE ROTATION STIFFNESS CAN BE DETERMINED BY REVIEWING THE DISPLACEMENTS OF THE NODES ADJACENT TO LOADING: IE

L 6"×6"× 3/4" CASE #1 LOADING = 1000 IN·LB

$$\left.\begin{aligned}\Delta Z_{21} &= .002049"\\ \Delta Z_{28} &= .001328"\end{aligned}\right\} \Delta = .000721"$$

$$\angle = \sin^{-1}\frac{.000721"}{1.5"} = .02754^\circ \text{ OR } .000481 \text{ RAD}$$

$$K = \frac{1000 \text{ IN·LB}}{.000481 \text{ RAD}} = 2080 \frac{\text{KP. IN}}{\text{RAD}}$$

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THE TRANSLATIONAL STIFFNESS FOR PULL-OUT LOADING CAN BE DETERMINED DIRECTLY BY REVIEWING THE DISPLACEMENT AT THE LOAD POINT: IE

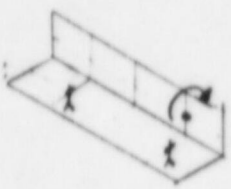
L 6"x6"x 3/4" CASE #2 LOADING = 1000 LB

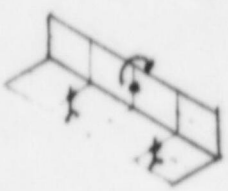
$$\Delta Z_{D_1} = .011590"$$

$$K = \frac{1000\ LB}{.011590\ IN} = 86\ \frac{KIP}{IN}$$

A DETAILED SKETCH OF THE BASEPLATE II MODEL FOLLOWS ON THE NEXT PAGE.

TWO ADDITIONAL LOAD CASES WERE CONSIDERED TO EVALUATE A POSITIVE X-X MOMENT FOR THE 2-BOLT BASE ANGLES AS FOLLOWS:

CASE 8:  MOMENT LOADING ON FREE LEG AT BOLT LOCATION

CASE 9:  MOMENT LOADING ON FREE LEG MIDWAY BETWEEN BOLTS.

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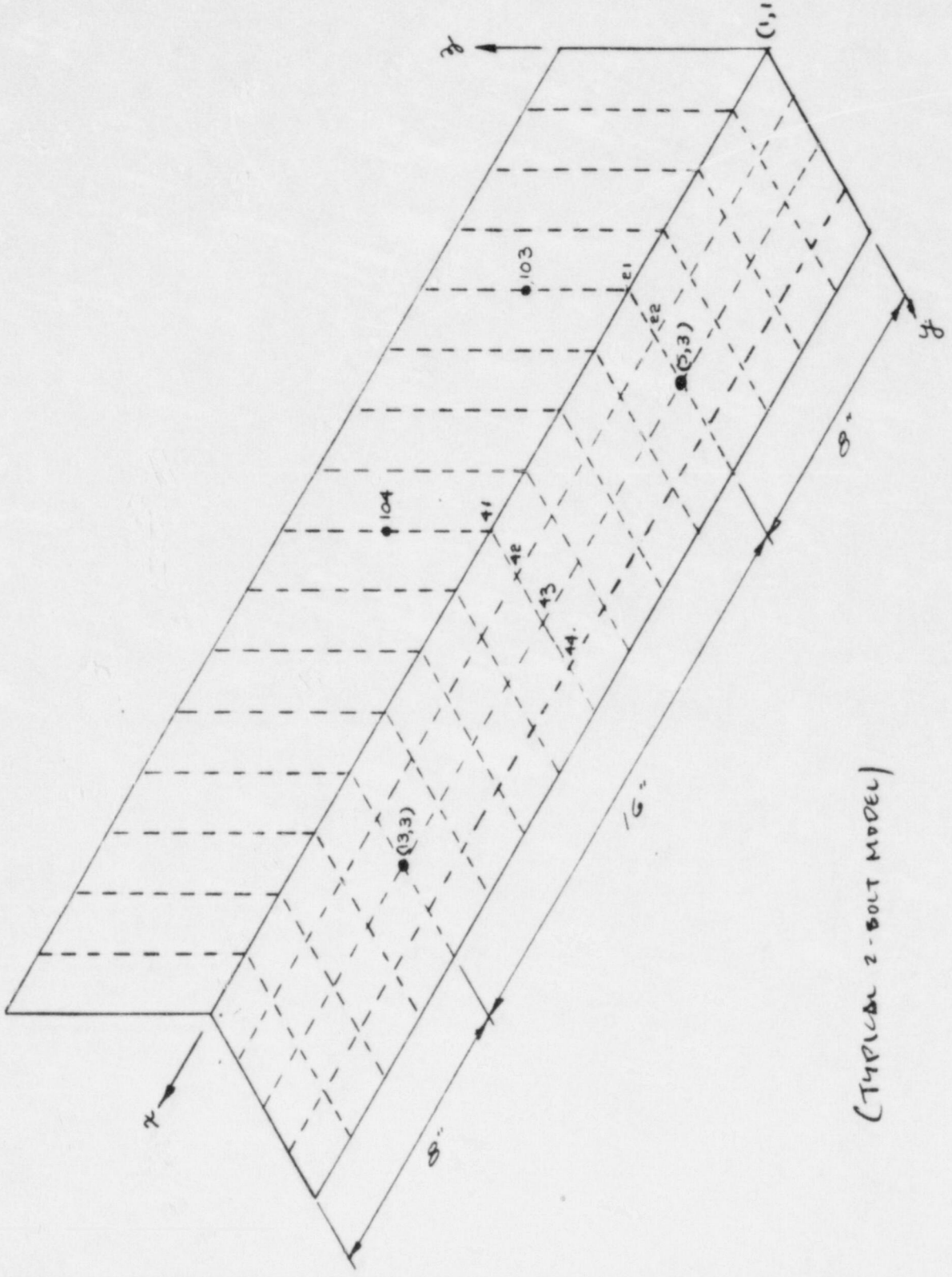

(TYPICAL 2-BOLT MODEL)

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1	BP	3-10-86	VJR	3-11-86
0	RLC	12-4-85	VJR	12-4-85

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REV	BY	DATE	CHECKED	DATE
0	GLC	13-1-85	VJR	12-4-85

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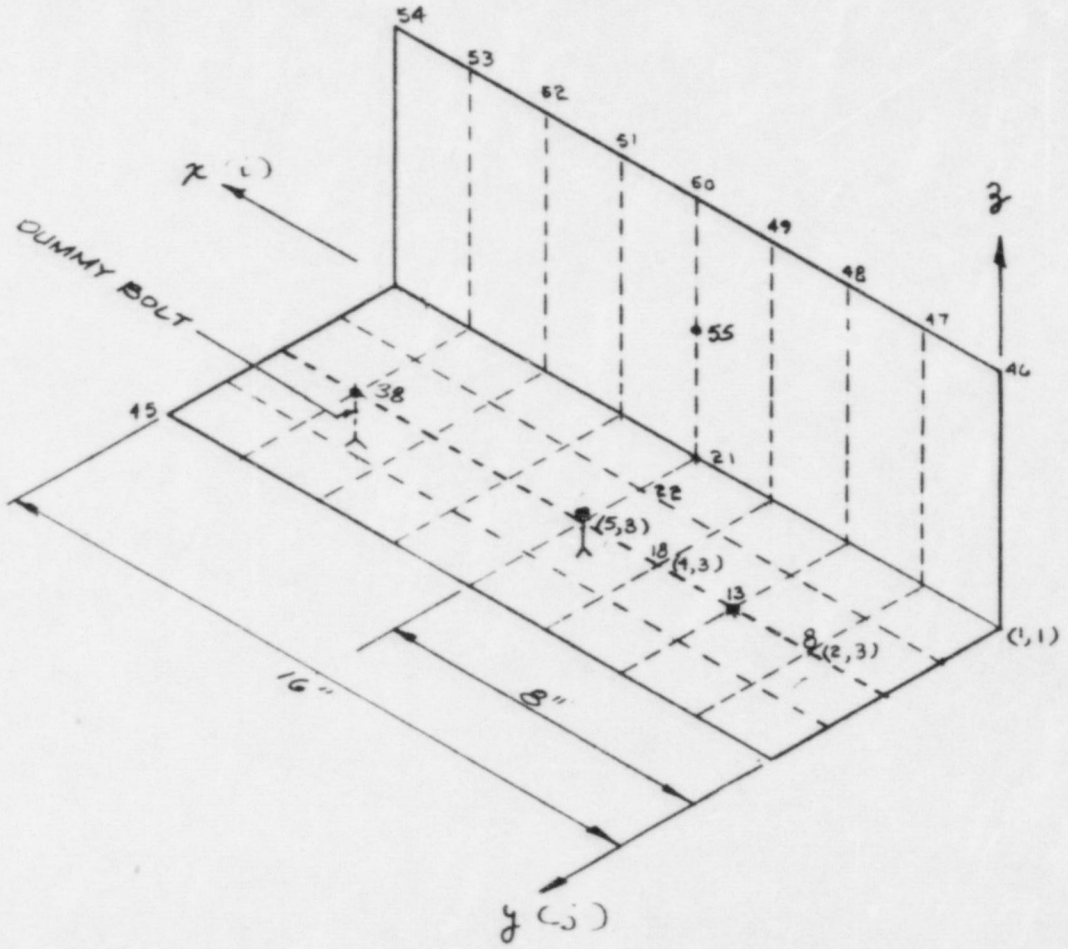
1-BOLT MODEL (WITH 1-DUMMY BOLT @ NODE 38)

THE 1-BOLT MODELS FOR THE BASE ANGLES ARE ALL SIMILAR. A 16-IN. LONG ANGLE WAS CONSIDERED WITH THE BOLT LOCATED IN THE MIDDLE (AS SHOWN BELOW). LIKE THE TWO-BOLT MODELS, THE MOST COMMONLY USED ANCHOR BOLT IS THE 1¼" SUPER HILTI KWIK.



REV	BY	DATE	CHECKED	DATE
0	[illegible]	11-26-85	[illegible]	12-4-85

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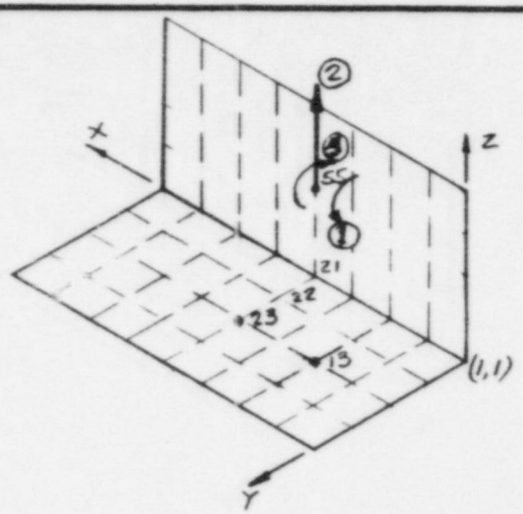
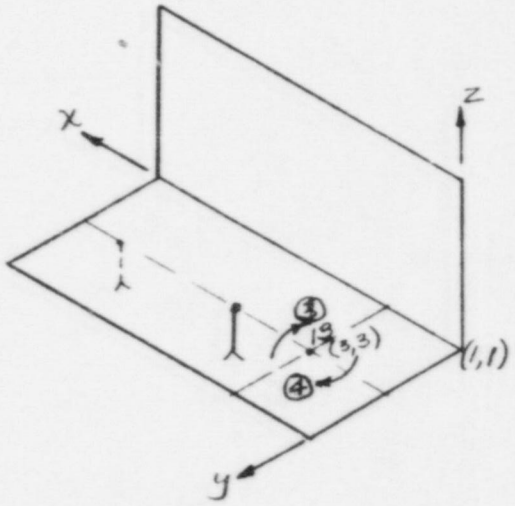


LOADCASES AT NODE 55

* LOAD CASE (1) - APPLY NEGATIVE MOMENT X EQUAL TO -1000 IN-#
* LOAD CASE (2) - APPLY POSITIVE FORCE Z=1000#
* LOAD CASE (5) - APPLY (+) MOMENT X=1000 IN-#.



LOADCASES AT NODE 13

* LOAD CASE (3) - APPLY (+) MOMENT X=1000 IN-#
* LOAD CASE (4) - APPLY (-) MOMENT X = 1000 IN-#

FIVE LOAD CASES ARE EVALUATED FOR EACH OF THE FOUR BASE ANGLE SIZES AS SHOWN ABOVE.

1.0

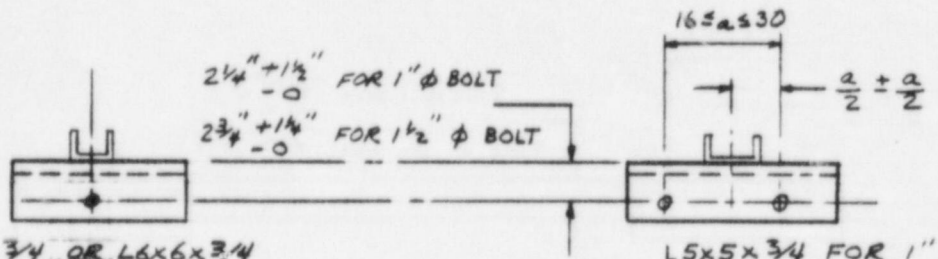
DESCRIPTION OF REV 1 ANALYSIS

THE PURPOSE OF REVISION 1 WAS TO INCORPORATE THE FOLLOWING:

- BASE ANGLE CONFIGURATIONS NOT COVERED IN REV. 0
- UPDATE $f'_c = 4000$ psi
- UPDATE STIFFNESS OF HILTI SUPER KWIK BOLT, $K_T = 461$ K/IN (REF. F)
  $K_V = 111$ K/IN (REF. F)

THE BASE ANGLES REPRESENTING LOWER BOUND STIFFNESSES WERE ANALYZED. IN ADDITION, THE UPPER BOUND STIFFNESSES FOR TYPICAL BASE ANGLE CONFIGURATIONS WERE ALSO ANALYZED. FROM THE RANGE OF STIFFNESSES DETERMINED, A REPRESENTATIVE OR "AVERAGE" STIFFNESS IS CALCULATED. ALL ANALYSES WERE PERFORMED USING THE CONCRETE AND BOLT STIFFNESS PROPERTIES SPECIFIED ABOVE.

REVIEW OF ACCEPTABLE BASE ANGLE CONFIGURATIONS GIVEN IN REFERENCE A SHOWED THE FOLLOWING DIMENSIONAL TOLERANCES FOR BASE ANGLE CONFIGURATIONS.



L5x5x¾ OR L6x6x¾ FOR 1" ϕ BOLT
L6x6x¾" FOR 1½" ϕ BOLT

L5x5x¾ FOR 1" ϕ BOLT WHEN a ≤ 24" ONLY
L6x6x¾ FOR ALL OCCASIONS

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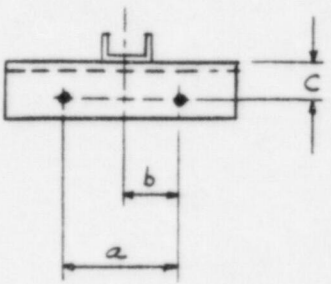
1.0

DESCRIPTION OF REV 1 ANALYSIS CONT'D

FROM THE PRECEDING SKETCHES IT WAS DETERMINED THAT THE FOLLOWING CASES SHOULD ALSO BE CONSIDERED.



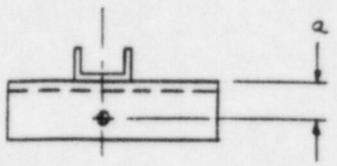
BASE ANGLE CONFIGURATION CASE	DIMENSIONS (INCH) a	b	c	ANGLE SIZE	COMMENTS
A	24	12	2 1/4	L5x5x3/4	STIFFNESS > CASE B *
B	24	12	3 3/4	L5x5x3/4	
C	24	0	2 1/4	L5x5x3/4	STIFFNESS > CASE D *
D	24	0	3 3/4	L5x5x3/4	
E	30	15	2 3/4	L6x6x3/4	STIFFNESS > CASE F *
F	30	15	4	L6x6x3/4	
G	30	0	2 3/4	L6x6x3/4	STIFFNESS > CASE H *
H	30	0	4	L6x6x3/4	

* WHEN 1 CASE HAD STIFFNESS > ANOTHER CASE, IT WAS UNNECESSARY TO RUN THE BASEPLATE II PROGRAM FOR THE STIFFER CASE.

EACH BASE ANGLE RUN ON BASEPLATE II WAS ANALYZED FOR THE (9) NINE LOAD CASES DESCRIBED ON PG 2,3&4.

1.0

DESCRIPTION OF REV 1 ANALYSIS CONT'D



BASE ANGLE CONFIGURATION CASE	DIMENSION "a" (INCH)	ANGLE SIZE	COMMENTS
I	2 1/4	L5x5x3/4	STIFFNESS > CASE J *
J	3 3/4	L5x5x3/4	
K	2 3/4	L6x6x3/4	STIFFNESS > CASE H *
L	4	L6x6x3/4	

* WHEN 1 CASE HAD STIFFNESS > ANOTHER CASE, IT WAS UNNECESSARY TO RUN THE BASEPLATE II PROGRAM FOR THE STIFFER CASE.

EACH BASE ANGLE RUN ON BASEPLATE II WAS ANALYZED FOR THE (9) NINE LOAD CASES DESCRIBED ON PG 2, 3 & 4.

2.0 BACK-UP CALCULATIONS

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0	ELL	12-6-85	RB	12-9-85	IMPELL CORPORATION	JOB NO 0210-040 CALC NO H-04	PAGE 1 OF 23

L 6"x6"x 3/4" 2-BOLT MODEL

CASE #1 : $\Delta Z_{21} = .002049"$, $\Delta Z_{22} = .001328"$ } $\Delta = .000721"$

(K_{xx} - FREE LEG) $\angle = \sin^{-1} \frac{.000721}{1.5} = .02754°$ OR $.000481$ RAD

$K = \frac{1000}{.000481} = 2080 \frac{KP.IN}{RAD}$

CASE #2 : $\Delta Z_{21} = .011590$

$K = \frac{1000}{.01159} = 86 \frac{KIP}{IN}$

(K_z - FREE LEG)

CASE #3 : $\Delta Z_{41} = .001674"$, $\Delta Z_{42} = .001087"$ } $\Delta = .000587"$

(K_{xx} - FREE LEG) $\angle = \sin^{-1} \frac{.000587"}{1.5} = .022422°$ OR $.000391°$

$K = \frac{1000}{.000391} = 2555 \frac{KP.IN}{RAD}$

CASE #4 $\Delta Z_{41} = .009356"$

$K = \frac{1000}{.009356} = 107 \frac{KIP}{IN}$

(K_z - FREE LEG)

CASE #5 $\Delta Z_{42} = .001168$, $\Delta Z_{44} = .000197$ } $.000971$

(K_{xx} - BOLTED LEG) $\angle = \sin^{-1} \frac{.000971}{3.0} = .018545°$ OR $.000324$ RAD

$K = \frac{1000}{.000324} = 3090 \frac{KP.IN}{RAD}$

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0	[illegible]	12-4-85	[illegible]	12-4-85	IMPELL CORPORATION	CALC NO M-04	

L 6"x6"x 3/4" 2-BOLT MODEL (CONT)

CASE #6:

$\Delta Z_{42} = .000425$
$\Delta Z_{44} = .001815$ } .001390

(K_{xx} - BOLTED LEG)

$\angle = \sin^{-1} \frac{.001390}{3.0} = .026547°$ OR .000463 RAD

$K = \frac{1000}{.000463} = 2158 \frac{KP \cdot IN}{RAD}$

CASE #7:

$\Delta Z_{43} = .003360$

$K = \frac{1000}{.003360} = 298 \frac{KIP}{IN}$

(K_Z - BOLTED LEG)

CASE #8

$\Delta Z_{21} = -.000073$
$\Delta Z_{22} = .000437$ } .000510

(K_{xx} - FREE LEG)

$\angle = \sin^{-1} \frac{.000510}{1.5} = .019481°$ OR .000340 RAD

$K = \frac{1000}{.000340} = 2941 \frac{KP \cdot IN}{RAD}$

CASE #9

$\Delta Z_{41} = -.000056$
$\Delta Z_{42} = .000502$ } .000558

(K_{xx} - FREE LEG)

$\angle = \sin^{-1} \frac{.000558}{1.5} = .021314°$ OR .000372 RAD

$K = \frac{1000}{.000372} = 2688 \frac{KP \cdot IN}{RAD}$

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6 x 6 x 3/8 (2 BOLTS) (OUTPUT 86/03/19. 17.41.54)

CASE #1:

$\Delta z_{21} = .004998$
$\Delta z_{22} = .002134$ $\Big\rangle$ .002864

$\angle = \sin^{-1} \frac{.002864}{1.5} = .1093968°$ OR .00190933 RAD

$K = 1000/.00190933 = \underline{524}$ K-IN/RAD

CASE #2:

$\Delta z_{21} = .019203$

$K = 1000/.019203 = \underline{52}$ K/IN

CASE #3:

$\Delta z_{41} = .002967$
$\Delta z_{42} = .001021$ $\Big\rangle$ .001946

$\angle = \sin^{-1} \frac{.001946}{1.5} = .07433175°$ OR .00129733 RAD

$K = 1000/.00129733 = \underline{771}$ K-IN/RAD

CASE #4:

$\Delta z_{41} = .012719$

$K = 1000/.012719 = \underline{79}$ K/IN

CASE #5:

$\Delta z_{42} = .001941$
$\Delta z_{44} = -.000086$ $\Big\rangle$ .002027

$\angle = \sin^{-1} \frac{.002027}{3} = .03871285°$ OR .00067567

$K = 1000/.00067567 = \underline{1480}$ K-IN/RAD

CASE #6:

$\Delta z_{44} = .006827$
$\Delta z_{42} = .001093$ $\Big\rangle$ .005734

$\angle = \sin^{-1} \frac{.005734}{3.0} = .1095114°$ OR .00191133 RAD

$K = 1000/.00191133 = \underline{523}$ K-IN/RAD

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1	[illegible]	9-14-86	[illegible]	9-18-86	IMPELL CORPORATION	CALC NO A1-04	OF 23

6+6+3/0 (2 BOLTS) CONT'D.

CASE 7: $\Delta_{Z43} = .011637$

$k = 1000/.011637 = \underline{\underline{86\ k/IN}}$

CASE 8: $\Delta_{Z21} = -.000098$, $\Delta_{Z22} = .000719$ $\Big\rangle$ .000817

$\angle = \sin^{-1} \frac{.000817}{1.5} = .0312971°$ OR .00054467

$k = \frac{1000}{.00054467} = \underline{\underline{1836\ k\text{-}IN/RAD}}$

CASE 9: $\Delta_{Z41} = -.000057$, $\Delta_{Z42} = .001693$ $\Big\rangle$ .00175

$\angle = \sin^{-1} \frac{.00175}{1.5} = .0668459°$ OR .00116667

$k = \frac{1000}{.00116667} = \underline{\underline{857\ \frac{k\text{-}IN}{RAD}}}$

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1	RD	3-19-86	JB	3-18-86		CALC NO M-04	OF 29

L 6x4x 3/4 (2 BOLTS) (OUTPUT 86/01/13 17.56.20)

CASE #1:

$\Delta z_{21} = .001397$
$\Delta z_{22} = .000826$ $\Big\rangle$ .000571

$\angle = \sin^{-1} = \frac{.000571}{1.5} = .024810^{\circ}$ OR .00038067 RAD

$K = 1000/.00038067 = \underline{\underline{2627}}$ K-IN/RAD

CASE #2:

$\Delta z_{21} = .007413$

$K = 1000/.007413 = \underline{\underline{135}}$ K/IN

CASE #3:

$\Delta z_{41} = .001062$
$\Delta z_{42} = .000618$ $\Big\rangle$ .000444

$\angle = \sin^{-1} = \frac{.000444}{1.5} = .016995^{\circ}$ OR .000296 RAD

$K = 1000/.000296 = \underline{\underline{3378}}$ K-IN/RAD

CASE #4:

$\Delta z_{41} =$

$K = 1000/.005681 = \underline{\underline{176}}$ K/IN

CASE #5:

$\Delta z_{42} = .00071$
$\Delta z_{44} = .00005$ $\Big\rangle$ .00066

$\angle = \sin^{-1} \frac{.00066}{3} = .012605^{\circ}$ OR .00022 RAD

$K = 1000/.00022 = \underline{\underline{4545}}$ K-IN/RAD

CASE #6:

$\Delta z_{42} = .000273$
$\Delta z_{44} = .001356$ $\Big\rangle$ .001083

$\angle = \sin^{-1} \frac{.001083}{3} = .020837^{\circ}$ OR .000364 RAD

$K = 1000/.000364 = \underline{\underline{2771}}$ K-IN/RAD

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∠6×4×3/4 (2 BOLTS) CONT'D:

CASE 7: $\Delta Z43 = .002443$

$k = 1000/.002443 = \underline{\underline{409}}$ K/IN

CASE 8:

$\Delta Z21 = -.000075$
$\Delta Z22 = .000266$ $\Big\rangle$ .000341

$\angle = \sin^{-1} \frac{.000341}{1.5} = .01302524°$ OR $.00022733$ RAD

$k = 1000/.00022733 = \underline{\underline{4399}}$ K-IN/RAD

CASE #9:

$\Delta Z41 = -.000057$
$\Delta Z42 = .00036$ $\Big\rangle$ .000417

$\angle = \sin^{-1} \frac{.000417}{1.5} = .01592823°$ OR $.000278$ RAD

$k = \frac{1000}{.000278} = \underline{\underline{3597}}$ $\frac{K\text{-}IN}{RAD}$

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1	AD	3-17-86	VJB	3-18-86	IMPELL CORPORATION	JOB NO 0210-040; CALC NO M-04; PAGE 7 OF 23

3.0 SUMMARY OF RESULTS / RECOMMENDATIONS

A SUMMARY OF THE RANGE OF THE STIFFNESSES DETERMINED IS PRESENTED IN TABLE 1 ON THE FOLLOWING PAGE. IT HAS BEEN SHOWN THAT BASE ANGLES WITH THE SAME NUMBER OF BOLTS, AND SAME THICKNESS, EXHIBIT APPROXIMATELY THE SAME STIFFNESS REGARDLESS WHETHER THE ATTACHMENT IS ON THE FREE OR FIXED LEG.

AS EXPECTED, THE THINNER ANGLES, AND THE 1-BOLT ANGLES EXHIBIT LOWER STIFFNESSES THAN THE THICKER AND 2-BOLT CONFIGURATIONS RESPECTIVELY.

IT IS RECOMMENDED THAT THE AVERAGE VALUES OF ROTATIONAL STIFFNESS BE USED FOR PRODUCTION WORK BASED ON ANGLE THICKNESS AND NUMBER OF BOLTS AS FOLLOWS:

BASE L THICKNESS	2-BOLT	1-BOLT
0.375"	1200 $\frac{KP.IN}{RAD}$	1000 $\frac{KP.IN}{RAD}$
0.75"	3600 $\frac{KP.IN}{RAD}$	2600 $\frac{KP.IN}{RAD}$

FOR THE PULL-OUT STIFFNESS, IT IS RECOMMENDED THAT THE CONNECTION BE MODELED AS RIGID SINCE THE STIFFNESS VARIES BETWEEN A MODERATELY STIFF CONNECTION AND A RIGID CONNECTION DEPENDING ON DIRECTION OF LOAD.

REV	BY	DATE	CHECKED	DATE	IMPELL CORPORATION	JOB NO 0210-040	PAGE 1
1	[illegible]	5-14-86	[illegible]	5-16-86		CALC NO M-04	OF 3
0	[illegible]	12-6-85	[illegible]	12-9-85			

TABLE 1
STIFFNESS SUMMARY
(UNITS: K_{xx} (KIP-IN/RAD), K_z (KIP/IN))

	2-BOLT				1-BOLT				COMMENTS
	BOLTED LEG		FREE LEG		BOLTED LEG		FREE LEG		
	K_{xx}	K_z	K_{xx}	K_z	K_{xx}	K_z	K_{xx}	K_z	
L5x6x3/8	523-1480	86-∞	[illegible]-1836	52-∞	479-644	N/A	382-1599	40-∞	
L6x6x3/4	2287-3615*	214-∞	1575-6369	59-∞	1141-2523		986-5013	39-∞	
L6x4x3/4	2771-4545	409-∞	2627-4999	135-∞	2013-2175		1718-3145	90-∞	15
L5x5x3/4	991-2647	217-∞	796-5041	36-∞	471-2157		437-4436	21-∞	

* 2158 (1.06) = 2287
3090 (1.17) = 3615

NOTE: ABOVE VALUES ARE ENVELOPED FROM THE RESULTS SHOWN ON PAGES 2-21 OF THIS CALC. THE ENVELOPING FOR L5x5x3/4 IS DONE SUCH THAT, THE STIFFNESS VALUES FOR L5x5x3/4 FROM REV.0 OF THIS CALC. WERE INCREASED BY THE SAME FACTOR AS THE STIFFNESS FOR L6x6x3/8 INCREASED THEN ENVELOPED W/ THE VALUES SHOWN ON PAGE 16,17 AND 20 OF THIS CALC.

PAGE 2 OF 3
JOB NO 0210-040
CALC NO M1-04
IMPELL CORPORATION

REV	BY	DATE	CHECKED	DATE
1	[illegible]	3-10-86	[illegible]	3-11-86

REV 1 SUMMARY
OF RESULTS AND RECOMMENDATIONS

PRELIMINARY REVIEW OF THE CPSES CABLE TRAY SYSTEMS CURRENTLY BEING ANALYZED BY IMPELL SHOWS THAT THE ANCHORAGES ARE COVERED BY THE RANGE OF CONFIGURATIONS CONSIDERED IN THIS CALC. THAT IS, NO ANCHORAGES HAVE BEEN FOUND WHICH ARE MORE FLEXIBLE THAN ALREADY ANALYZED IN THIS CALC.

IN FUTURE CABLE TRAY SYSTEM ANALYSES, ANY ANCHORAGES IDENTIFIED AS BEING MORE FLEXIBLE THAN THOSE COVERED IN THIS CALC SHOULD BE BROUGHT TO THE ATTENTION OF THE LEAD ENGINEER AND ANALYZED ON A CASE BY CASE BASIS. ANCHORAGE STIFFNESS VALUES ARE SUMMARIZED IN THE TABLE SHOWN ON Pg 2 OF 3. RECOMMENDED VALUES FOR PRODUCTION ARE AS SHOWN ON P. 1 OF 3.

REV. 1 OF THIS CALC. ALSO INCORPORATED THE FOLLOWING CHANGES:

1.) BASE ANGLE DIMENSION CHANGES

2.) CONCRETE COMPRESSIVE STRENGTH VALUE TO 4000 PSI.

3.) BOLT STIFFNESS VALUE TO; K_T = 461,000 #/IN
K_V = 111,000 #/IN

REV	BY	DATE	CHECKED	DATE	IMPELL CORPORATION	JOB NO 0210-040	PAGE 3
1	[illegible]	3-9-86	[illegible]	3-10-86		CALC NO M-04	OF 3

4.0 REFERENCES:

A) BASEPLATE-II COMPUTER RUNS:

CALC. NO.	ANGLE	BOLTS	DATE/TIME I.D	CASES
M-04-CR01	L 6×6× 3/4	2	85/11/04. 18.20.50.	1-7
M-04-CR02	L 6×6× 3/4	2	85/11/12. 12.30.28.	8,9
M-04-CR03	L 6×6× 3/8	2	85/11/04. 18.56.44.	1-7 *
M-04-CR04	L 6×6× 3/8	2	85/11/12. 12.41.20.	8,9 *
M-04-CR05	L 6× 4× 3/4	2	85/11/04. 19.06.34.	1-7 *
M-04-CR06	L 6× 4× 3/4	2	85/11/12. 13.08.30.	8,9 *
M-04-CR07	L 5× 5× 3/4	2	85/11/11. 11.46.23.	1-7
M-04-CR08	L 5× 5× 3/4	2	85/11/12. 13.09.18.	8,9
M-04-CR09	L 6×6× 3/4	1	85/11/11. 12.40.56.	1,2.
M-04-CR10	L 6×6× 3/4	1	85/11/25. 14.59.25.	3-5
M-04-CR11	L 6×6× 3/8	1	85/11/11. 13.37.38.	1,2 *
M-04-CR12	L 6×6× 3/8	1	85/11/26. 18.28.39.	3-5 *
M-04-CR13	L 6× 4× 3/4	1	85/11/11. 13.42.43.	1,2 *
M-04-CR14	L 6× 4× 3/4	1	85/11/26. 18.29.36.	3-5 *
M-04-CR15	L 5× 5× 3/4	1	85/11/11. 13.41.02.	1,2
M-04-CR16	L 5× 5× 3/4	1	85/11/26. 18.35.54.	3-5

(SEE PAGE 2 OF 2 FOR ADDITIONAL REFERENCES)

1

B) COMPUTER PROGRAM: BASEPLATE-II VERSION 2.5

C) EDS BASEPLATE DESIGN PROCEDURE 2.6.1 REV 0

D) REF. DWGS. 2323-G-903 REV. 5
2323-G-906 REV. 1 & 909 REV. 1

1

E) CABLE TRAY SYSTEM PARAMETRIC SENSITIVITY STUDY CALC 0210-040-M11 REV 0.

F) ERASCO GENERAL INSTRUCTIONS FOR CABLE TRAY HANGER ANALYSIS FOR CPSES UNIT 1 & 2, ATTACHMENT G6 REV. 2

REV	BY	DATE	CHECKED	DATE
1	AD	3-10-86	KB	3-10-86
0	ELG	10-9-85	KB	12-9-85

IMPELL CORPORATION

JOB NO 0210-040

CALC NO M-04

PAGE 1 OF 2

4.0 REFERENCES (CONT'D)

A) BASEPLATE II COMPUTER RUNS

CALC. NO.	SKETCH	BOLTS	DATE / TIME	LOAD CASES
M-04-CR17	5×5×3/4	2-BOLTS	86/03/04. 19.10.59	1-9
M-04-CR18	6×6×3/4	2-BOLTS	86/03/05 19.30.09	1-9
M-04-CR19	5×5×3/4	1-BOLT	86/03/04 19.14.02	1-2
M-04-CR20	5×5×3/4	1-BOLT	86/03/04 19.16.17	3-5
M-04-CR21	6×6×3/4	1-BOLT	86/03/05 13.36.33	1-2
M-04-CR22	6×6×3/4	1-BOLT	86/03/05 13.24.12	3-5
23	6×4×3/4	1-BOLT	86/03/13 18.28.58	1-2
24	6×4×3/4	1-BOLT	86/03/13 18.37.33	3-5
25	6×4×3/4	2-BOLTS	86/03/13 17.56.20	1-9
26	6×6×3/4	2-BOLTS	86/03/13 17.41.59	1-9
29	6×6×3/8	1-BOLT	86/03/13 18.14.21	1-2
28	6×6×3/8	1-BOLT	86/03/13 18.17.52	3-5

* NOTE: SUPERSEDES BASEPLATE II RUNS

REV	BY	DATE	CHECKED	DATE		JOB NO 010-040	PAGE 2
1	AD	9-10-86	[illegible]	9-10-86	IMPELL CORPORATION	CALC NO M-04	OF 2

APPENDIX A

SUPERCEDED PAGES (REPLACED)

REV	BY	DATE	CHECKED	DATE		
1	[illegible]	3-10-86	[illegible]	3-11-86	IMPELL CORPORATION	JOB NO 0210-040
						CALC NO M-04
						PAGE 1 OF 2

SUPERSEDED

TABLE 1

STIFFNESS SUMMARY

(UNITS: K_{xx} (KP-IN/RAD), K_z (KIP/IN))

ANGLE SIZE	2-BOLT				1-BOLT				COMMENTS
	BOLTED LEG		FREE LEG		BOLTED LEG		FREE LEG		
	K_{xx}	K_z	K_{xx}	K_z	K_{xx}	K_z	K_{xx}	K_z	
L 6" x 6" x 3/8"	496-1261	80-∞	492-1426	41-∞	436-548	N/A	354-1204	31-∞	
L 6" x 6" x 3/4"	2158-3090	298-∞	2080-2941	86-∞	1431-1511		1293-1931	54-∞	
L 6" x 4" x 3/4"	2155-3090	298-∞	2063-2935	87-∞	1425-1503		1270-1911	54-∞	
L 5" x 5" x 3/4"	1647-2258	318-∞	1676-2170	92-∞	1062-1125		1018-1369	56-∞	

IMPELL CORPORATION

JOB NO 0210-1140

CALC NO M-04

PAGE 2 OF 2

REV	BY	DATE	CHECKED	DATE
0	ELC	12-9-85	[illegible]	12-9-85

L 6"x6"x 3/8" 2-BOLT MODEL

CASE #1 (K_{xx} - FREE LEG)

$\Delta Z_{21} = .005740$
$\Delta Z_{22} = .002693$
$\} .003047$

$\angle = \sin^{-1} \frac{.003047}{1.5} = .116387^\circ$ OR .002031 RAD

$K = \frac{1000}{.002031} = 492 \frac{KP\ IN}{RAD}$

CASE #2 (K_z - FREE LEG)

$\Delta Z_{21} = .024524$

$K = \frac{1000}{.024524} = 41 \frac{KIP}{IN}$

CASE #3 (K_{xx} - FREE LEG)

$\Delta Z_{41} = .003542$
$\Delta Z_{42} = .001426$
$\} .002116$

$\angle = \sin^{-1} \frac{.002116}{1.5} = .080825^\circ$ OR .001411 RAD

$K = \frac{1000}{.001411} = 709 \frac{KP-IN}{RAD}$

CASE #4 (K_z - FREE LEG)

$\Delta Z_{41} = .016492$

$K = \frac{1000}{.016492} = 61 \frac{KIP}{IN}$

CASE #5 (K_{xx} - BOLTED LEG)

$\Delta Z_{42} = .002332$
$\Delta Z_{44} = -.000047$
$\} .002379$

$\angle = \sin^{-1} \frac{.002379}{3.0} = .045436^\circ$ OR .000793 RAD

$K = \frac{1000}{.000793} = 1261 \frac{KP\ IN}{RAD}$

REV	BY	DATE	CHECKED	DATE		JOB NO	PAGE
0	MLC	12-4-85	VTS	12-4-85	IMPELL CORPORATION	0210-050	4
						CALC NO M-04	OF 23

L 6"x6"x 3/8" 2-BOLT MODEL (CONT)

CASE #6:

(K_{xx} - BOLTED LEG)

$\Delta Z_{44} = .007298$
$\Delta Z_{42} = .001248$ } .006050

$\angle = \sin^{-1} \frac{.006050}{3.0} = .115547°$ OR .002017 RAD

$K = \frac{1000}{.002017} = 496 \frac{KP.IN}{RAD}$

CASE #7:

(K_z - BOLTED LEG)

$\Delta Z_{43} = .012575$

$K = \frac{1000}{.012575} = 80 \frac{KIP}{IN}$

CASE #8:

(K_{xx} - FREE LEG)

$\Delta Z_{21} = -.000100$
$\Delta Z_{22} = .000952$ } .001052

$\angle = \sin^{-1} \frac{.001052}{1.5} = .040183°$ OR .000701 RAD

$K = \frac{1000}{.000701} = 1426 \frac{KIP}{IN}$

CASE #9:

(K_{xx} - FREE LEG)

$\Delta Z_{41} = -.000060$
$\Delta Z_{42} = .001848$ } .001908

$\angle = \sin^{-1} \frac{.001908}{1.5} = .072880°$ OR .001272 RAD

$K = \frac{1000}{.001272} = 786 \frac{KIP}{IN}$

REV	BY	DATE	CHECKED	DATE	IMPELL CORPORATION	JOB NO 0210-000	PAGE 5
0	BLC	12-4-85	[illegible]	12-4-85		CALC NO M-04	OF 23

L 6"x 4"x 3/4" 2-BOLT MODEL

CASE # 1

K_{XX} - FREE LEG

$\Delta Z_{21} = .002035$
$\Delta Z_{22} = .001308$ } $.000727$

$\angle = \sin^{-1} \frac{.000727}{1.5} = .027769°$ OR $.000485$ RAD

$K = \frac{1000}{.000485} = 2063 \frac{KP.IN}{RAD}$

CASE #2

K_Z - FREE LEG

$\Delta Z_{21} = .011499$

$K = \frac{1000}{.011499} = 87 \frac{KIP}{IN}$

CASE # 3

K_{XX} - FREE LEG

$\Delta Z_{41} = .001676$
$\Delta Z_{42} = .001078$ } $.000598$

$\angle = \sin^{-1} \frac{.000598}{1.5} = .022842°$ OR $.000399$ RAD

$K = \frac{.000399}{1000} = 2508 \frac{KP.IN}{RAD}$

CASE #4

K_Z - FREE LEG

$\Delta Z_{41} = .009358$

$K = \frac{1000}{.009358} = 107 \frac{KIP}{IN}$

CASE #5

K_{XX} - BOLTED LEG

$\Delta Z_{42} = .001169$
$\Delta Z_{44} = .000198$ } $.000971$

$\angle = \sin^{-1} \frac{.00097}{3.0} = .018545°$ OR $.000324$ RAD

$K = \frac{1000}{.000324} = 3090 \frac{KP.IN}{RAD}$

REV	BY	DATE	CHECKED	DATE		JOB NO	PAGE
0	ELC	8-1-85	[illegible]	8-4-85	IMPELL CORPORATION	0210-040	6
						CALC NO M-04	OF 23

L 6"x 4"x 3/4" 2-BOLT MODEL (CONT)

CASE # 6

K_{44} - BOLTED LEG

$\Delta Z_{42} = .000424$
$\Delta Z_{44} = .001815$ } .001391

$\angle = \sin^{-1} \frac{.001391}{3.0} = .026566°$ OR .000464 RAD

$K = \frac{1000}{.000464} = 2155 \frac{KP\ IN}{RAD}$

CASE # 7

K_2 - BOLTED LEG

$\Delta Z_{43} = .003358$

$K = \frac{1000}{.003358} = 298 \frac{KIP}{IN}$

CASE # 8

K_{44} - FREE LEG

$\Delta Z_{21} = -.000075$
$\Delta Z_{22} = .000436$ } .000511

$\angle = \sin^{-1} \frac{.000511}{1.5} = .019519°$ OR .000341 RAD

$K = \frac{1000}{.000341} = 2935 \frac{KP.IN}{RAD}$

CASE # 9

K_{44} - FREE LEG

$\Delta Z_{41} = -.000060$
$\Delta Z_{42} = .000511$ } .000571

$\angle = \sin^{-1} \frac{.000571}{1.5} = .021811°$ OR .000381 RAD

$K = \frac{1000}{.000381} = 2627 \frac{KP.IN}{RAD}$

REV	BY	DATE	CHECKED	DATE		JOB NO 0210-040	PAGE 7
0	RHS	11-4-85	VMB	11-4-85	IMPELL CORPORATION	CALC NO M-04	OF 23

L 5"x5"x 3/4" 2-BOLT MODEL

CASE # 1

$\Delta Z_{21} = .002256$
$\Delta Z_{22} = .001510$ } $.000746$

$\angle = \sin^{-1} \frac{.000746}{1.25} = .034194°$ OR $.000597$ RAD

$K = \frac{1000}{.000597} = 1676 \frac{KP \cdot IN}{RAD}$

CASE # 2

$\Delta Z_{21} = .010816$

$K = \frac{1000}{.010816} = 92 \frac{KIP}{IN}$

CASE #3

$\Delta Z_{41} = .001896$
$\Delta Z_{42} = .001276$ } $.000620$

$\angle = \sin^{-1} \frac{.000620}{1.25} = .028419°$ OR $.000496$ RAD

$K = \frac{1000}{.000496} = 2016 \frac{KP \cdot IN}{RAD}$

CASE #4

$\Delta Z_{41} = .009073$

$K = \frac{1000}{.009073} = 110 \frac{KIP}{IN}$

CASE #5

$\Delta Z_{42} = .001353$
$\Delta Z_{44} = .000246$ } $.001107$

$\angle = \sin^{-1} \frac{.001107}{2.50} = .025371°$ OR $.000443$ RAD

$K = \frac{1000}{.000443} = 2258 \frac{KP \cdot IN}{RAD}$

L 5"x5"x 3/4" 2-BOLT MODEL (CONT)

CASE #6

$\Delta Z_{42} = .000501$
$\Delta Z_{44} = .002019$ } .001518

$\angle = \sin^{-1} \frac{.001518}{2.50} = .034790°$ OR .000607 RAD

$K = \frac{1000}{.000607} = 1647 \frac{KP.IN}{RAD}$

CASE #7

$\Delta Z_{43} = .003141$

$K = \frac{1000}{.003141} = 318 \frac{KIP}{IN}$

CASE #8

$\Delta Z_{21} = -.000093$
$\Delta Z_{22} = .000483$ } .000576

$\angle = \sin^{-1} \frac{.000576}{1.25} = .026402°$ OR .000461 RAD

$K = \frac{1000}{.000461} = 2170 \frac{KP.IN}{RAD}$

CASE #9

$\Delta Z_{41} = -.000074$
$\Delta Z_{42} = .000560$ } .000634

$\angle = \sin^{-1} \frac{.000634}{1.25} = .029060°$ OR .000507 RAD

$K = \frac{1000}{.000507} = 1972 \frac{KP.IN}{RAD}$

REV	BY	DATE	CHECKED	DATE		JOB NO 0210-040	PAGE 9
0	DAL	12-4-85	[signature]	12-4-85	IMPELL CORPORATION	CALC NO M-04	OF 23

L6" x 6" x 3/4 (1-BOLT MODEL)

CASE I: (-)Mx @ NODE 55

$\Delta z(21) = 0.003465$
$\Delta z(22) = 0.002305$ } $\Delta = 0.001160$

$L = \sin^{-1}\frac{0.001160}{1.5} = 0.04431°$ OR 0.000773 RAD

$K = \frac{1000}{0.000773} = 1293$ KP·IN/RAD.

CASE 2: (+) Fz @ NODE 55

$\Delta z(21) = 0.018396$

$K = \frac{1000}{0.018396} = 54$ KP/IN

CASE 3: (+) Mx @ NODE 13

$\Delta z(12) = 0.000743$
$\Delta z(14) = 0.002839$ } $\Delta = 0.002096$

$L = \sin^{-1}\frac{0.002096}{3} = 0.040031$ OR 0.000699 RAD

$K = \frac{1000}{0.000699} = 1431$ KIP·IN/RAD.

CASE 4: (-) Mx @ NODE 13

$\Delta z(12) = 0.002697$
$\Delta z(14) = 0.000712$ } $\Delta = 0.001985$

$L = \sin^{-1}\frac{0.001985}{3} = 0.037911°$ OR 0.000662 RAD

$K = \frac{1000}{0.000662} = 1511$ KIP·IN/RAD.

CASE 5: (+)Mx @ NODE 55

$\Delta z(21) = -0.000088$

$\Delta z(22) = 0.0.000689$

$\} \Delta = 0.000777$

$L = \sin^{-1}\frac{0.000777}{1.5} = 0.029679°$ OR 0.000518 RAD

$K = \frac{1000}{0.000518} = 1931$ KIP-IN/RAD.

L6" x 6" x 3/8" (1-BOLT MODEL)

CASE 1: (-) Mx @ NODE 55

$\Delta z(21) = 0.008276$

$\Delta z(22) = 0.004037$

$\} \Delta = 0.004239"$

$L = \sin^{-1}\frac{0.004239}{1.5} = 0.161918°$ OR 0.002826 RAD.

$K = \frac{1000}{0.002826} = 354$ KIP-IN/RAD.

CASE 2: (+) Fz @ NODE 55

$\Delta z(21) = 0.032456$

$K = \frac{1000}{0.032456} = 31$ KIP/IN.

CASE 3: (+) Mx @ NODE 13

$\Delta z(12) = 0.001552$

$\Delta z(14) = 0.008433$

$\} \Delta = 0.006881$

$L = \sin^{-1}\frac{0.006881}{3} = 0.131418°$ OR 0.002294 RAD

$K = \frac{1000}{0.002294} = 436$ KIP-IN/RAD

REV	BY	DATE	CHECKED	DATE
1	[illegible]	3-16-86	[illegible]	3-18-86
0	RB	11-26-85	ELL	12-6-85

IMPELL CORPORATION

JOB NO 0210-040

CALC NO M-04

CASE 4 : (−) M_x @ NODE 13

$\Delta z(12) = 0.006695$
$\Delta z(14) = 0.001220$
$\Delta = 0.005475$

$L = \sin^{-1} \frac{0.005475}{3} = 0.104565$ OR 0.001825 RAD

$K = \frac{1000}{0.001825} = 548$ KIP-IN/RAD

CASE 5 : (+) M_x @ NODE 55

$\Delta z(21) = -0.000100$
$\Delta z(22) = 0.001146$
$\Delta = 0.001246"$

$L = \sin^{-1} \frac{0.001246}{1.5} = 0.047594°$ OR 0.0008308

$K = \frac{1000}{0.0008308} = 1204$ KIP-IN/RAD.

L6" x 4 x 5/16" (1-BOLT MODEL)

CASE 1 : (−) M_x @ NODE 55

$\Delta z(21) = 0.003489$
$\Delta z(22) = 0.002308$
$\Delta = 0.001181"$

$L = \sin^{-1} \frac{0.001181}{1.5} = 0.045111°$ OR 0.000787 RAD.

$K = \frac{1000}{0.000787} = 1270$ KIP-IN/RAD

CASE 2 : (+) F_z @ NODE 55

$\Delta z(21) = 0.018418"$

$K = \frac{1000}{0.018418} = 54$ KIP/IN.

REV	BY	DATE	CHECKED	DATE		JOB NO 0210-040	PAGE 12
0	VRR	11-27-95	ELC	12-6-95	IMPELL CORPORATION	CALC NO M-04	OF 23

CASE 3 : (+) M_x @ NODE 13

$\Delta z(12) = 0.000749$
$\Delta z(14) = 0.002854$
} $\Delta = 0.002105$

$L = \sin^{-1} \frac{0.002105}{3} = 0.040203$ OR 0.000702 RAD

$K = \frac{1000}{0.000702} = 1425$ KIP-IN/RAD.

CASE 4 : (-) M_x @ NODE 13

$\Delta z(12) = 0.002712$
$\Delta z(14) = 0.000716$
} $\Delta = 0.001996$

$L = \sin^{-1} \frac{0.001996}{3} = 0.038121°$ OR 0.000665 RAD

$K = \frac{1000}{0.000665} = 1503$ KIP-IN/RAD.

CASE 5 : (+) M_x @ NODE 55

$\Delta z(21) = -0.000090$
$\Delta z(22) = 0.000695$
} $\Delta = 0.000785$"

$L = \sin^{-1} \frac{0.000785}{1.5} = 0.029985°$ OR 0.000523 RAD

$K = \frac{1000}{0.000523} = 1911$ KIP-IN/RAD

REV	BY	DATE	CHECKED	DATE		JOB NO	PAGE
0	VRB	11-27-85	ELL	12-6-85	IMPELL CORPORATION	0210-040	13
						CALC NO M-04	OF 23

$\angle$ 6x6x 3/40 (1 BOLT)

CASE 1:

$\Delta z_{21} = .007065$
$\Delta z_{22} = .003138$ $\Big\rangle$ .003927

$\angle = \sin^{-1} \frac{.003927}{1.5} = .15$ - OR .002618 RAD

$k = 1000/.002618 \approx$ 382 K-IN/RAD

CASE 2:

$\Delta z_{21} = .025104$

$k = 1000/.025104 =$ 40 K/IN

CASE 3:

$\Delta z_{12} = .00125$
$\Delta z_{14} = .007516$ $\Big\rangle$ .006266

$\angle = \sin^{-1} \frac{.006266}{3} = .1196787°$ OR .0020887 RAD

$k = 1000/.0020887 =$ 479 K-IN/RAD

CASE 4:

$\Delta z_{12} = .005407$
$\Delta z_{14} = .000747$ $\Big\rangle$ .00466

$\angle = \sin^{-1} \frac{.00466}{3} = .0889944°$ OR .0015533 RAD

$k = 1000/.0015533 =$ 644 K-IN/RAD

CASE 5:

$\Delta z_{21} = -.000095$
$\Delta z_{22} = .000843$ $\Big\rangle$ .000938

$\angle = \sin^{-1} \frac{.000938}{1.5} = .0358896°$ OR .0006267 RAD

$k = 1000/.0006267 =$ 1594 K-IN/RAD

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1	AD	3-14-86	JCB	3-18-86		CALC NO M-04	

L6x4x3/4 (1 BOLT MODEL)

CASE 1: $\Delta z_{21} = .002262$, $\Delta z_{22} = .001389$ $\Big\rangle$ $\Delta = .000873$

$\angle = \sin^{-1} \frac{.000873}{1.5} = .03334615°$ OR $.000582$ RAD

$k = 1000 / .000582 = \underline{1718}$ K-IN/RAD

CASE 2: $\Delta z_{21} = .011073$

$k = 1000 / .011073 = \underline{90}$ K/IN

CASE 3: $\Delta z_{12} = .000446$, $\Delta z_{14} = .001936$ $\Big\rangle$ $.00149$

$\angle = \sin^{-1} \frac{.00149}{3} = .02845691°$ OR $.00049667$ RAD

$k = 1000 / .00049667 = \underline{2013}$ K-IN/RAD

CASE 4: $\Delta z_{12} = .001793$, $\Delta z_{14} = .000414$ $\Big\rangle$ $.001379$

$\angle = \sin^{-1} \frac{.001379}{3} = .02633296°$ OR $.00045967$ RAD

$k = 1000 / .00045967 = \underline{2175}$ K-IN/RAD

CASE 5: $\Delta z_{21} = -.000085$, $\Delta z_{22} = .000392$ $\Big\rangle$ $.000477$

$\angle = \sin^{-1} \frac{.000477}{1.5} = .01822006°$ OR $.00031813$ RAD

$k = 1000 / .000318 = \underline{3145}$ K-IN/RAD

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1	JM	3-17-86	[illegible]	3-18-86	IMPELL CORPORATION	CALC NO M-04	

L 5" x 5" x 3/4" (1-BOLT MODEL)

CASE 1: (-) M_x @ NODE 55

$\Delta z(21) = 0.003908$
$\Delta z(22) = 0.002680$
$\Delta = 0.001228$

$L = \sin^{-1} \frac{0.001228}{1.25} = 0.056287°$ OR 0.000982 RAD

$K = \frac{1000}{0.000982} = 1018$ KIP-IN/RAD.

CASE 2: (+) F_z @ NODE 55

$\Delta z(21) = 0.017808"$

$K = \frac{1000}{0.017808} = 56$ KIP-IN/RAD

CASE 3: (+) M_x @ NODE 13

$\Delta z(12) = 0.000889$
$\Delta z(14) = 0.003242$
$\Delta = 0.002353"$

$L = \sin^{-1} \frac{0.002353}{2.5} = 0.053927$ OR 0.000941 RAD.

$K = \frac{1000}{0.000941} = 1062$ KIP-IN/RAD.

CASE 4: (-) M_x @ NODE 13

$\Delta z(12) = 0.003051$
$\Delta z(14) = 0.000829$
$\Delta = 0.002222$

$L = \sin^{-1} \frac{0.002222}{2.5} = 0.050924$ OR 0.000889 RAD.

$K = \frac{1000}{0.000889} = 1125$ KIP-IN/RAD.

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0	VRB	11-27-85	ELC	12-6-85	IMPELL CORPORATION	CALC NO M-04	

CASE 5 : (H) M_X @ NODE 55

$\Delta_Z(21) = -0.000115$

$\Delta_Z(22) = 0.000798$

$\Delta = 0.000913''$

$L = \sin^{-1} \frac{0.000913}{1.25} = 0.041849^\circ$ OR 0.000730 RAD

$K = \frac{1000}{0.000730} = 1369$ KIP-IN/RAD.

REV	BY	DATE	CHECKED	DATE		JOB NO 0210-040	PAGE 15
0	VJB	11-27-85	ELC	12-6-85	IMPELL CORPORATION	CALC NO H-04	OF 23

L5x5x3/4: 2BOLT MODEL (CONFIG. CASE B&D)

LOAD CASE #1: $\Delta z_{11} - \Delta z_{12} = .005798 - .003277 = .002521$

$\theta = \sin^{-1} \frac{.002521}{3.75/2} = .077036°$ OR $.001345$

$K = 1000/.001345 = \underline{744 \frac{\text{KIP-IN}}{\text{RAD}}}$

LOAD CASE #2: $\Delta z_{21} = .027555$

$K = 1000/.027555 = \underline{36.\ \text{K/IN}}$

LOAD CASE #3: $\Delta z_{51} - \Delta z_{52} = .005148 - .003017 = .002131$

$\theta = \sin^{-1} \frac{.002131}{3.75/2} = .065°$ OR $.0011365$ RAD.

$K = 1000/.0011365 = \underline{880\ \text{KIP/IN}}$

LOAD CASE #4: $\Delta z_{51} = .024988$

$K = 1000/.024988 = \underline{40\ \text{K/IN}}$

LOAD CASE #5: $\Delta z_{52} - \Delta z_{54} = .003088 - .000281 = .002807$

$\theta = \sin^{-1} \frac{.002807}{2.5} = .064°$ OR $.001123$ RAD.

$K = 1000/.001123 = \underline{891 \frac{\text{KIP-IN}}{\text{RAD}}}$

LOAD CASE #6: $\Delta z_{54} - \Delta z_{52} = .001695 - .000487 = .001208$

$\theta = \sin^{-1} \frac{.001208}{2.5} = .028°$ OR $.0004832$ RAD

$K = 1000/.0004832 = \underline{2070\ \text{K-IN/RAD}}$

LOAD CASE #7: $\Delta z_{53} = .004606$

$K = 1000/.004606 = \underline{217\ \text{K/IN}}$

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1	[illegible]	3-5-86	[illegible]	3-10-86

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L 5×5×3/4 : 2 BOLT MODEL (CONT'D)

LOAD CASE #8 : $\Delta z_{21} = -.00005$, $\Delta z_{22} = .000271$ $\Big\rangle = .000321$

$\theta = \sin^{-1} \frac{.000321}{3.75/2} = .0098°$ OR $.00017$ RAD

$K = 1000/.00017 = 5,841$ K-IN/RAD

LOAD CASE #9 : $\Delta z_{51} = -.000031$, $\Delta z_{52} = .000495$ $\Big\rangle = .000526$

$\theta = \sin^{-1} \frac{.000526}{3.75/2} = .016°$ OR $.00028053$ RAD

$K = 1000/.00028053 = 3565$ K-IN/RAD

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1	[illegible]	3-5-86	[illegible]	3-10-86	IMPELL CORPORATION	CALC NO M-04	OF 23

L 6×6×3/4 : 2 BOLT MODEL. (CONFIG CASE F & H)

LOAD CASE #1 : $\Delta z_{21} = .002978$, $\Delta z_{22} = .001708$ $\Big\rangle = .00127$

$\theta = \sin^{-1} .00127/2 = .036°$ OR $.00064$ RAD

$K = 1000/.00064 = 1575$ K-IN/RAD

LOAD CASE #2 : $\Delta z_{21} = .016846$

$K = 1000/.016846 = 59$ K/IN

LOAD CASE #3 : $\Delta z_{51} = .002943$, $\Delta z_{52} = .001411$ $\Big\rangle .000932$

$\theta = \sin^{-1} .000932/2 = .027°$ OR $.00047$ RAD

$K = 1000/.00047 = 2146$ K-IN/RAD

LOAD CASE #4 : $\Delta z_{51} = .01352$

$K = 1000/.01352 = 74$ K/IN

LOAD CASE #5 : $\Delta z_{52} = .001502$, $\Delta z_{54} = .000243$ $\Big\rangle = .001259$

$\theta = \sin^{-1} .001259/3 = .024°$ OR $.00042$ RAD

$K = 1000/.00042 = 2383$ K-IN/RAD

LOAD CASE #6 : $\Delta z_{52} = .000496$, $\Delta z_{54} = .00169$ $\Big\rangle .001194$

$\theta = \sin^{-1} \dfrac{.001194}{3} = .0228°$ OR $.000398$ RAD

$K = 1000/.000398 = 2513$ K-IN/RAD

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1	BM	3-5-86	VJC	3-10-86	IMPELL CORPORATION	CALC NO M-04	

L 6×6×3/4 : 2 BOLT MODEL (CONT'D)

LOAD CASE 7 : $\Delta z_{51} = .004684$

$k = 1000/.004684 = \underline{214\ K/IN}$

LOAD CASE 8 : $\Delta z_{21} = -.000048$, $\Delta z_{22} = .000266$ $\Big\rangle$ $.000314$

$\theta = \sin^{-1} \frac{.000314}{2} = .0089°$ OR $.000159$ RAD

$k = 1000/.000157 = \underline{6369\ K\text{-}IN/RAD}$

LOAD CASE 9 : $\Delta z_{51} = -.000021$, $\Delta z_{52} = .000477$ $\Big\rangle$ $.000498$

$\theta = \sin^{-1} \frac{.000498}{2} = .0143°$ OR $.000249$ RAD

$k = 1000/.000249 = \underline{4016\ K\text{-}IN/RAD}$

REV	BY	DATE	CHECKED	DATE		JOB NO 0210-040	PAGE 19
1	DD	7-5-86	VJC	3-10-86	IMPELL CORPORATION	CALC NO M-04	OF 23

L 5×5×3/4 : 1 BOLT MODEL (CONFIG CASE 3)

LOAD CASE 1 : $\Delta z_{21} = .010065$, $\Delta z_{22} = .005778$ $\rangle$ .004287

$\theta = \sin^{-1} \frac{.004287}{3.75/2} = .131°$ or .00229 RAD

$k = 1000/.00229 =$ 437 K-IN/RAD

LOAD CASE 2 : $\Delta z_{21} = .046733$

$k = 1000/.046733 =$ 21 K/IN

LOAD CASE 3 : $\Delta z_{12} = .000461$, $\Delta z_{14} = .00162$ $\rangle$ .001159

$\theta = \sin^{-1} \frac{.001159}{2.5} = .0266°$ or .0004636 RAD

$k = 1000/.0004636 =$ 2157 K-IN/RAD

LOAD CASE 4 :

$\Delta z_{12} = .006152$, $\Delta z_{14} = .000848$ $\rangle$ .005304

$\theta = \sin^{-1} \frac{.005304}{2.5} = .1216°$ or .002 RAD

$k = 1000/.002 =$ 471 K-IN/RAD

LOAD CASE 5 : $\Delta z_{21} = -.000053$, $\Delta z_{22} = .000365$ $\rangle$ .000418

$\theta = \sin^{-1} \frac{.000418}{3.75/2} = .0128°$ or .0002 RAD

$k = 1000/.0002 =$ 4486 K-IN/RAD

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1	[illegible]	2-5-86	[illegible]	3-10-86	IMPELL CORPORATION	CALC NO M-04	OF 23

L6×6×3/4 : 1 BOLT MODEL (CONFIG. CASE 'L')

LOAD CASE 1:

$\Delta_{221} = .004849$
$\Delta_{222} = .002820$ $\Big\rangle$ .002029

$\theta = \sin^{-1} \frac{.002029}{2} = .058°$ OR .001 RAD

$K = 1000/.001 = 986$ K-IN/RAD

LOAD CASE 2:

$\Delta_{221} = .025833$

$K = 1000/.025833 = 39$ K/IN

LOAD CASE 3:

$\Delta_{212} = .000382$
$\Delta_{214} = .001571$ $\Big\rangle = .001189$

$\theta = \sin^{-1} \frac{.001189}{3} = .023°$ OR .0004 RAD

$K = 1000/.0004 = 2523$ K-IN/RAD

LOAD CASE 4:

$\Delta_{211} = .003217$
$\Delta_{214} = .000587$ $\Big\rangle$ .00263

$\theta = \sin^{-1} \frac{.00263}{3} = .05°$ OR .00088 RAD

$K = 1000/.00088 = 1141$ K-IN/RAD

LOAD CASE 5:

$\Delta_{221} = -.000049$
$\Delta_{222} = .00035$ $\Big\rangle$ .000399

$\theta = \sin^{-1} \frac{.000399}{2} = .011°$ OR .0002 RAD

$K = 1000/.0002 = 5013$ K-IN/RAD

REV	BY	DATE	CHECKED	DATE		JOB NO 0210-040	PAGE 21
1	[illegible]	7-5-86	[illegible]	8-10-86	IMPELL CORPORATION	CALC NO H-04	OF 23

BASE ANGLE STIFFNESS TABLE (2-BOLT BASE ANGLE)

BASE ANGLE CONFIGURATION CASE	ANGLE SIZE	LOADING CASE	STIFFNESS (K)	COMMENTS / REF.
B	L5×5×3/4	3	$K_z = 880 \frac{K\text{-}IN}{RAD}$	BASEPLATE II OUTPUT 86/03/04 19.10.59
		4	$K_z = 40 \ K/IN$	
		5	$K_{xx} = 891 \frac{K\text{-}IN}{RAD}$	
		6	$K_{xx} = 2070 \frac{K\text{-}IN}{RAD}$	
D		1	$K_{xx} = 744 \frac{K\text{-}IN}{RAD}$	
D		2	$K_z = 36 \ K/IN$	
B		7	$K_z = 217 \ K/IN$	
D		8	$K_{xx} = 5841 \frac{K\text{-}IN}{RAD}$	
B		9	$K_{xx} = 3565 \frac{K\text{-}IN}{RAD}$	
F	L6×6×3/4	3	$K_{xx} = 7146 \frac{K\text{-}IN}{RAD}$	BASEPLATE II OUTPUT 86/02/05 19.30.09
		4	$K_z = 74 \ K/IN$	
		5	$K_{xx} = 2383 \frac{K\text{-}IN}{RAD}$	
		6	$K_{xx} = 2513 \frac{K\text{-}IN}{RAD}$	
		7	$K_z = 214 \ K/IN$	
		9	$K_{xx} = 4016 \frac{K\text{-}IN}{RAD}$	
H		1	$K_{xx} = 1575 \frac{K\text{-}IN}{RAD}$	
		2	$K_z = 59 \ K/IN$	
		8	$K_{xx} = 6369 \frac{K\text{-}IN}{RAD}$	

REV	BY	DATE	CHECKED	DATE
1	AP	3-5-86	[illegible]	3-10-86

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BASE ANGLE STIFFNESS TABLE (1-BOLT BASE ANGLE)

BASE ANGLE CONFIGURATION CASE	ANGLE SIZE	LOADING CASE	STIFFNESS (K)	COMMENTS/REF.
J	L5x5x 3/4	1	K_{xx} = 437 K-IN/RAD	BASEPLATE II OUTPUT 86/03/04 19.14.02
		2	K_z = 21 K/IN	"
		3	K_{xx} = 2157 K-IN/RAD	BASEPLATE II OUTPUT 86/03/04 19.16.17
		4	K_{xx} = 471 K-IN/RAD	↓
		5	K_{xx} = 4486 K-IN/RAD	
L	L6x6x 3/4	1	K_{xx} = 986 K-IN/RAD	BASEPLATE II OUTPUT 86/03/05 13.36.33
		2	K_z = 39 K/IN	"
		3	K_{xx} = 2503 K-IN/RAD	BASEPLATE II OUTPUT 86/03/07 13.24.12
		4	K_{xx} = 1141 K-IN/RAD	↓
		5	K_{xx} = 5013 K-IN/RAD	

REV	BY	DATE	CHECKED	DATE
1	[signature]	3-5-86	[signature]	3-10-86

IMPELL CORPORATION

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CALC NO M-04

IMPELL

Calc. No.
M-10

CABLE TRAY HANGER STIFFNESS

(1 of 2)

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