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ARAPAHO RD.

STEP-BY-STEP CONSTRUCTION ANALYSIS

WITH DEFLECTIONS AND CABLE FORCES

STATE OF TEXAS
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LICENSED
PROFESSIONAL ENGINEER

8/15/05

PREPARED FOR:
ARCHER WESTERN CONTRACTORS

August 15, 2005

REVIEWED	
APPROVED (X)	REVISE AND RESUBMIT ( )
APPROVED AS CORRECTED ( )	NOT APPROVED ( )

Review is only for conformance with the design concept of the Project and compliance with the information given in the Contract Documents. Approval does not authorize any deviation from the Contract Documents and any change from the Contract Documents must be processed by Change Order. Contractor is responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to the fabrication processes or to techniques of construction, and for coordination of the work of all trades.

URS

DATE 8/24/05 BY PBeaupre

ARAPAHO RD.

STEP-BY-STEP CONSTRUCTION ANALYSIS
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August 15, 2005

TABLE OF CONTENTS

SUMMARY

The enclosed calculations are for the step-by-step longitudinal construction analysis of the Arapaho Road steel arch bridge. BRUCO, a two-dimensional finite element analysis program that considers time dependent losses, was used for the step-by-step analysis. Stardyne, a three-dimensional finite element analysis program, was used to verify the load distribution to the north and south arches and the BRUCO deck deflections. A step-by-step check of the stresses in the superstructure will follow in a separate submittal.

The step-by-step construction analysis follows the construction sequence shown in the contract plans, with the exception of the steel arch being erected prior to erecting the precast u-beams. This change in the construction sequence was chosen by the contractor and does not effect the stresses in structure in any way. The hangers were stressed to the forces shown in table 1 of the contract plans.

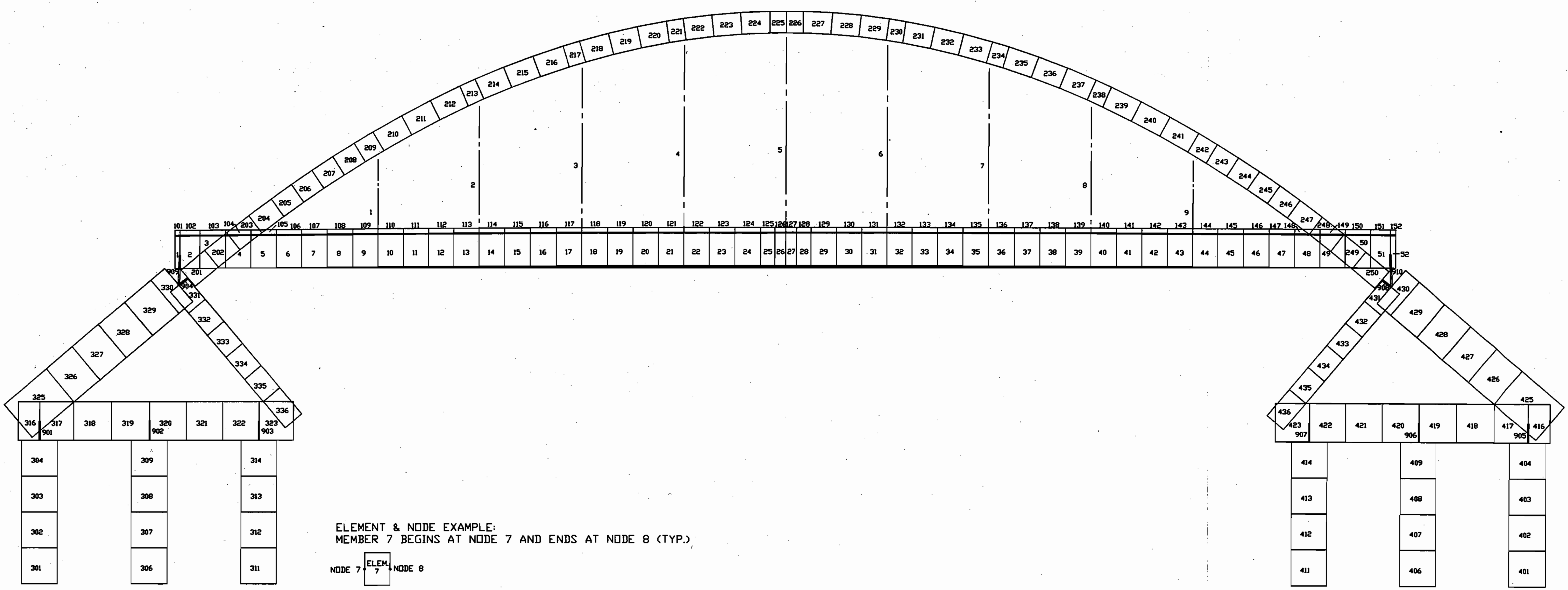
The BRUCO step-by-step cable force table shows the comparison between plan cable forces and BRUCO cable forces at bridge opening. The results show that the majority of the cable forces are within a reasonable tolerance to contract plans, with the exception of cables 2 and 8, which are vary from contract plans by approximately 15%. However, the maximum final cable force (north cable 9) is within 1% of plan and therefore, none of the cable are overstressed.

The comparison of BRUCO and Stardyne cable forces and support reactions verifies the assumed distribution of loads in the two-dimensional BRUCO analysis. The Stardyne deflections at bridge completion are approximately ½" upwards on the north edge of deck and 3/8" upwards on the south edge of deck. These deflections are similar to BRUCO, however, the BRUCO deflections also consider the creep of the prestressed concrete u-beams.

BRUCO MODEL LAYOUT

BRUCO MODEL LAYOUT

NORTH AND SOUTH LAYOUTS IDENTICAL



ELEMENT & NODE EXAMPLE:
MEMBER 7 BEGINS AT NODE 7 AND ENDS AT NODE 8 (TYP.)

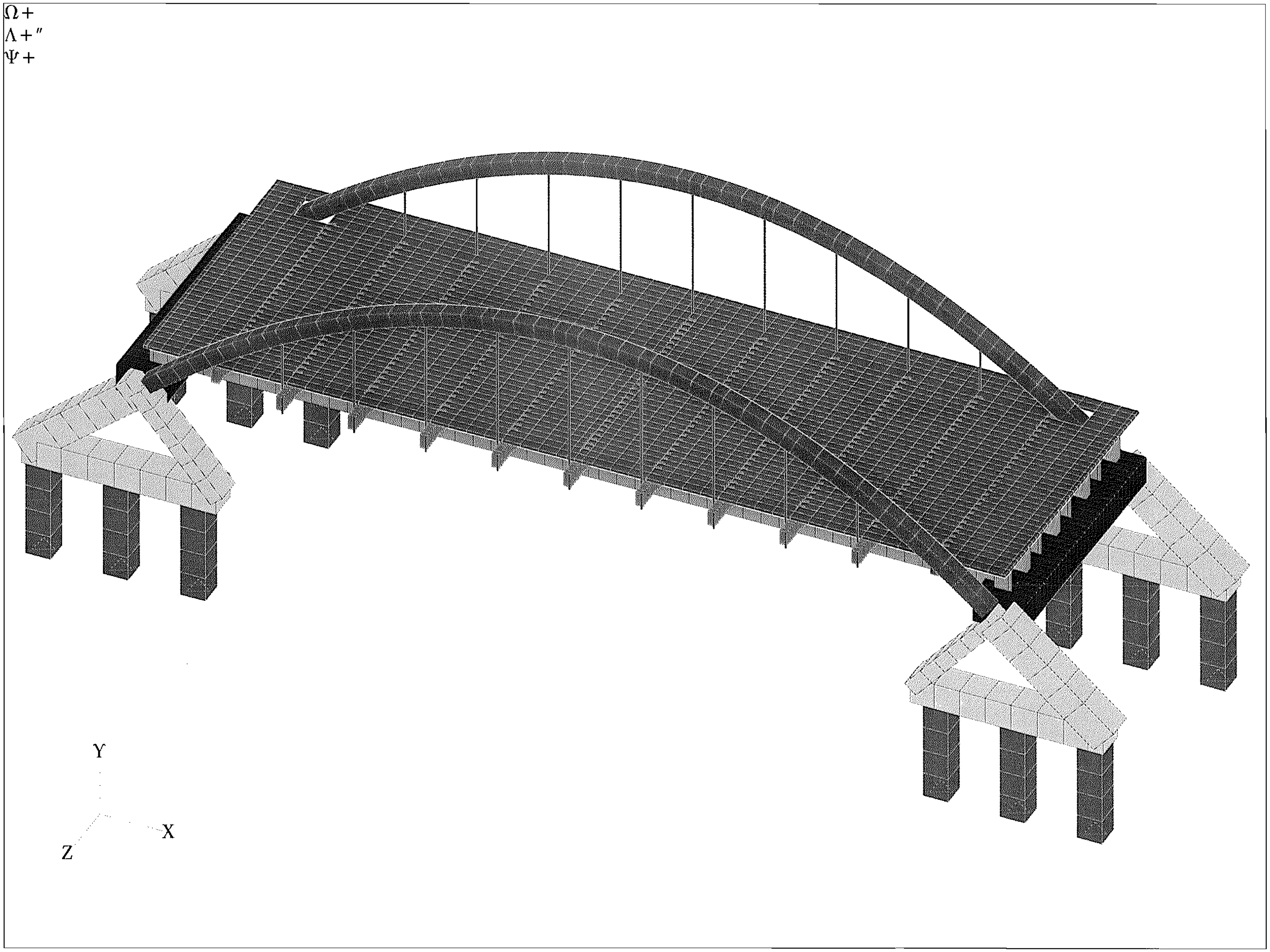
NODE 7 ELEM. 7 NODE 8

3

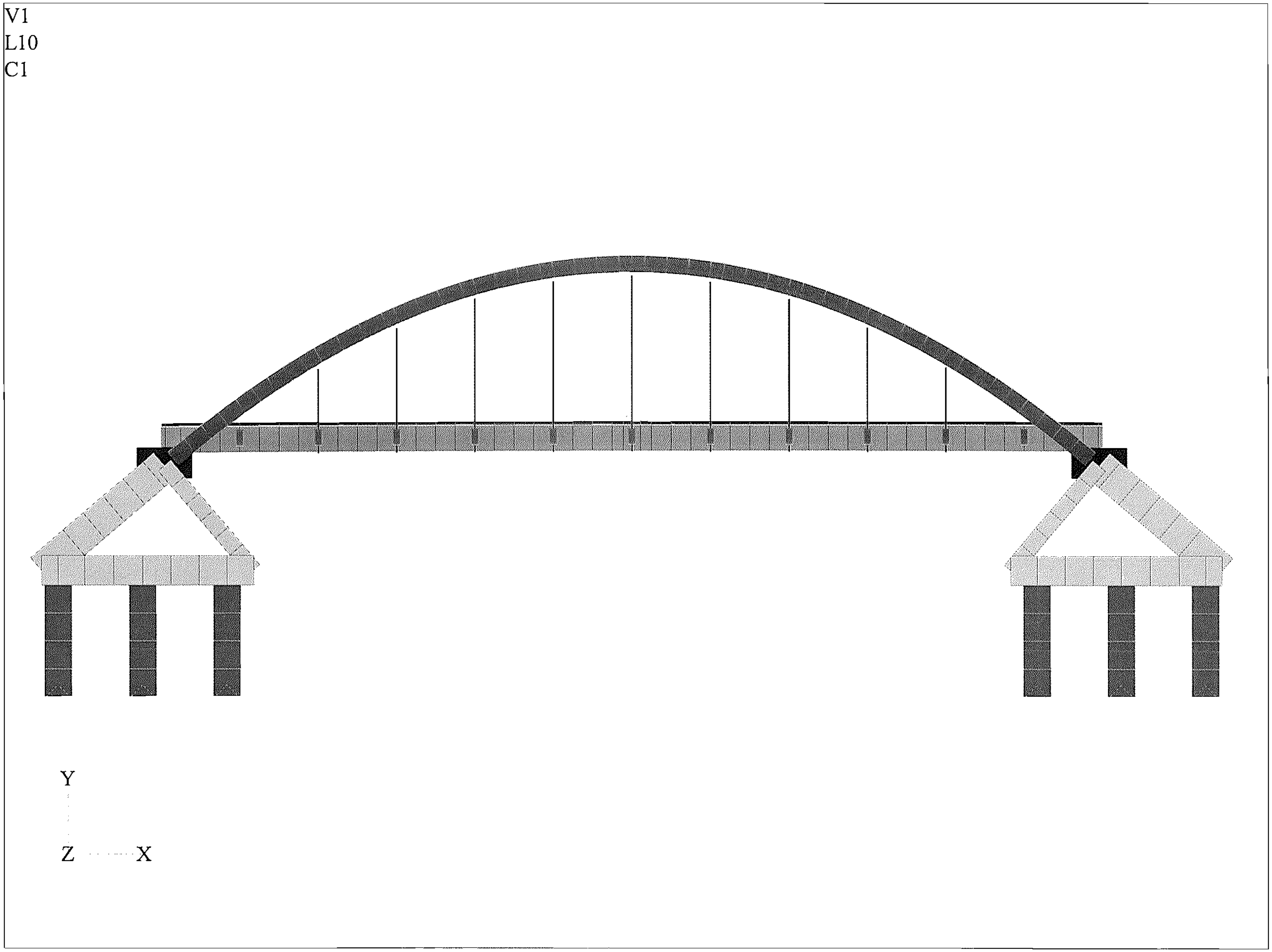
STARDYNE MODEL LAYOUT

H

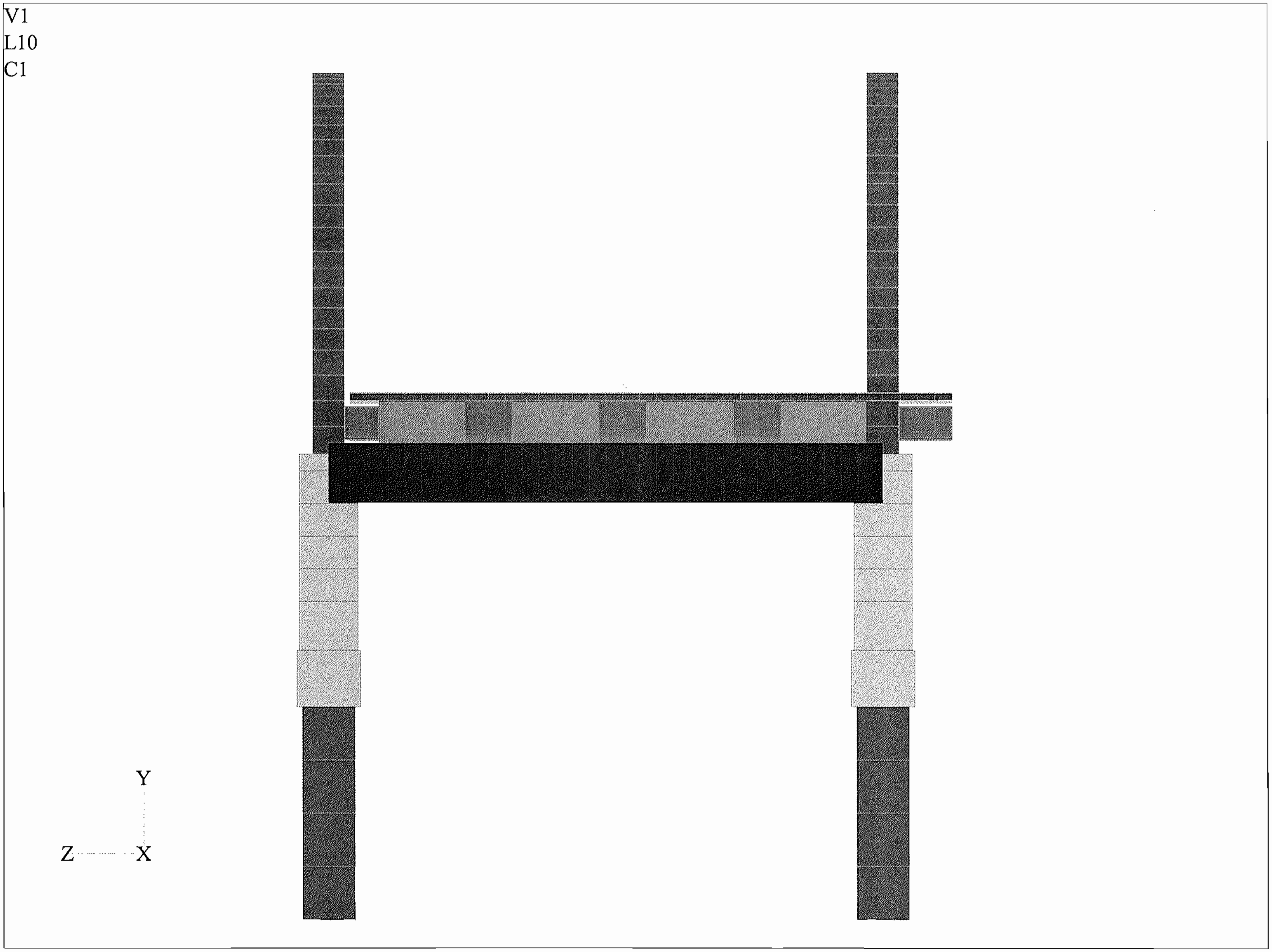
Stardyne Model: Isometric View



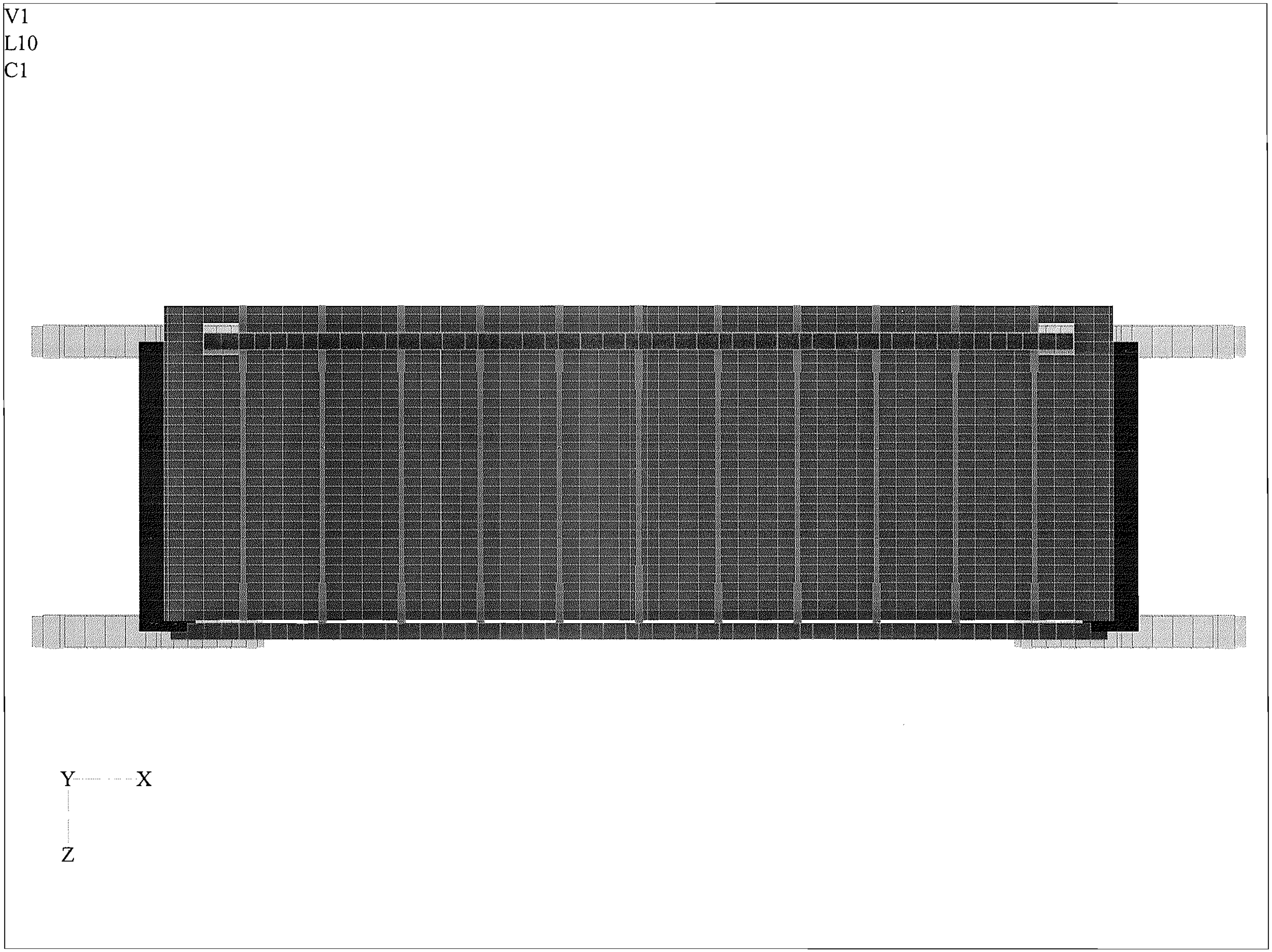
Stardyne Model: Elevation View



Stardyne Model: Elevation View

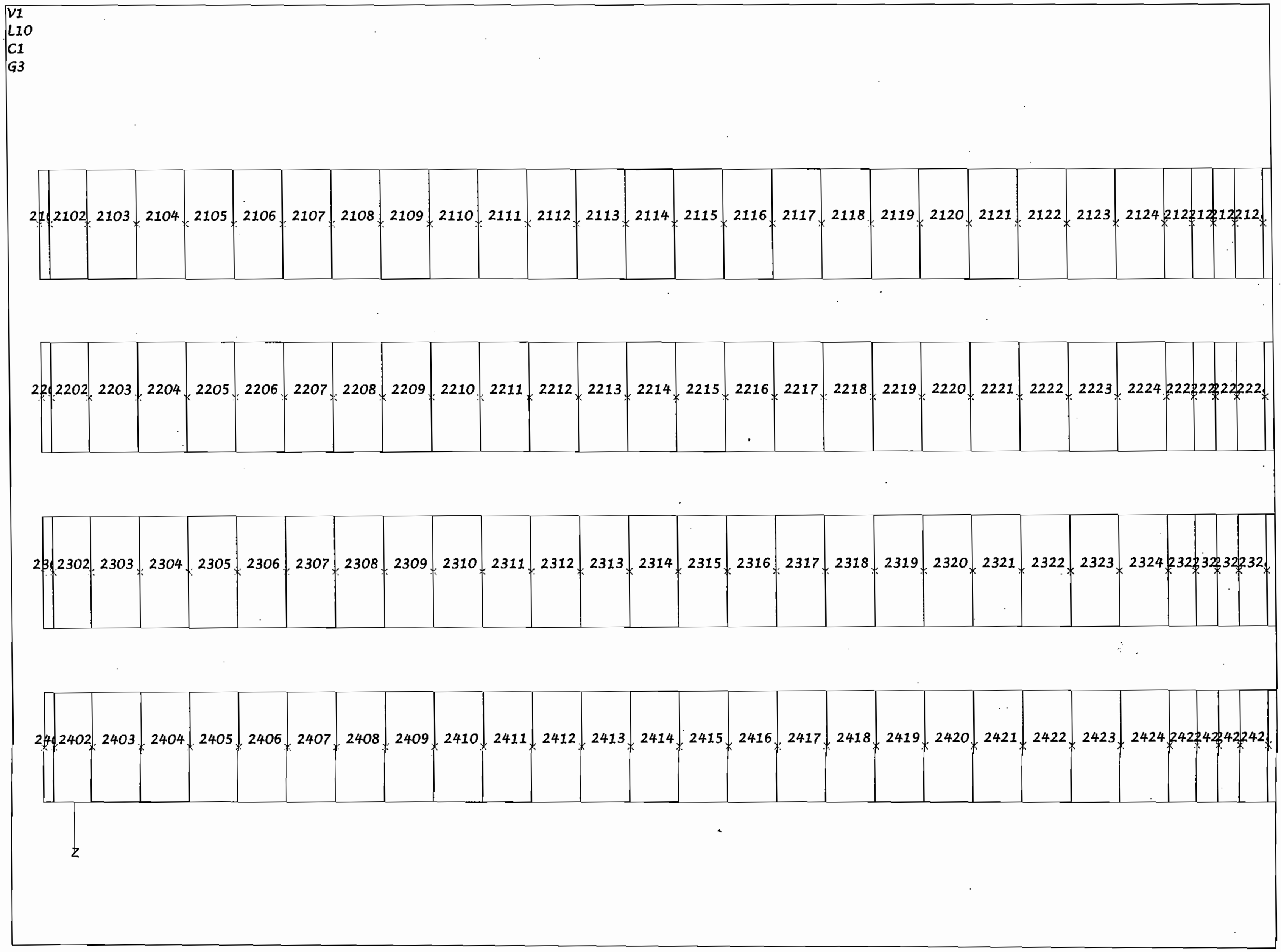


Stardyne Model: Plan View

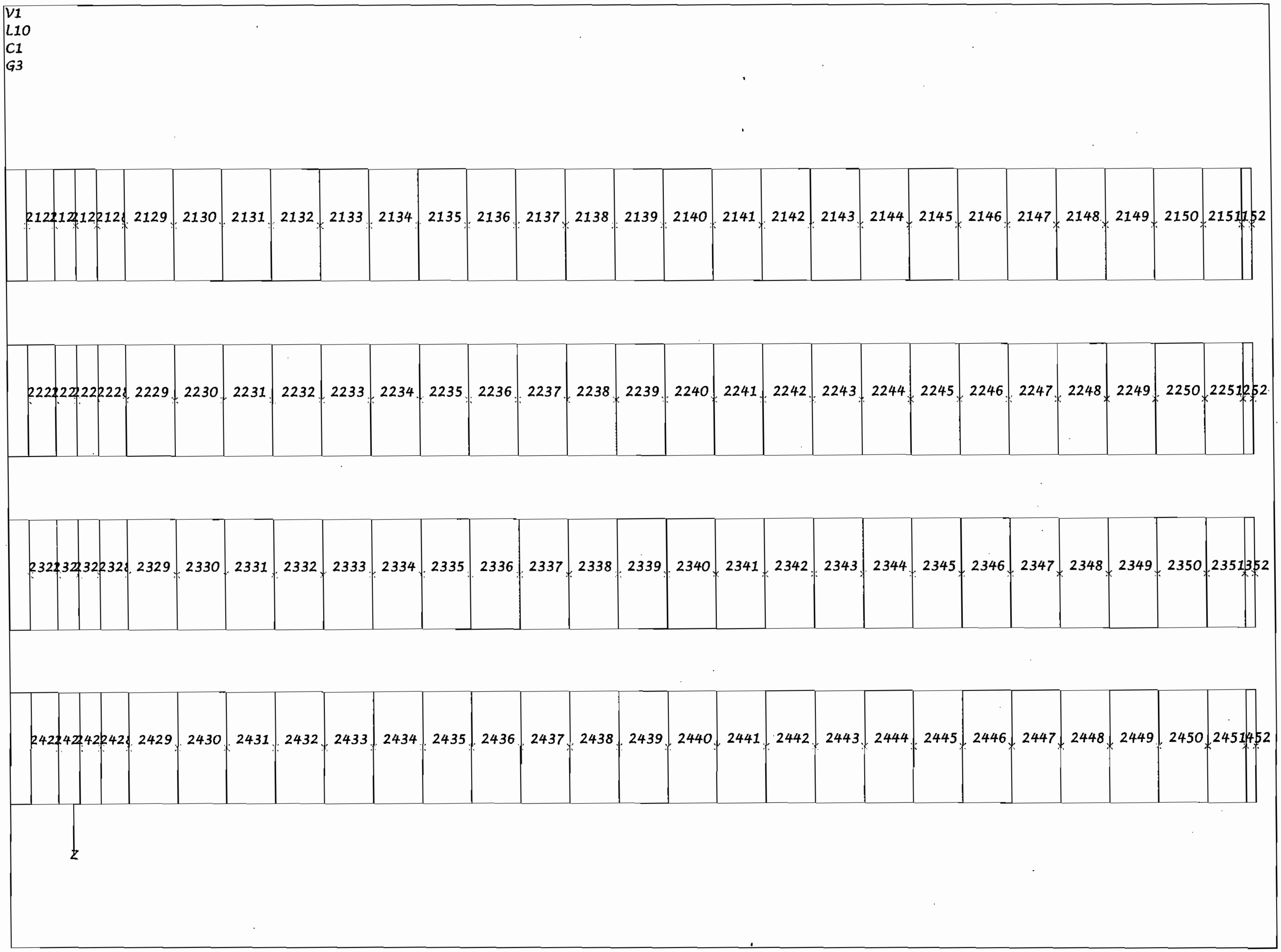


8

Stardyne Model: Beam Element Designation (West End)

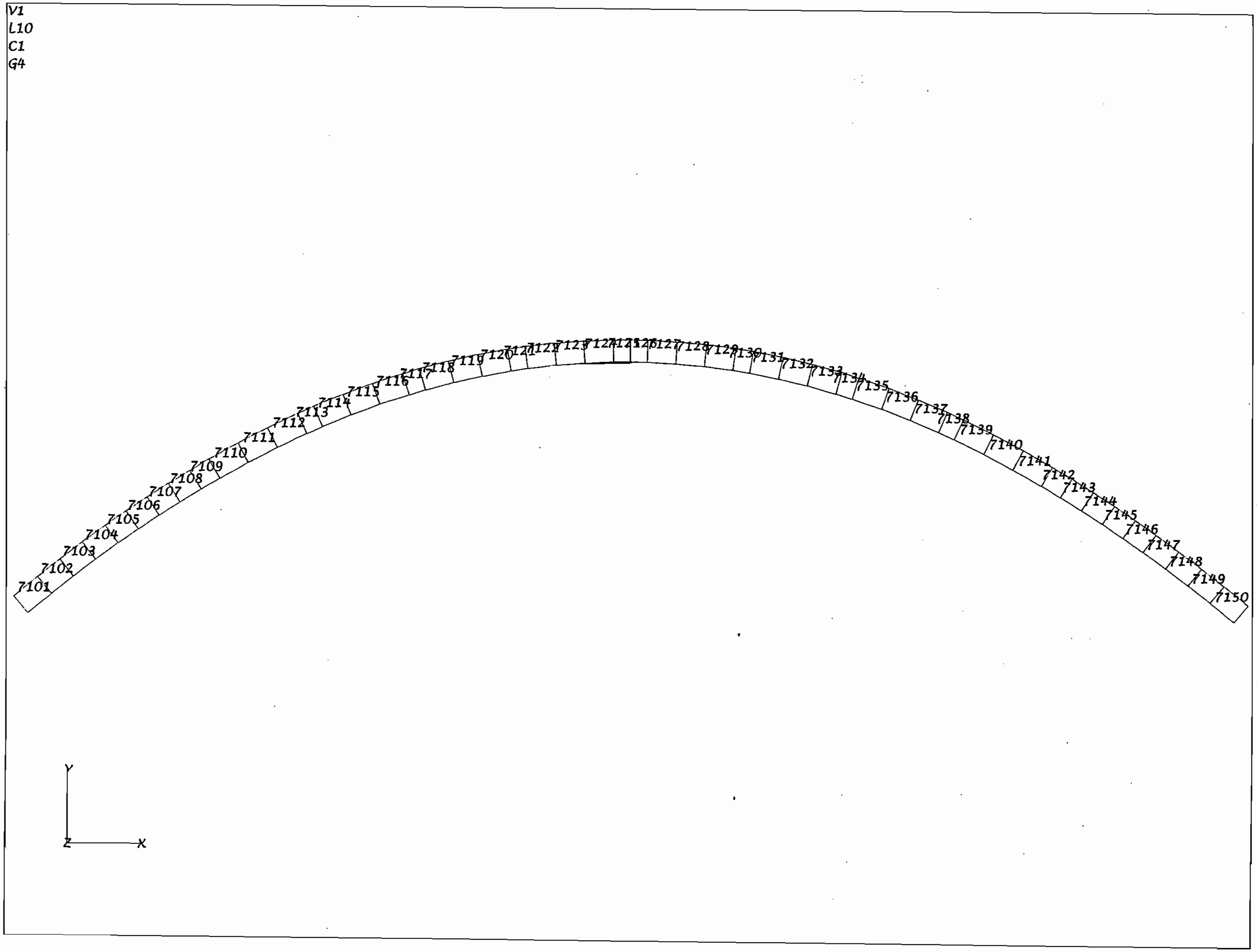


Stardyne Model: Beam Element Designation (East End)

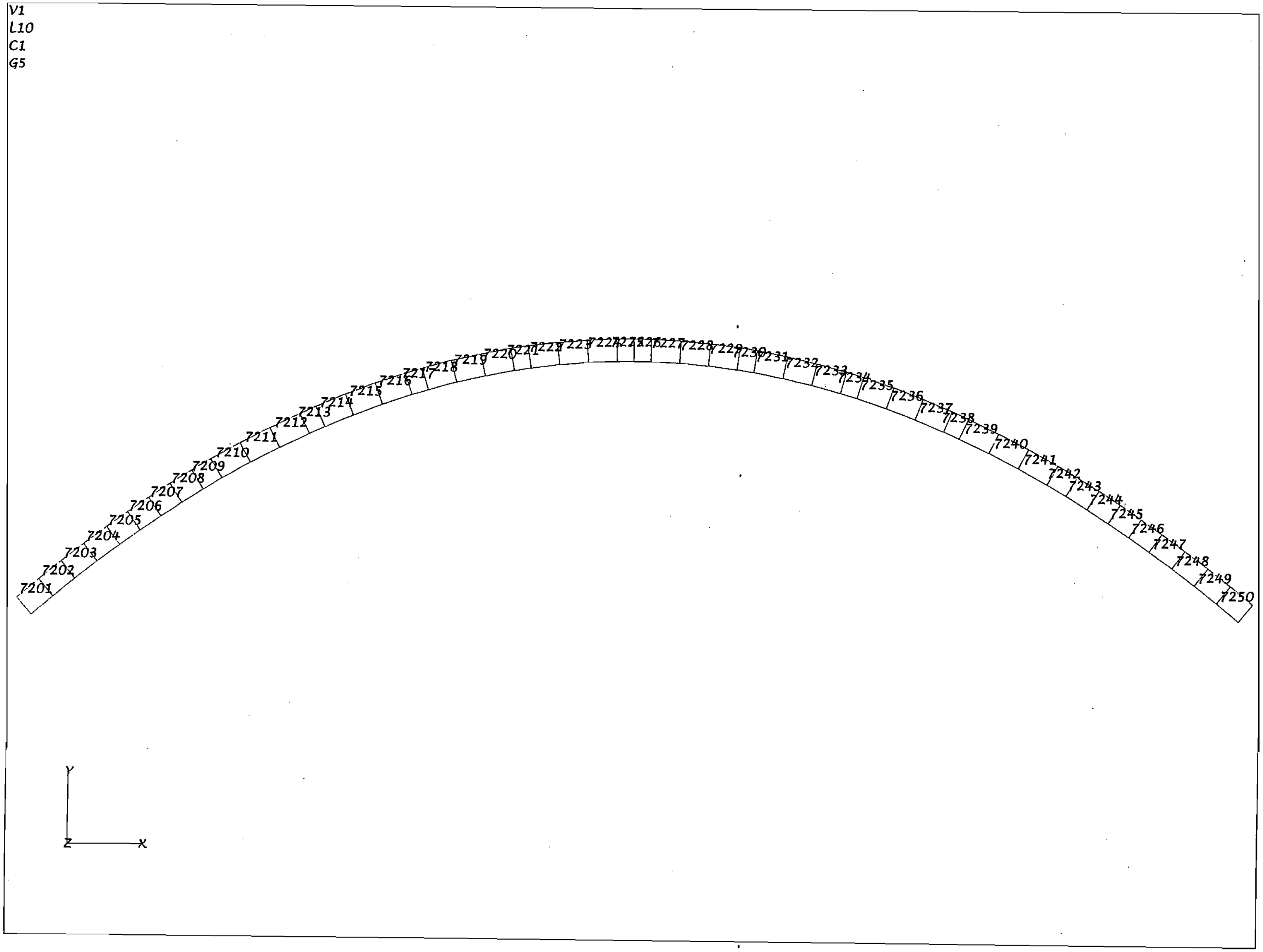


10

Stardyne Model: North Arch Element Designation



Stardyne Model: South Arch Element Designation



BRUCO CONSTRUCTION SEQUENCE

ARAPAHO RD - BRUCO ERECTION SEQUENCE

STEP	ERECTION DAY	CASTING DAY	DESCRIPTION
1	30	0	ERECT PIERS 9 AND 10
2	90		ERECT STEEL ARCH
3	120	90	ERECT PRECAST BEAMS ON TEMPORARY BENT
4	130		CAST U-BEAM SPLICE AND TRANSVERSE DIAPHRAGMS
5	160		POUR DECK (ADD DECK WEIGHT TO PRECAST U-BEAMS)
6	160	130	DECK HARDENED (ERECT WEIGHTLESS DECK ELEMENTS)
7	190		STRESS CABLE 5 TO 5 KIPS
8	190		STRESS CABLE 6 TO 5 KIPS
9	190		STRESS CABLE 4 TO 5 KIPS
10	190		STRESS CABLE 7 TO 5 KIPS
11	190		STRESS CABLE 3 TO 5 KIPS
12	190		STRESS CABLE 8 TO 5 KIPS
13	190		STRESS CABLE 2 TO 5 KIPS
14	190		STRESS CABLE 9 TO 5 KIPS
15	190		STRESS CABLE 1 TO 5 KIPS
16 - 20	190		STRESS CABLE 5 TO 238.1 KIPS
21 - 24	190		STRESS CABLE 6 TO 146.2 KIPS
25 - 28	190		STRESS CABLE 4 TO 159.0 KIPS
29 - 32	190		STRESS CABLE 7 TO 162.4 KIPS
33 - 36	190		STRESS CABLE 3 TO 192.6 KIPS
37 - 39	190		STRESS CABLE 8 TO 158.9 KIPS
40 - 42	190		STRESS CABLE 2 TO 171.1 KIPS
43 - 44	190		STRESS CABLE 9 TO 142.1 KIPS
45 - 46	190		STRESS CABLE 1 TO 146.1 KIPS
47	220		ADD BARRIER WEIGHT

NOTE: CABLES WERE STRESSED IN MULTIPLE STEPS TO ALLOW MORE ITERATIONS FOR THE NON-LINEAR BRUCO ANALYSIS

BRUCO STEP-BY-STEP CABLE FORCES

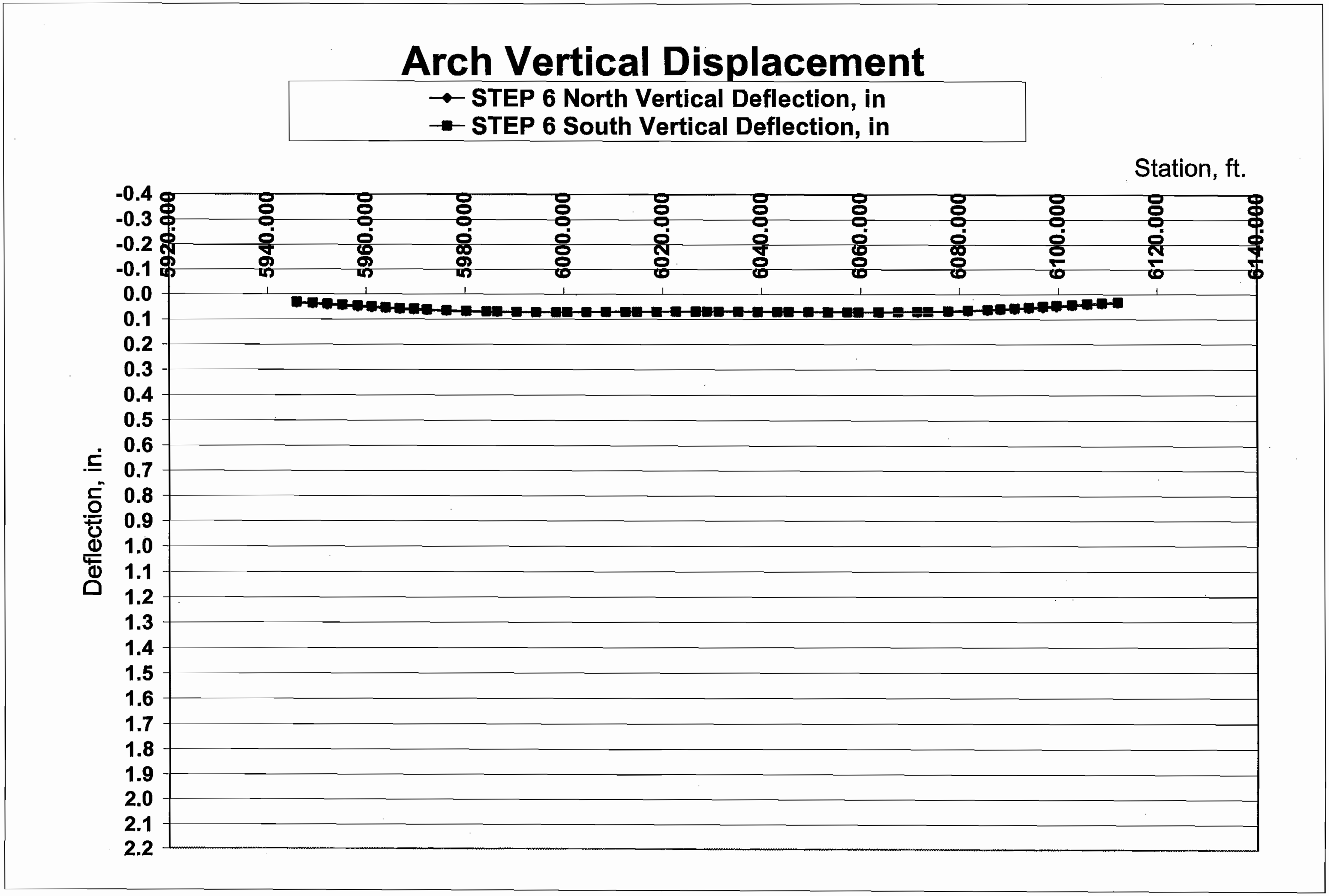
BRUCO STEP-BY-STEP CABLE FORCES (kips)

BRUCO STEP	CABLE 1 North (LT)	CABLE 1 South (RT)	CABLE 2 North (LT)	CABLE 2 South (RT)	CABLE 3 North (LT)	CABLE 3 South (RT)	CABLE 4 North (LT)	CABLE 4 South (RT)	CABLE 5 North (LT)	CABLE 5 South (RT)	CABLE 6 North (LT)	CABLE 6 South (RT)	CABLE 7 North (LT)	CABLE 7 South (RT)	CABLE 8 North (LT)	CABLE 8 South (RT)	CABLE 9 North (LT)	CABLE 9 South (RT)
7									5.0	5.0								
8									2.6	2.6	4.9	5.0						
9							5.0	5.0	0.0	0.0	6.2	6.3						
10							6.9	6.9	0.0	0.0	2.9	3.0	5.1	5.0				
11					5.1	5.0	4.1	4.0	0.0	0.0	3.9	4.0	6.5	6.4				
12					6.0	5.9	4.9	4.9	0.2	0.1	4.0	4.2	3.5	3.4	5.1	5.0		
13			5.0	5.0	3.1	3.0	5.0	5.0	1.0	0.9	4.7	4.8	4.0	3.9	5.8	5.6		
14			5.3	5.2	3.3	3.2	5.2	5.2	1.3	1.2	5.1	5.3	3.9	3.8	3.1	2.9	5.0	5.0
15	5.0	5.0	2.7	2.5	3.3	3.1	5.7	5.6	1.7	1.6	5.3	5.5	4.1	4.0	3.3	3.0	5.2	5.2
20	67.2	55.8	17.5	13.6	0.0	0.0	0.0	0.0	**238.1**	**194.8**	0.0	0.0	0.0	0.0	18.3	14.5	67.7	56.2
24	84.2	68.7	52.3	41.3	0.0	0.0	0.0	0.0	174.7	143.6	**146.2**	**116.3**	0.0	0.0	0.0	0.0	66.7	54.8
28	102.0	82.9	3.3	2.1	0.0	0.0	**159.0**	**125.6**	98.6	82.4	158.4	126.6	0.0	0.0	4.0	2.5	102.5	83.1
32	115.0	93.0	26.4	18.9	0.0	0.0	186.1	146.8	97.6	81.8	79.2	63.1	**162.4**	**127.1**	0.0	0.0	50.8	41.0
36	69.8	55.5	0.0	0.0	**192.6**	**150.4**	98.2	76.4	93.2	78.9	100.8	80.1	188.4	147.0	0.0	0.0	72.9	57.6
39	80.9	64.3	0.0	0.0	204.0	159.3	110.5	86.0	105.8	89.0	96.0	77.0	120.9	93.7	**158.9**	**124.6**	0.0	0.0
42	0.0	0.0	**171.1**	**134.7**	117.0	90.6	98.2	77.1	113.0	95.0	102.6	82.2	123.8	95.9	158.3	124.4	0.0	0.0
44	0.0	0.0	168.0	132.2	115.9	89.7	98.6	77.3	116.6	97.7	108.5	86.9	115.2	89.9	70.8	54.0	**142.1**	**111.9**
46	**146.1**	**115.2**	78.4	60.1	107.0	83.3	104.6	82.1	120.2	100.3	108.8	87.0	114.3	89.0	69.6	53.0	138.9	109.4
47 (FINAL)	149.5	118.5	80.0	61.9	108.5	85.1	106.9	84.6	123.4	103.7	111.1	89.5	115.8	90.8	71.1	54.8	142.3	112.9
PLAN	148.4	115.2	93.4	72.5	98.8	77.5	106.7	83.5	113.5	88.7	106.8	83.6	99.1	77.7	93.7	72.7	146.6	113.7

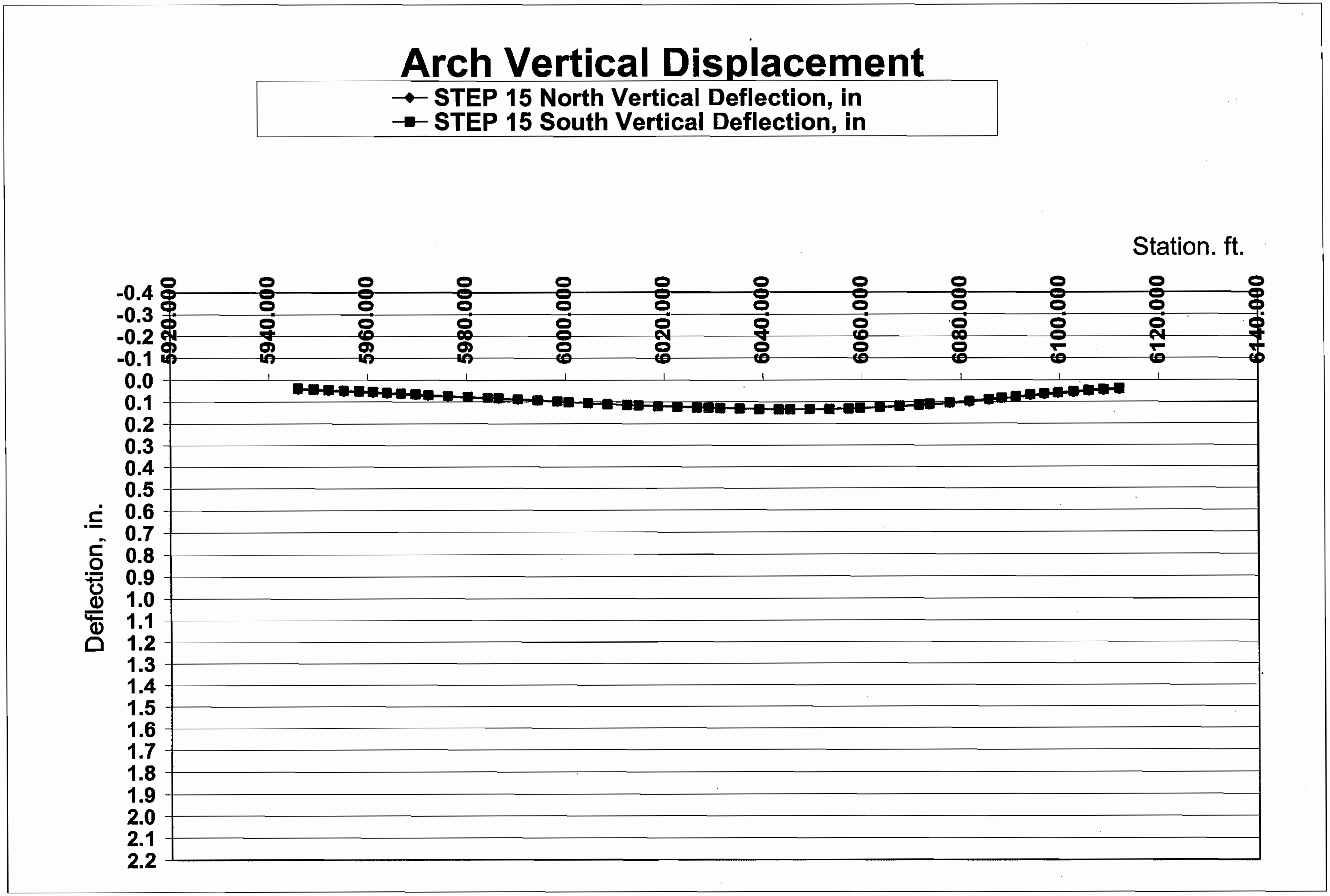
PLAN JACKING FORCE (TYP)

8/15/2005

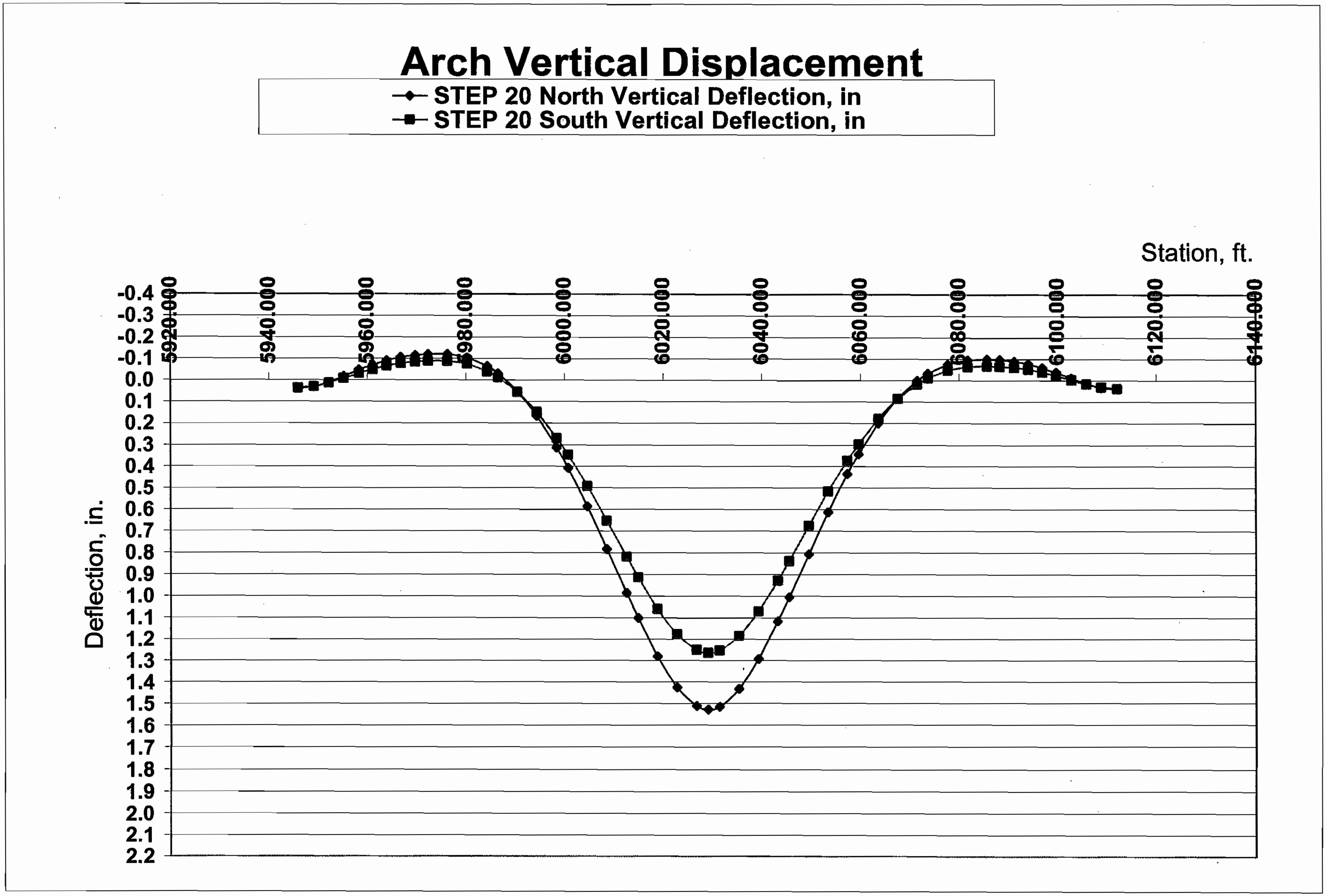
BRUCO STEP-BY-STEP ARCH DEFLECTIONS



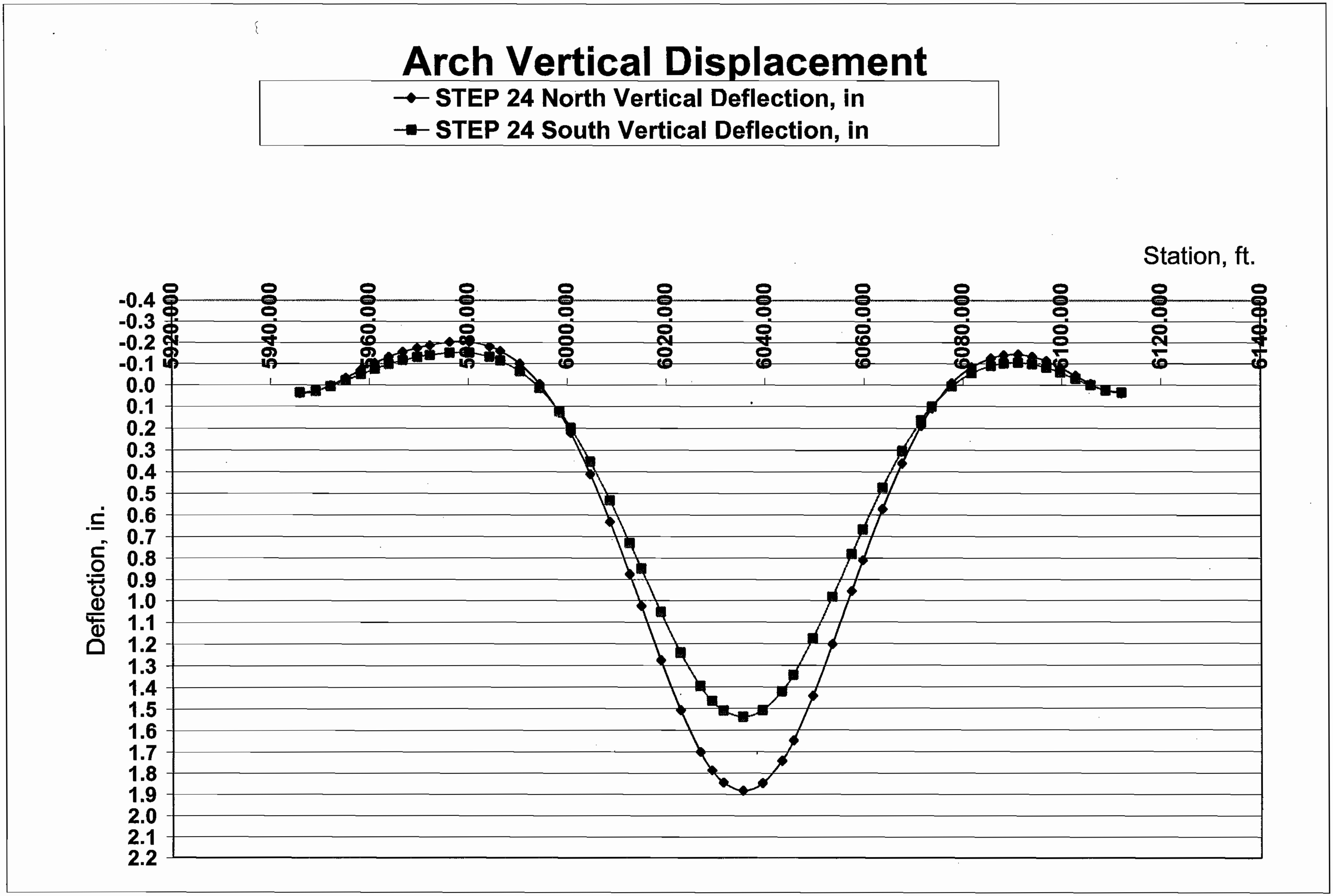
Arch Vertical Displacement
STEP 6 North Vertical Deflection, in
STEP 6 South Vertical Deflection, in
Station, ft.
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000



Arch Vertical Displacement
STEP 15 North Vertical Deflection, in
STEP 15 South Vertical Deflection, in
Station. ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2

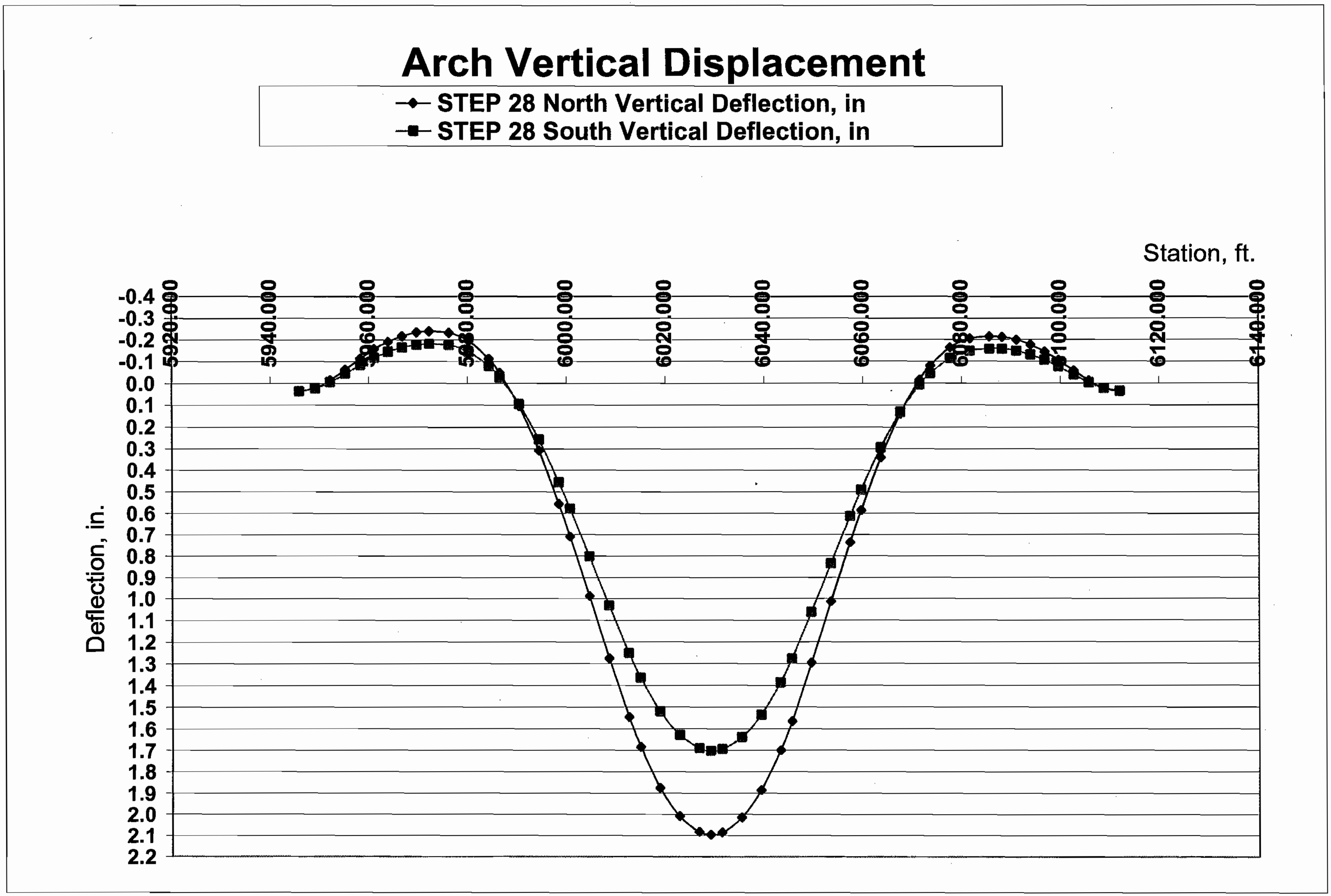


Arch Vertical Displacement
STEP 20 North Vertical Deflection, in
STEP 20 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2



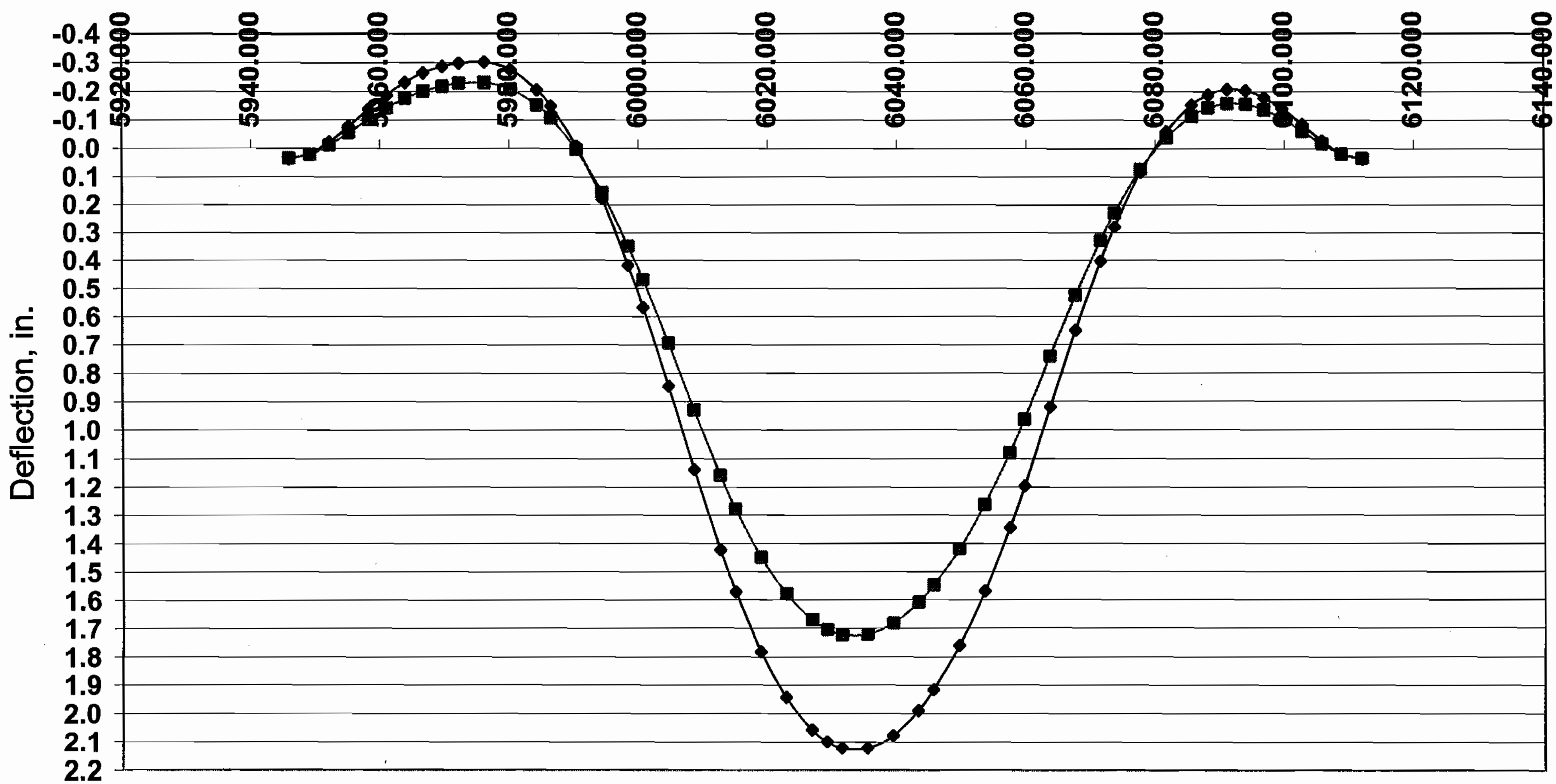
Arch Vertical Displacement
STEP 24 North Vertical Deflection, in
STEP 24 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2

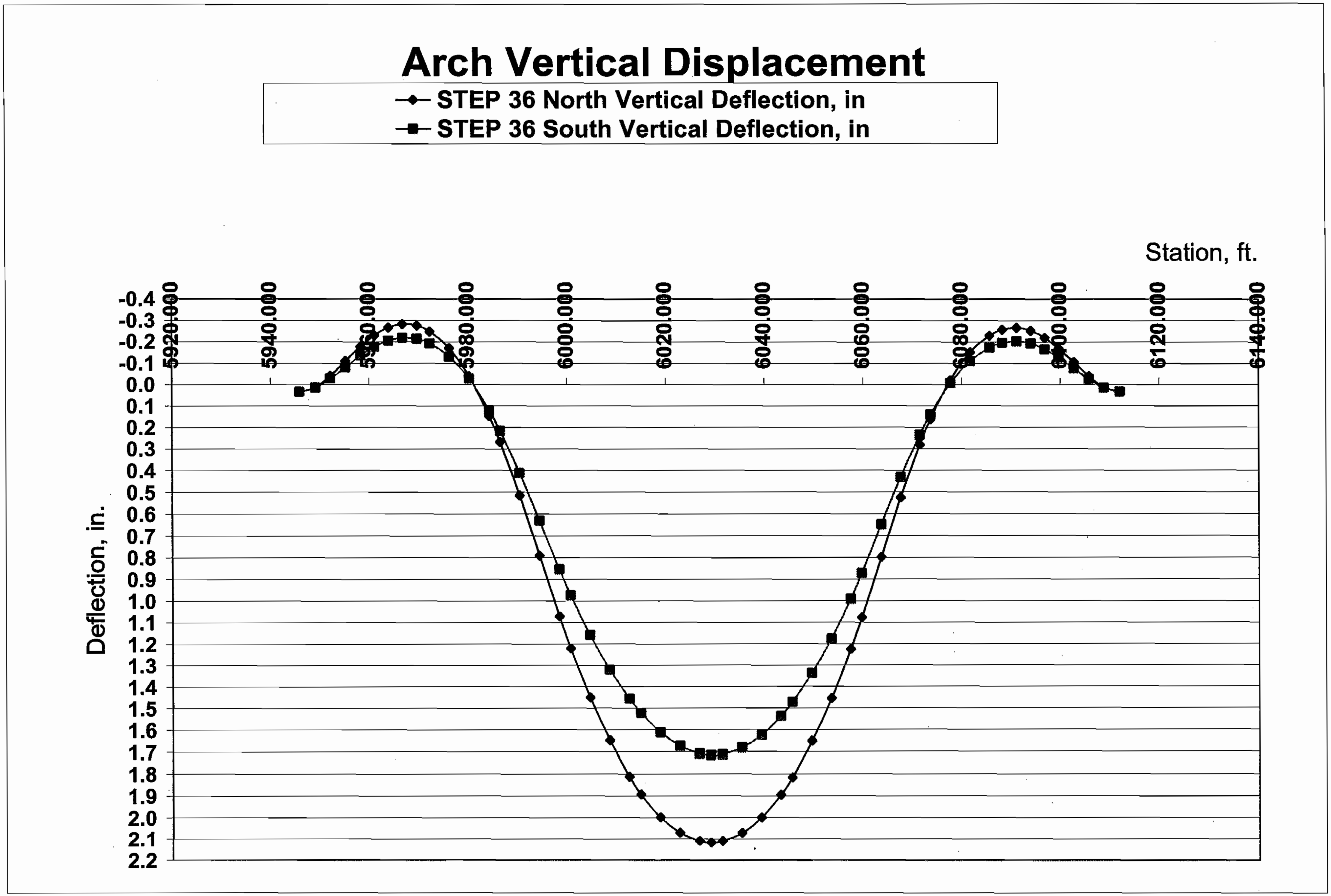
2

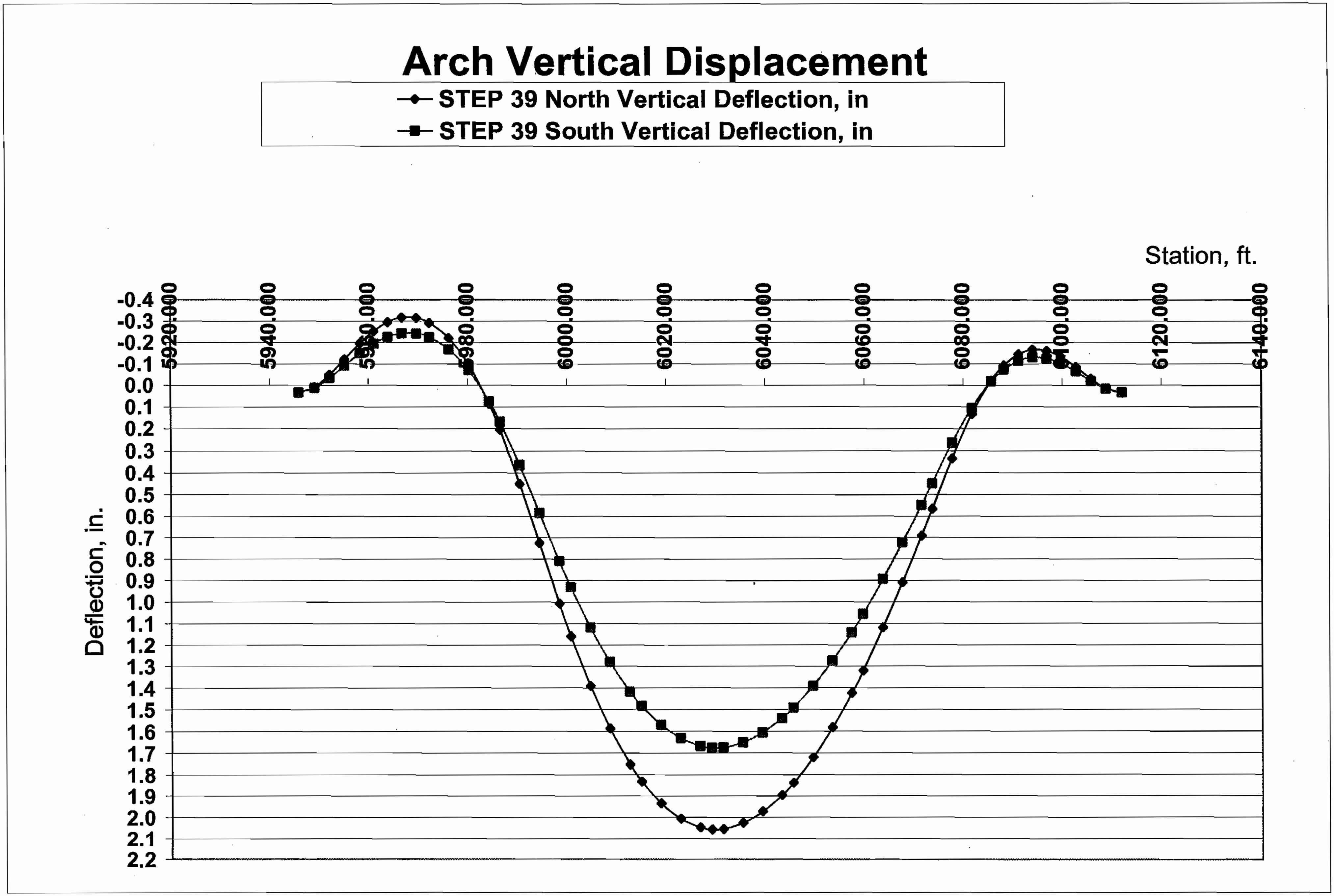


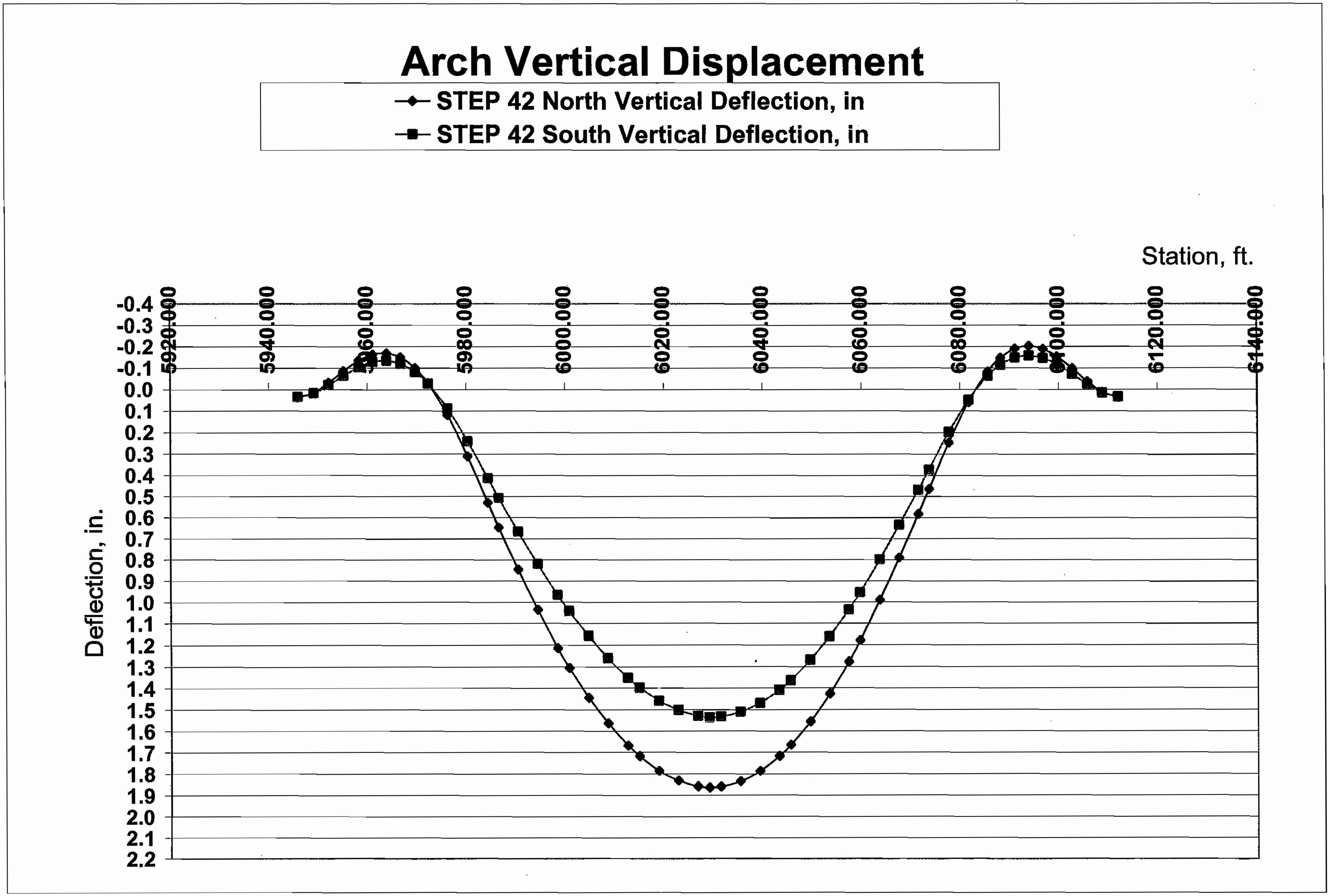
Arch Vertical Displacement
STEP 28 North Vertical Deflection, in
STEP 28 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2

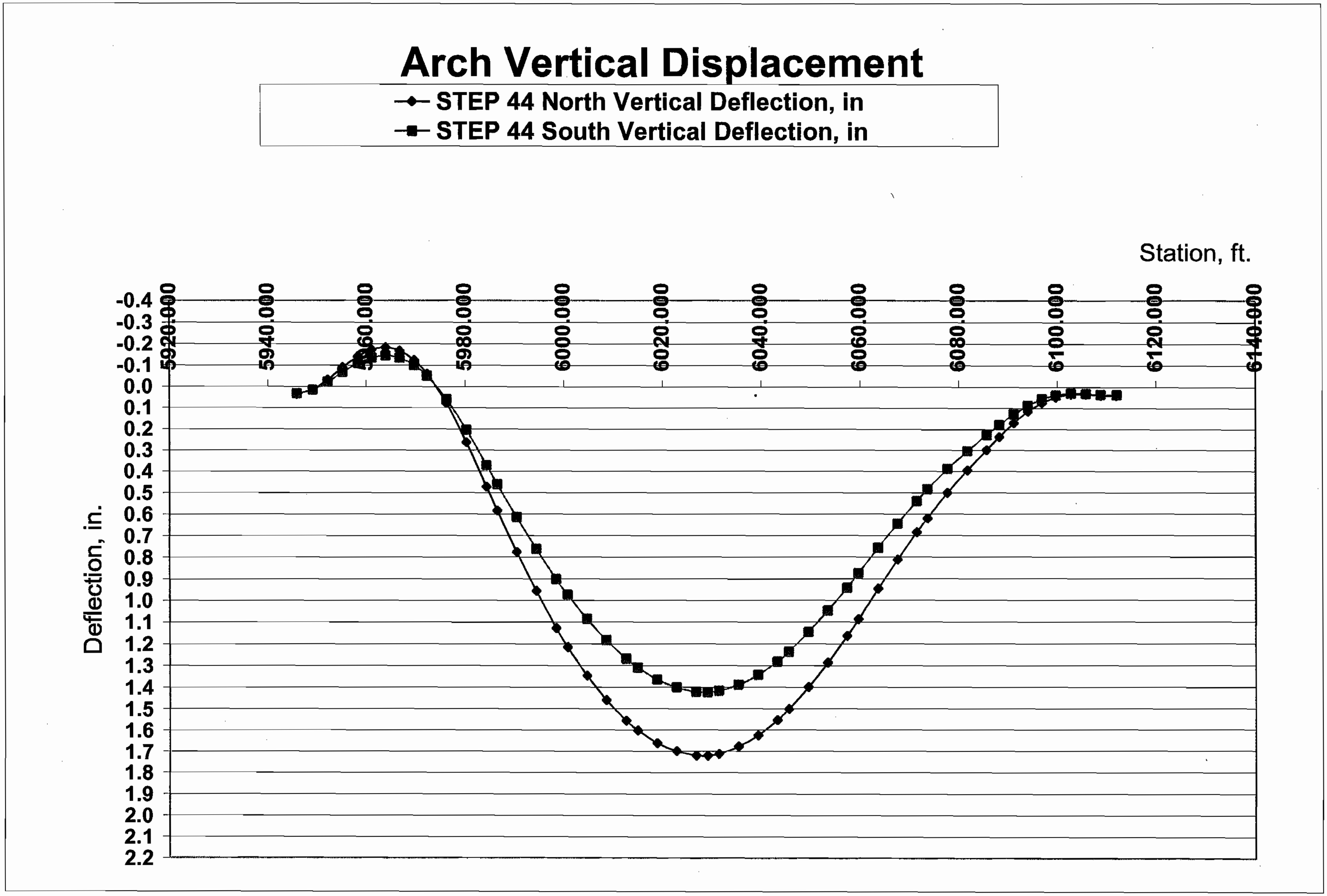
Arch Vertical Displacement



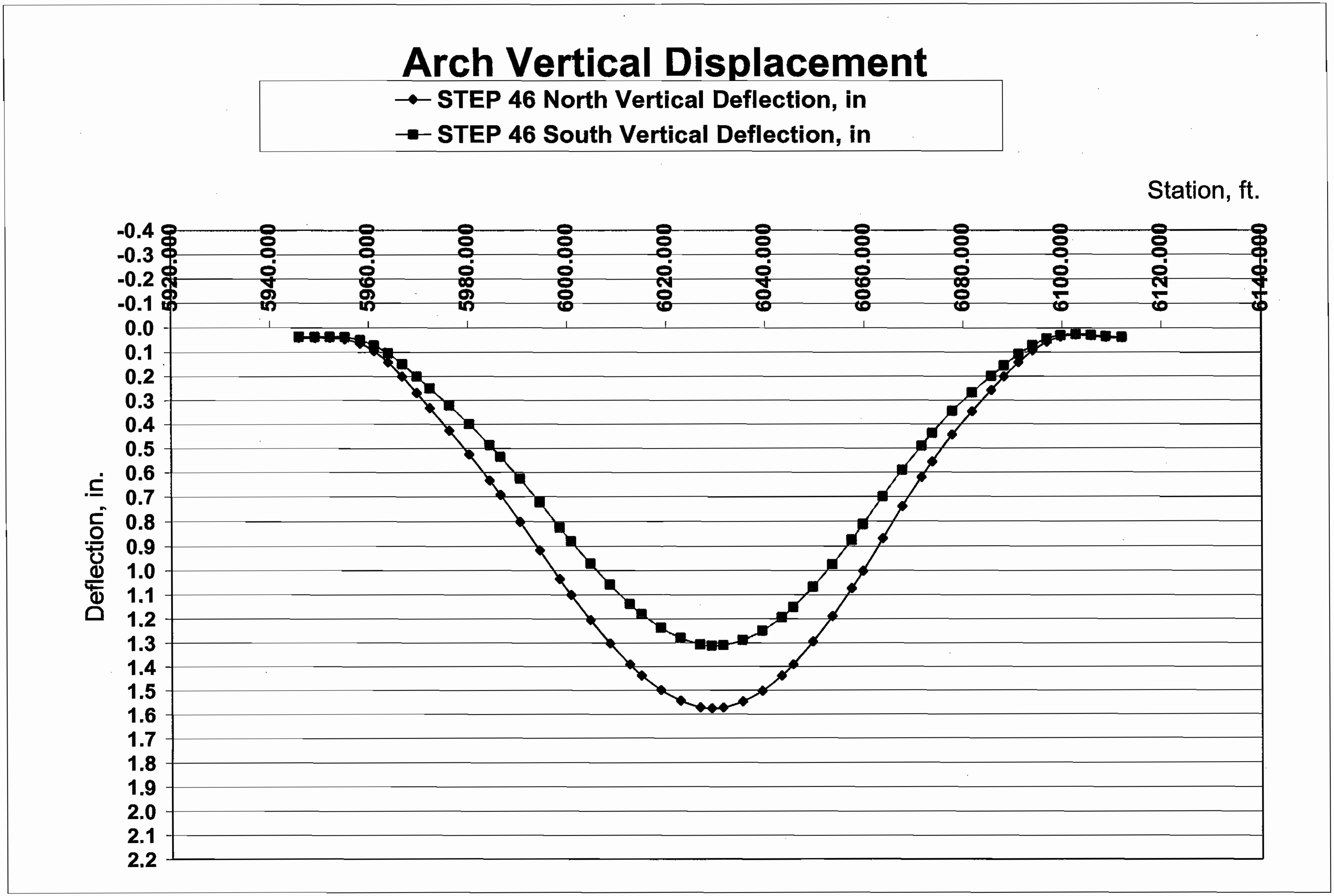

Arch Vertical Displacement
STEP 36 North Vertical Deflection, in
STEP 36 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2


Arch Vertical Displacement
STEP 39 North Vertical Deflection, in
STEP 39 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2


Arch Vertical Displacement
STEP 42 North Vertical Deflection, in
STEP 42 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2

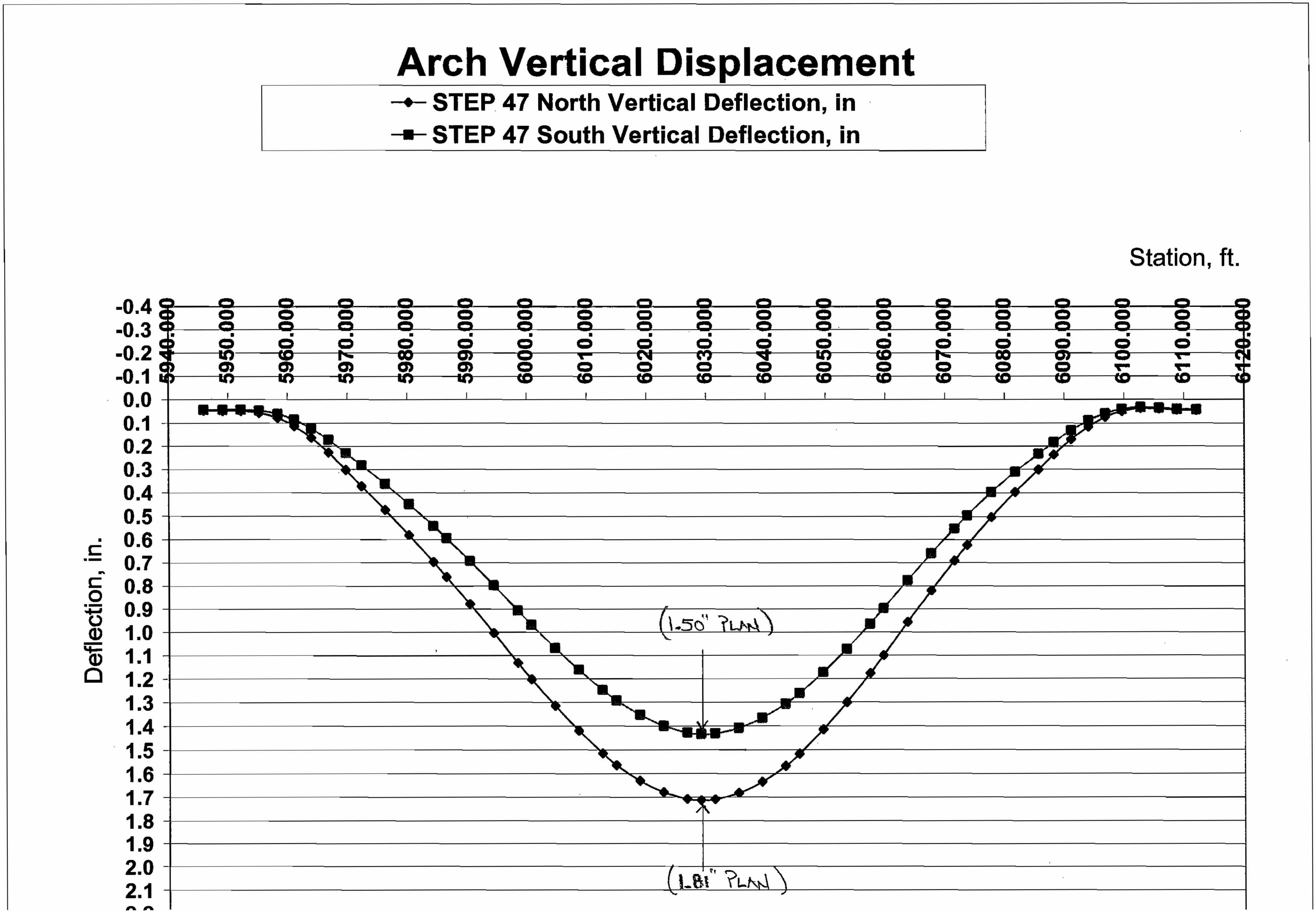


Arch Vertical Displacement
STEP 44 North Vertical Deflection, in
STEP 44 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2



Arch Vertical Displacement
STEP 46 North Vertical Deflection, in
STEP 46 South Vertical Deflection, in
Station, ft.
5920.000
5940.000
5960.000
5980.000
6000.000
6020.000
6040.000
6060.000
6080.000
6100.000
6120.000
6140.000
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2

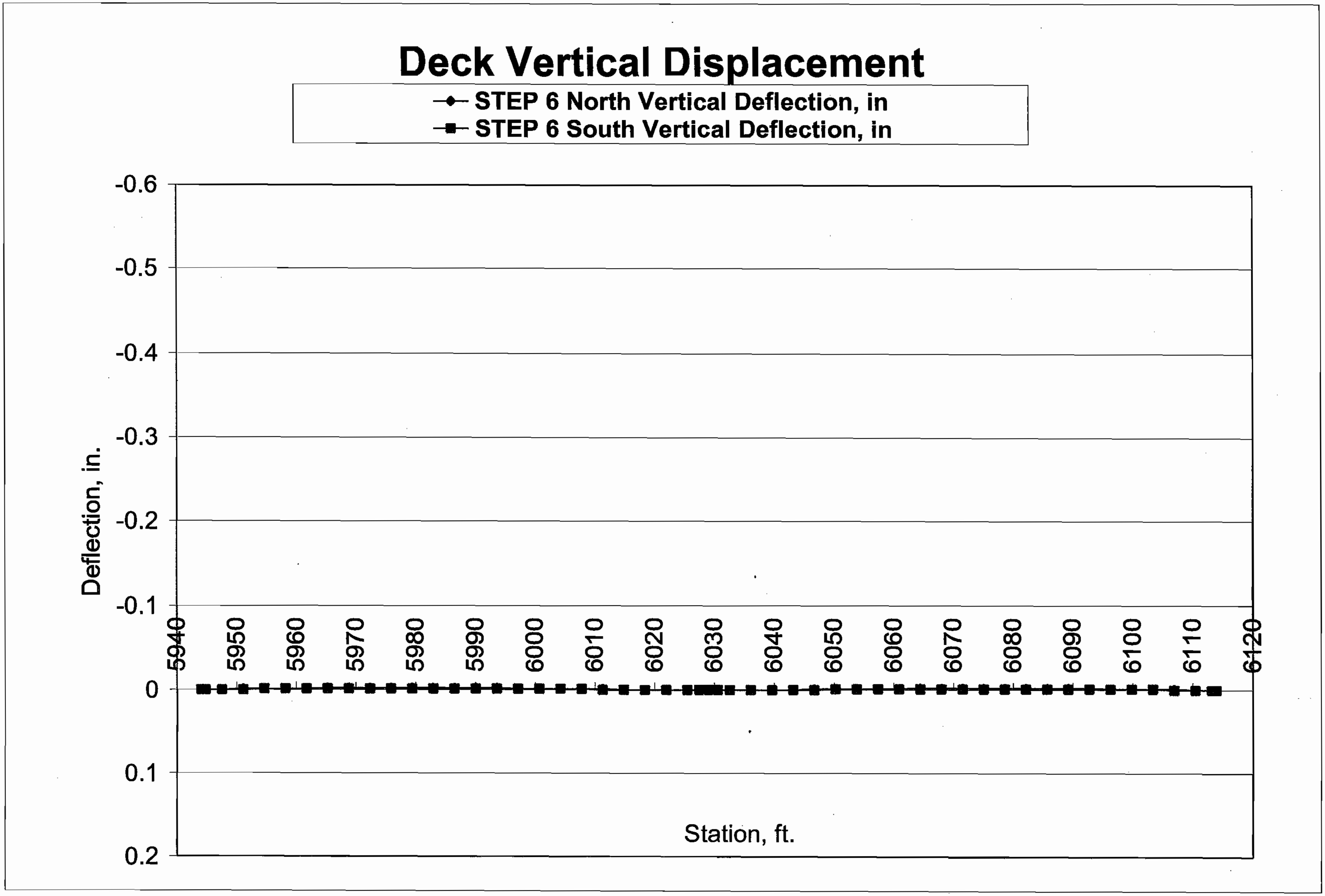
28



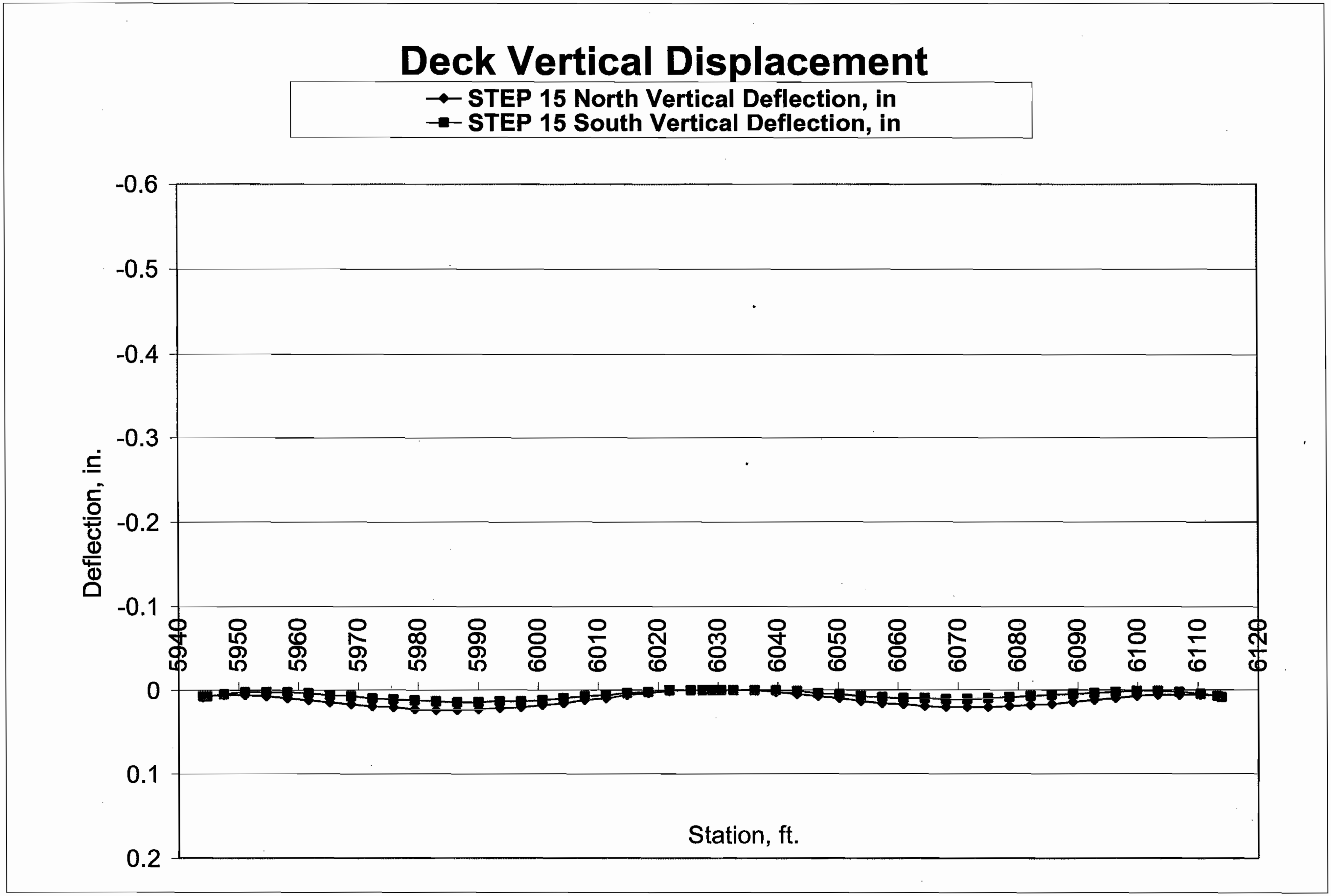
Arch Vertical Displacement
STEP 47 North Vertical Deflection, in
STEP 47 South Vertical Deflection, in
Station, ft.
Deflection, in.
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
5940.000
5950.000
5960.000
5970.000
5980.000
5990.000
6000.000
6010.000
6020.000
6030.000
6040.000
6050.000
6060.000
6070.000
6080.000
6090.000
6100.000
6110.000
6120.000
(1.50" PLAN)
(1.81" PLAN)

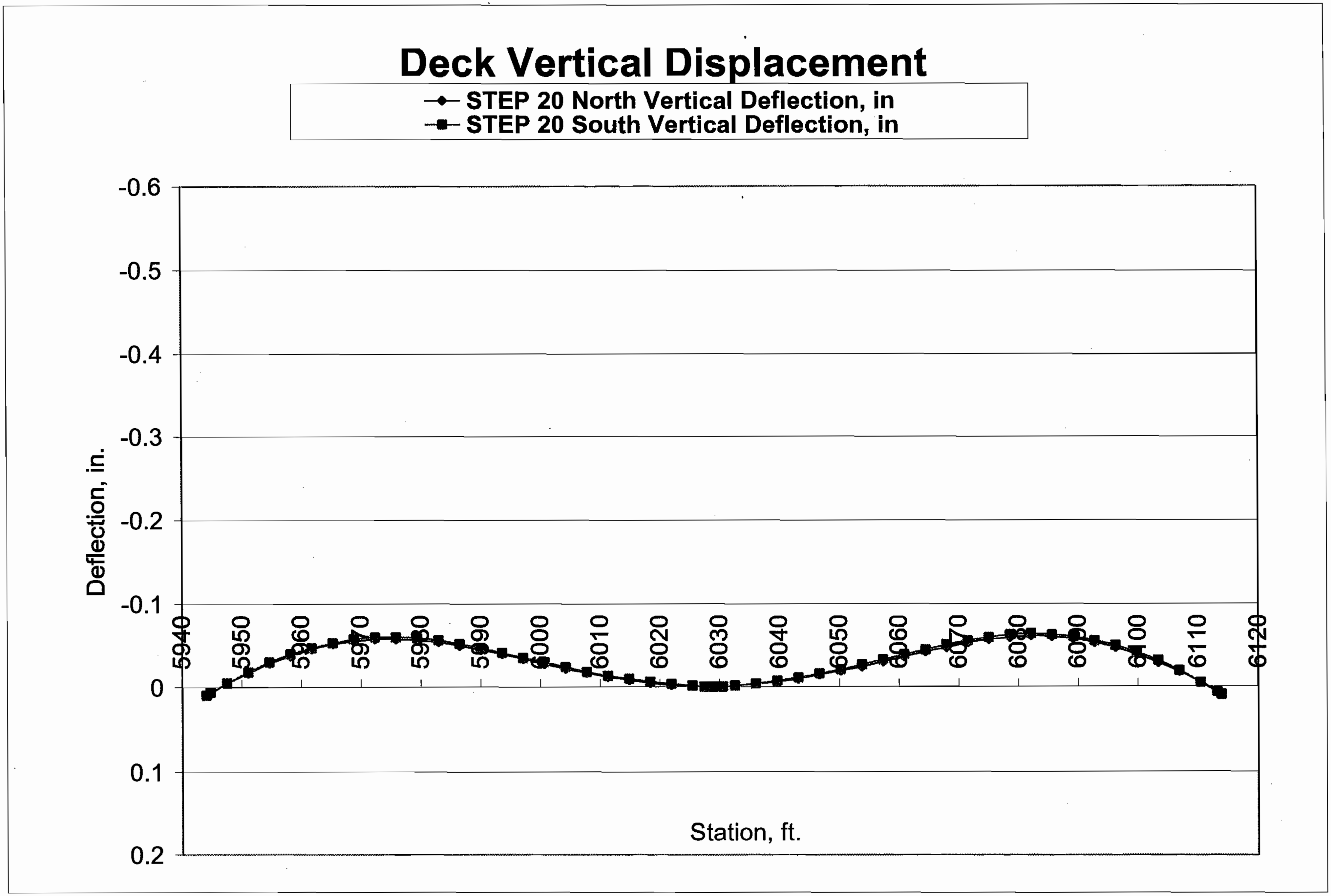
27

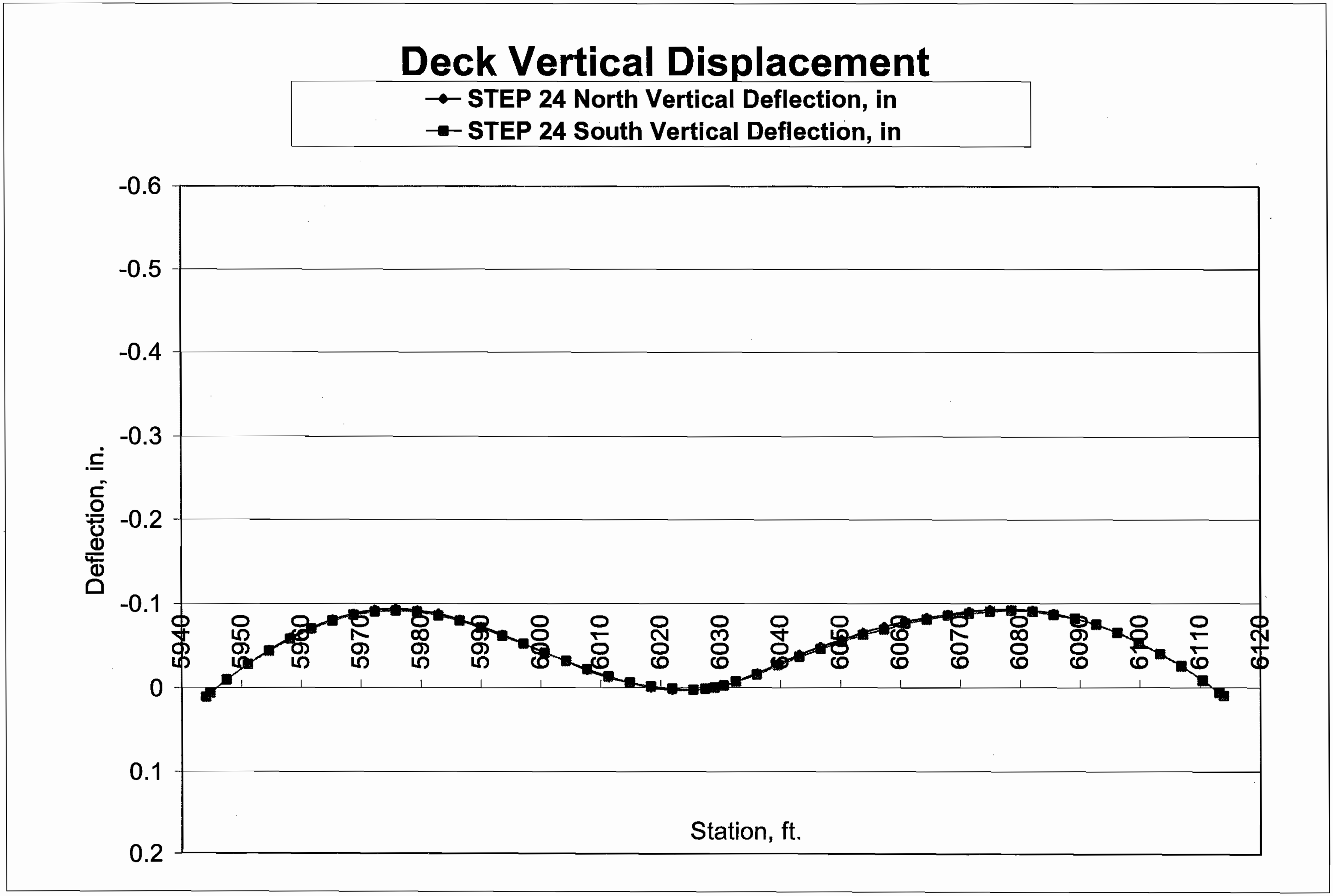
BRUCO STEP-BY-STEP DECK DEFLECTIONS

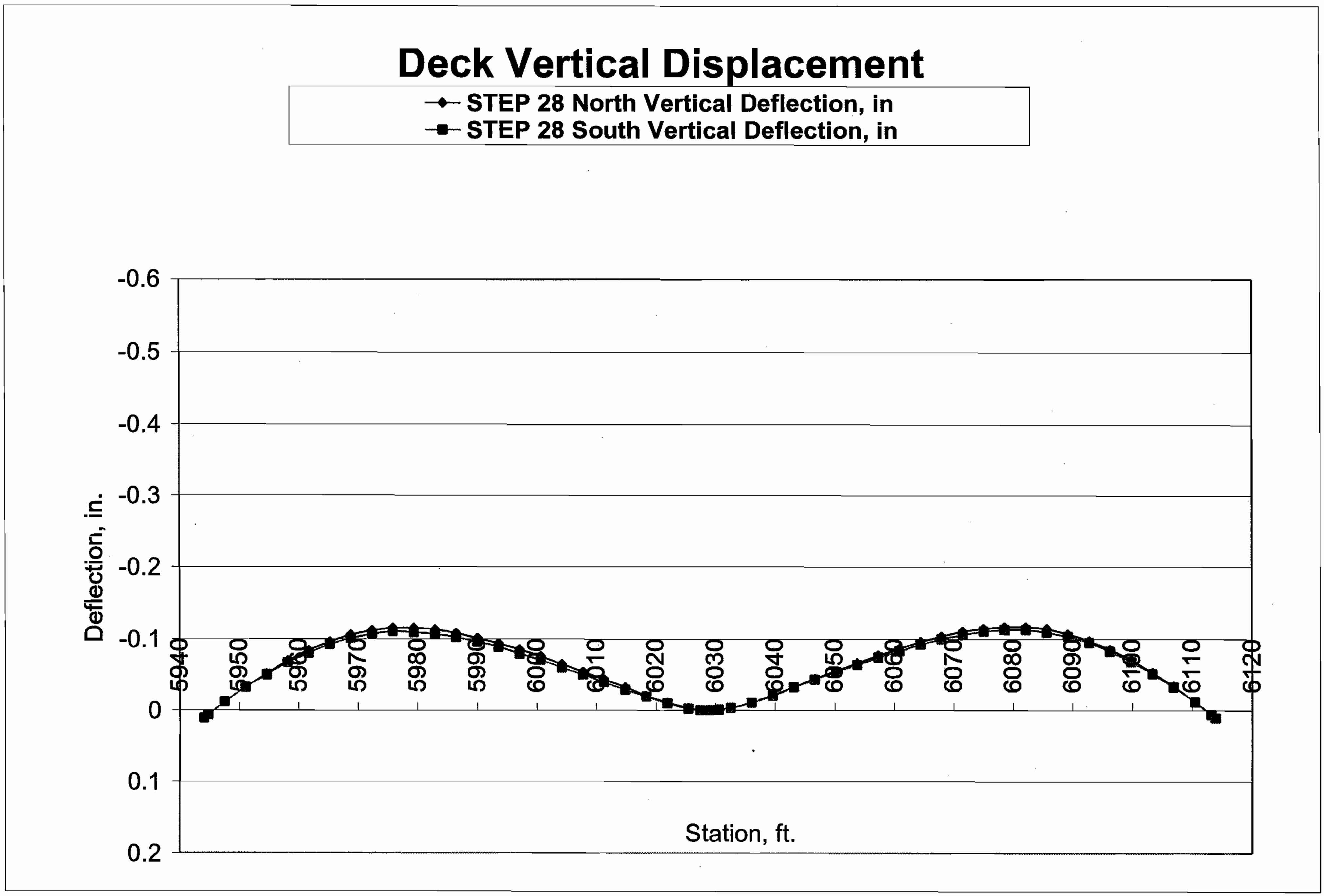

Deck Vertical Displacement
STEP 6 North Vertical Deflection, in
STEP 6 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

3


Deck Vertical Displacement
STEP 15 North Vertical Deflection, in
STEP 15 South Vertical Deflection, in
Deflection, in.
Station, ft.
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120

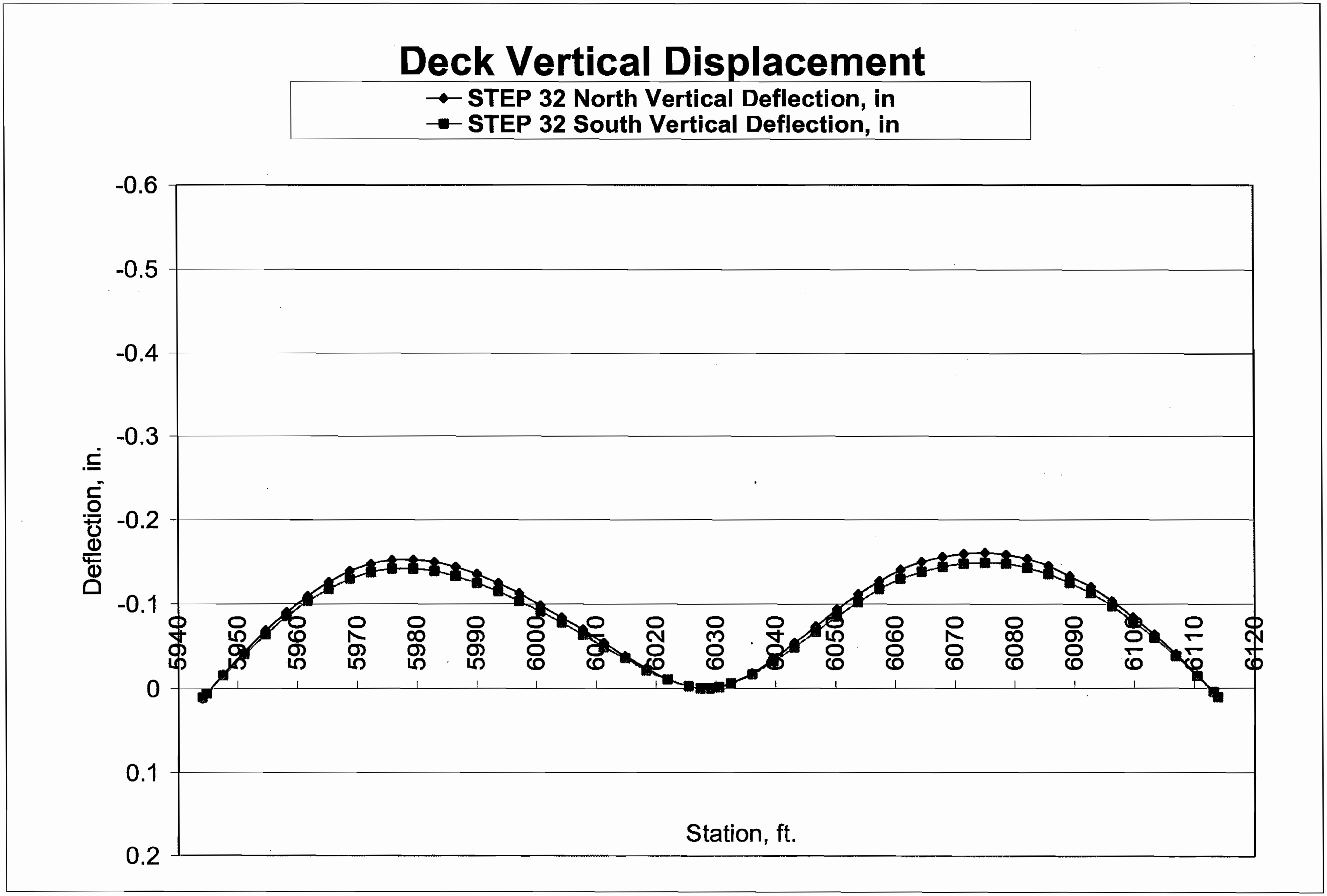

Deck Vertical Displacement
STEP 20 North Vertical Deflection, in
STEP 20 South Vertical Deflection, in
Deflection, in.
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.


Deck Vertical Displacement
STEP 24 North Vertical Deflection, in
STEP 24 South Vertical Deflection, in
Deflection, in.
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

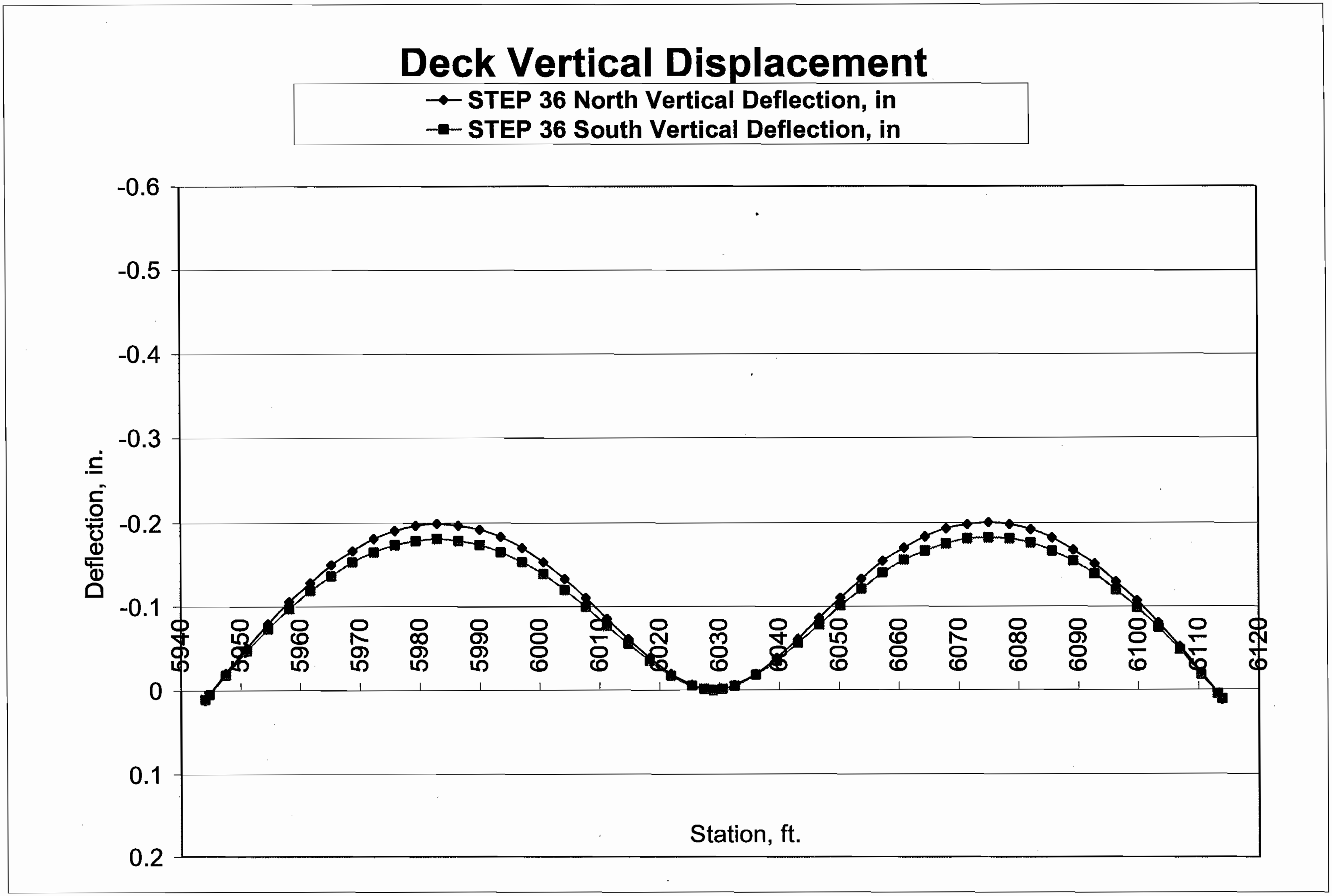


Deck Vertical Displacement
STEP 28 North Vertical Deflection, in
STEP 28 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

35

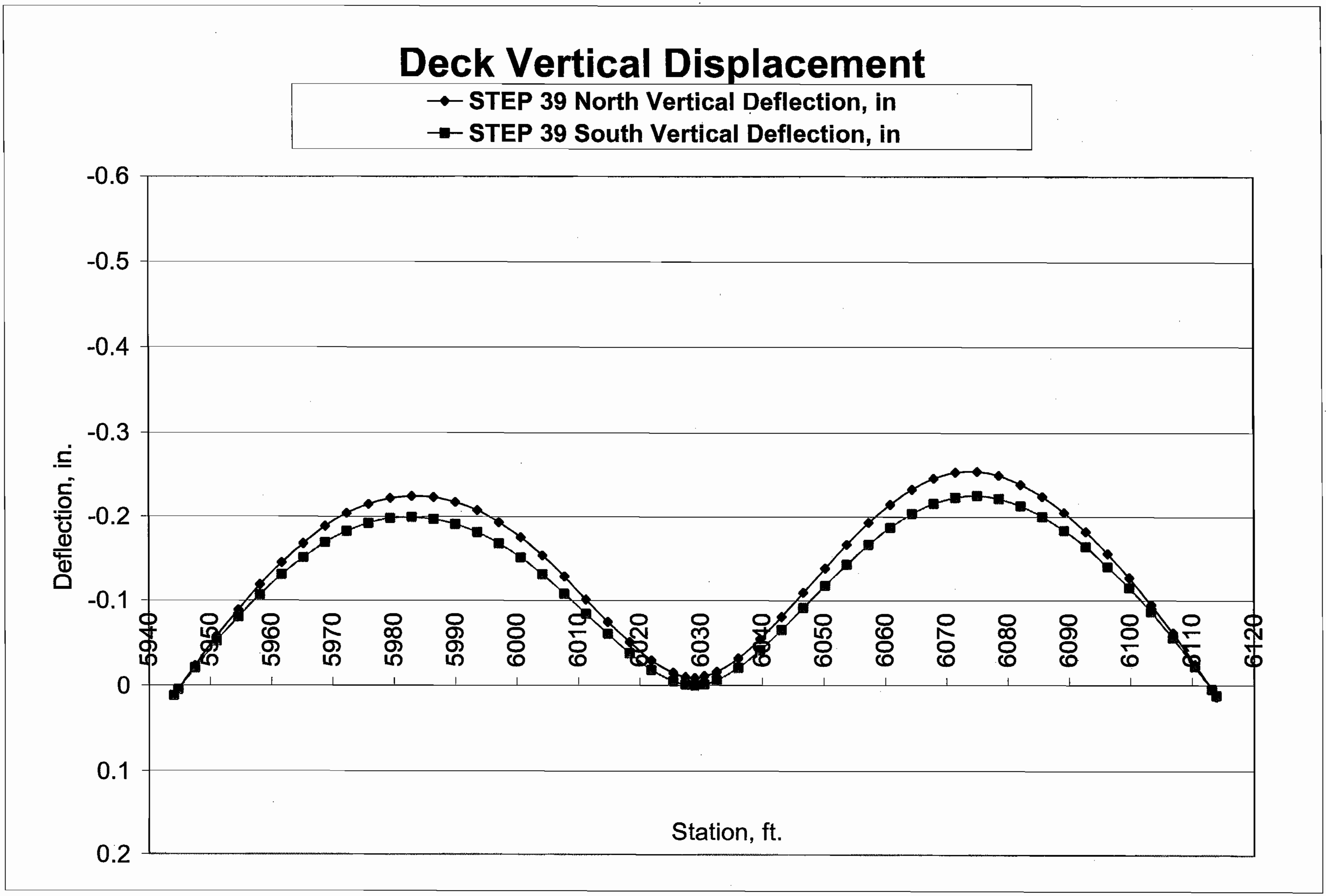


Deck Vertical Displacement
STEP 32 North Vertical Deflection, in
STEP 32 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.



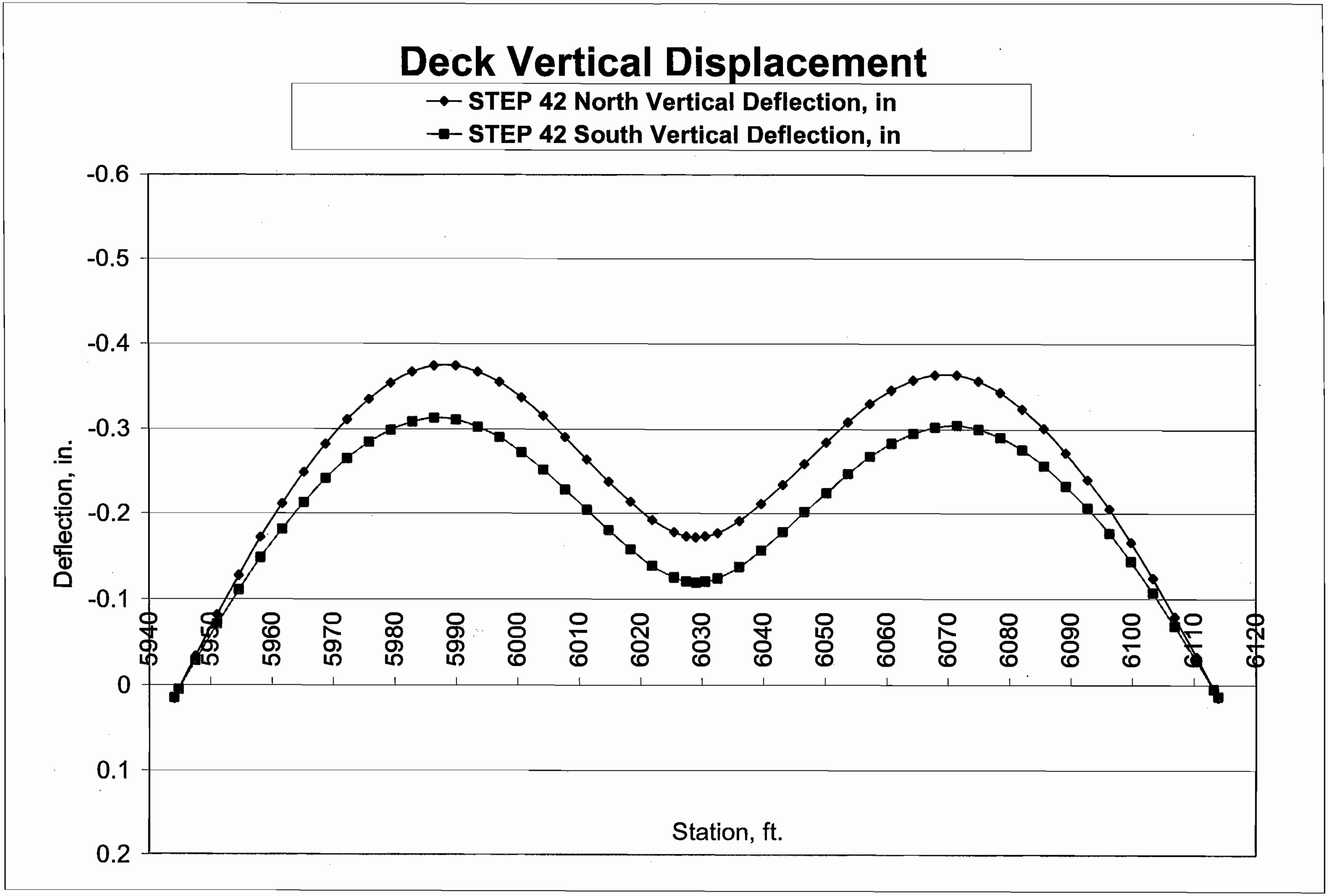
Deck Vertical Displacement
STEP 36 North Vertical Deflection, in
STEP 36 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

37

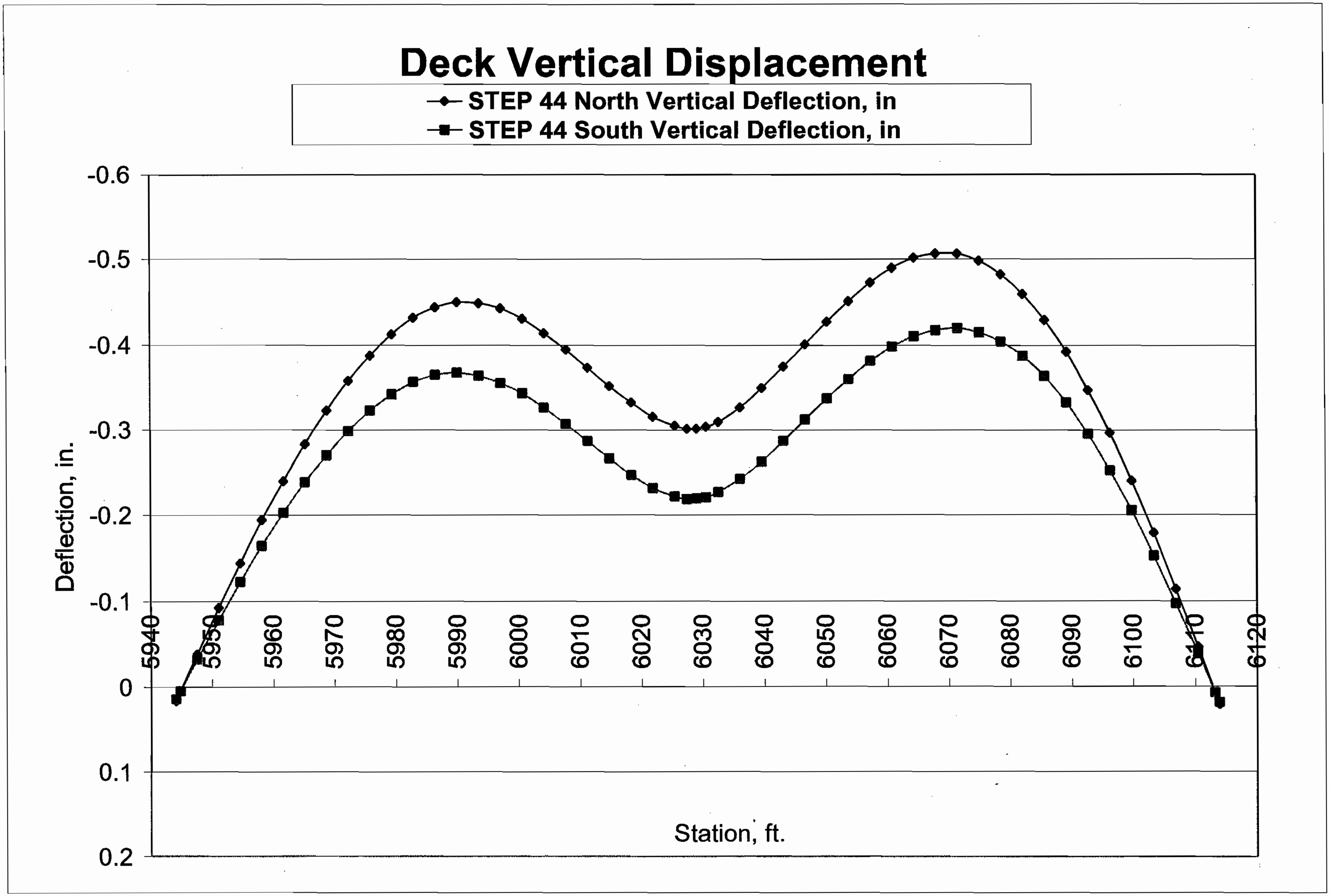


Deck Vertical Displacement
STEP 39 North Vertical Deflection, in
STEP 39 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

38

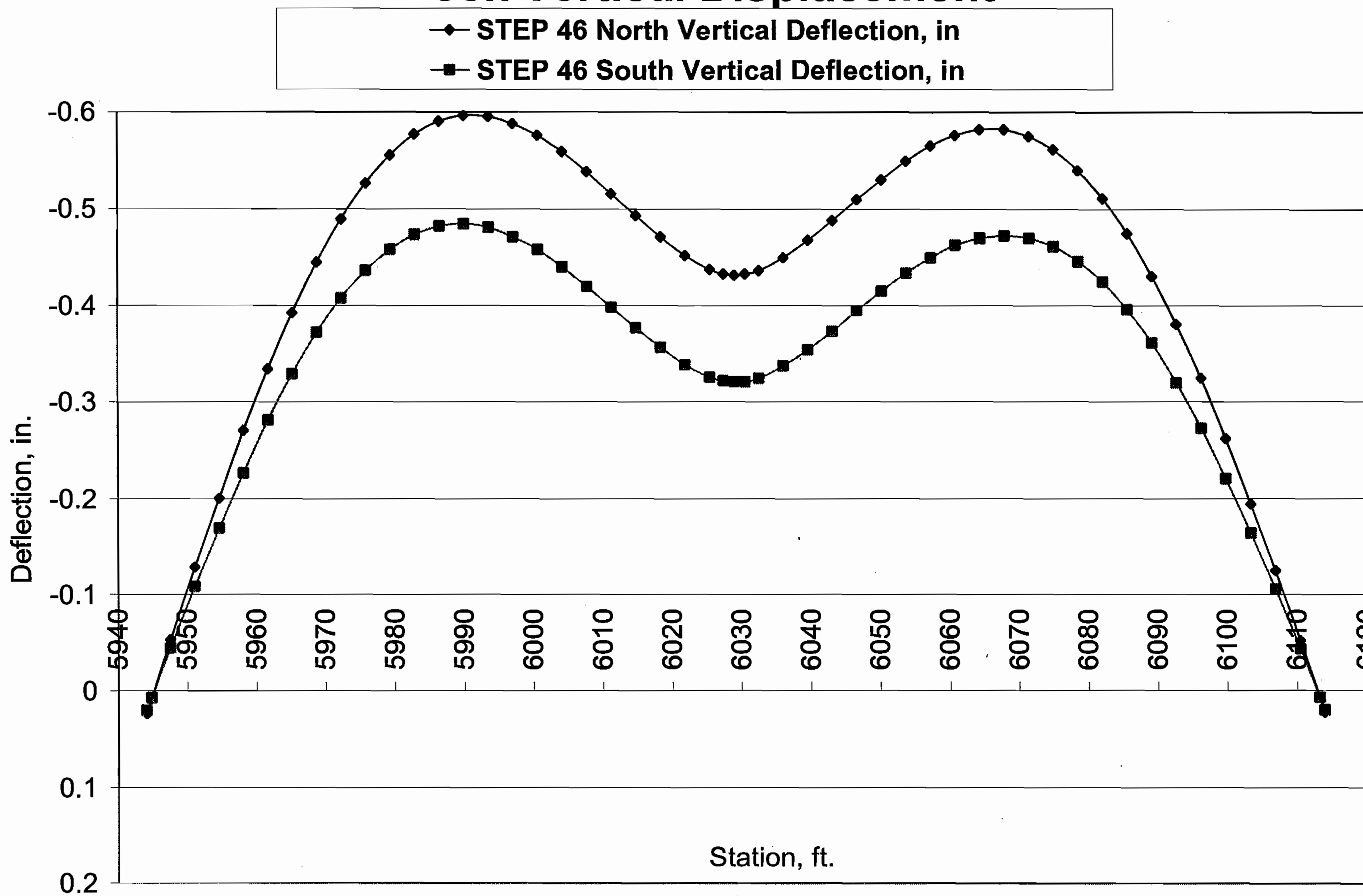


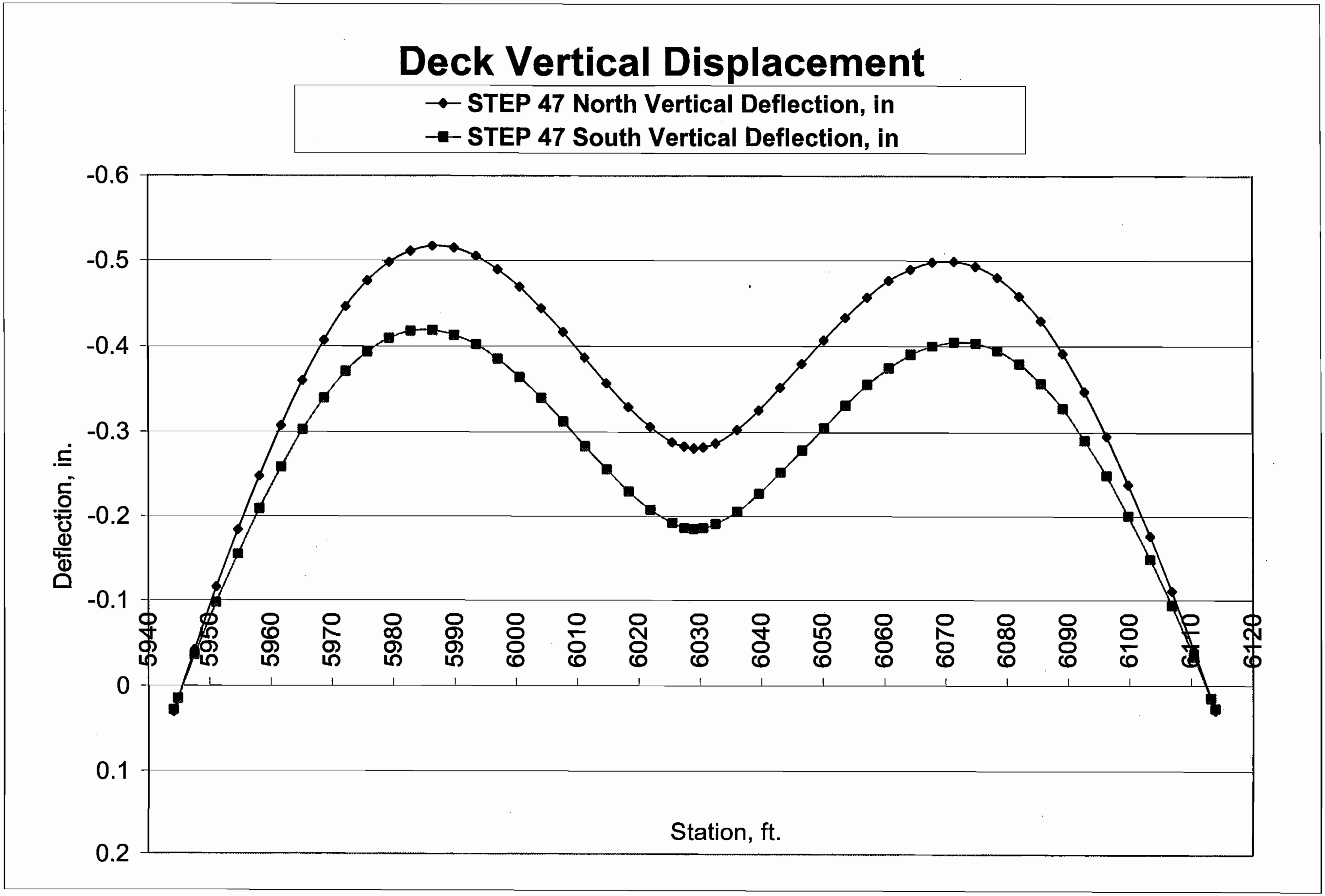
Deck Vertical Displacement
STEP 42 North Vertical Deflection, in
STEP 42 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.



Deck Vertical Displacement
STEP 44 North Vertical Deflection, in
STEP 44 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

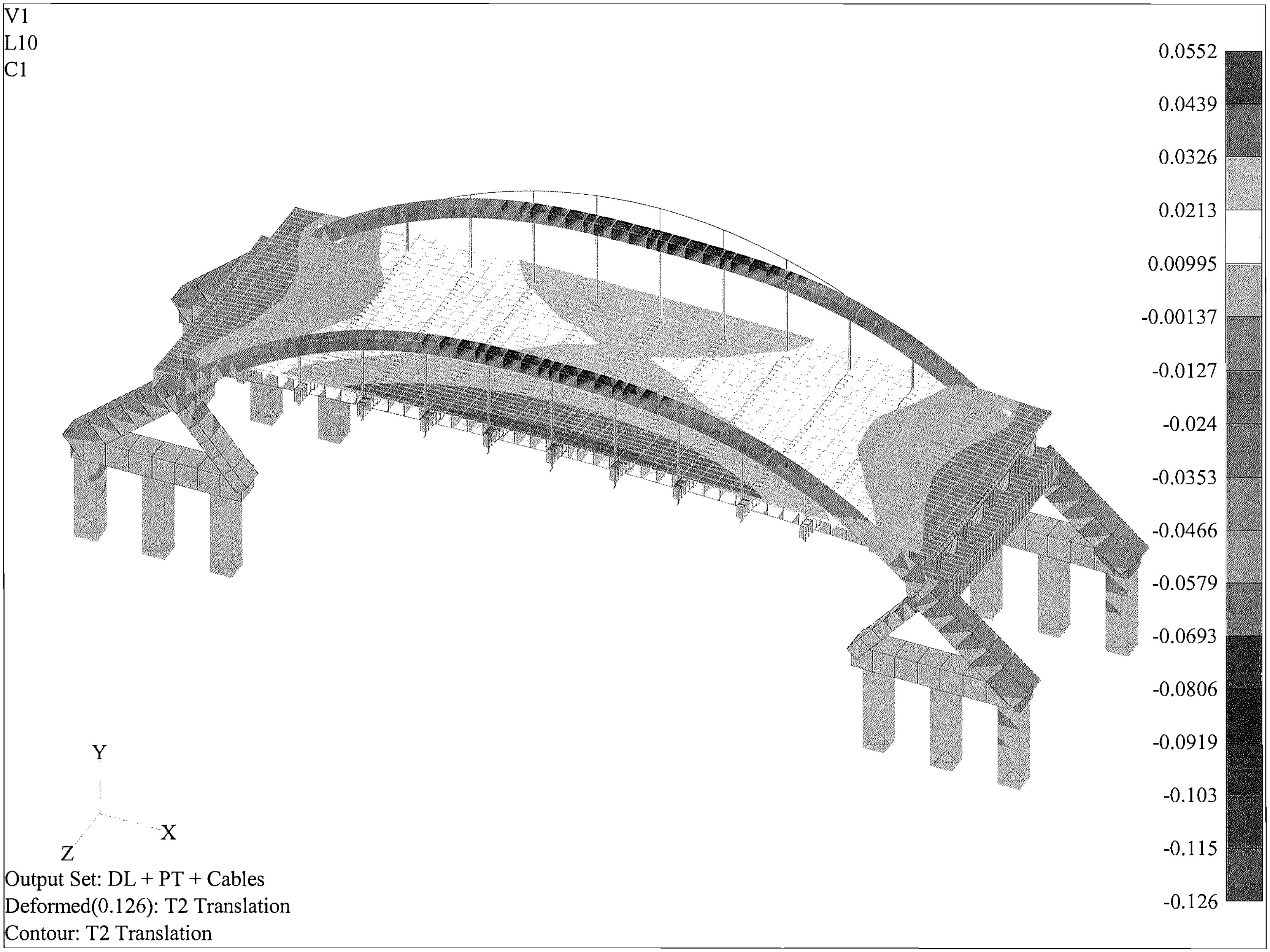
Deck Vertical Displacement



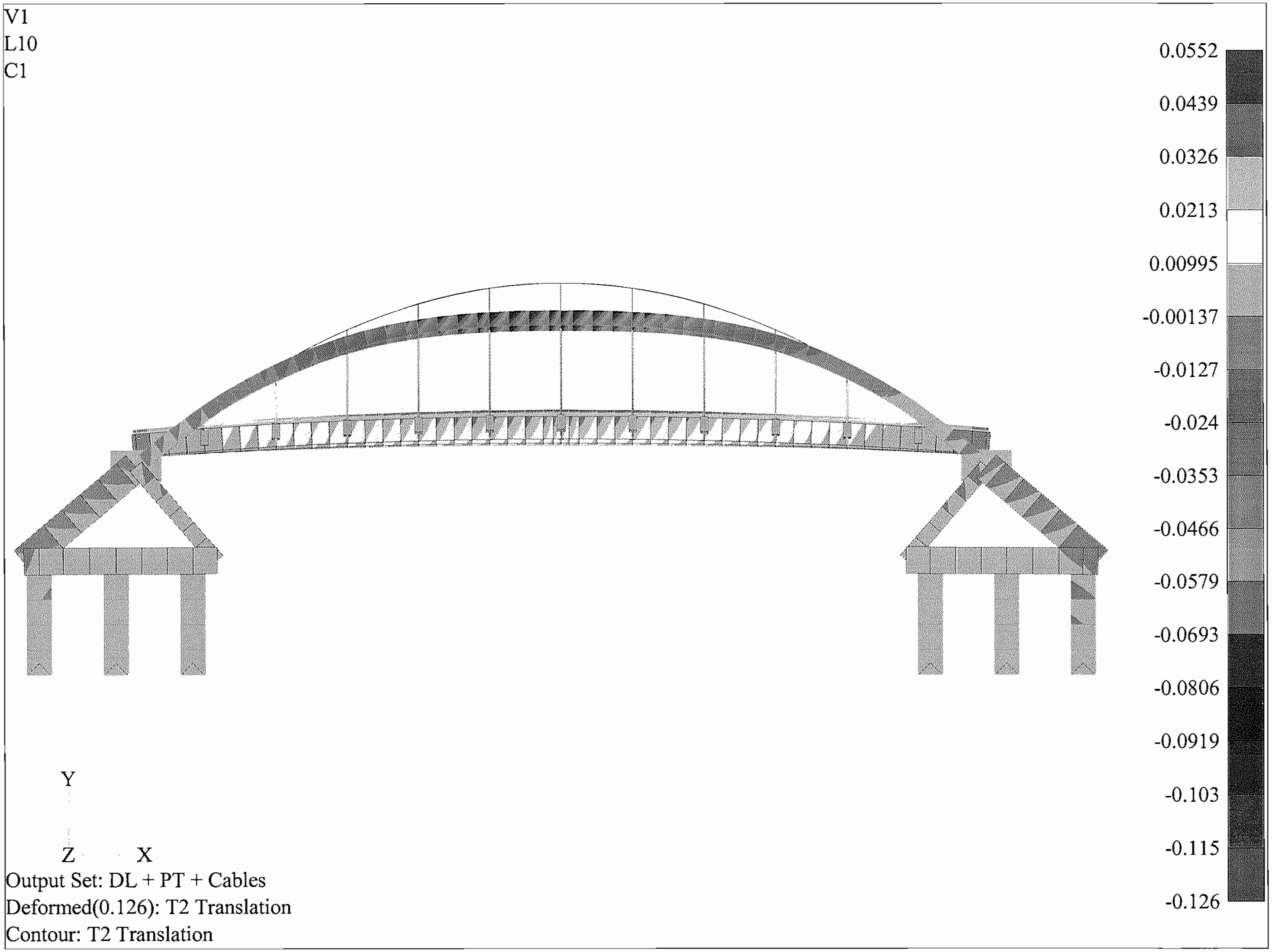

Deck Vertical Displacement
STEP 47 North Vertical Deflection, in
STEP 47 South Vertical Deflection, in
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
Deflection, in.
5940
5950
5960
5970
5980
5990
6000
6010
6020
6030
6040
6050
6060
6070
6080
6090
6100
6110
6120
Station, ft.

STARDYNE DEFLECTIONS

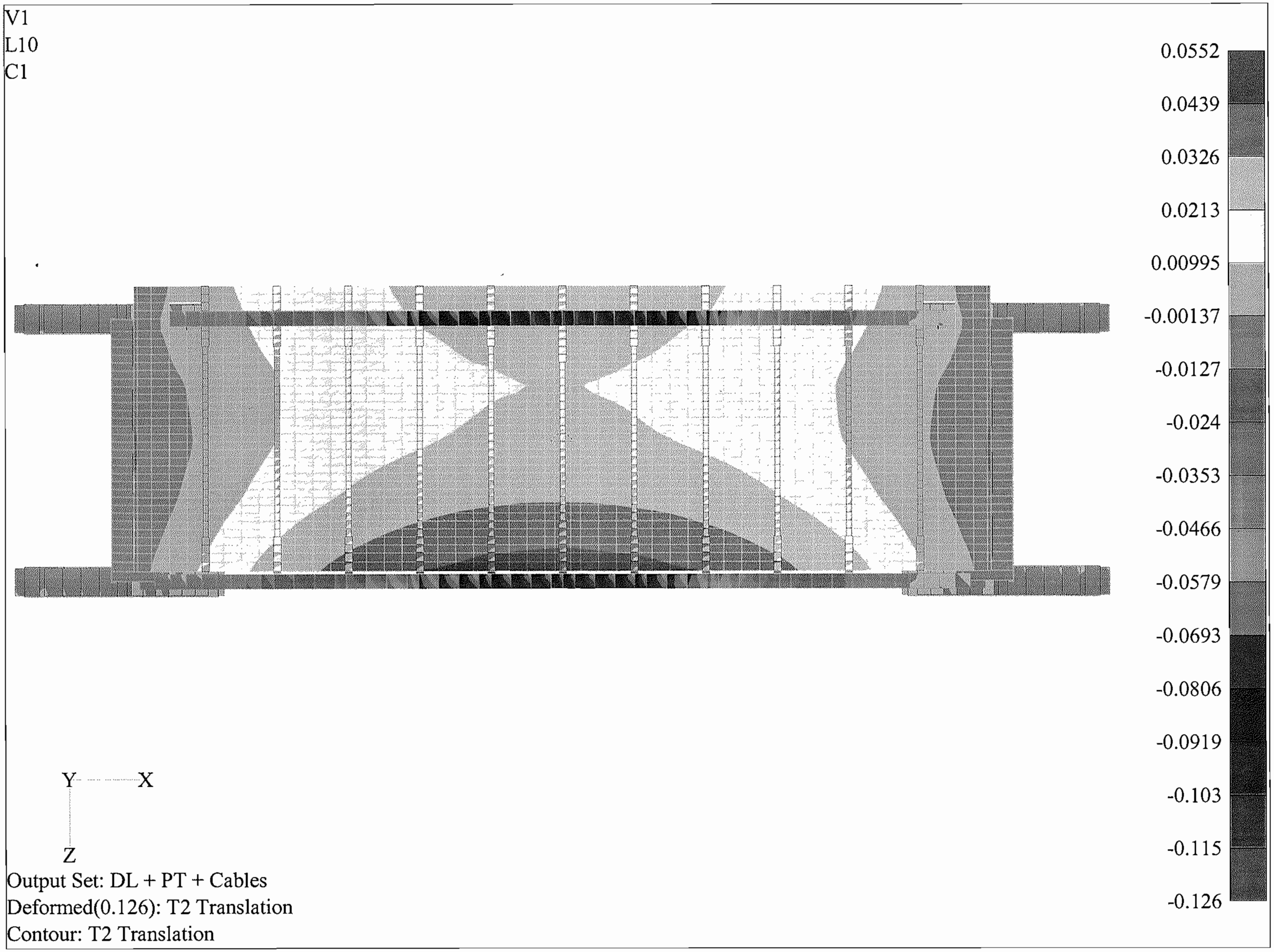
Stardyne Model: Vertical Deflection (ft)



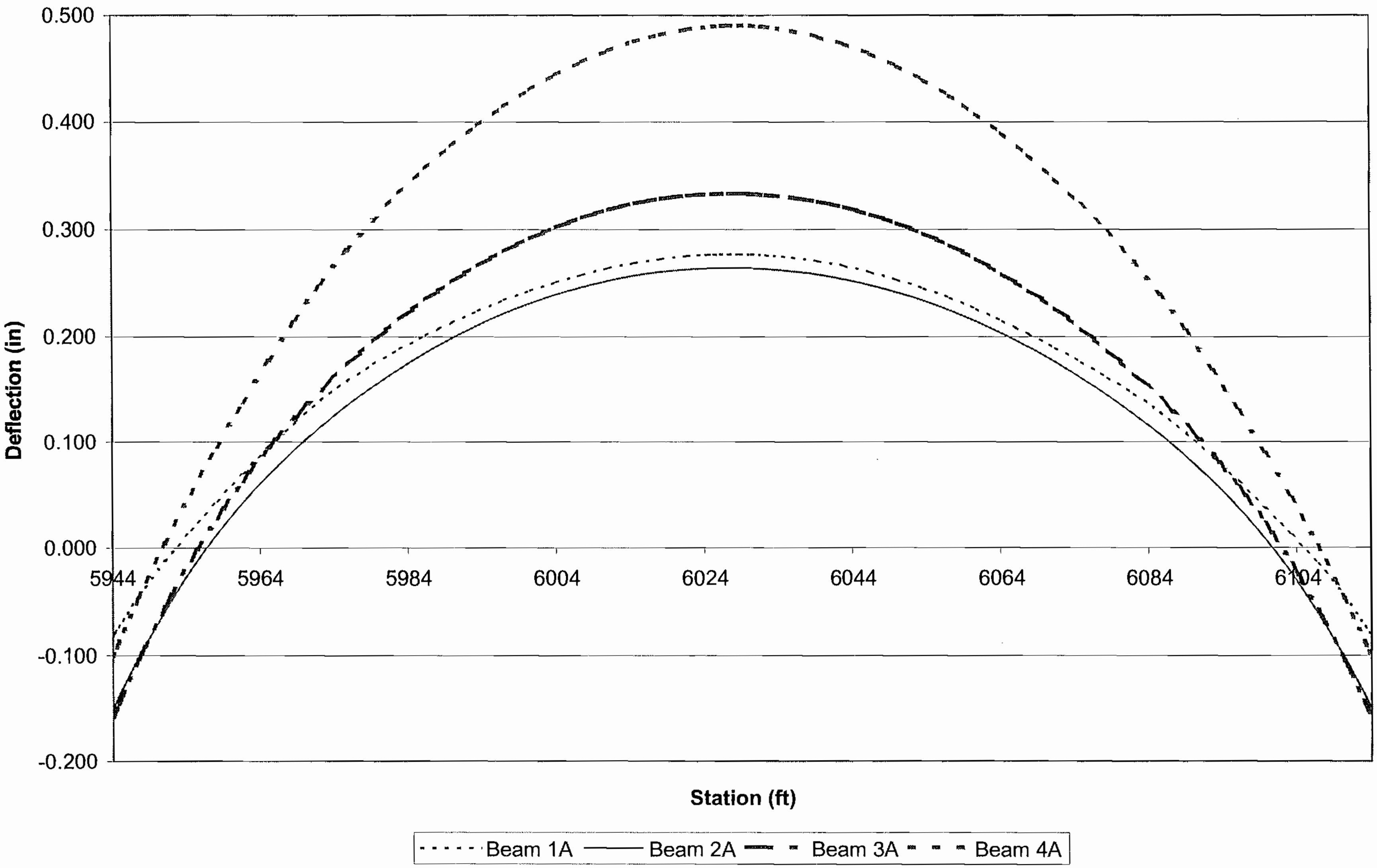
Stardyne Model: Vertical Deflection (ft)

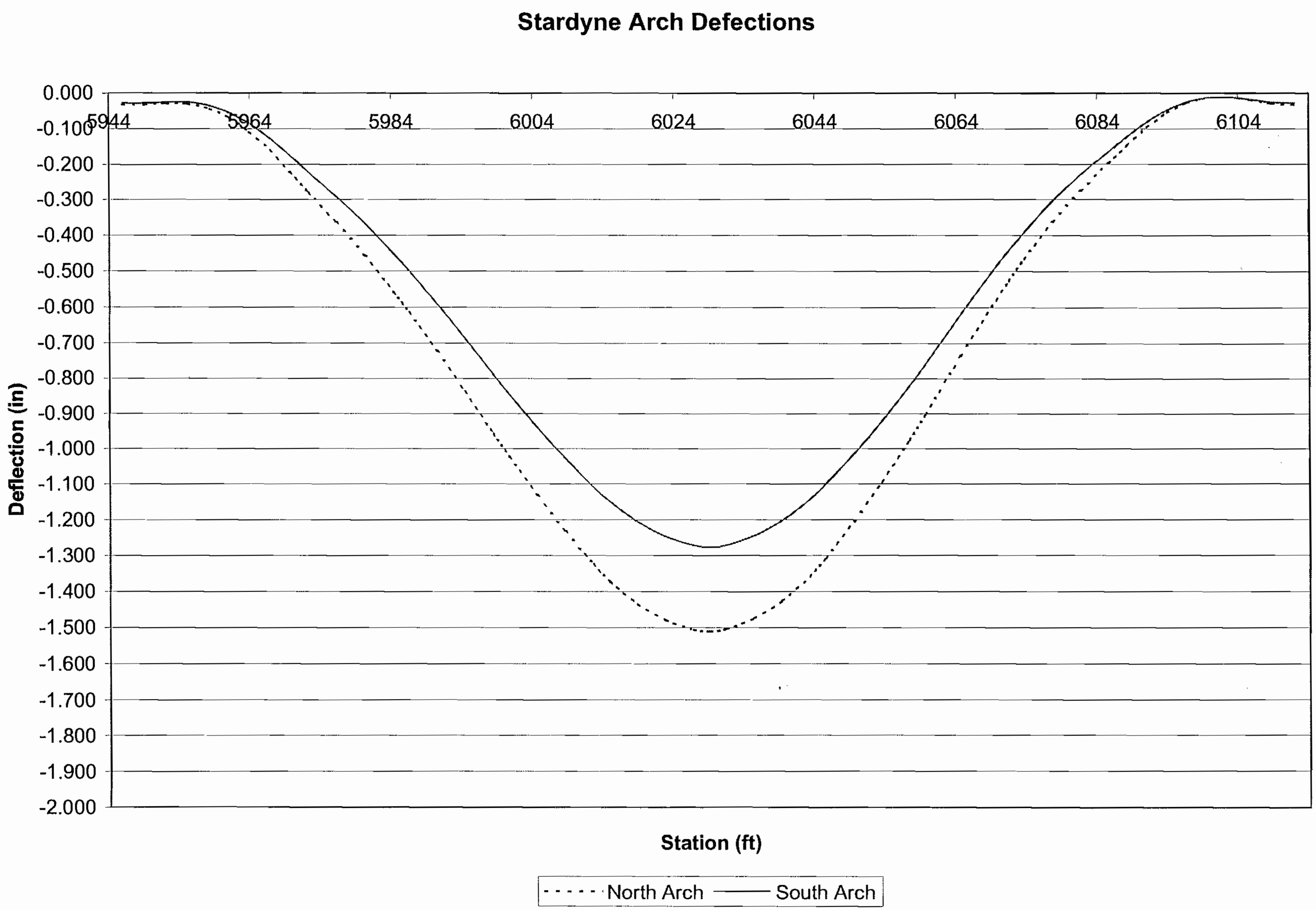


Stardyne Model: Vertical Deflection (ft)



Stardyne Beam Defections




Stardyne Arch Defections
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
-0.700
-0.800
-0.900
-1.000
-1.100
-1.200
-1.300
-1.400
-1.500
-1.600
-1.700
-1.800
-1.900
-2.000
5944
5964
5984
6004
6024
6044
6064
6084
6104
Deflection (in)
Station (ft)
North Arch
South Arch

STARDYNE – BRUCO CABLE FORCE AND SUPPORT REACTION COMPARISON

Arapaho

BRUCO - Stardyne Cable Force Comparison *

NORTH CABLES

Cable	BRUCO Force (kips)	Stardyne Force (kips)	Δ Force (kips)	Δ (%)
1N	149.5	147.1	-2.4	-1.6
2N	80.0	76.4	-3.6	-4.5
3N	108.5	107.6	-0.9	-0.8
4N	106.9	110.1	3.2	3.0
5N	123.4	124.4	1.0	0.8
6N	111.1	113.4	2.3	2.1
7N	115.8	114.3	-1.5	-1.3
8N	71.1	68.2	-2.9	-4.1
9N	142.3	141.2	-1.1	-0.8

SOUTH CABLES

Cable	BRUCO Force (kips)	Stardyne Force (kips)	Δ Force (kips)	Δ (%)
1S	118.5	120.6	2.1	1.7
2S	61.9	61.5	-0.4	-0.6
3S	85.1	88.4	3.3	3.9
4S	84.6	88.5	3.9	4.7
5S	103.7	108.2	4.5	4.3
6S	89.5	89.4	-0.1	-0.1
7S	90.8	94.8	4.0	4.4
8S	54.8	56.6	1.8	3.2
9S	112.9	114.4	1.5	1.3

* CABLE FORCES WERE INPUT INTO STARDYNE TO MATCH BRUCO FORCES

Arapaho Cable Strucuture

BRUCO - Stardyne Support Reaction Comparison

North Side of Structure - West End

	BRUCO Reactions (kips)	Stardyne Reactions (kips)	Δ Reaction (kips)	Δ Reaction (%)
Rear Thrust Location	1279.3	1291.3	12.0	
Middle Location	189.5	176.5	-13.0	
Forward Location	-75.3	-71.7	3.6	
TOTAL	1393.5	1396.1	2.6	0.19

North Side of Structure - East End

	BRUCO Reactions (kips)	Stardyne Reactions (kips)	Δ Reaction (kips)	Δ Reaction (%)
Rear Thrust Location	1281.4	1293.7	12.3	
Middle Location	190.9	177.9	-13.0	
Forward Location	-80.9	-76.8	4.1	
TOTAL	1391.4	1394.8	3.4	0.24

South Side of Structure - West End

	BRUCO Reactions (kips)	Stardyne Reactions (kips)	Δ Reaction (kips)	Δ Reaction (%)
Rear Thrust Location	1090.2	1121.8	31.6	
Middle Location	181.6	170.7	-10.9	
Forward Location	0.9	-27.4	-28.3	
TOTAL	1272.7	1265.1	-7.6	-0.60

South Side of Structure - East End

	BRUCO Reactions (kips)	Stardyne Reactions (kips)	Δ Reaction (kips)	Δ Reaction (%)
Rear Thrust Location	1091.8	1123.8	32.0	
Middle Location	182.6	171.8	-10.8	
Forward Location	-3.2	-31.6	-28.4	
TOTAL	1271.2	1264.0	-7.2	-0.57

MATERIAL PROPERTIES

BRUCO DATA

CONCRETE PROPERTIES FOR U54 BEAM
6000 PSI CONCRETE

		BRUCO UNITS (ft & kips):
STRENGTH:	$fc = 6000\,psi$	$fc = 864\,ksf$
MODULUS OF ELASTICITY:	$E := 57000\cdot\sqrt{fc\cdot psi}$	$E = 635789\,ksf$
DENSITY:	$w = 150\,pcf$	$w = 0.15\,kcf$
POISSON'S RATIO:	$\nu = 0.20$	$\nu = 0.20$
COEFFICIENT OF THERMAL EXPANSION:	$\alpha = 0.000006\,F^{-1}$	$\alpha = 0.000006\,F^{-1}$
ALLOWABLE TENSION:		
$\sigma_{tens} := 3\cdot\sqrt{\frac{fc}{psi}}\cdot psi$	$\sigma_{tens} = 232.379\,psi$	$\sigma_{tens} = 33.463\,ksf$
ALLOWABLE COMPRESSION:		
$\sigma_{comp} := 0.4\cdot fc$	$\sigma_{comp} = 2400\,psi$	$\sigma_{comp} = 345.6\,ksf$
**SHRINKAGE STRAIN:	$\varepsilon s1 = 0.00032$	$\varepsilon s1 = 0.00032$
**BASIC COEFFICIENT OF CREEP:	$\phi_{f1} = 2.0$	$\phi_{f1} = 2.0$
**DELAYED ELASTIC DEFORMATION (t = 0):	$\beta_1 = 0.108$	$\beta_1 = 0.108$
**DELAYED ELASTIC DEFORMATION (t = ∞):	$\beta_2 = 0.40$	$\beta_2 = 0.40$
**HALFWAY TIME:	$t = 30\,days$	$t = 30\,days$
CEMENT:	$Z = 1.0$	$Z = 1.0$

** SEE FOLLOWING PAGE.

BRUCO DATA

CONCRETE PROPERTIES FOR DIAPHRAGMS & BENT CAP
5000 PSI CONCRETE

		BRUCO UNITS (ft & kips):
STRENGTH:	$fc = 5000\,psi$	$fc = 720\,ksf$
MODULUS OF ELASTICITY:	$E := 57000\cdot\sqrt{fc\cdot psi}$	$E = 580393\,ksf$
DENSITY:	$w = 150\,pcf$	$w = 0.15\,kcf$
POISSON'S RATIO:	$\nu = 0.20$	$\nu = 0.20$
COEFFICIENT OF THERMAL EXPANSION:	$\alpha = 0.000006\,F^{-1}$	$\alpha = 0.000006\,F^{-1}$
ALLOWABLE TENSION:		
$\sigma_{tens} := 3\cdot\sqrt{\frac{fc}{psi}}\cdot psi$	$\sigma_{tens} = 212.132\,psi$	$\sigma_{tens} = 30.547\,ksf$
ALLOWABLE COMPRESSION:		
$\sigma_{comp} := 0.4\cdot fc$	$\sigma_{comp} = 2000\,psi$	$\sigma_{comp} = 288\,ksf$
**SHRINKAGE STRAIN:	$\varepsilon s1 = 0.00032$	$\varepsilon s1 = 0.00032$
**BASIC COEFFICIENT OF CREEP:	$\phi_{f1} = 2.0$	$\phi_{f1} = 2.0$
**DELAYED ELASTIC DEFORMATION (t = 0):	$\beta_1 = 0.108$	$\beta_1 = 0.108$
**DELAYED ELASTIC DEFORMATION (t = ∞):	$\beta_2 = 0.40$	$\beta_2 = 0.40$
**HALFWAY TIME:	$t = 30\,days$	$t = 30\,days$
CEMENT:	$Z = 1.0$	$Z = 1.0$

** SEE FOLLOWING PAGE.

BRUCO DATA

CONCRETE PROPERTIES FOR DECK
4000 PSI CONCRETE

		BRUCO UNITS (ft & kips):
STRENGTH:	$fc = 4000\,psi$	$fc = 576\,ksf$
MODULUS OF ELASTICITY:	$E := 57000 \cdot \sqrt{fc \cdot psi}$	$E = 519120\,ksf$
DENSITY:	$w = 150\,pcf$	$w = 0.15\,kcf$
POISSON'S RATIO:	$\nu = 0.20$	$\nu = 0.20$
COEFFICIENT OF THERMAL EXPANSION:	$\alpha = 0.000006\,F^{-1}$	$\alpha = 0.000006\,F^{-1}$
ALLOWABLE TENSION:		
$\sigma_{tens} := 3 \cdot \sqrt{\frac{fc}{psi}} \cdot psi$	$\sigma_{tens} = 189.737\,psi$	$\sigma_{tens} = 27.322\,ksf$
ALLOWABLE COMPRESSION:		
$\sigma_{comp} := 0.4 \cdot fc$	$\sigma_{comp} = 1600\,psi$	$\sigma_{comp} = 230.4\,ksf$
**SHRINKAGE STRAIN:	$\varepsilon s1 = 0.00032$	$\varepsilon s1 = 0.00032$
**BASIC COEFFICIENT OF CREEP:	$\phi_{f1} = 2.0$	$\phi_{f1} = 2.0$
**DELAYED ELASTIC DEFORMATION (t = 0):	$\beta_1 = 0.108$	$\beta_1 = 0.108$
**DELAYED ELASTIC DEFORMATION (t = ∞):	$\beta_2 = 0.40$	$\beta_2 = 0.40$
**HALFWAY TIME:	$t = 30\,days$	$t = 30\,days$
CEMENT:	$Z = 1.0$	$Z = 1.0$

** SEE FOLLOWING PAGE.

BRUCO DATA

CONCRETE PROPERTIES FOR DRILLED SHAFT
3600 PSI CONCRETE

		BRUCO UNITS (ft & kips):
STRENGTH:	$fc = 3600\,psi$	$fc = 518.4\,ksf$
MODULUS OF ELASTICITY:	$E := 57000\cdot\sqrt{fc\cdot psi}$	$E = 492480\,ksf$
DENSITY:	$w = 150\,pcf$	$w = 0.15\,kcf$
POISSON'S RATIO:	$\nu = 0.20$	$\nu = 0.20$
COEFFICIENT OF THERMAL EXPANSION:	$\alpha = 0.000006\,F^{-1}$	$\alpha = 0.000006\,F^{-1}$
ALLOWABLE TENSION:		
$\sigma_{tens} := 3\cdot\sqrt{\frac{fc}{psi}}\cdot psi$	$\sigma_{tens} = 180\,psi$	$\sigma_{tens} = 25.92\,ksf$
ALLOWABLE COMPRESSION:		
$\sigma_{comp} := 0.4\cdot fc$	$\sigma_{comp} = 1440\,psi$	$\sigma_{comp} = 207.36\,ksf$
**SHRINKAGE STRAIN:	$\varepsilon s1 = 0.00032$	$\varepsilon s1 = 0.00032$
**BASIC COEFFICIENT OF CREEP:	$\phi_{f1} = 2.0$	$\phi_{f1} = 2.0$
**DELAYED ELASTIC DEFORMATION (t = 0):	$\beta_1 = 0.108$	$\beta_1 = 0.108$
**DELAYED ELASTIC DEFORMATION (t = ∞):	$\beta_2 = 0.40$	$\beta_2 = 0.40$
**HALFWAY TIME:	$t = 30\,days$	$t = 30\,days$
CEMENT:	$Z = 1.0$	$Z = 1.0$

** SEE FOLLOWING PAGE.

BRUCO DATA

0.5" ϕ PRE-STRESSING STRAND PROPERTIES

YOUNG'S MODULUS: $E_{ps} = 28500\,ksi$

STRAND AREA: $As = 0.153000\,in^2$

ULTIMATE STRAND FORCE:

f_{pu} = tensile strength of strand

$f_{pu} = 270\,ksi$ $\quad Pu := f_{pu} \cdot As$ $\quad Pu = 41.31\,kips$

MAXIMUM JACK FORCE:

$Pj := 0.75 \cdot Pu$ $\quad Pj = 31.0\,kips$ $\quad$ (75% ultimate)

MAXIMUM INITIAL TENDON FORCE:

$Pi := 0.75 \cdot Pu$ $\quad Pi = 31.0\,kips$ $\quad$ (75% ultimate)

MINIMUM BENDING RADIUS: $r = 0\,ft$

FRICTION COEFFICIENT: $\mu_s = 0$ $\quad$ (Input a small number in Bruco)

WOBBLE COEFFICIENT:

$K = 0$

BRUCO program multiplies μ and K internally

$$wobble := \frac{K}{\mu_s}$$

$wobble = 0$ $\quad$ (Input a small number in Bruco)

MINIMUM ANCHOR SET: $set = 0.001\,in$

$set = 0.0001\,ft$

RELAXATION COEFFICIENT: $relax := 3 \cdot (0.035)$ $\quad$ (Multiply by 3 for infinity)

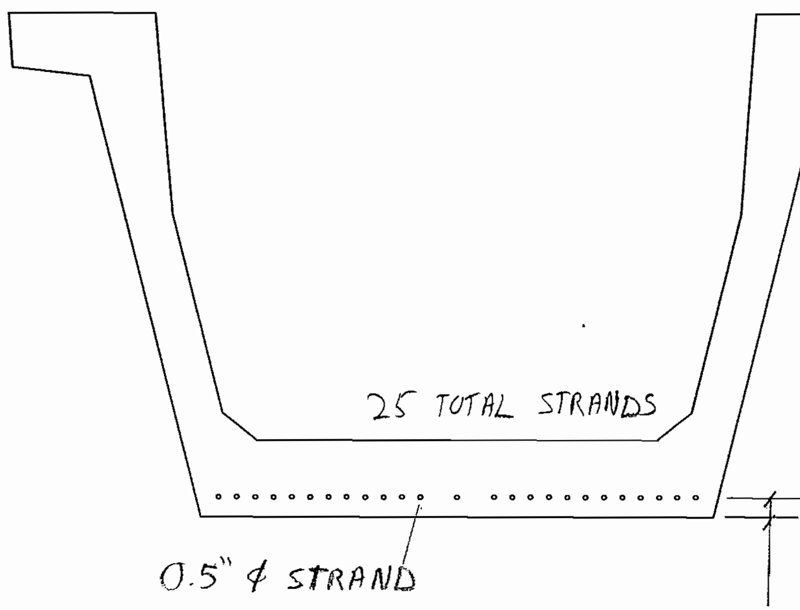
$relax = 0.105$

HALFWAY TIME: $K_{halfway} = 0.20$

MAXIMUM ANCHORAGE FORCE:

$Pa := 0.75 \cdot Pu$ $\quad Pa = 31.0\,kips$ $\quad$ (70% ultimate)

TYPICAL SPAN 9 U54
PRESTRESSING LAYOUT



AREA = 0.153 $in.^2$

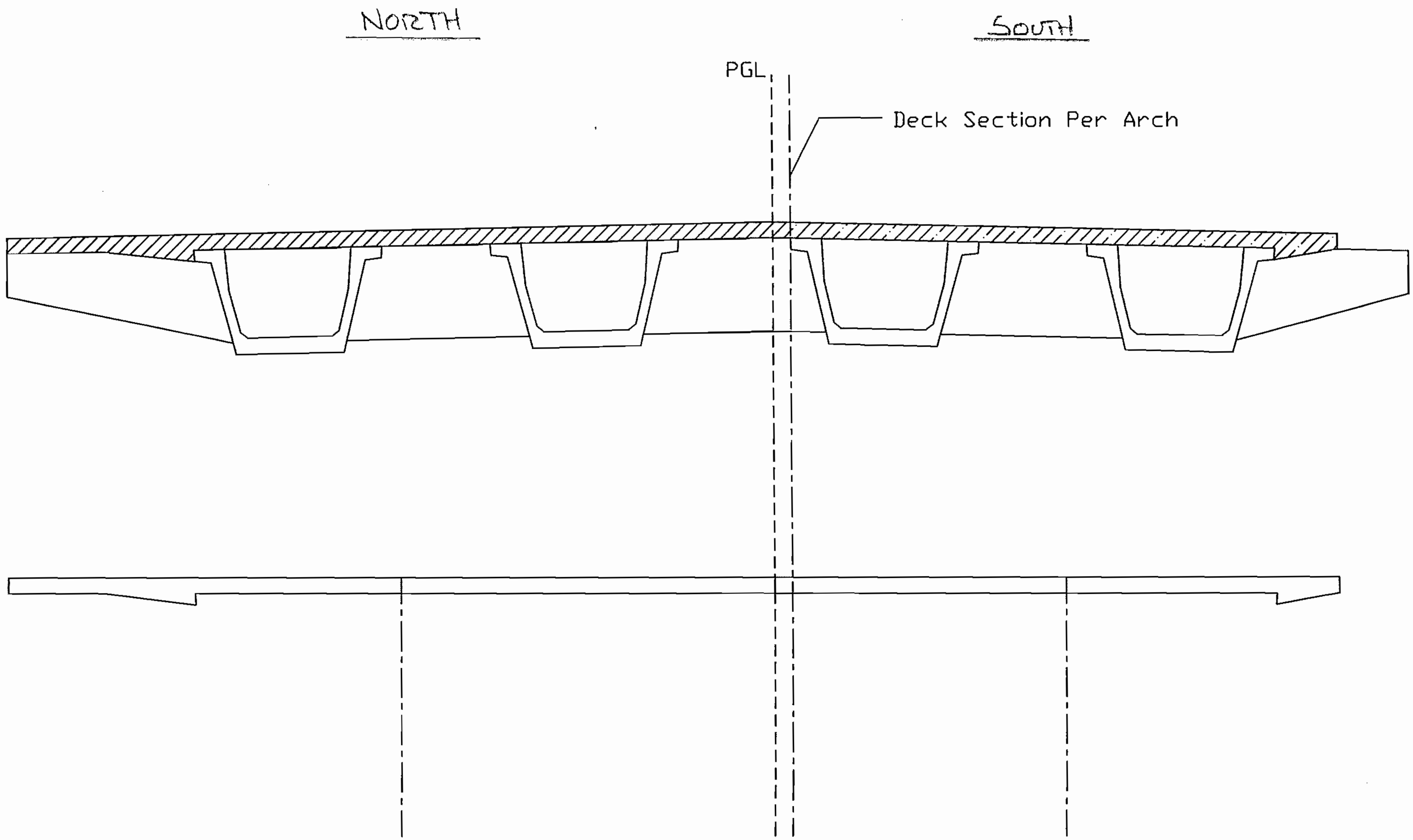
STRESSING FORCE = 31.0 KIPS.

TRANSFER LENGTH = 50 STRAND DIAMETERS

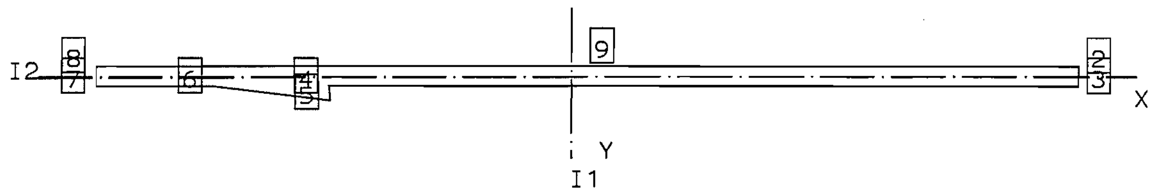
= 50 × 0.5" = 25 in.

= 2.0833 FT

SECTION PROPERTIES



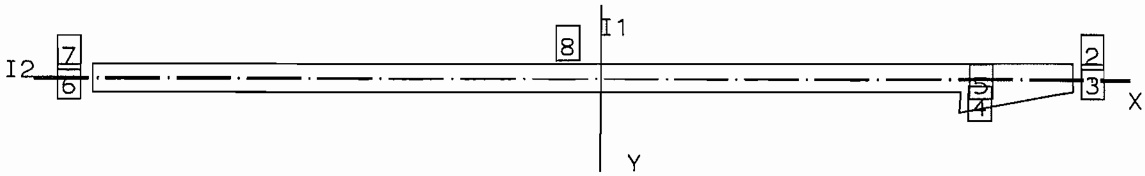
NORTH
SOUTH
PGL
Deck Section Per Arch



		Concrete only	
Area		23.144626	
Centroid	c(x)	-0.436003	
	c(y)	0.353891	
Moment of	I(x)	1.060632	
Inertia	I(y)	2141.031979	
	I(xy)	-4.523479	
	I(1)	2141.041540	
	I(2)	1.051071	
	Angle	89.878889	degr.
RSTRS factor	R(1)	1.572131	
	R(2)	2.371738	

ARAPAHO BRIDGE
DECK CROSS-SECTION (NORTH)
Janssen & Spaans Engineering, inc.
2825 E 56th street
Indianapolis 46220

PROGRAM DSNR (2.50)
PLOT 2; DATE 08/08/2005

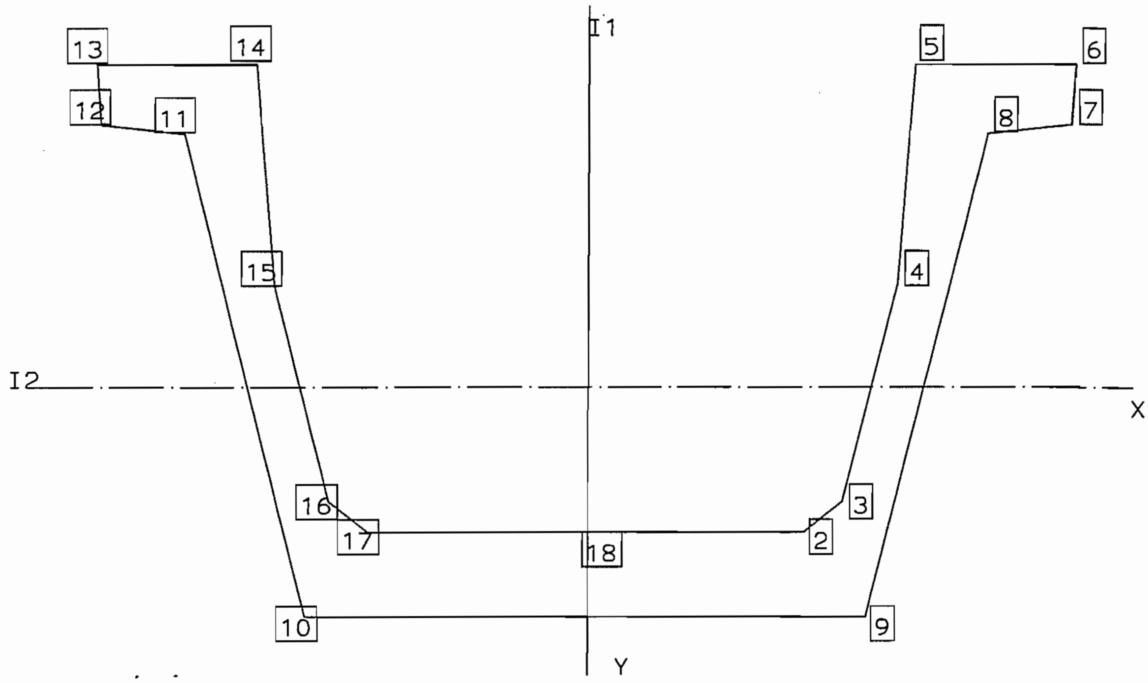


		Concrete only	
Area		16.148546	
Centroid	c(x)	0.400223	
	c(y)	0.353387	
Moment of	I(x)	0.736650	
Inertia	I(y)	758.687631	
	I(xy)	3.034880	
	I(1)	758.699783	
	I(2)	0.724499	
	Angle	-89.770589	degr.
RSTRS factor	R(1)	1.537496	
	R(2)	2.256625	

ARAPAHO BRIDGE
DECK CROSS-SECTION (SOUTH)

Janssen & Spaans Engineering, inc.
2825 E 56th street
Indianapolis 46220

PROGRAM DSNR (2.50)
PLOT 3; DATE 08/08/2005

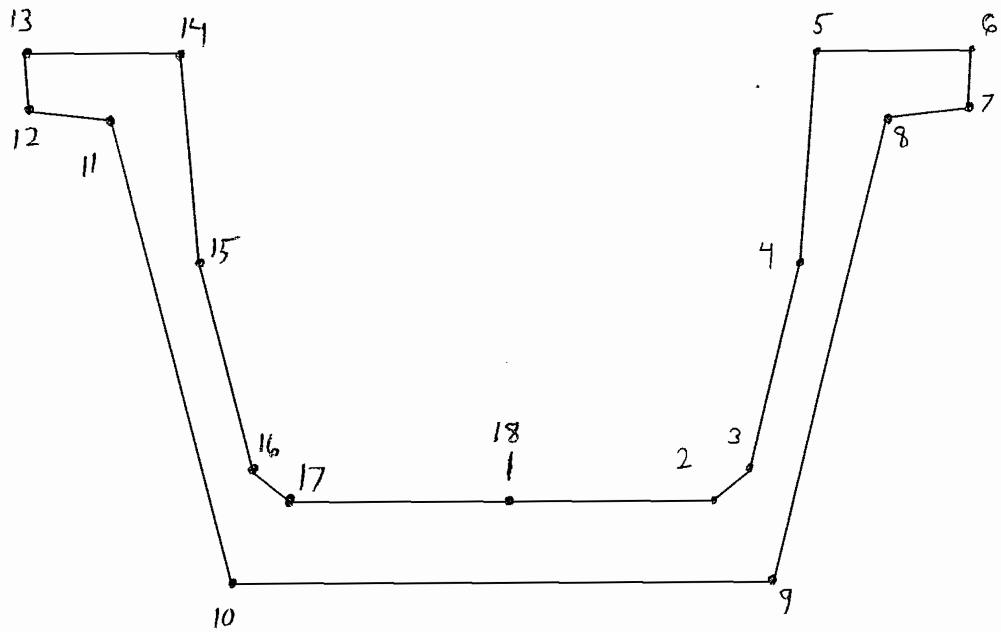


		Concrete only	
Area		7.814925	
Centroid	c(x)	0.000003	
	c(y)	2.630837	
Moment of	I(x)	19.509021	
Inertia	I(y)	44.079824	
	I(xy)	0.000026	
	I(1)	44.079824	
	I(2)	19.509021	
	Angle	-89.999940	degr.
RSTRS factor	R(1)	2.174584	
	R(2)	2.630762	

ARAPAHO BRIDGE
U54 BEAM CROSS-SECTION
Janssen & Spaans Engineering, inc.
2825 E 56th street
Indianapolis 46220

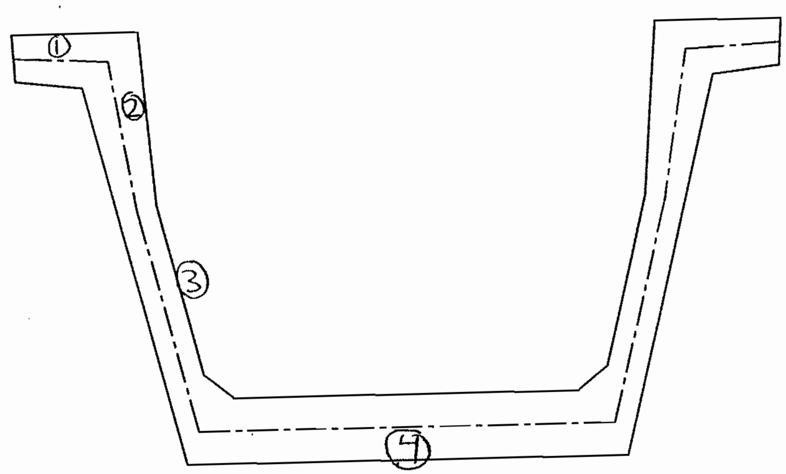
PROGRAM DSNR (2.50)
PLOT 1; DATE 21/07/2005

U54 BEAM



	X	Y
1	0	3.8125
2	1.7848	3.8125
3	2.0977	3.5625
4	2.5424	1.7928
5	2.6875	0
6	4.0000	0
7	3.9687	0.4896
8	3.2812	0.5625
9	2.2917	4.5000
10	-2.2917	4.5000
11	-3.2812	0.5625
12	-3.9687	0.4896
13	-4.0000	0
14	-2.6875	0
15	-2.5424	1.7928
16	-2.0977	3.5625
17	-1.7848	3.8125
18	0	3.8125

U54 BEAM



TORSIONAL CONSTANT (J)

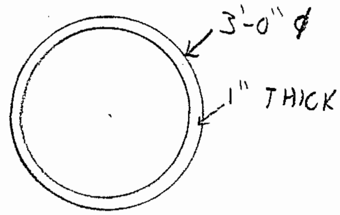
$= \sum \frac{1}{3} bt^3$

SECTION	b	t	$\sum \frac{1}{3} bt^3$
①	0.980'	0.544'	$2 \times \frac{1}{3}(0.980')(0.544')^3 = 0.105$
②	1.570'	0.548'	$2 \times \frac{1}{3}(1.570')(0.548')^3 = 0.166$
③	2.385'	0.417'	$2 \times \frac{1}{3}(2.385')(0.417')^3 = 0.115$
④	4.327'	0.688'	$\frac{1}{3}(4.327')(0.688')^3 = 0.470$
TOTAL			$0.856\ FT^4$

CROSS-SECTION PROPERTIES

ARCH RIB

3'-0" ϕ PIPE 1" WALL THICKNESS



$A = \pi[(1.5')^2 - (1.4167')^2] = 0.7636\ FT^2$

$I = \frac{1}{4}\pi[(1.5')^4 - (1.4167')^4] = 0.8123\ FT^4$

$C_T = C_B = 1.5\ FT$

RSTRS = 1.5

THRUST BLOCK : 3 SECTIONS

6'-0" x 5'-6" :

$A = 33 FT^2$

$I = \frac{1}{12}(5.5')(6.0')^3 = 99\ FT^4$

$C_T = C_B = 3.0\ FT$

RSTRS = 1.5

3'-0" x 5'-6" :

$A = 16.5 FT^2$

$I = \frac{1}{12}(5.5')(3.0')^3 = 12.375\ FT^4$

$C_T = C_B = 1.5\ FT$

RSTRS = 1.5

5'-4" x 6'-0" :

$A = 32\ FT^2$

$I = \frac{1}{12}(6.0')(5.333')^3 = 75.84\ FT^4$

$C_T = C_B = 2.667\ FT$

RSTRS = 1.5

PROJECT:	COMPUTED BY:	DATE: / /	JOB NUMBER:
	CHECKED BY:	DATE: / /	SHEET A-15 OF

CROSS-SECTION PROPERTIES

DIAPHRAGM: 3 SECTIONS

2.917' × 1.5':

$A = 4.376\ FT^2$

$I_x = \frac{1}{12}(1.5')(2.917')^3 = 3.103\ FT^4$

$I_y = \frac{1}{12}(2.917')(1.5')^3 = 0.820\ FT^4$

$J = C_2 a b^3$

$a = 2.917'$

$b = 1.5'$

$a/b = 1.915 \Longrightarrow C_2 = 0.223$

$J = 0.223(2.917')(1.5')^3 = 2.195\ FT^4$

4' × 1.5':

$A = 6.000\ FT^2$

$I_x = \frac{1}{12}(1.5')(4')^3 = 8.000\ FT^4$

$I_y = \frac{1}{12}(4')(1.5')^3 = 1.125\ FT^4$

$J = C_2 a b^3$

$a = 4'$

$b = 1.5'$

$a/b = 2.667 \Longrightarrow C_2 = 0.254$

$J = 0.254(4.000')(1.5')^3 = 3.429\ FT^4$

4' × 1':

$A = 4.000\ FT^2$

$I_x = \frac{1}{12}(1')(4')^3 = 5.333\ FT^4$

$I_y = \frac{1}{12}(4')(1')^3 = 0.333\ FT^4$

$J = C_2 a b^3$

$a = 4'$

$b = 1'$

$a/b = 4 \Longrightarrow C_2 = 0.281$

$J = 0.281(4.000')(1.0')^3 = 1.124\ FT^4$

PROJECT:	COMPUTED BY:	DATE: / /	JOB NUMBER:
	CHECKED BY:	DATE: / /	SHEET A-16 OF

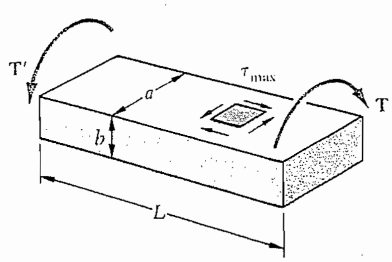


Fig. 3.47

The determination of the stresses in noncircular members subjected to a torsional loading is beyond the scope of this text. However, results obtained from the mathematical theory of elasticity for straight bars with a *uniform rectangular cross section* will be indicated here for convenience.† Denoting by L the length of the bar, by a and b, respectively, the wider and narrower side of its cross section, and by T the magnitude of the torques applied to the bar (Fig. 3.47), we find that the maximum shearing stress occurs along the center line of the *wider* face of the bar and is equal to

$$\tau_{max} = \frac{T}{c_1 ab^2} \tag{3.43}$$

The angle of twist, on the other hand, may be expressed as

$$\phi = \frac{TL}{c_2 ab^3 G} \tag{3.44}$$

The coefficients c_1 and c_2 depend only upon the ratio a/b and are given in Table 3.1 for a number of values of that ratio. Note that Eqs. (3.43) and (3.44) are valid only within the elastic range.

Table 3.1 Coefficients for Rectangular Bars in Torsion

a/b	c_1	c_2
1.0	0.208	0.1406
1.2	0.219	0.1661
1.5	0.231	0.1958
2.0	0.246	0.229
2.5	0.258	0.249
3.0	0.267	0.263
4.0	0.282	0.281
5.0	0.291	0.291
10.0	0.312	0.312
∞	0.333	0.333

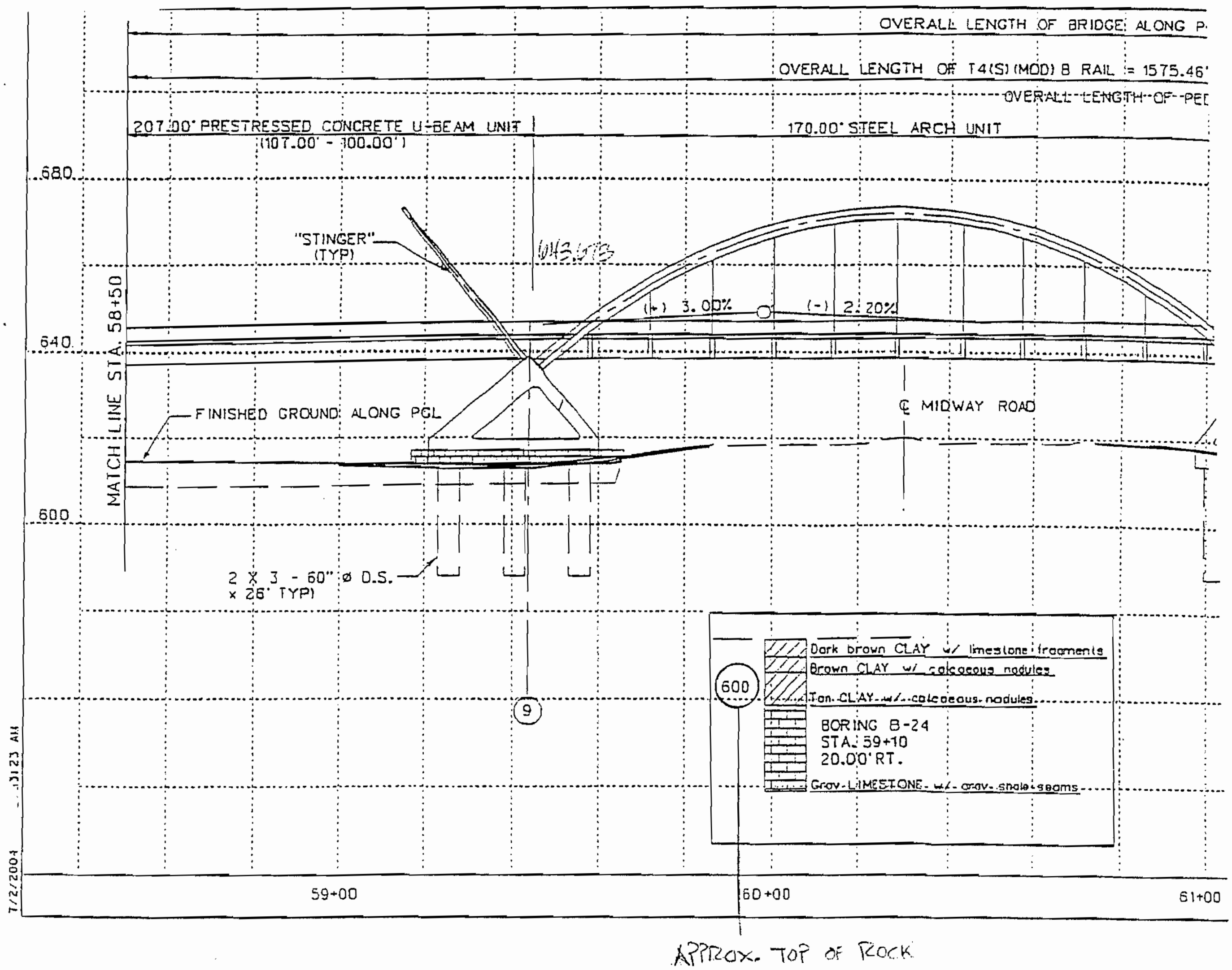
We note from Table 3.1 that for $a/b \geq 5$, the coefficients c_1 and c_2 are equal. It may be shown that for such values of a/b, we have

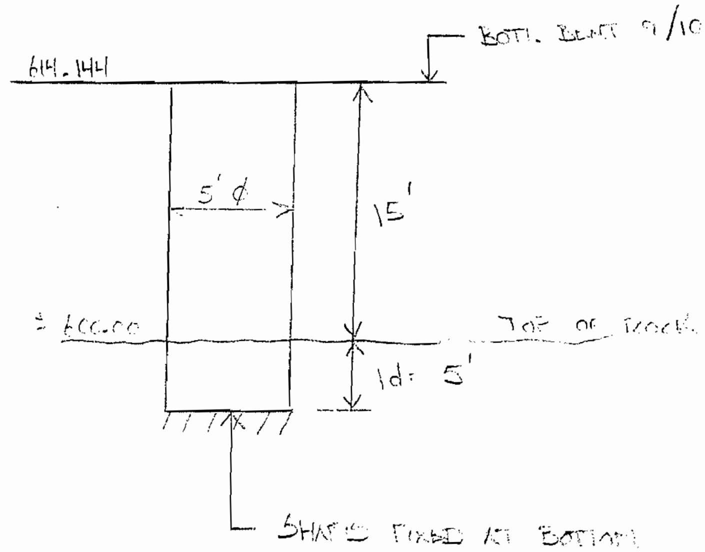
$$c_1 = c_2 = \tfrac{1}{3}(1 - 0.630b/a) \qquad (\textit{for } a/b \geq 5 \textit{ only}) \tag{3.45}$$

The distribution of shearing stresses in a noncircular member may be visualized more easily by using the *membrane analogy*. A homogeneous elastic membrane attached to a fixed frame and subjected to a uniform pressure on one of its sides happens to constitute an *analog* of the bar in torsion, i.e., the determination of the deformation of the membrane depends upon the solution of the same partial differential equation as the

†See S. P. Timoshenko and J. N. Goodier, *Theory of Elasticity*, 3d ed., McGraw-Hill, New York, 1970, sec. 109.

DRILLED SHAFT PROPERTIES



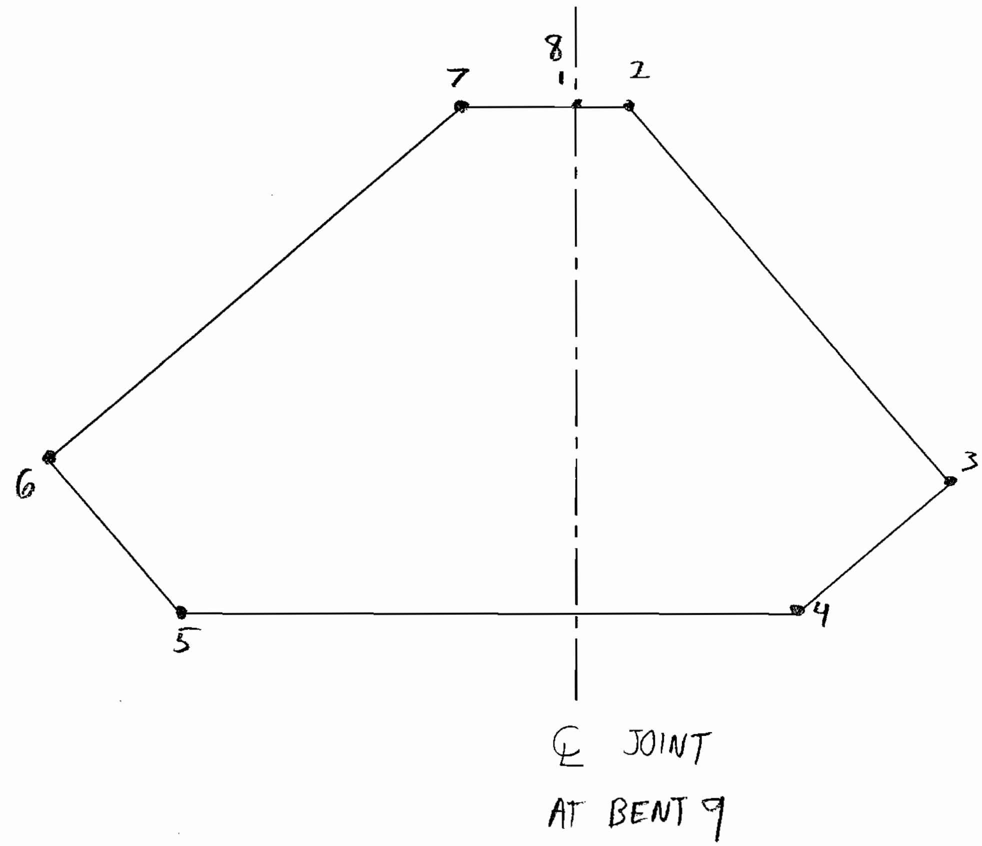


$A = \dfrac{\pi (5.0)^2}{4} = 19.635 \text{ FT}^2$

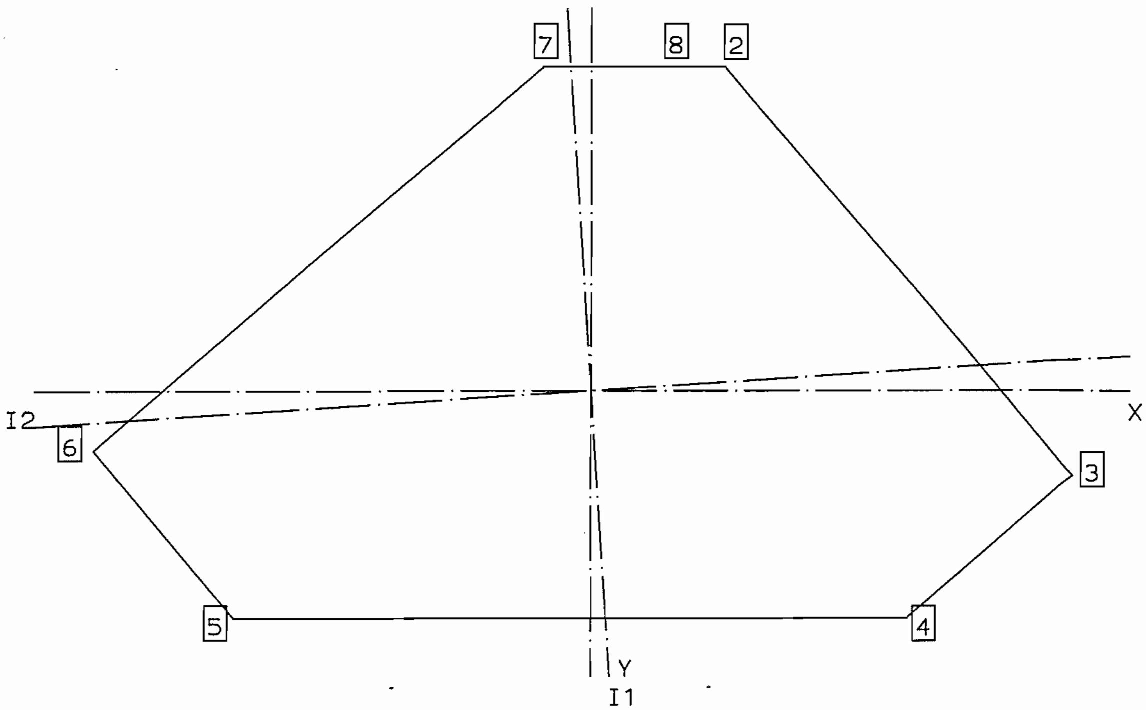
$I = \dfrac{\pi (5.0)^4}{64} = 30.680 \text{ FT}^4$

$C_T = C_B = 2.5'$

TRANSVERSE THRUST BLOCK TIE



	X	Y
1	0	0
2	0.594	0
3	4.157	4.188
4	2.443	5.646
5	-4.421	5.646
6	-5.885	3932
7	-1.265	0
8	0	0



		Concrete only	
Area		37.649136	
Centroid	c(x)	-0.780469	
	c(y)	3.318044	
Moment of	I(x)	76.809969	
Inertia	I(y)	189.589297	
	I(xy)	-7.258222	
	I(1)	190.054501	
	I(2)	76.344765	
	Angle	86.332737	degr.
RSTRS factor	R(1)	1.241681	
	R(2)	1.269752	

ARAPAHO BRIDGE
TRANASVERSE THRUST BLOCK TIE
Janssen & Spaans Engineering, inc.
2825 E 56th street
Indianapolis 46220

PROGRAM DSNR (2.50)
PLOT 4; DATE 25/07/2005

A-20

LOADS

LOADS

HAUNCH

WIDTH OF U-BEAM FLANGE = $15\frac{3}{4}''$

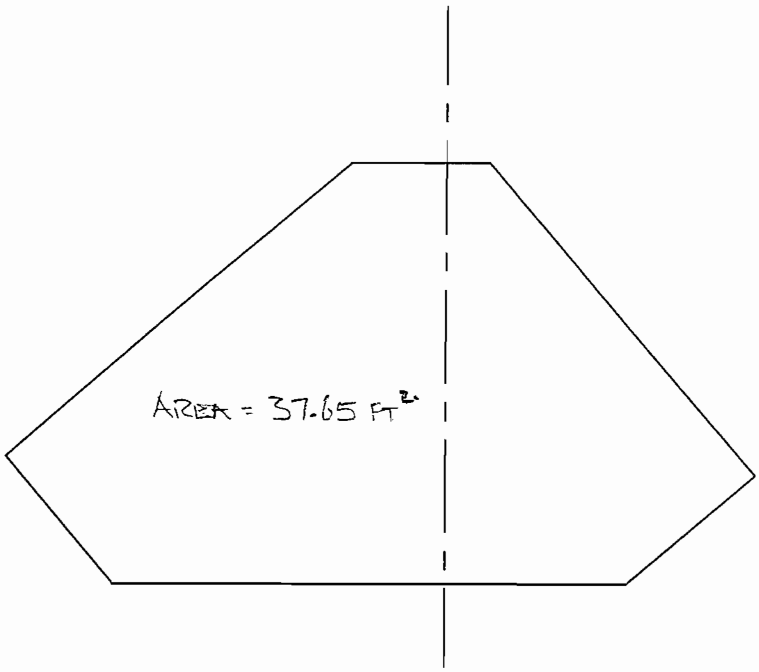
ASSUME HAUNCH THICKNESS = $1\frac{1}{2}''$

$WT = [(15.75'')(1.5'')/144\ in^2/FT] \times 0.150\ K/FT^3 = 0.025\ KLF$

4 HAUNCHES : $4 \times 0.025\ KLF = 0.1\ KLF$

PROJECT:	COMPUTED BY:	DATE: / /	JOB NUMBER:
	CHECKED BY:	DATE: / /	SHEET A-22 OF

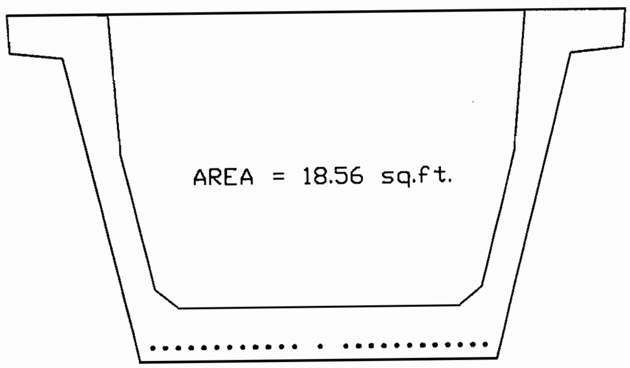
PIER TRANSVERSE BEAM



$W_t = 37.65\ FT^2 \times 23.50' \times 0.15\ KCF = \underline{132.7\ K}$

PROJECT:	COMPUTED BY:	DATE: / /	JOB NUMBER:
	CHECKED BY:	DATE: / /	SHEET A-23 OF

PRECAST DIAPHRAGM LOADS



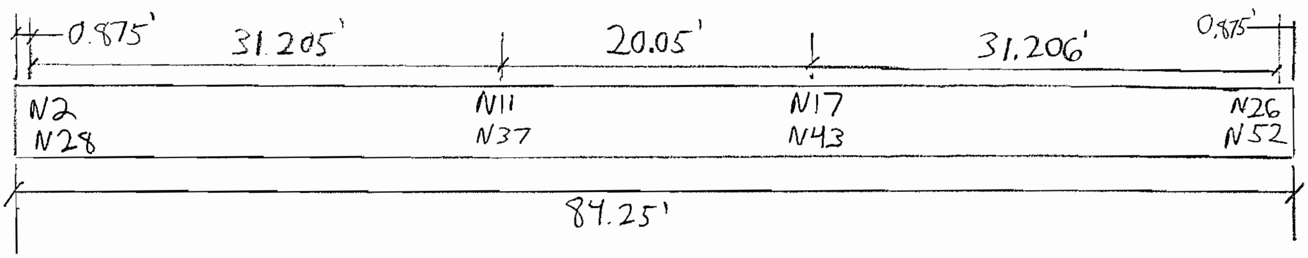
END DIAPHRAGMS

Wt. = 18.56 ft^2 × 1.75' × 0.15 Kcf × 2 BEAMS = **9.74 K**

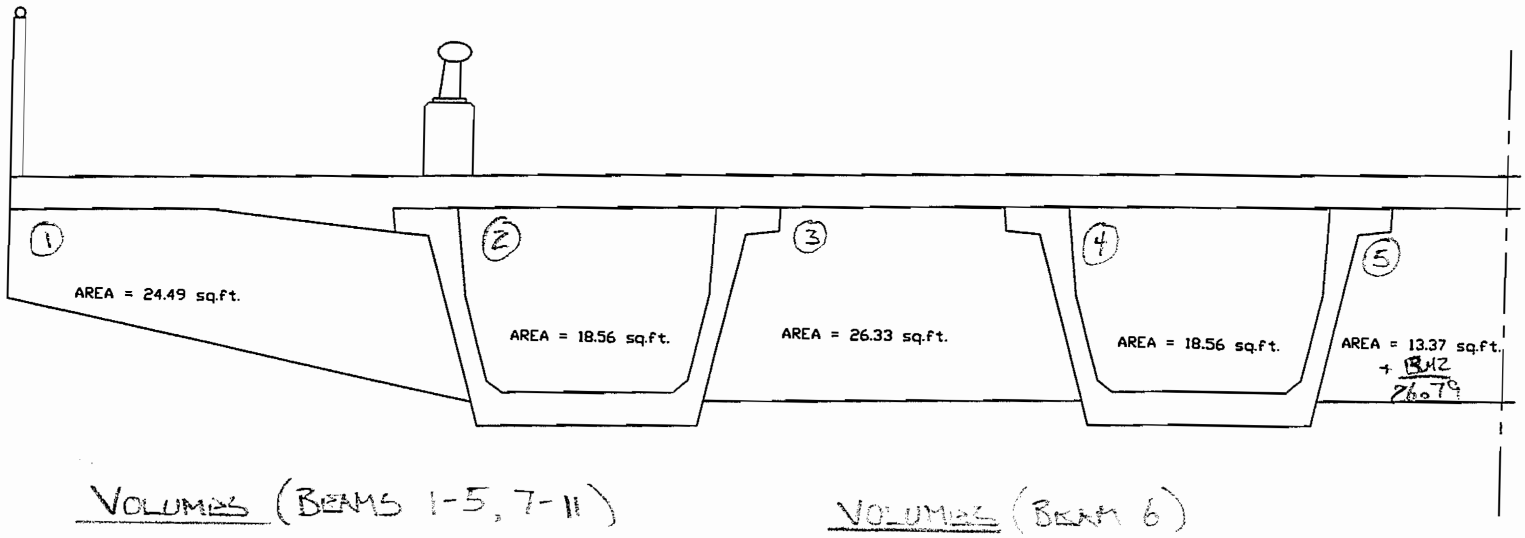
INTERMEDIATE DIAPHRAGMS

Wt. = 18.56 ft^2 × 0.50' × 0.15 Kcf × 2 BEAMS = **2.78 K**

DIAPHRAGM SPACING



LEFT (NORTH) TRANSVERSE DIAPHRAGMS



VOLUMES (BEAMS 1-5, 7-11)

① 24.49 × 1.5 = 36.74

② 18.56 × (1.5+1.0)/2 = 23.20

③ 26.33 × 1.0 = 26.33

④ 18.56 × 1.0 = 18.56

⑤ 13.37 × 1.0 = 26.79

131.62 FT^3

VOLUMES (BEAM 6)

① " "

② 18.56 × 1.5 = 27.84

③ " "

④ " "

⑤

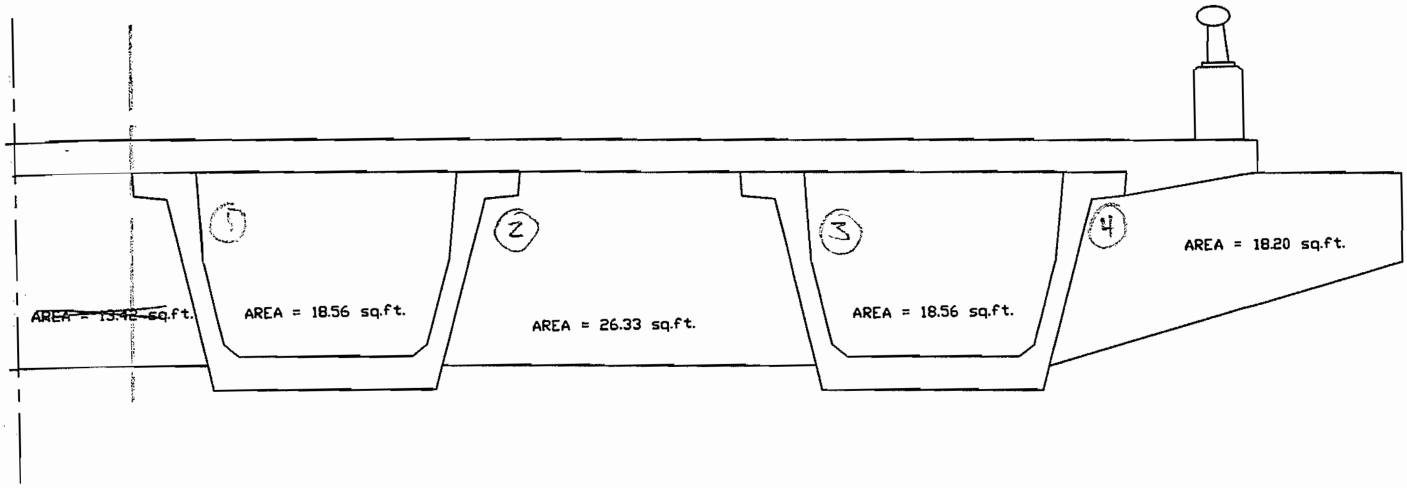
136.26 FT^3

WT

Wt = 131.62 FT^3 × 0.15 Kcf = **19.74 K** (BEAMS 1-5, 7-11)

Wt = 136.26 FT^3 × 0.15 Kcf = **20.44 K** (BEAM 6)

RIGHT (SOUTH) TRANSVERSE DIAPHRAGMS



VOLUMES (BEAMS 1-5, 7-11)

(1) 18.56 × 1.0 = 18.56
(2) 26.33 × 1.0 = 26.33
(3) $18.56 \times \left(\frac{1.0+1.5}{2}\right) = 23.20$
(4) 18.20 × 1.5 = 27.30

95.39 FT^3

VOLUMES (BEAM 6)

(1) " "
(2) " "
(3) 18.56 × 1.5 = 27.84
(4) " "

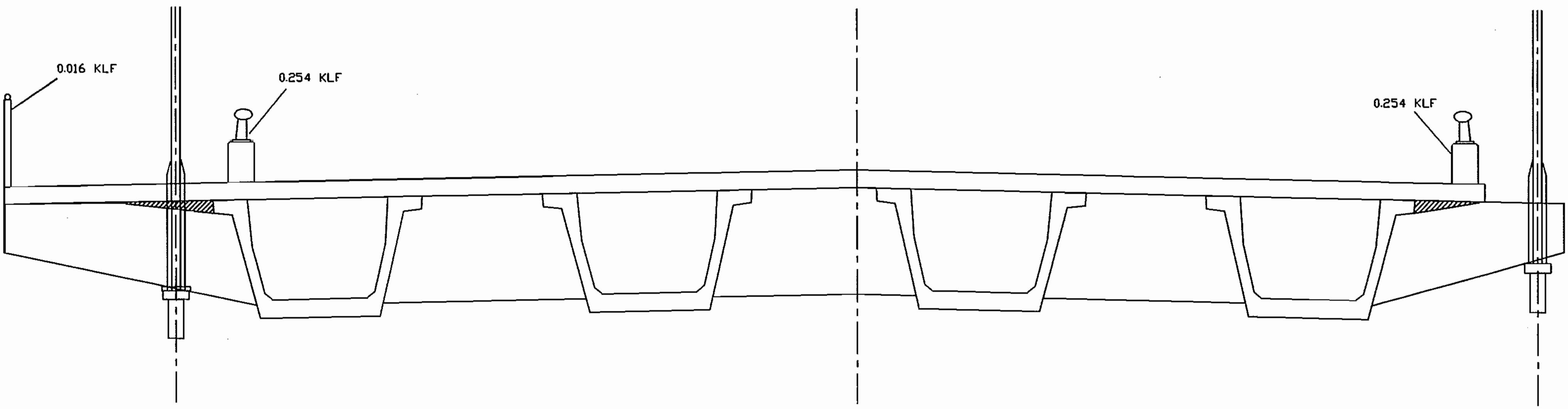
100.03 FT^3

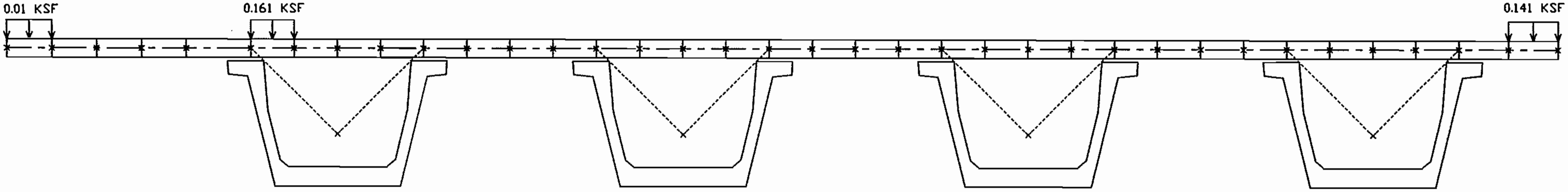
WT

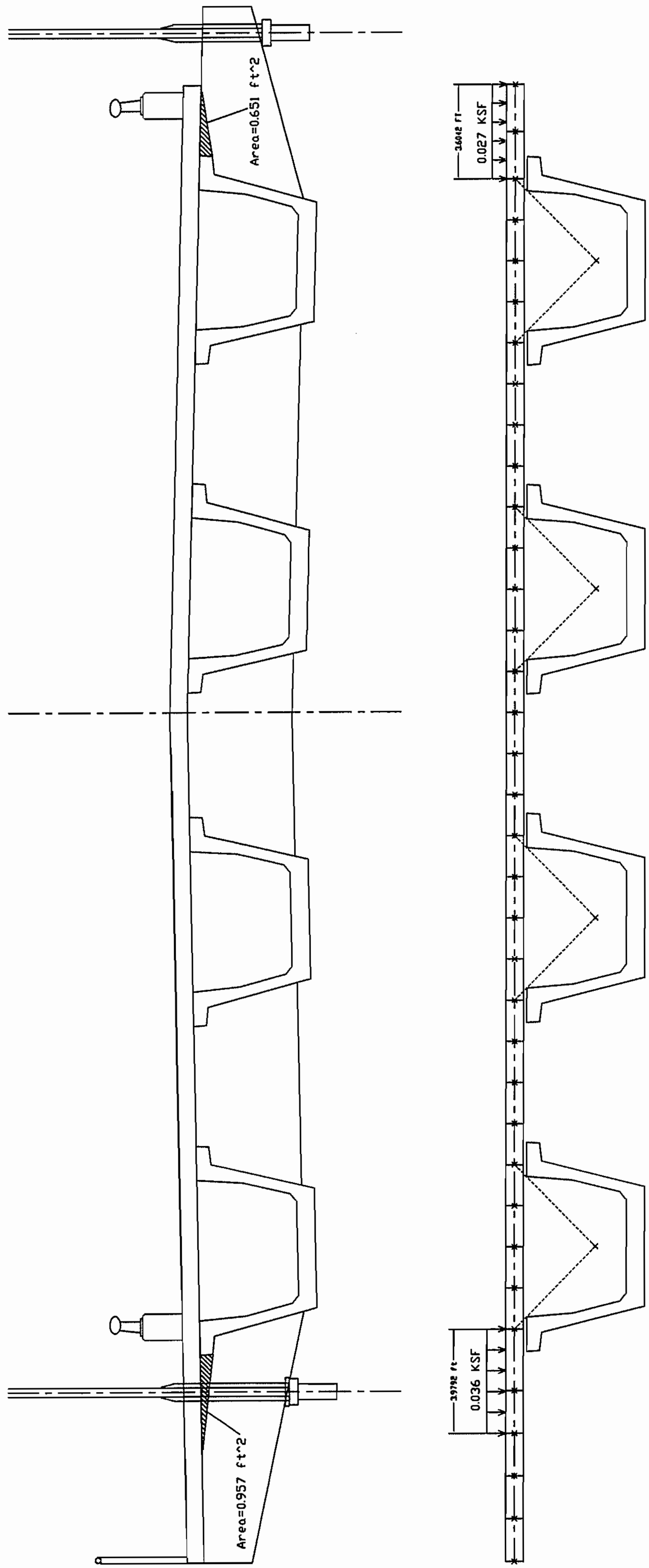
W_T = 95.39 FT^3 × 0.15 KCF = **14.31 K** (BEAMS 1-5, 7-11)

W_T = 100.03 FT^3 × 0.15 KCF = **15.00 K**

BARRIER LOADS







Area=0.651 ft^2
3.6042 ft
0.027 KSF
3.9792 ft
0.036 KSF
Area=0.957 ft^2

STARMAP Version 4.41 Tue Jul 26 09:14:46 2005
Model : p:\674-ar~1\star\full.mod Report : Element
Format : STARDYNE Bar/Beam Element

Output Set 4 - TOTAL Dead Load

B E A M E L E M E N T L O A D S

BEAM			AXIAL P	SHEAR V2	SHEAR V3	TORSION MT	BENDING M2	BENDING M3	
9101	JA	0.0	-1.414560E+2	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	1.414560E+2	0.	0.	0.	0.	0.	
9102	JA	0.0	-9.186250E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	9.186250E+1	0.	0.	0.	0.	0.	
9103	JA	0.0	-8.845610E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	8.845610E+1	0.	0.	0.	0.	0.	
9104	JA	0.0	-9.095080E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	9.095080E+1	0.	0.	0.	0.	0.	
9105	JA	0.0	-9.218400E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	9.218400E+1	0.	0.	0.	0.	0.	
9106	JA	0.0	-9.094580E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	9.094580E+1	0.	0.	0.	0.	0.	
9107	JA	0.0	-8.862550E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	8.862550E+1	0.	0.	0.	0.	0.	
9108	JA	0.0	-9.199920E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	9.199920E+1	0.	0.	0.	0.	0.	
9109	JA	0.0	-1.410070E+2	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	1.410070E+2	0.	0.	0.	0.	0.	
9201	JA	0.0	-1.114650E+2	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	1.114650E+2	0.	0.	0.	0.	0.	
9202	JA	0.0	-7.555400E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.555400E+1	0.	0.	0.	0.	0.	
9203	JA	0.0	-7.218080E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.218080E+1	0.	0.	0.	0.	0.	
9204	JA	0.0	-7.377050E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.377050E+1	0.	0.	0.	0.	0.	
9205	JA	0.0	-7.456300E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.456300E+1	0.	0.	0.	0.	0.	
9206	JA	0.0	-7.376920E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.376920E+1	0.	0.	0.	0.	0.	
9207	JA	0.0	-7.214460E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.214460E+1	0.	0.	0.	0.	0.	
9208	JA	0.0	-7.543730E+1	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	7.543730E+1	0.	0.	0.	0.	0.	
9209	JA	0.0	-1.118130E+2	0.	0.	0.	0.	0.	BEAMG
	JB	100.0	1.118130E+2	0.	0.	0.	0.	0.	

LOADS

TRAFFIC RAILING (T4S MOD A)

CONCRETE BASE WT: $(1.5\,FT)(1.0\,FT) \times 0.150\,^{K}/_{FT^3} = 0.225\,KLF$

STEEL RAIL: 6" ϕ STD PIPE; WT = 0.019 KLF

MISC STEEL: USE 0.010 KLF

TOTAL RAILING WT: $(0.225 + 0.019 + 0.010)\,KLF = \boxed{0.254\,KLF}$

PEDESTRIAN RAILING (7'-1" SECTION)

2½" Φ STD PIPE:	7.0833' × 5.79 LBS/FT = 41 LBS
3" × 2" × ¼" HSS:	3.2917' × 3.90 LBS/FT = 13 LBS
2" × 1" × ⅛" HSS:	2 × 6.9167' × 2.55 LBS/FT = 35 LBS
½" × ½" SQUARE BAR:	13 × 2.0' × 0.851 LBS/FT = 22 LBS
TOTAL:	111 LBS

WT PER FT: $\frac{111\,LBS}{7.0833'} = 16\,^{LB}/_{FT} = \boxed{0.016\,KLF}$

PROJECT:	COMPUTED BY:	DATE: / /	JOB NUMBER:
	CHECKED BY:	DATE: / /	SHEET A-30 OF

STARDYNE

OVERLAPPING LOADS

PIER TRANSVERSE BEAM

ACTUAL BEAM LENGTH = 47 FT

STARDYNE NODE - NODE DISTANCE = 52 FT

FACTOR CONCRETE DENSITY BY: $\frac{47\,FT}{52\,FT} = 0.9038$

CONCRETE DENSITY = $0.150\ k/FT^3 \times 0.9038 = \boxed{0.136\ k/FT^3}$

TRANSVERSE DIAPHRAGMS

OVERLAP BEAM AREA = $5.46\ FT^2$

EXTRA WEIGHT (APPLY AS POINT LOAD IN THE GLOBAL +Y DIR.)

- BEAMS 1-5, 7-11 (EXTERIOR BEAMS)

$5.46\,FT^2\left(\frac{1'+1.5'}{2}\right) \times 0.150\ k/FT^3 = \underline{\underline{1.02\ k}}$

- BEAMS 1-5, 7-11 (INTERIOR BEAMS)

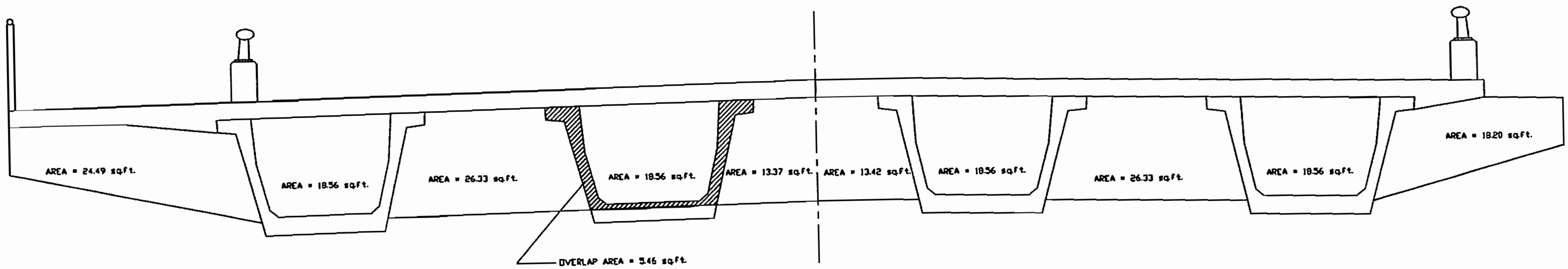
$5.46\,FT^2(1') \times 0.150\ k/FT^3 = \underline{\underline{0.82\ k}}$

- BEAM 6 (EXTERIOR BEAMS)

$5.46\,FT^2(1.5') \times 0.150\ k/FT^3 = \underline{\underline{1.23\ k}}$

- BEAM 6 (INTERIOR BEAMS)

$5.46\,FT^2(1.0') \times 0.150\ k/FT^3 = \underline{\underline{0.82\ k}}$


AREA = 24.49 sq.ft.
AREA = 18.56 sq.ft.
AREA = 26.33 sq.ft.
AREA = 18.56 sq.ft.
AREA = 13.37 sq.ft.
AREA = 13.42 sq.ft.
AREA = 18.56 sq.ft.
AREA = 26.33 sq.ft.
AREA = 18.56 sq.ft.
AREA = 18.20 sq.ft.
OVERLAP AREA = 5.46 sq.ft.