Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project: NOVA

Title: FHEP Pivoter Temporary Support Beam Sizing

Author(s): Dave Pushka

Reviewer(s): AngLee 10-15-2010

Key Words: Beam Sizing, Dunnage, FHEP, Pivoter

Applicable Codes: AISC 9th edition ASD

Abstract Summary:

Calculations to determine sizing and show the temporary support beams used to hold the FHEP pivoter table are suitable for the anticipated load.

Four towers designed by Ernie Villegas and documented in engineering note 251 support the table when the main pivot pin is being installed. This will occur initially with a bare, empty table and later with the table, a pallet and the FHEP detector. This note describes the beams used to span between the two front towers (the front beam) and the beams used to span between the rear towers (the rear beam). Each beam is assembled by bolting two W10 by 45 Wide flange sections together. A pair of short W8by31 columns are used near the rear while two W8 by 31 sections support the cylinder rod ends when the table is removed.

Image:

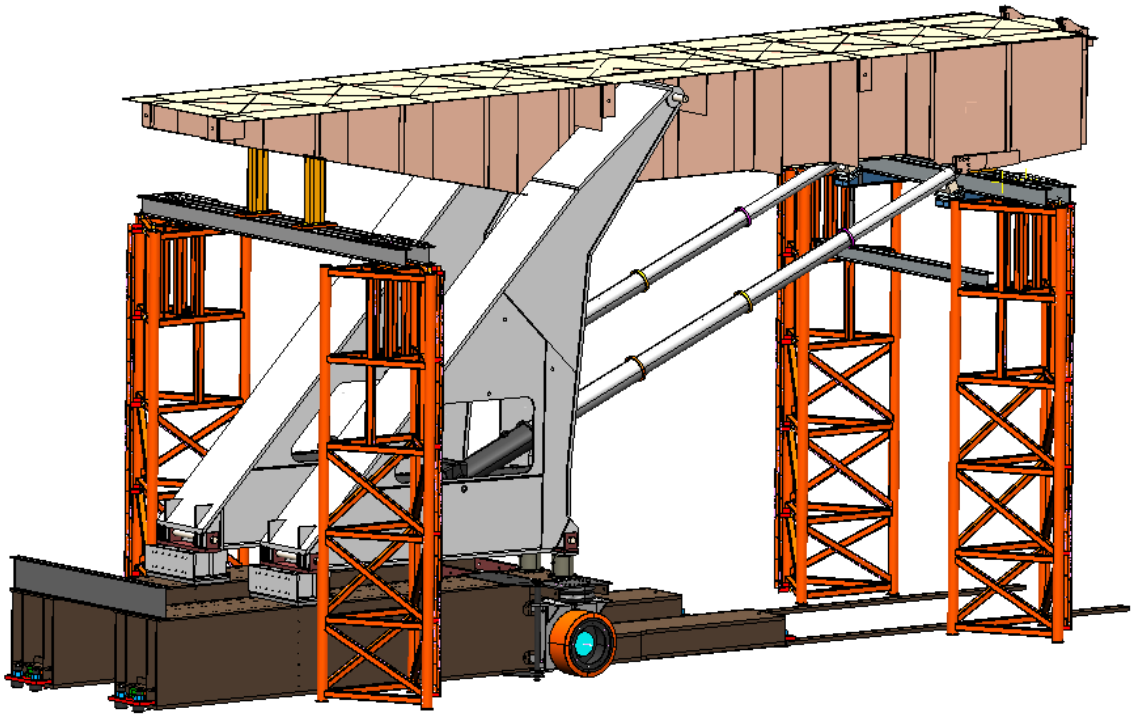

Image 1, NOvA FHEP Pivoter in CDF sitting on the dunnage.

Legend for Image 1:

Towers are shown in Orange
Pivoter Table is shown in beige
Dunnage beams are shown in gray and span between towers
Front beam is to the right of the image
Rear beam is to the left of the image

Yellow columns shown on the rear beams are W8 by 31 columns A36 material. Length is approximately 3 feet and the allowable AISC axial load on this section at this length with K = 2 is given at 178,000 pounds. – Far in excess of the load of the entire table and FHEP detector. See AISC 9th page 3-31.

Front beam include a support to holding the extended cylinders when the table is removed for building the FHEP on it at Argonne – these are in blue.

Refer to engineering note 174 for the layout of the preliminary version of the pivoter in CDF.

Calculations follow on the next page.

NOVA FHEP Pivoter Temporary Support (Dunnage) Beams				
Load:				
Weight of Table	24,000	pounds		
Weight of FHEP Plastic	50,500	pounds		
Weight of Pallet	2,850	pounds		
Sum of Table and FHEP Plastic	77,350	pounds	See drawing 466566	
Distance along table length from support to support	432	inches		
Distance from rear support to c.g. along Table	228	inches		
Total weigh on front towers	40,824	pounds		
Total weigh on rear towers	36,526	pounds		
Use the front tower load to drive the design of the beams.				
	W10x45		W8x67	W14 by 68
Area	13.3	in2	19.7	20
Ixx	248	in4	272	723
Iyy	53.4	in4	88.6	121
y	5.05		4.5	7
Allowable Stress based on A36 material, = 0.6Fy	21,600	psi		
Allowable Shear Stress based on A36 material, = 0.4Fy	14,400	psi		
load on one beam (assume equal sharing)	20,412	pounds	20,412	20,412
Span	192	inches	192	192
Check simple case (not the actual loading)				
Simple Span with single concentrated point load:				
Moment, pL/4 (simple span, single load at center)	979,767	in-pounds	979,767	979,767
Bending stress, My/I	26,272	psi	35,481	13,551
Shear Stress = P(per beam)/A	1,535	psi	1,036	1,021
Actual Shear Stress is less than the allowable shear stress	OK			
Actual Span with two equal, symmetric, concentrated loads				
dimension 'a'	70		70	70
P = 1/2 of the P for a simple span	10,206	pounds		
Moment, pa	714,413	in-pounds	714,413	714,413
Bending stress, My/I	14,548	psi	18,386	6,917
Deflection, inches	0.377	inches		
Shear Stress = P (per beams) / Area of beam	1,535	psi		
Bending stress is less than the allowable	OK			
Shear Stress is less than the allowable	OK			
Transverserse Top Plates				
thickness	1	inch		
Length	36	inch		
span, L	16	inch		
Load	10205.9	pounds		
Moment of Inertia, I	3	in^4		
Bending Moment, M = PL/4	40,824	in-lbs		
Bending Stress, sigma = My/I	6,804	psi		
Material Yield Stress	36,000	psi		
Allowable Bending Stress	23,760	psi		
Bending stress is less than the allowable	OK			
Plate to beam Bolting:				
Number of Bolts per beam to pl conn	4			
Tensile load per bolt	5,103	pounds		
bolt Size	3/4 - 10 tpi			
Allowable Tensile per AISC 9th for A325	19,400	pounds		
Actual bolt tension is less than the allowable	OK			

Weight of Extended Cylinders:			
OD of Final (Forth) Stage	8.375	in	
OD of third Stage	10	in	
OD of second Stage	11.5	in	
OD of first Stage	13.25	in	
OD of Barrel	15.125	in	
Wall Thickness	0.5	in	
Length of Final (Forth) Stage	121	in	
Length of third Stage	121	in	
Length of second Stage	121	in	
Length of first Stage	121	in	
length of Barrel	121	in	
Weight of steel for final (Forth) Stage	451.4	pounds	
Weight of steel for third Stage	539.0	pounds	
Weight of steel for second Stage	619.8	pounds	
Weight of steel for first Stage	714.1	pounds	
Weight of steel for Barrel	815.2	pounds	
Sum of weights above	3,139	pounds	
Indicated weight on Phelps Drawing 10114-C	3,514	pounds	
S.G. of oil	0.9		
Volume of oil for final (Forth) Stage	22.4	gallons	
Volume of oil for third Stage	33.3	gallons	
Volume of oil for second Stage	45.4	gallons	
Volume of oil for first Stage	61.7	gallons	
Volume of oil for Barrel	82.1	gallons	
Sum of Volumes above	245	gallons	
Weight of oil for final (Forth) Stage	168.0	pounds	
Weight of oil for third Stage	250.2	pounds	
Weight of oil for second Stage	340.5	pounds	
Weight of oil for first Stage	463.5	pounds	
Weight of oil for Barrel	616.2	pounds	
Sum of the Weights above	1838	pounds	
Weight of one oil filled extended cylinder	4,978	pounds	
Assume uniform load (not true, the rod end is lighter, but this is a conservative assumption)			
Reaction at the rod end when supported	2,489	pounds	
Size W8by 31 rod end support beam			
Cantilever Distance Measured off model (max)	14.14	inches	
Cantilever Distance to Design to	16	inches	
Bending Moment	39,823	inch-pounds	
Ixxfor a W 8 by 31	110	in^4	
Bending Stress, sigma = My/I	1,448.10	psi	
Allowable bending stress for A36 material	21,600	psi	
Actual bending stress is far less than allowable,	OK		
Assume all vertical load is taken by 2 bolts on W10x45			
Load per bolt is	1,244	pounds	
Bolts are 3/4-10 A307 (cheap, hardwared store quality)			
Allowable bolt tension per AISC is	8800	pounds	
Actual tensile is less than the allowable therefore,	OK		

Size W8by 31 rod end support beam spanning towers		
Actual Span with two equal, symmetric, concentrated loa	138	inches
dimension 'a'	86	inches
Load, from rod end of each cylinder in pounds	2,489	pounds
Moment, pa	214,047	in-pounds
For a W8 by 31, Ixx	110	in^4
half the depth of the beam, y	4	inches
Bending stress, My/I	7,784	psi
Deflection, inches	0.077	inches
Shear Stress = P / Area of beam (A = 9.13 in^2)	273	psi
Allowable Stress based on A36 material, = 0.6Fy	21,600	psi
Allowable Shear Stress based on A36 material, = 0.4Fy	14,400	psi
Bending stress is less than the allowable	OK	
Shear Stress is less than the allowable	OK	