TOTAL OIL MARINE

FRIGG FIELD

INTERMEDIATE MANIFOLD PLATFORM

MCP-01

STRUCTURAL DESIGN

REPORT

Volume 8

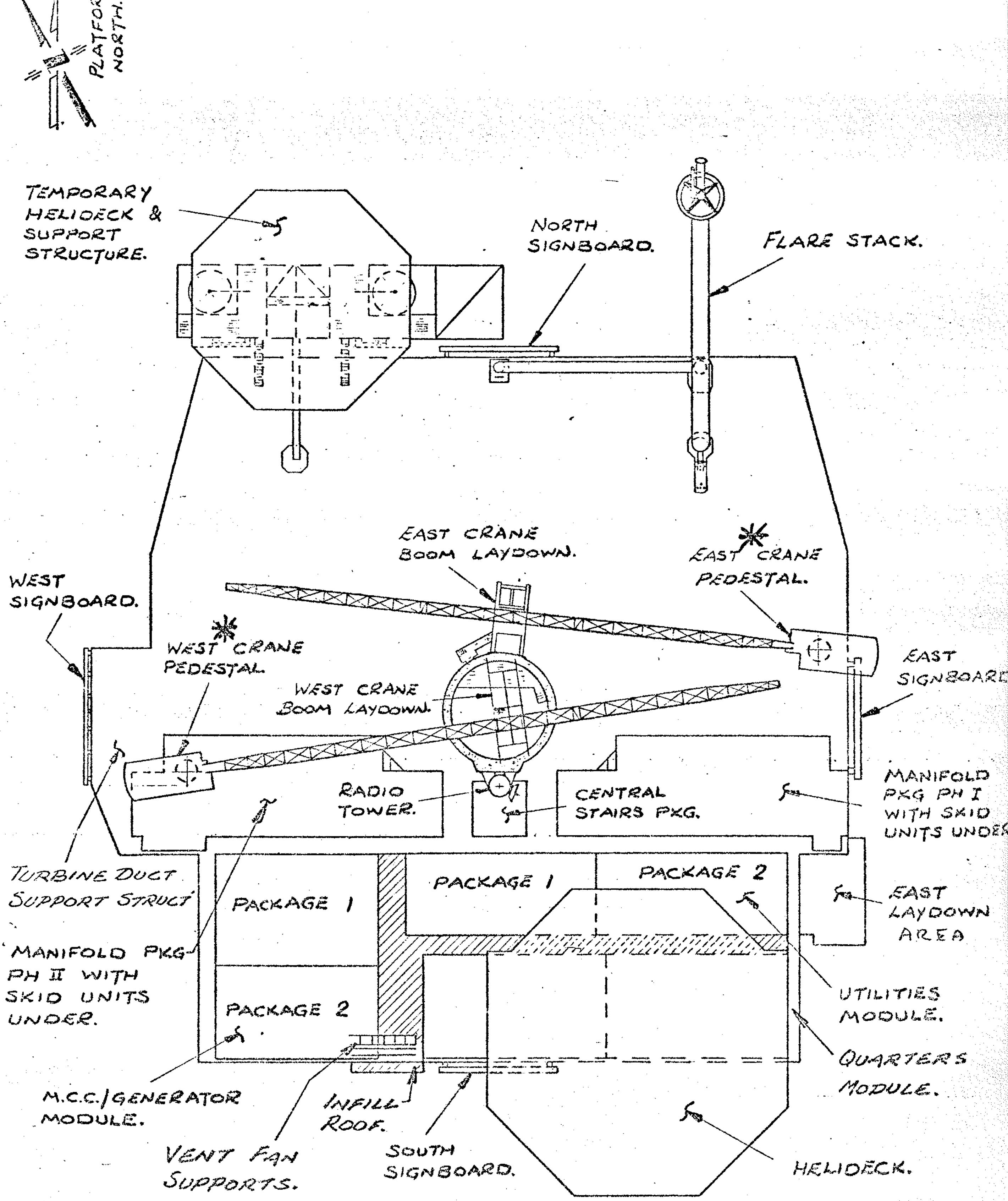
Crane Pedestals

Brown & Root, (U.K.) Ltd

Engineers - Constructors

INDEX OF VOLUME 8

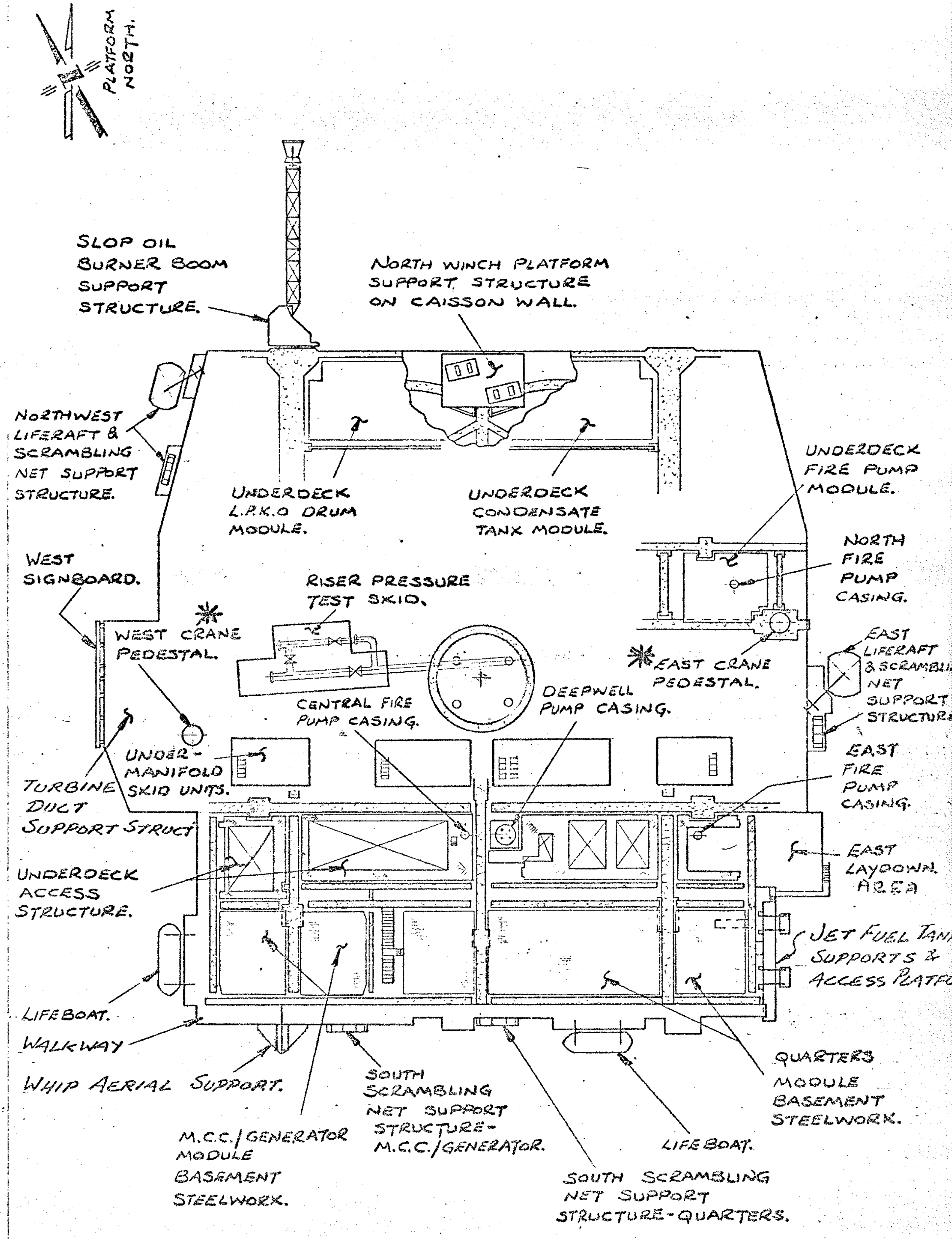
INDEX OF ALL VOLUMES



TOTAL OIL MARINE PLATFORM MCP-01.

PLAN AT PACKAGE ROOF LEVEL.

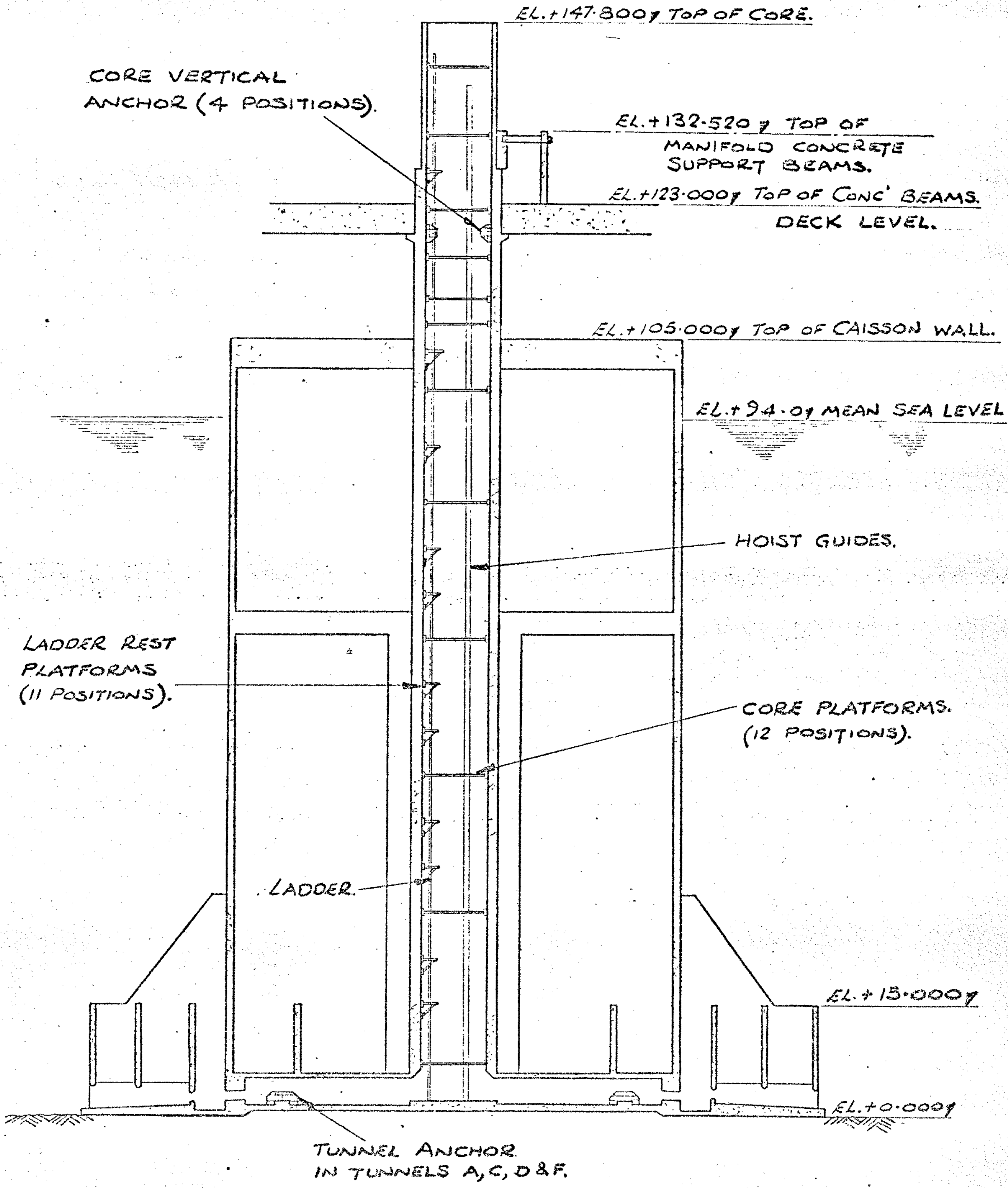
* = STRUCTURES IN THIS VOLUME.



TOTAL OIL MARINE PLATFORM MCP-01.

PLAN AT DECK LEVEL.

* = STRUCTURES IN THIS VOLUME.



TOTAL OIL MARINE PLATFORM MCP-01

SECTION THRU' PLATFORM LOOKING EAST.

STRUCTURES OUTSIDE OF CORE & PIPELINE RISERS OMITTED FOR CLARITY.

* = STRUCTURES IN THIS VOLUME.

SECTION. 1

weakening of suitable Crane Components within the Crane's own design Code of Practice. In the event, as shown in these calculations, the Crane is weaker than its supports.

It should be noted however that the Manufacturers own figures reveal that the weakest part of his crane is apparently underneath the Operator. Although the most probable extreme overloads would presumably be transient and never therefore reach static equilibrium, this situation is considered to be undesirable.

Consultants' reports on possible wind induced oscillations were obtained and are included in the calculations for a discussion of these phenomena see Volume 7.1. In this case the mass of the crane was sufficient to inhibit the build up of damaging oscillations and no vortex breakers were needed.

The post-tensioned deck connection was selected as a truly coherent joint. It was believed to be a guarantee against any 'snatch' under load reversal and had a superior torsional potential. It is believed that it led to an easier concrete block detail and is also thought to improve the chances of keeping water out from the underside of the pedestal. Although secondary moments due to vertical load acting through a deflected pedestal head can be shown to be trivial, it was considered desirable to take every possible step to minimise deflections at the top, as these would be sensed by the Operator. The standoff of the cables from the main tubular, needed to operate the tensioning ram, does however necessitate heavy base re-inforcement.

The conical transition piece on top of the Pedestal was vendor supply. Calculations were unobtainable for this proprietary

(8)

1. INTRODUCTION

Agreement was reached with Lloyds that suitable design loads for the pedestals were rational loads with lifted load augmented by 20%.

At initial design stage it was decided that a factor of 2.0 on lifted load would be more appropriate despite the Certifying Authority's agreement to 1.2. Note that this imposes a much greater increase in moment on the pedestal than that given by the ratio 2.0:1.2 in view of the effect of the counter weight. Concrete deck beams and attachments were sized on these loads.

It was believed that the true design process would be one which recognised the possible design situation of extreme overload, for example, attempted picking up of an improperly released deck cargo from a heaving Supply Boat. The design philosophy would then be a matter of ensuring that there were no failure modes in the pedestal (or its foundation) at loads which could be transmitted to it from the crane. It also follows as a matter of interest, that first failure in the crane should be between the Operator and the load and not between the Operator and the Pedestal.

The Crane Manufacturer was asked for collapse mode calculations but was unable to supply these at the time. He was therefore awarded a contract to develop and supply a report on Collapse Loads (which is included here). Data was not available however until well into fabrication and this was one of the considerations in the selection of the Load Factor 2.0 referred to above. It was agreed in-house that should it be apparent that overload could cause Pedestal or Foundation to fail before Crane Failure released the load then consideration would be given to selective item but were supplied in confidence to Lloyds by the Manufacturers.

Internal access was stipulated by Client to improve Operator protection when gaining access to or from his crane, especially under Platform Fire conditions.

1. INTRODUCTION

Following is an analysis to evaluate the behaviour and stresses of the two crane pedestals on Total Marine Ltd. Platform MPX. The general configuration of the crane pedestals are shown in the following pages.

The crane data is based on the Proposal by American Hoist and Derrick Co.,

"Proposal No: S-3464, Date 11/11/1974, Subject: American Model 1170 Pedestal Cranes" and telex correspondence for various queries on the report.

The Pedestal data is based on Following Brown and Root Drawings:

Dwg No.	Rev.	Drawing Title
2147-A1-MP/M248	2	East Crane Pedestal Platforms and Ladders
2147-A1-MP/M249	2	West Crane Pedestal Platforms and Ladders
2147-A1-MP/M250	3	East and West Crane Pedestals. Details

SECTION. 2

SECTION 2 - EVALUATE WEIGHT, LIFT AND WIND EFFECTS FROM CRANE.

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

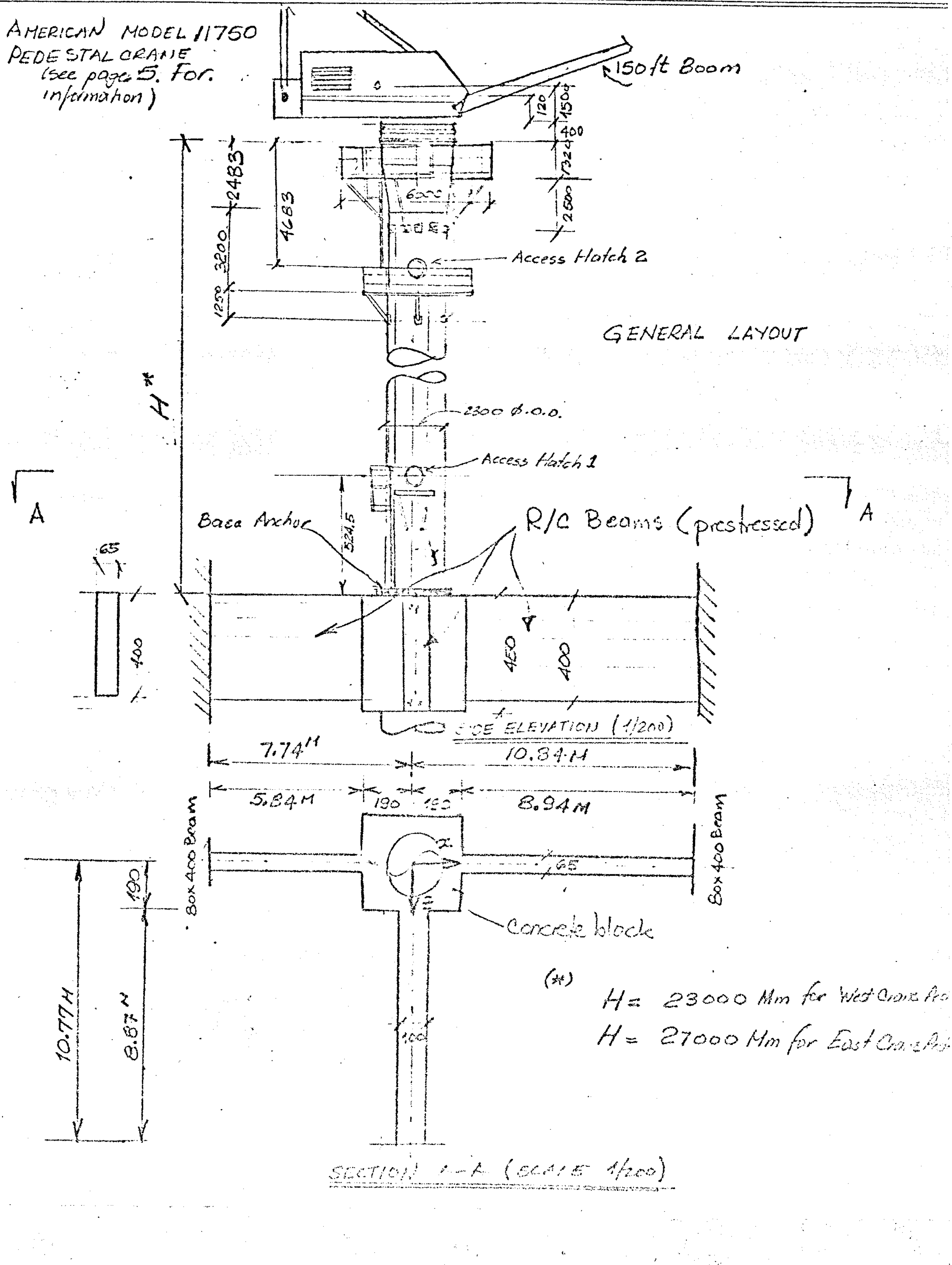
SHEET No. 4 OF __

CLIENT: TOTAL OIL MARINE — JOB NO. TO-100

SUBJECT: Engineering Design Deck Modules – Crane Pedestal

BASED ON __ DRAWING NO __

COMPUTER: KARSAN — CHK'D. BY: [illegible] — APP'D BY: [illegible] — DATE: NOV. 21 197[illegible]



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FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 5 OF

CLIENT TOTAL JOB NO TO -100

SUBJECT Engineering Design, Deck Modules - Crane Pedestals

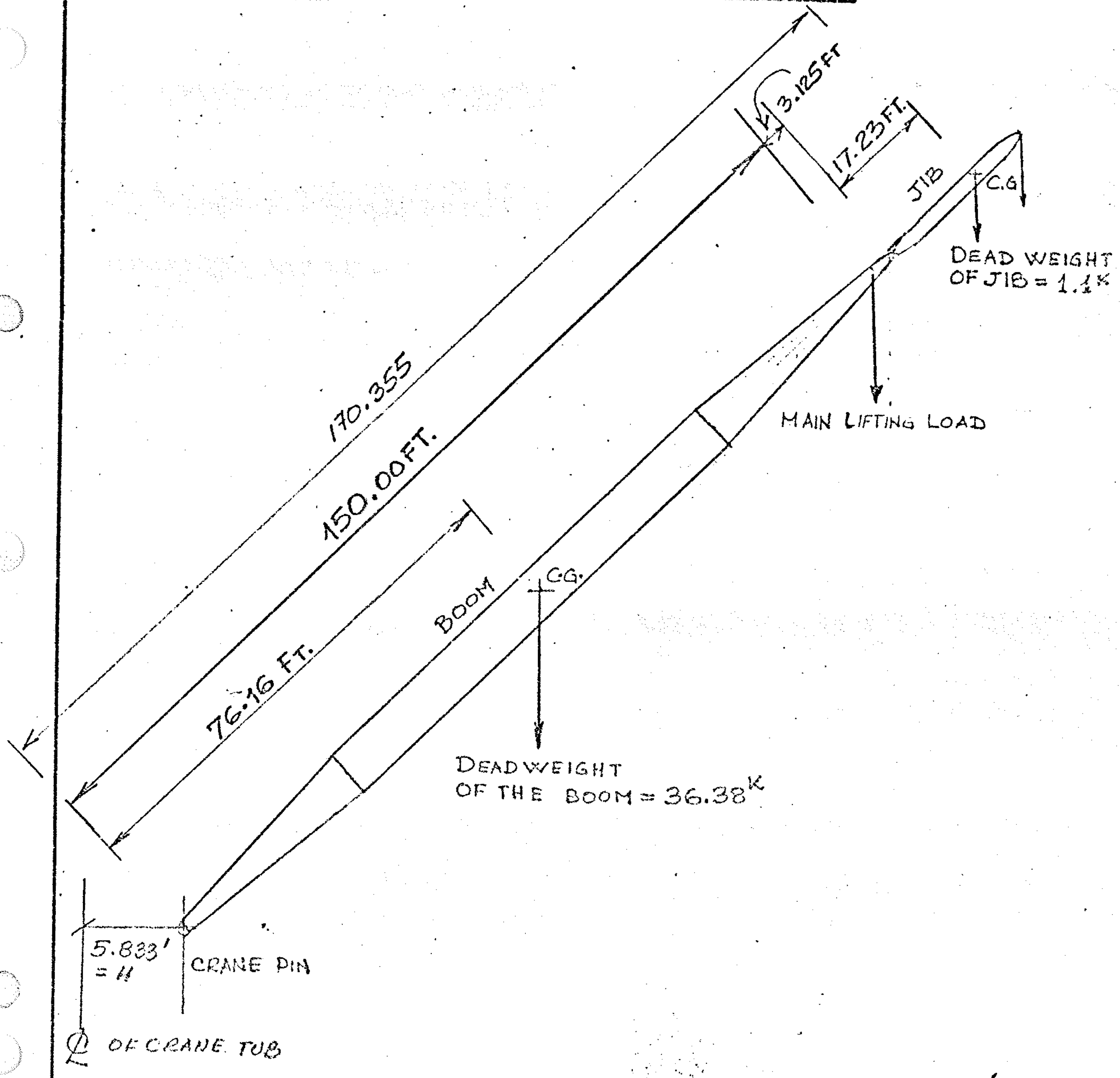
BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY DL APP'D BY DATE MAY 5 1975

STEP A. Evaluate Weight, Lift and Wind Effects from Crane.

PHYSICAL CHARACTERISTICS OF CRANE BOOM.

AMERICAN H&D 11750



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ENGINEERING DEPARTMENT

SHEET No. 6 OF

CLIENT TOTAL OIL MARINE JOB NO TO-100-2

SUBJECT Engineering Design, Deck Modules, Crane Pedestals

BASED ON DRAWING NO.

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE MAY 5 1975

Compute Loads on Tub Centre For various Lift Conditions.(*)

TABLE 1.A

LIFTING RADIUS (FT.)	LIFTING ANGLE (DEGREES)	LIFTING LOAD * (KIPS)	TOTAL VERTICAL LOAD RESULTANT CENTRE OF TUB (KIPS)	TOTAL MOMENT RESULTANT ON CENTRE OF TUB (KIP-FT)
30 **	81.3	272.92	314.40	8853.66
45	75.5	166.72	204.20	8461.67
60	69.5	105.10	142.58	7560.57
75	63.2	74.50	111.98	7139.87
90	56.5	56.26	93.74	6914.70
105	49.2	43.86	81.34	6756.80
120	41.1	35.00	72.48	6647.73
135	31.2	28.60	66.08	6609.87
150	16.7	23.40	60.88	6561.87
150	16.7	0.00	37.48	3051.95
105	49.2	0.00	37.48	2151.50
60	69.5	0.00	37.48	1254.57
30	81.3	0.00	37.48	666.06

(*) Based on American Model 11750 Pedestal Crane Rating Chart A 11750.07 with #15Jib.

(**) Moment due to Lift at 30 radius is 8187.6 KIP-FT.

A

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FORM D—IA

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ENGINEERING DEPARTMENT

SHEET No. 7 OF

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-100-

SUBJECT Engineering Design, Deck Modules - Crane Pedestals

BASED ON DRAWING NO.

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE MAY 5 - 1975

TABLE 1.B.

LIFTING RADIUS (FT.)	LIFTING ANGLE (DEGREES)	LIFTING LOAD (KIPS) (*)	TOTAL VERTICAL LOAD RESULTANT CENTRE OF TUB (KIPS)	TOTAL MOMENT RESULTANT ON CENTRE OF TUB (KIP-FT)
30	81.3	276.92**	313.30	8938.91
45	75.5	170.70	207.08	8587.43
60	69.5	109.10	145.48	7728.52
75	63.2	78.50	114.88	7343.95
90	56.5	60.26	96.64	7164.85
105	49.2	47.86	84.24	7047.93
120	41.1	39.00	75.38	6980.10
135	31.2	32.60	68.98	6983.16
150	16.7	27.40	63.78	6976.04
150	16.7	0.00	36.38	2866.04
105	49.2	0.00	36.38	2022.63
60	69.5	0.00	36.38	1182.52
30	81.3	0.00	36.38	631.30

(*) Based on American Model 11750 Pedestal Crane Rating Chart B 11750 with no Jib.
(**) Moment due to 30 ft Radius Lift with 276.92k is 8289.6 K-ft.

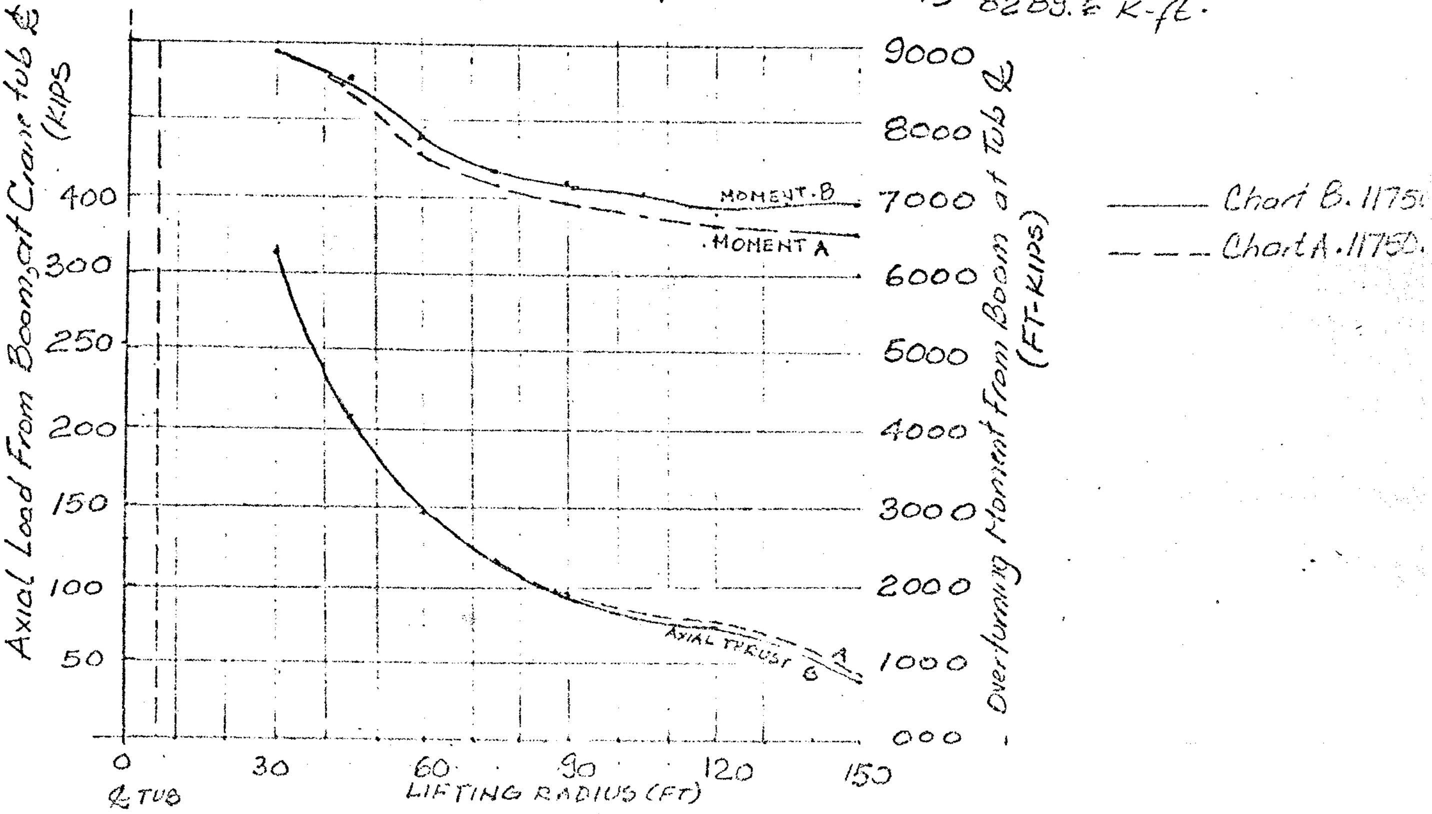


CHART SHOWING AXIAL LOAD AND O.T. MOMENT AT TUB. C.L. FROM LOADS & D.W. ON BOOM.

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

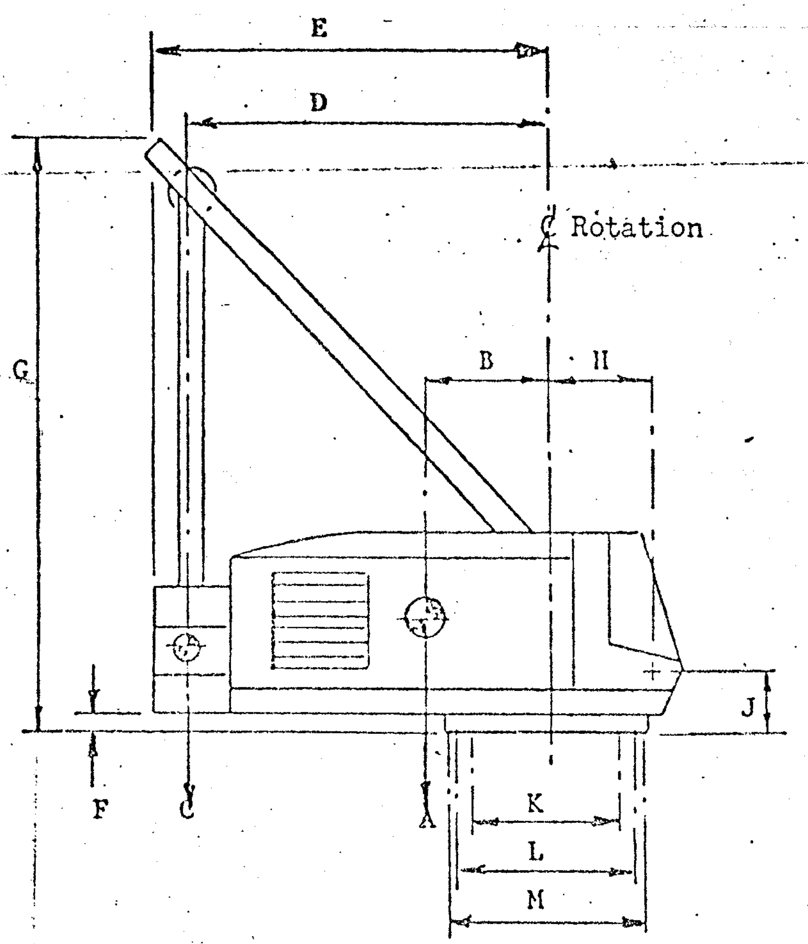
SHEET No. 8 OF ___

CLIENT TOTAL JOB NO TO-100-2

SUBJECT Engineering Design, Deck modules – Crane Pedestal

BASED ON ___ DRAWING NO ___

COMPUTER KARSAN CHK'D. BY DRC APP'D BY ___ DATE NOV 21 1974



PHYSICAL DIMENSION OF CRANE CAB

AMERICAN MODEL 11750

A = Weight of Upper Deck - - - - - - - - - - 132,000 lbs.
B = ℄ Rotation to C. G. of Upper Deck - - - - - - 4.77 ft.
C = Weight of Counterweight - - - - - - - - 110,800 lbs.
D = ℄ Rotation to C. G. of Counterweight - - - - - 16.92 ft.
E = Tail Swing - - - - - - - - - - 19.0 ft.
F = Clearance From Bottom Turntable Bearing to Bottom of Counterweight 7.25 inch.
G = Height Over Raised A-Frame - - - - - - - - 33.1667 ft.
H = ℄ Rotation to ℄ Boom Foot - - - - - - - - 5.833 ft.
J = Height of Boom Foot From Bottom Turntable Bearing - - - - 1.739 ft
K = Pitch Diameter of Bull Gear (1.25 D.P.) - - - - - - 100.00 inch.
L = Lower Mounting Bolt Circle Diameter - - - - - - 105.00 inch
M = Pitch Diameter of Shear Ball Bearing - - - - - - 111.00 inch

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ENGINEERING DEPARTMENT

SHEET No. 9 OF ___

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-100-2

SUBJECT FRIGG FIELD, MDX CRANE PEDESTALS

BASED ON ___ DRAWING NO ___

COMPUTER KARSAN CHK'D. BY DRP APP'D BY ___ DATE MAY 5 1975

Compute Axial Force and Overturning Moment on Centerline of crane tub due to dead weight of Crane and Counterweight.

Item	Total Weight (Kips)	Moment Arm (Ft)	Overturning Moment (Ft. Kips)
Weight of Upper Deck	132.00	4.77	629.64
Weight of Counterweight	111.80	16.92	1891.66
TOTAL	243.80	10.342	2521.30

TABLE 2. SUMMARY FOR TOTAL AXIAL FORCE AND MOMENT AT TUB CENTER WHEN D.W. OF CRANE AND LIFT ARE CONSIDERED.*

LIFTING RADIUS (FT.)	LIFTING ANGLE (DEGREES)	TOTAL AXIAL LOAD (KIPS)	TOTAL OVERTURNING MOMENT (K-FT)	
30	81.30	557.10	6417.61	← Maximum Operating case
45	75.50	450.88	6066.13	
60	69.50	389.28	5207.22	
75	63.20	358.68	4822.65	
90	56.50	340.44	4643.55	
105	49.20	328.04	4526.63	
120	41.10	319.18	4458.80	
135	31.20	312.78	4461.85	
150	16.70	307.58	4454.74	
150	16.70	280.18	344.74	← Storm case
105	49.20	280.18	−498.67	
60	69.50	280.18	−1338.78	
30	81.30	280.18	−1890.00	← Minimum Operating case

(*) CONSIDERING CASE B WHICH IS MORE CRITICAL FOR OVERTURNING MOMENT

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ENGINEERING DEPARTMENT

SHEET No. 10 OF

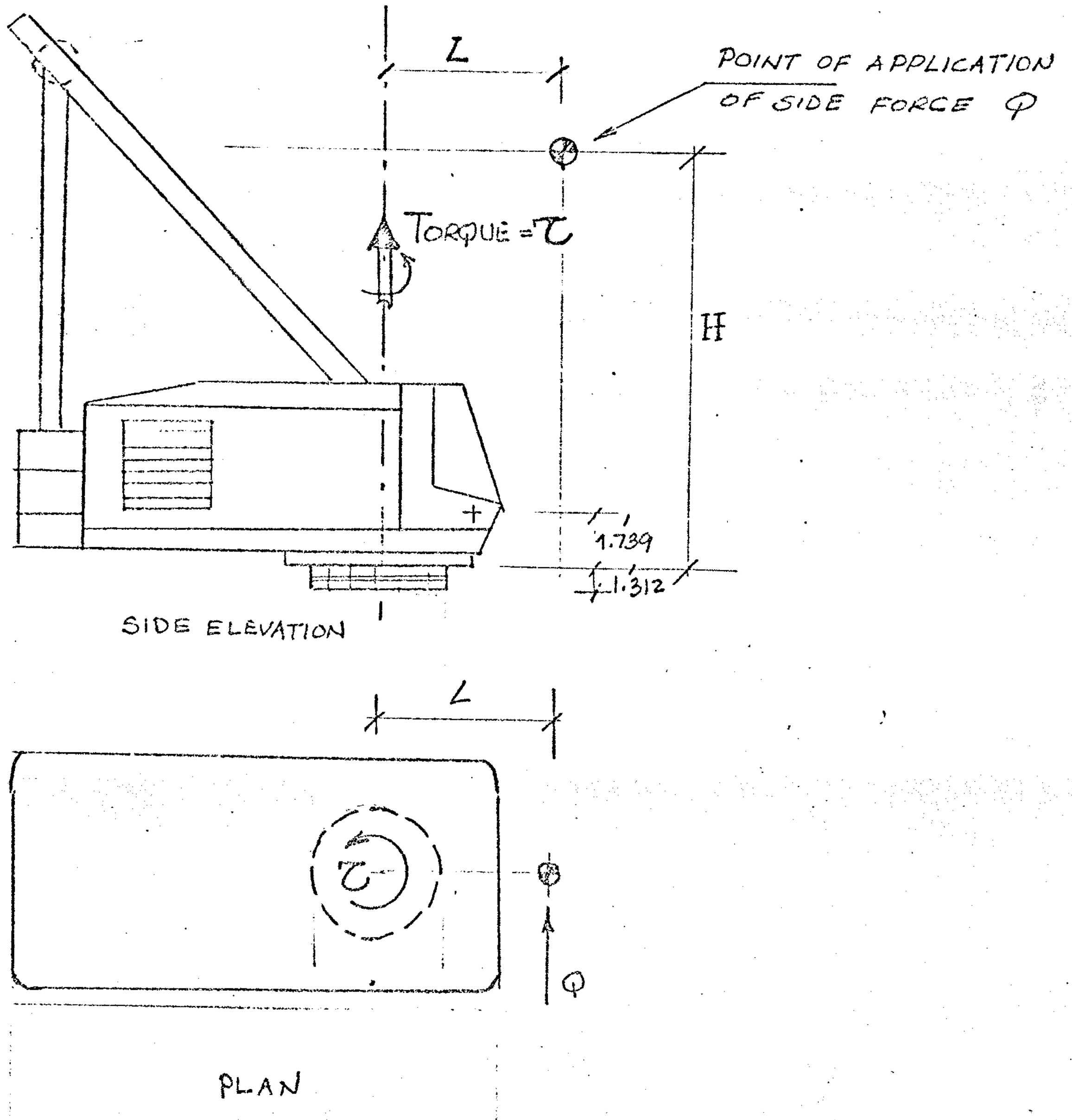
CLIENT TOTAL OIL MARINE LTD. JOB NO TO-100-

SUBJECT FRIGG FIELD, MPX CRANE: PEDESTALS

BASED ON DRAWING NO.

COMPUTER KARSAN CHK'D. BY APP'D BY DATE MAY 6 1975

Forces and moments on Horizontal Plane.



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ENGINEERING DEPARTMENT

SHEET No. 11 OF

CLIENT TOTAL OIL MARINE LTD.

JOB NO TD-100-

SUBJECT FRIGG FIELD, MDX CRANE PEDESTALS

BASED ON

DRAWING NO

COMPUTER KARSAN CHK'D. BY ORR APP'D BY DATE MAY 6 1975

Following is a summary of data Obtained from various Telex correspondance with A. H.&D ....

(NOTE: Below figures were reduced from boom pin to tub Centreline Axis)

No	LOADING CASE	SWING MOMENT (KIP-FT.)	SIDE SWING FORCE			SIDE WIND FORCE (INCLUDES LOAD AREA)		
			MAGNITUDE (KIPS)	H (FT.)	L (FT.)	MAGNITUDE (KIPS)	H (FT.)	L (FT.)
1	STORM, by A. H.D – No Cradle – No Lift, 53M/sec wind	——	——	——	——	59.8	6.80	46.67
2	STORM, by A.H.&D – Boom on Cradle – No Lift, 53M/sec wind	——	——	——	——	41.83	3.050	5.833
3	SERVICE CONDITION – 272.92 lb At 30' Radius – 24.6M/sec/(55Mph) Wind – Load on hook	——	9.323	9.02	11.60	19.56	36.54	16.75
4	SERVICE CONDITION – No Load – Full Swing Force – 24.6 M/sec/(55Mph. Wind)	430.00	17.207	12.809	6.85	7.556	10.33	11.60
5	STORM BY ATKINS REPORT – No Cradle – No Lift – 53M/sec. Wind Load (Amplified by 3.25)	——	——	——	——	(*) 101.56	6.801	46.67
6	SERVICE CONDITION (ATKINS) – 272.92 lb at 30' Radius – 24.6M/sec (55Mph) Wind – Load on hook	——	9.323	9.02	11.60	(**) 28.35	36.54	16.75
7	Service CONDITION (ATKINS) – No Load – Full Swing Force – 24.6 M/sec (55MPh) wind					(***) 16.35	10.33	11.60
8	STORM BY ATKINS – Boom On cradle – No Lift. 53M/sec Wind	——	——	——	——	(*) 71.21	3.050	5.833

(*) Derived from Atkins report FIG 2 (Amplified by 3.25). Point of Application same as AHD.

(**) Derived from Atkins report, Amplified by 2.45 (Fig 3 and 4). 12K wind Load on hook added. Point of Application assumed same as A.H&D. Spec.

(***) Derived from Atkins report. Amplified by 2.45 (Fig 3 & 4). Point of Application assumed same as A.H&D Spec.

SECTION . 3

SECTION 3 - EVALUATE WEIGHT AND WIND EFFECTS ON PEDESTALS AND APPURTENANCE.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 12 OF

CLIENT: TOTAL OIL MARINE

JOB NO: TO - 100 -

SUBJECT: Engineering Design, Deck Modules - Crane Pedestal

BASED ON:

DRAWING NO:

COMPUTER: KARSAN

CHK'D. BY: D2P

APP'D BY:

DATE: MAY 7 1975

STEP B. Evaluate weight, Lift and wind Effects on Pedestal.

B.1 WIND EFECTS.

Wind Effects Under Storm. (FROM ATKINS REPORT)

Elevation	Forces In Line (Weighted Average = 0.704 K/FT.)	Side Forces (Weighted Average = 0.168 K/FT)
88.6' (27.00M)	0.744 K/FT	0.181 K/FT.
80' (24.38M)	0.731 K/FT.	0.178 K/FT
75.5 (23.00M)	0.722 K/FT.	0.177 K/FT
70' (21.34M)	0.718 K/FT.	
60' (18.29M)	0.709 K/FT.	0.169 K/FT
50' (15.24M)	0.702 K/FT	
40' (12.19M)	0.696 K/FT	0.164 K/FT
30' (9.15M)	0.689 K/FT	
20' (6.10M)	0.683 K/FT	0.158 K/FT
10' (3.05M)	0.673 K/FT	
Pedestal Base 0 (0.00M)	0.672 K/FT	0.150 K/FT

Forces In Line. (FIG. 2)
(AMPLIFIED BY 3.25)

Side Forces Due to Vortex Shedding at 53M/sec Wind (Fig. 6)

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FORM D—IA

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ENGINEERING DEPARTMENT

SHEET No. 13 OF ____

CLIENT TOTAL OIL MARINE JOB NO TC-100-02

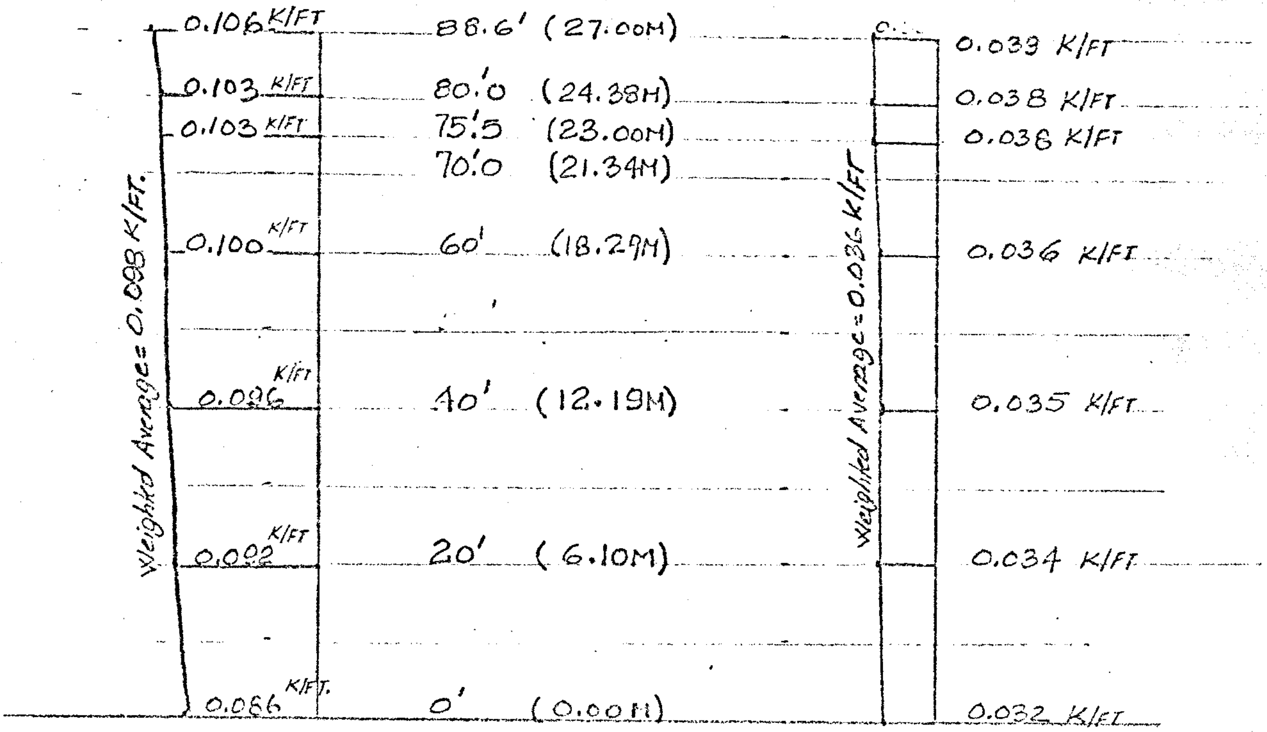
SUBJECT ENGINEERING DESIGN, Deck Modules, Crane Pedestals

BASED ON ____ DRAWING NO ____

COMPUTER KARSAN CHK'D. BY [illegible] APP'D BY ____ DATE MAY 7 1975

WIND EFFECTS UNDER OPERATING CONDITIONS (FROM ATKINS REPT)

24.6 M/SEC (55 MPH) WIND



In Line Forces (Fig. 3)
Amplified by 2.45 (Fig. 4)

Side Forces Due to Vortex Shedding at 24.6 M/sec Wind (Fig. 6)

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FORM D—1A

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ENGINEERING DEPARTMENT

SHEET No. 14 OF

CLIENT TOTAL JOB NO TO-100-

SUBJECT ENGINEERING DESIGN OF DECK MODULES - CRANE PEDESTAL

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY U.R.P. APP'D BY DATE May 7 1975

DEAD WEIGHT OF PEDESTALS.

Calculate weight per unit length of pedestal column.

R=115 cm t= 4.5cm

Area ≈ (115−2.25)π × 4.5 × 2 = 3187.9 cm^2

Weight of pipe = 5516.4 lb/Meter

Ladders

stringers	= 2× ∠65×7	= 30.2 lb/M
Rungs φ20, @ 30cm or 3.333/M × 46 cm wide	=	18.2 lb/M Conserv.
Intermediate hoops 0.8/M × 100×6	=	18.5 lb/M
flat cage bars 7×140×6	=	29.0 lb/M

Total 95.9 lb/m.

total Ladder length = 27 M + 2×1.09 overlaps = 29.18 m.

∴ Weight / M of Ladder ≈ $\frac{95.9 \times 29.18}{27.40}$ = 103.6 lb/M

∴ μ ≅ 103.6 + 5516.4 = 5620. lb/M.

with %5 contingency

μ ≈ 5901 Lb M = 5.901 Kips /meter

= 1.799 Kips / ft

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FORM D–1A

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ENGINEERING DEPARTMENT

SHEET No. 15 OF

CLIENT TOTAL JOB NO TO-100-

SUBJECT ENGINEERING DESIGN OF DECK MODULES – CRANE PEDESTAL

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE May 7 1975

Calculate weight of platform 1:)

8 × [160 Ring beams 2.70M ea	=	900 lbs
8 × [200 × 2.30M ea	=	1026 lbs
8 × L75×10 inside ring × 1.10M ea	=	245 lbs
8 × HP 100 × 1.90 M @	=	381 lbs
10 MM Thick PL × 24.92 M^2	=	4306 lbs
16 × 1.30M high φ2 handrail verticals	=	186 lbs
16 × 2.70M ea × φ2 horizontals	=	385 lbs
Wire Mesh ≈ 5#/M^2 × .60 × 2.70 × 8	=	65 lbs
8 kick PLs 120×6 flats × 2.70M @	=	249 lbs
Total		7743 lbs
%5 Contingency		387 lbs
W_1	=	8.13 Kips

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ENGINEERING DEPARTMENT

SHEET No. 16 OF ____

CLIENT TOTAL OIL MARINE JOB NO TO-100-(

SUBJECT Engineering Design for Crane Pedestals

BASED ON ____ DRAWING NO ____

COMPUTER KARSAN CHK'D. BY ORP APP'D BY ____ DATE MAY 7 19 75

Calculate Weight of Platform 2.

4 x I 200 x 1M @	= 230 lbs
2 x [160 x 2.2M @	= 190 lbs
1 x [160 x 1.7M	= 75 "
1 x [160 x 1.2M	= 50 "
10 MM R x 0.355ΦM	= 65 "
10 M cheq. R x 4.55ΦM	= 790 "
TOTAL	= 1400 lb
+ 10% Contingency	= 140 lb.
W/2	= 1.54 Kips

SECTION.4

SECTION 4 - EVALUATE DYNAMIC AND STATIC STRESSES IN CRANE PEDESTAL TUB, STUDY FATIGUE.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 17 OF

CLIENT TOTAL OIL Marine Ltd. JOB NO TO-102

SUBJECT Frigg Field, MDX, Crane Pedestals.

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY ORP APP'D BY [signature] DATE May 7 1975

STEP C. Evaluate Static and Dynamic Stresses in crane Pedestal Tub. Study Fatigue.

C.1 Evaluate Static and Dynamic Stresses in Crane Pedestal Tub.

C.1.1 LOADINGS.

The Lifting, Dead and Wind Loads on the Crane pedestal are tabulated in pages 5 Through 16. These Loads will be used to simulate the static and dynamic loadings on crane pedestals. Following basic Loadings can be defined.

LOADING 1. Maximum Operating Lift + Dead Load From crane. (Impact Factor of 2 on Load as A.H.D.rec.)

O.T. Moment = 15356.52 K.Ft. at tub ℄
TOTAL Axial Load = 871.24 Kips. at tub ℄
Side Swing force = 9.323 Kips 10.33 Ft high from tub top, 11.60 Ft from tub ℄. towards Load.

LOADING 2. Minimum Operating Dead Load plus Maximum Swing Torque.

O.T. Moment = -1890.00 K.ft. at tub ℄
Axial Load = 280.18 Kips at tub ℄
Side Swing force = 17.207 Kips 14.12' high from tub top, 6.85 Ft From tub ℄. towards Counterweight direction
Swing Moment = 430. K-ft at tub ℄.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 18 OF

CLIENT Total Oil Marine Ltd. JOB NO TO-102-

SUBJECT Frigg Field, MPX Crane Pedestals

BASED ON ____ DRAWING NO ____

COMPUTER KARSAN CHK'D. BY DRP APP'D BY ____ DATE May 7 1975

Loading 3 — Dead Load from boom and Cab, When boom is on Cradle

O.T. Moment = 344.74^K
Axial Load = 261.99^K

Loading 4. — Dead Load from boom and cab when the boom is upright.

O.T. Moment = −1890.00 K.ft at tub ℄
Axial Load = 280.18 Kips " " "

Loading 5 — Storm Wind On Crane and Boom, Across the Boom, Boom on cradle. (53M/Sec)

Q = 71.21^K Applied 3.05 ft above tub, 5.833 from Tub ℄ towards Boom

Loading 6 — Storm Wind on Crane and Boom, Across the Boom, Boom upright (53 M/sec.)

Q = 101.56^K Applied at 6.80 ft. above top of tub, 46.67 ft towards boom

Loading 7. — Operating wind on Crane Boom and Load, Across the Boom. (24.6 M/sec)

Q = 28.35^K applied at 36.54' Above top of tub 16.75' towards Load.

Loading 8 — Operating Wind on Crane, Boom and Load. Along the Boom — Same as Load 8 but along the boom.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 19 OF

CLIENT Total Oil Marine Ltd.

JOB NO TO-102-C

SUBJECT Frigg Field, MDX Crane Pedestals

BASED ON

DRAWING NO

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE May 7 1975

Loading 9. Operating wind on Crane, Boom. No Load, (Accross the boom.)

$P = 16.35^K$ at 10.33ft above top of tub
11.60ft towards boom

Loading 10. Operating wind on Crane Boom. No Load (Along the Boom).

Same as 10 but along the Boom.

Loading 11 Dead Weight of Pedestal pipe and Platforms.

Weight of Pipe + Stairs = 3.05 K/ft.
Weight of Platform 1 = 8.13K at Height minus 4.33 ft from top

Weight of Platform 2 = 1.54 K at Height Minus 18.65 ft from top.

Loading 12 Wind Effect due to 50yr Storm Gust on pedestal pipe (Combines In line and Side forces) (53 M/sec)

$q = \sqrt{0.704^2 + 0.168^2}$ = 0.725 Kips/ft of pipe acting along any direction in Horizontal plane

Loading 13. Wind Effect due to Operating Storm Gust on pedestal pipe (24.6 M/sec)

$q = \sqrt{0.098^2 + 0.036^2}$ = 0.105 Kips/ft of pipe acting along any direction in horizontal Plane.

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ENGINEERING DEPARTMENT

SHEET No. 20 OF

CLIENT Total Oil Marine Ltd. JOB NO TO-102-C

SUBJECT Frigg Field, MPX Crane Pedestals

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY [illegible] APP'D BY DATE May 7 1975

C.1.2 LOAD CONDITIONS.

LOAD COND. 1. Maximum Operating Lift Condition
No wind

LOAD COND. 2. Maximum Operating Lift Condition
Wind Across Boom.

LOAD COND. 3. Maximum Operating Lift Condition
Wind Along Boom.

LOAD COND. 4 Minimum Operating No Lift Condition
No wind

LOAD COND. 5 Min. Oper. No. Lift. Cond. Wind Across
Boom

LOAD COND. 6 Min. Operating. No Lift. Cond. Wind
Along Boom.

LOAD COND. 7 Storm Condition, Boom on Cradle
Wind Across Boom.

LOAD COND. 8 Storm Condition Boom Upright.
Wind Across Boom.

LOAD COND 9 Fatigue Condition /
Unit Wind Load Along Boom
(Boom Upright)

CP BR 21
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BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 21 OF

CLIENT Total Oil Marine Ltd. JOB NO TO-102-

SUBJECT Frigg Field, MPX, Crane Pedestals

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE May 8 1975

LOAD CONDITION 10 — Fatigue Condition 2

Unit Wind Load Across Boom (Boom Upright)

LOAD CONDITION 11 — Fatigue Condition 3

Unit Wind Load Across Boom (Boom On Cradle.)

C.1.3. STRESS LEVELS.

Above Load Conditions will be checked against following material properties.

Crane Tub Material : ST-52-3N
51.2 Ksi. Yield Strength.

All Other Pedestal Material: ST-37-3 Galvanized.
31.2 Ksi. Yield Strength.

Check for Local Buckling.

$$\frac{D}{t} = \frac{230}{4.5} = 51.12$$

$$\frac{3300}{51.2} = 64.45$$

Thus, $\frac{D}{t} < \frac{3300}{F_y}$ ∴ No local buckling problem exists However Reduce F_y to F_{yr} as recommended in API, RP2A, page 13 Formula 11

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 22 OF ___

CLIENT Total Oil Marine Ltd. JOB NO TO-102-0

SUBJECT Frigg Field, MDX, Crane Pedestals

BASED ON ___ DRAWING NO ___

COMPUTER KARSAN CHK'D. BY DRP APP'D BY ___ DATE May 8 1975

$$F_{yr} = \left[1-\left(1-\frac{64.45}{51.12}\right)^2\right] 51.2 = 47.72 \text{ Ksi.}$$

- Allowable bending for No wind Operating cases

$$F_b = 0.66 F_{yr} = 0.66 \times 47.72 = 31.49 \text{ Ksi}$$

- for bending, with wind.

$$F_b = 1.33 \times 31.49 = 41.88 \text{ Ksi.}$$

- For Axial Loads

$K = 2$ $L = 88.583$ Ft $= 1063$ in

$D = 230$ cm $= 90.551$ in $t = 45$ mm $= 1.7717$ in

$$\text{Area} = \pi \frac{(90.551^2 - 87.00766^2)}{4} = 494.142 \text{ in}^2$$

$$I = \frac{\pi}{64}(90.551^4 - 87.00766^4) = 478098.29 \text{ in}^4$$

$$\text{Section Modulus} = S = \frac{478098.29 \times 2}{90.551} = 10559.76 \text{ in}^2$$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{478098.29}{494.149}} = 31.105 \text{ in.}$$

$$\frac{KL}{r} = \frac{2 \times 1063}{31.105} = 68.35$$

$F_a = 20.53$ ksi for no wind case

$F_a = 1.33 \times 20.53 = 27.30$ Ksi with wind

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 23 OF

CLIENT Total Oil Marine Ltd. JOB NO. TO-102

SUBJECT Frigg Field, MPX, Crane Pedestals

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE May 8 1975

- For Shear, $F_V = 0.4 F_y$

$= 0.4 \times 47.72 = 19.09\,Ksi$ For no wind

$F_V = 1.33 \times 19.09 = 25.39\,Ksi$ Under wind.

- For Combined Loading.

$$I_1 = \frac{f_a}{F_a} + \frac{C_m \cdot f_b}{\left(1 - \frac{f_a}{F_e'}\right) F_b} \leq 1.0$$

$$I_2 = \frac{f_a}{\alpha F_y} + \frac{f_b}{F_b} \leq 1.0$$

where:

$C_m = 0.85$

$F_e' = 31.97\,ksi$ for no wind

$F_e' = 1.33 \times 31.97 = 42.52\,ksi$, with wind

$\alpha = 0.60$ for No wind

$\alpha = 0.80$ with wind.

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 24 OF ____

CLIENT: TOTAL OIL MARINE LTD. JOB NO: TO-102-[illegible]

SUBJECT: FRIGG FIELD, MDX, CRANE PEDESTALS

BASED ON: ____ DRAWING NO: ____

COMPUTER: KARSAN CHK'D. BY: OCP APP'D BY: ____ DATE: MAY 8 1975

TABLE 3. LOADING COMBINATIONS AND STRESS LEVELS FOR LOAD CONDITIONS

LOADING NUMBER	LOADING DESCRIPTION	LOAD CONDITION & DESCRIPTION										
		1	2	3	4	5	6	7	8	9	10	11
		Max. Oper. Cond. with Lift. No wind.	Max. Oper. Cond. with Lift. Wind Across Boom.	Max. Oper. Cond. with Lift. Wind Along Boom.	Min. Oper. Cond. No Lift. No wind.	Min. Oper. Cond. No Lift. Wind Across Boom.	Min. Operating Cond. No Lift. Wind Along Boom.	Storm C. Boom on Cradle. Wind Across Boom.	Storm Condition Boom Upright. Wind Along Boom.	Fatigue Condition 1	Fatigue Condition 2	Fatigue Condition 3
1	Max Crane Operating Load	X	X	X								
2	Min. Crane Oper. Ld. + Swing.				X	X	X					
3	D.L of Boom + Cab, Boom on Cradle.							X				
4	D.L of Boom + Cab. Boom Upright.								X			
5	Storm Wind on Cab & Boom, Boom on Cradle, Across Boom							X				
6	Storm wind on Cab & Boom, Boom Upright, Along Boom.								X			
7	Operating Wind on Crane, Boom And Load, Across Boom.		X									
8	Operating Wind on Crane, Boom + Load, Along Boom.			X								
9	Operating Wind on Crane & Boom No Lift, Across Boom.					X						
10	Operating Wind on Crane & Boom No Lift, Along Boom.						X					
11	Dead Weight of Pedestal Pipe And Platforms	X	X	X	X	X	X	X	X			
12	Wind Effect due to Storm on Pedestal Pipe							X	X			
13	Wind Effect due to Operating wind on Pedestal Pipe		X	X		X	X					
14	Unit Wind Load Across Boom										X	X
15	Unit Wind Load Along Boom									X		
F_b (KSI)		31.49	41.86	41.86	31.49	41.86	41.88	41.88	41.89	Calculations.	Use B.S.153 for Fatigue	Not Applicable
F_a (KSI)		20.53	27.30	27.30	20.53	27.30	27.30	27.30	27.30			
F_v (KSI)		10.09	25.39	25.39	10.09	25.39	25.39	25.39	25.39			
F_e' (KSI)		31.97	42.52	42.52	31.97	42.52	42.52	42.52	42.52			

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 25 OF

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-102-

SUBJECT Frigg Field, MPX, Crane Pedestals

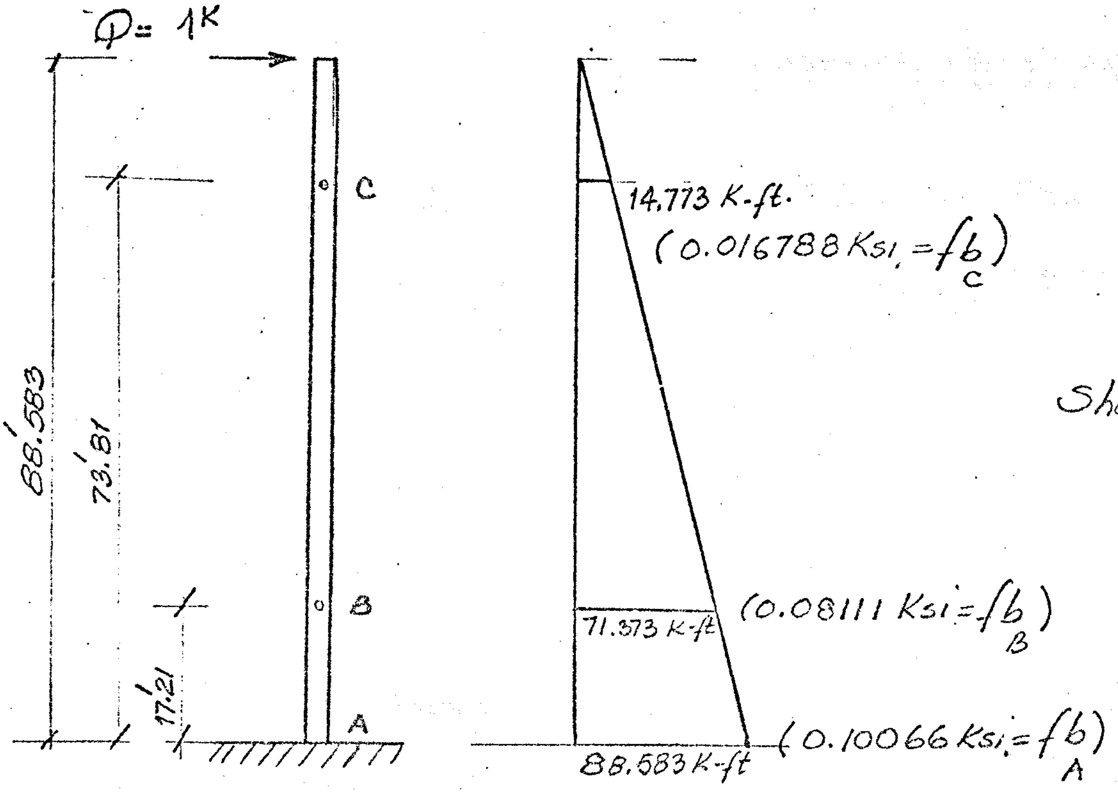
BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY APP'D BY DATE MAY 6 1975

C.1.4 Set Up Unit Loads to cover Load Conditions.

(Analyse 27 Meter pedestal only. Should cover the 23 M pedestal)

a) Unit Shear at pedestal top. (Q)



Moments and Bending Stresses :

$$Shear = 1.5 \frac{1}{494.149} = 0.003036\ Ksi$$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 26 OF

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-102-

SUBJECT Frigg Field, MDX, Crane Pedestals

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY OPP APP'D BY DATE May 5 1975

b) Unit Axial Load at Pedestal top. ($P = 1 kip$)

$$fa_A = fa_B = fa_C = \frac{1}{494.149} = 0.0020237 \text{ Ksi compression}$$

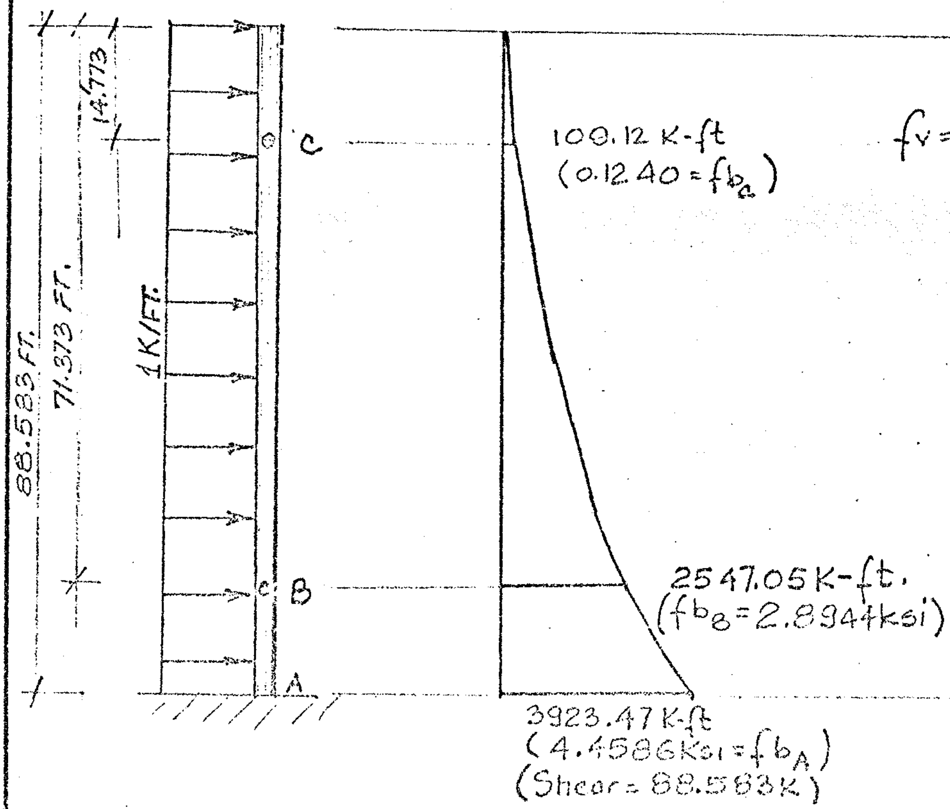
c) Unit Torsion at Pedestal top ($T = 1 k.ft.$)

$$\tau_A = \tau_B = \tau_C = \frac{12}{2 \times 10559.76} = 0.000568195 \text{ Ksi. shear.}$$

c) Unit Overterning Moment at Pedestal top ($N = 1 k\text{-}ft$)

$$fb_A = fb_B = fb_C = \frac{12}{10559.76} = 0.001136389 \text{ Ksi.}$$

d) Unit Wind Lood along the pedestal Pipe. (W)



$$fv = 1.5 \frac{14.773}{494.149} = 0.0448 \text{ Ksi}$$

$$fv = 1.5 \frac{71.373}{494.149} = 0.2167 \text{ K}$$

$$fv = 1.5 \frac{88.583}{494.149} = 0.2689$$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 27 OF

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-102-

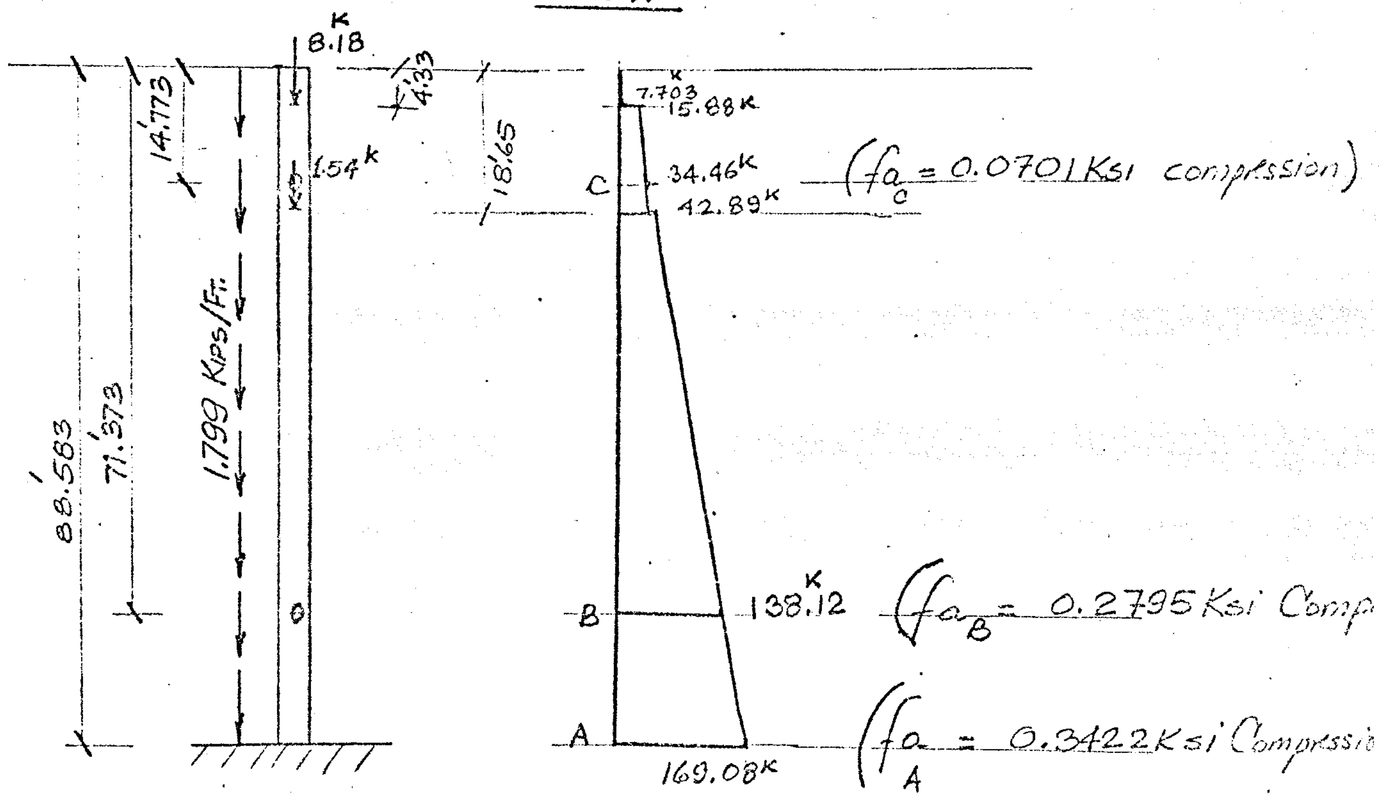
SUBJECT Frigg Field, MPX, Crane Pedestals

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY D.C.C. APP'D BY DATE May 8 1975

a) Dead weight of Pedestal and Platforms.

DW.



C.1.5 Combine Unit Loads. When Wind & Lift are coaxial.

At Point A.

(A)

$$fb_{AX} = 0.10066\, Q_{crane}$$

$$fb_{AY} = 0.10066\, Q_{wind} + 0.001136389\, N_{crane+wind} + 4.4586\, W$$

$$fb_A = \sqrt{fb_{AX}^2 + fb_{AY}^2}$$

$$fa_A = 0.0020237 \times P + 0.3422$$

$$fv_A = \sqrt{(0.003036\, Q_{Wind} + 0.2669\, W)^2 + 0.003036\, Q_{crane}^2}$$

$$\tau_A = 0.000568195\, T.$$

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 23 OF ___

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-102-

SUBJECT Frigg Field, MPX, Crane Pedestals

BASED ON ___ DRAWING NO ___

COMPUTER KARSAN CHK'D. BY D.P. APP'D BY ___ DATE May 8 1975

At Point B

△A

$$f_{b_{By}} = 0.08111 \times \varphi_{wind} + 0.001136389\, N_{(wind+crane)} + 2.8944\, W$$

$$f_{b_{Bx}} = 0.08111 \times \varphi_{crane}$$

$$f_{b_B} = \sqrt{\overline{f_{b_{By}}}^2 + \overline{f_{b_{Bx}}}^2}$$

$$f_{a_B} = 0.0020237 \times P + 0.2795$$

$$f_{v_B} = \sqrt{(0.003036\, \varphi_{wind} + 0.2167\, W)^2 + (0.003036\, \varphi_{crane})}$$

$$Z_B = Z_A$$

Reactions at Crane Base.

△A

$$\text{O.T. Moment} = \sqrt{(88.538\, \varphi_{wind} + N_{wind+crane} + 3923.47W)^2 + (88.583\, \varphi_{crane})^2}$$

$$\text{Axial Compression} = P + 169.08$$

$$\text{Torsion} = T$$

$$\text{Shear} = \sqrt{(\varphi_{wind} + 88.583\, W)^2 + \varphi_{crane}^2}$$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 29 OF ___

CLIENT: TOTAL OIL MARINE LTD. JOB NO: TO-102-

SUBJECT: Frigg Field, MPX, Crane Pedestals

BASED ON ___ DRAWING NO ___

COMPUTER: KARSAN CHK'D. BY: [illegible] APP'D BY ___ DATE: MAY 8 1975

C.1.6 Combine Unit Loads When Wind is Across the Boom.

At Point A.

(A) $fb_{A_X} = 0.1066\,Q_{Wind+Cr} + 4.4586\,W + 0.001136389\,N_{WIND}$

$fb_{A_Y} = 0.001136389\,N_{crane}$

$fb_A = \sqrt{fb_{A_X}^2 + fb_{A_Y}^2}$

$fa_A = 0.0020237\,P + 0.3422$

$fv_A = \sqrt{(0.003036\,Q_{WIND} + 0.2689\,W)^2 + \overline{0.003036\,Q_{CRANE}}^2}$

$\tau_A = 0.000568195\,T$

At Point B.

$fb_{B_X} = 0.0811\,Q_{WIND+Crane} + 0.001136389\,N_{WIND} + 2.8944\,W$

$fb_{B_Y} = 0.001136389\,N_{crane}$

$fb_B = \sqrt{fb_{B_X}^2 + fb_{B_Y}^2}$

$fa_B = 0.0020237\,P + 0.2795$

$fv_B = 0.003036\,Q_{WIND+CRANE} + 0.2167\,W$

$\tau_B = \tau_A$

Reactions At crane Base.

$\triangle$A

$$\text{O.T. Moment} = \sqrt{(88.583\, Q_{WIND+CRANE} + 3923.47\,W)^2 + N_{CRANE}^2}$$

$$\text{Axial Compression} = P + 169.08$$

$$\text{Torsion} = T$$

$$\text{Shear} = Q_{WIND} + Q_{CRANE} + 88.583\,W$$

CP BR 21
FORM D–IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 131 OF

CLIENT TOTAL OIL MARINE LTD JOB NO TO-102-

SUBJECT Frigg Field, MPX, Crane Pedestals

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY DCI APP'D BY DATE MAY 2 1975

LOAD CONDITION NO.	Shear Force At Pedestal top Q (KIPS)		Axial Load At Pedestal top ℄ P (Kips)	Torsional Moment At Ped'l Top T (K-FT.)	Overturning Moment At Ped'l Top N (K-FT)		Wind Load On Pedestal Pipe W (K/FT.)	
1	9.323 CRANE		871.24	108.15	15452.8		0	
2	9.323 CRANE	28.35 WIND	871.24	1144.06	15452.8 CRANE	474.86 WIND	0.105	
3	9.323 CRANE	28.35 WIND	871.24	108.15	15927.66		0.105	
4	17.207 CRANE		280.18	547.87	-2132.96		0	
5	17.207 CRANE	16.35 Wind	280.18	737.53	-2132.96 CRANE	168.90 WIND	0.105	
6	17.207 CRANE	16.35 Wind	280.18	547.87	-2301.86		0.105	
7	0 CRANE	71.21 Wind	261.99	415.37	344.74 CRANE	217.19 WIND	0.725	
8	101.56		280.18	4739.80	-2580.68		0.725	
9	4.6847		0	0	171.179		0.01735	Note :- Unit wind is taken as 10m/sec
10	4.6847		0	78.469	171.179		0.01735	
11	2.535		0	14.914	7.732		0.01735	

TABLE 4 - BASIC LOADS FOR LOAD CONDITIONS

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 32 OF ____

CLIENT: TOTAL OIL MARINE LTD. JOB NO. TO-103-C

SUBJECT: Frigg Field, MPX, Crane Pedestals

BASED ON ____ DRAWING NO ____

COMPUTER: KARSAN CHK'D. BY: DRP APP'D BY ____ DATE: MAY-9 1975

(A)

LOAD CONDITION	STRESS POINT A									STRESS POINT B				
	Axial Load KIPS	SHEAR KIPS	TORSION MOMENT K-FT	BENDING MOMENT K-FT	f_a KSI	f_b KSI	f_v KSI	τ KSI	Interaction Ratio (Highest)	f_a KSI	f_b KSI	f_v KSI	τ KSI	Interaction Ratio (Highest)
1	1040.32	9.323	108.15	15414.4	2.105	17.585	0.028	0.061	0.627	2.05	17.58	0.028	0.061	0.625
2	1040.32	46.974	1144.06	16019.7	2.105	18.265	0.137	0.650	0.513	2.05	17.988	0.137	0.650	0.505
3	1040.32	38.788	108.15	18869.03	2.105	21.442	0.118	0.061	0.589	2.05	20.72	0.112	0.061	0.570
4	449.26	17.207	547.87	3657.2	0.909	4.156	0.052	0.311	0.138	0.847	2.797	0.052	0.311	0.130
5	449.26	42.86	737.53	4144.81	0.909	4.882	0.125	0.419	0.150	0.847	4.147	0.228	0.419	0.130
6	449.26	30.89	547.87	4432.5	0.909	5.037	0.093	0.311	0.154	0.847	4.469	0.089	0.311	0.137
7	431.07	135.43	415.37	9376.04	0.872	11.077	0.411	0.236	0.287	0.810	8.131	0.373	0.236	0.215
8	449.26	165.78	4739.80	14421.69	0.909	16.388	0.503	2.693	0.415	0.847	13.268	0.466	2.693	0.339
9	0	6.2216	0	654.24	0	0.7434	0.0189	0	N.A.	0	0.625	0.0180	0	N.A.
10	0	6.2216	73.469	654.24	0	0.7434	0.0189	0.045	N.A.	0	0.625	0.0180	0.045	N.A.
11	0	4.0719	14.914	300.36	0	0.3413	0.0124	0.0085	N.A.	0	0.265	0.0115	0.0085	N.A.

TABLE 5- STRESSES AND INTERACTION RATIOS [illegible]

CONCLUSION.

The overall Behavior of Pedestal pipe satisfies API-RP2 and AISC code requirements. The highest interaction ratio being 0.627 at crane base for Load Condition 1. in Load Condition 1, an operating condition with maximum Lift was considered.

C.2. Study Overall stability and Safety Factors.

- Normal Axial Buckling

$$f_{cr} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2} = \frac{\pi^2 \times 30 \times 10^6}{(68.35)^2} = 63.378 \text{ Kips}$$

Yielding strength ≈ 51.2 Ksi.

Amplified bending stress for L.Cond 1

$$f_b^* \cong \frac{17.585}{1 - \frac{2.105}{63.378}} \cong 18.19 \text{ ksi.}$$

Amplified Combined Stress $= f_c \cong 18.19 + 2.105 = 20.299$

Factor of safety against Yield $\approx \frac{51.2}{20.299} = \underline{\underline{2.52}}$ > Safety factor for A.ionic which is 2.10 (TEX A.H.S by WRIGHT/BURS)

A

– Factor of safety against ultimate wrinkling Stress.

$$F_W = \left[1 - \left(1 - \frac{3300/F_y}{D/t}\right)^2\right] F_y$$

$$= \left[1 - \left(1 - \frac{3300/51.2}{230/4.5}\right)^2\right] 51.2 = 47.72 \text{ Ksi}$$

(A) F.S. against wrinkling $= \dfrac{47.72}{20.299} = 2.35 >$ S.F. 'A' Frame $= 2.10$

– Factor of safety Against Ultimate Bending capacity.

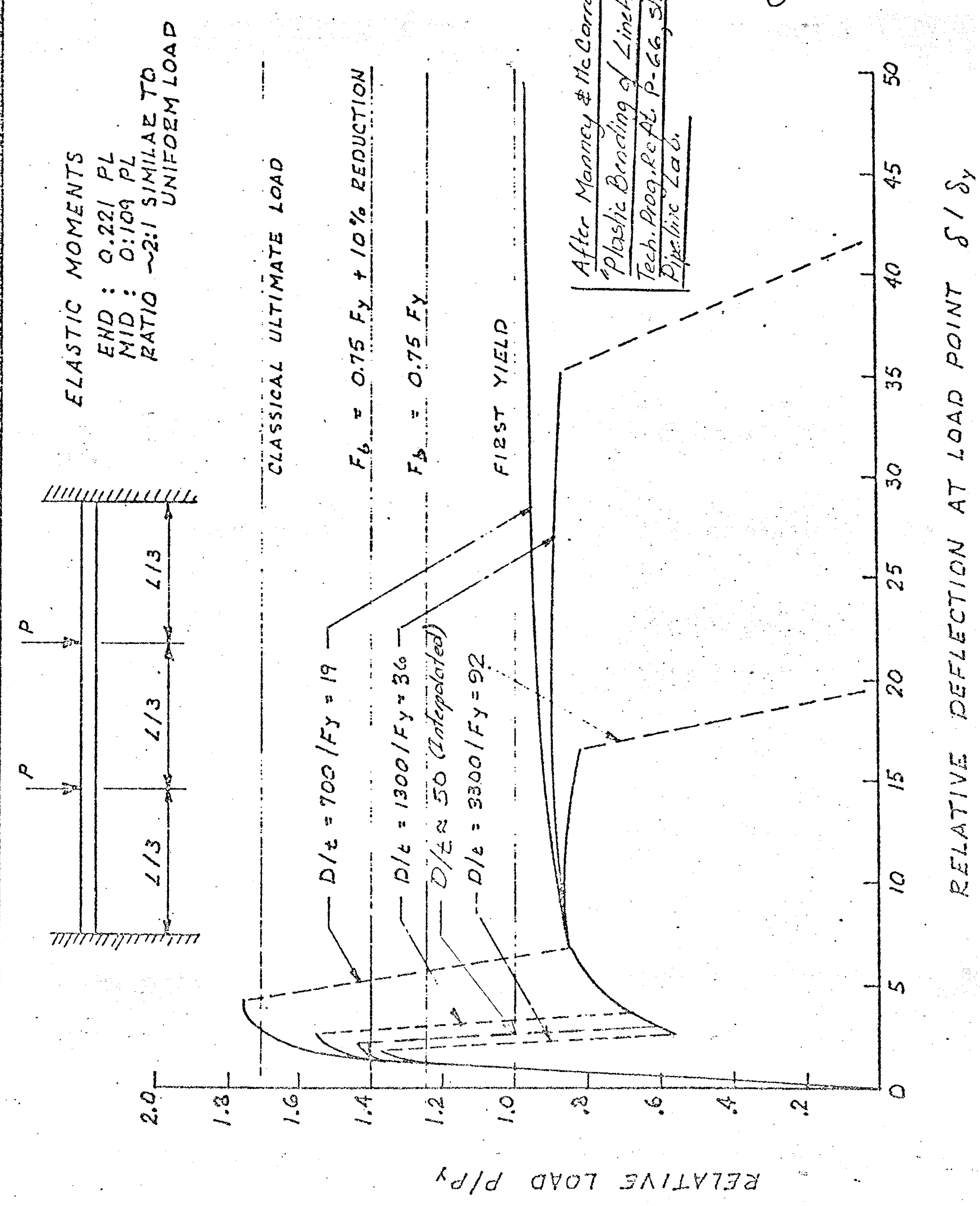
As per Brown & Root Spec. FIG. 6. for a Beam with $D/t = 230/4.5 = 51.$ an $M_u/_H$ ratio of 1.40 Can be expected. If we define a Conservative interaction diagram consisting of a straight line, one axis being the axial load, other the moment and def a hypothetical bending stress fb such that

$$\left(\frac{f_b}{F_y}\right)_{max} = \left(\frac{M_u}{M_y}\right)_{max} = 1.40$$

and

$$\left(\frac{f_a}{F_y}\right)_{max} = \frac{47.72}{51.20} = 0.93$$

the interaction diagram can be plotted as shown in page 36.



BROWN & ROOT Inc. HOUSTON, TEXAS

CONT. NO.

BEAM BEHAVIOR

DWG. NO.

FIGURE #6

DRAWN BY ______ CHECKED ______ APPROVED ______ DATE ______ SHT ______ OF ______

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

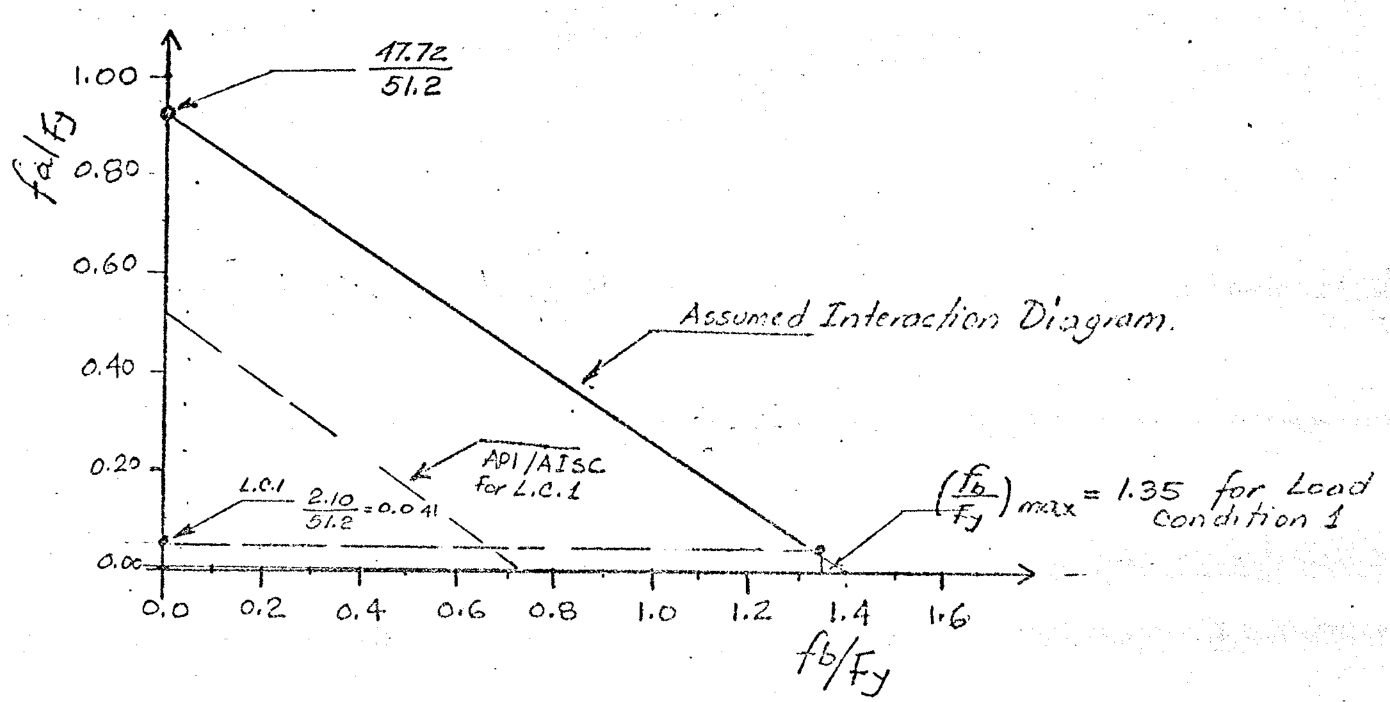
SHEET No. 36 OF

CLIENT TOTAL OIL MARINE | JOB NO. TO-102-

SUBJECT FRIGG FIELD, MPX, CRANE PEDESTALS

BASED ON | DRAWING NO.

COMPUTER KARSAN | CHK'D. BY | APP'D BY | DATE MAY-12- 1975



∴ For Load condition 1 $f_b/F_y = 1.35 \Rightarrow f_{b_{ult}} = 1.35\,F_y = 1.35 \times 51.2$

$f_{b_{ult}} = 69.12$ ksi [Note: This is a hypothetical value and should be considered as a nondimensionalized moment only. However the comparison to existing stress should still give valid factor of safety]

Factor Of Safety against combined Load Failure $\cong \frac{69.12}{17.585} \cong 3.93$ ✓

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 37 OF

CLIENT TOTAL OIL MARINE JOB NO TO-102-(

SUBJECT FRIGG FIELD, MPX, CRANE PEDESTALS

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY DRP APP'D BY DATE MAY-13 1975

C. 3. Study Fatigue.

In the Light of the Report prepared by Atkins R& D and probable Lifting history of the crane, Assume Following history of Loading.

C.1.1 — One 40K Lift every day for 30 years = 30×365, 10950 cycles, plus 5 metr/sec. wind vibrations at 1cps for a 10 minute Lift Period (600 × 10950 = 6570000)

a) Find Minimum stress at Base, no wind, no Lift.

$$f_c = f_a + f_{b_{ampl.}}^{*} = 0.909 + \frac{4.156}{1 - \frac{0.909}{63.378}} = 5.125 \text{ Ksi}$$ (Load Cond. 4, page

b) Find Maximum stress at Base, 40k Lift no wind.

Total axial Load = 328.06 + 40 = 368.06^K

(for impact fact of 2)

Total O.T. Moment = 4526.63 + 40 × 105 = 8726.63

Side Swing force = 9.323^K at 9.02 Ft high 11.6 Ft toward Boom

See page 7 and 9

∴ $Q = 9.323^K$

$P = 368.06^K$

$M = 8726.63 + 9.323 \times 11.6 = 8834.78$ K-Ft.

$T = 9.323 \times 11.60 = 108.15$ K-Ft

∴

$f_a = 0.0020237 \times 368.06 + 0.3422 = 1.087$ Ksi

$f_b = 0.10066 \times 9.323 + 0.00113\,6389 \times 8834.78 = 10.98$ Ksi

$$f_c = 1.087 + \frac{10.98}{1 - \frac{1.087}{63.378}} = 12.257 \text{ ksi}$$

c) Stresses superimposed due to 5 m/sec Wind.

assuming across the boom.

$f_a = 0$, $f_b = 0.625\left(\frac{5}{10}\right)^2 = 0.157$ ksi.

$$f_c = \frac{0.157}{1 - \frac{1.06}{63.378}} = 0.159 \text{ ksi}$$

Using BS 153 Parts 3B & 4:1972 Class B. (Table 2 Page 15)

10950 cycles of no wind, $\frac{f_{min}}{f_{max}} = -1$ (assume full rotation)

$f_{max} = 12.257$ ksi $= 84.45$ N/mm²

$$\log_{10} N = 8 - \frac{\log 84.45 - \log 74.7}{\log 91.9 - \log 74.7} = 7.41$$

$N = 2.558 \times 10^7$ cycles

∴ Fatigue Ratio$_1$ $= FR_1 = \frac{1.095}{2.558} 10^{-3} = 0.428 \times 10^{-3}$

– 6.57×10^5 cycles of 5 M/sec. wind

$$\frac{f_{min}}{f_{max}} = \frac{12.257}{12.257 + 0.159} = 0.987$$

$f_{max} = 12.416$ $f_8 = 432$ $f_7 = 430$

$\log_{10} N = 350$, Negligible effect.

C.1.2. One Full capacity Lift every week for 30 years = 1560 cycl
no wind.

$f_a = 2.105 ksi,\ f_b = 18.499 ksi$ Load Cond. 1.

$f_{min} = 2.105 - \dfrac{18.499}{1-\dfrac{2.105}{63.373}} = -17.03 ksi.,\quad f_{max} = +\dfrac{18.499}{1-\dfrac{2.105}{63.373}} + 2.105 = 21.24k$

(considering one full swing)

$\dfrac{f_{min}}{f_{max}} = -\dfrac{17.03}{21.24} = -0.801,\quad f_{max} = 21.24 ksi = 146.34 N/mm^2$

$Log_{10} N = 6 - \dfrac{Log\,146.34 - Log\,127.9}{Log\,150.3 - Log\,127.9} = 5.1654$

$N = 1.464 \times 10^5$ cycles.

Fatigue $Ratio_2 = FR_2 = \dfrac{1.56}{1.464} \times 10^{-2} = 1.066 \times 10^{-2} = 0.010$

C.1.3. 9.94×10^9 cycles/yr of 10 M/sec wind with No Load
(Atkins Report Fig 5, Exceedance diagram.)

$f_{average} = 5.125^{ksi}$ (L.C. 4)

Amplitude of vibratory stresses will be

$f_b = \dfrac{0.7434}{1-\dfrac{0.909}{63.373}} = 0.754 ksi$ ∴ $f_{min} = 5.125 - 0.754 = 4.37 ks$

$f_{max} = 5.125 + 0.754 = 5.88 ksi = 40.51 N/$

$\dfrac{f_{min}}{f_{max}} = \dfrac{4.37}{5.88} = +0.743$

∴ from BS153 Table 2, $f_8 = 240.19\ N/mm^2$ $f_7 = 277.51$

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 40 OF ____

CLIENT: TOTAL OIL MARINE — JOB NO: TC-102-02

SUBJECT: FRIGG Field, MPX, crane Pedestals

BASED ON: ____ DRAWING NO: ____

COMPUTER: KARSAN — CHK'D. BY: D.F.C. — APP'D BY: ____ — DATE: MAY-13 1975

Exceedance Diagram for Turbulence Forces. V_M is 5sec. gust speed at 10m above sea at mid-tide

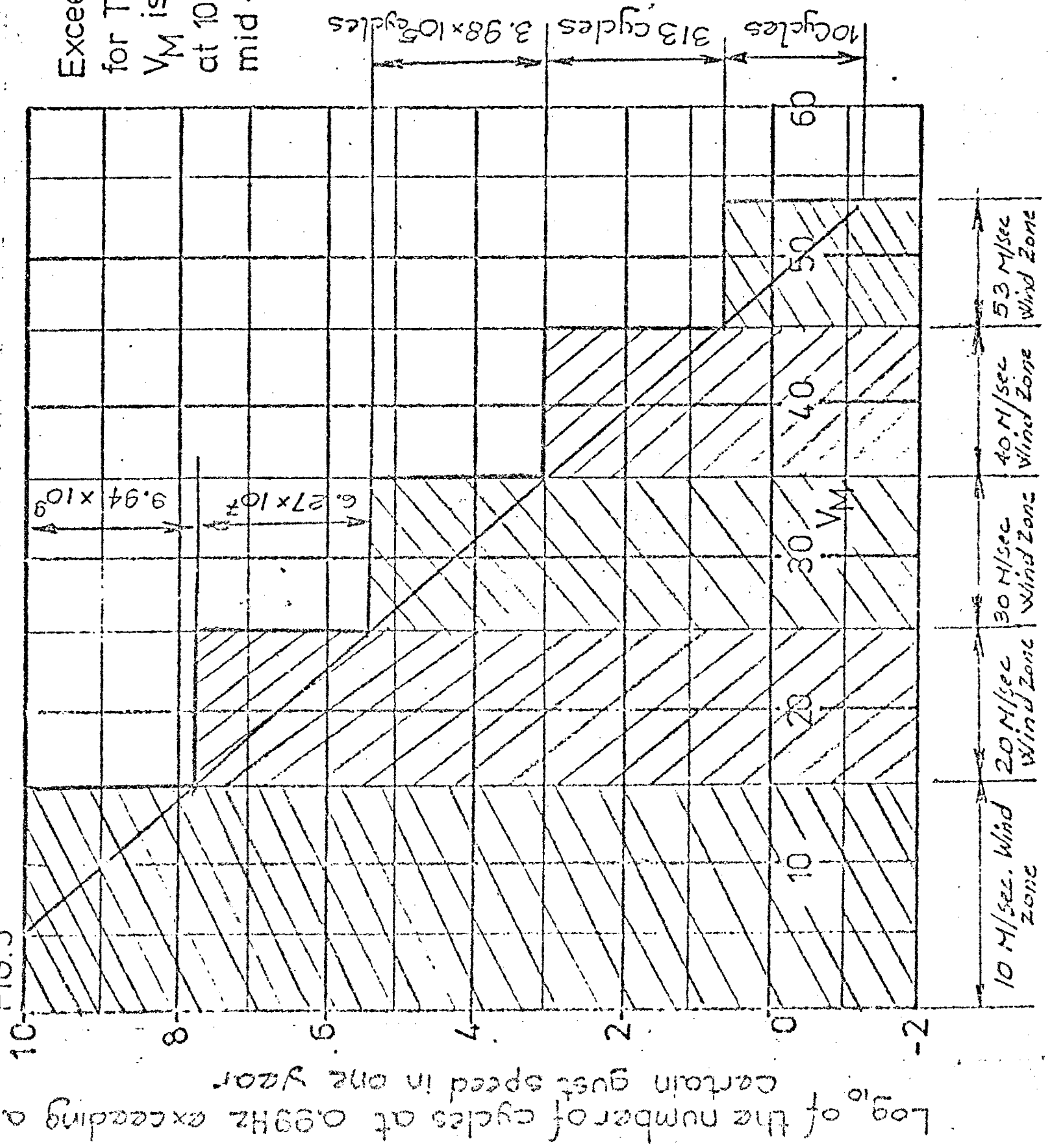


FIG.5

CP BR 21
FORM D—1A

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ENGINEERING DEPARTMENT

SHEET No. 41 OF

CLIENT TOTAL OIL MARINE JOB NO TO-102-C

SUBJECT FRIGG FIELD, MDX, CRANE PEDESTALS

BASED ON DRAWING NO

COMPUTER KARSAN CHK'D. BY [illegible] APP'D BY DATE MAY-13 19 75

$$Log_{10} N = 8 + \frac{Log\,240.19 - Log\,40.51}{Log\,277.5 - Log\,240.19} = 20.324$$

$N = 2.122 \times 10^{20}$ cycles.

THE EFFECT OF THESE CYCLES CAN BE NEGLECTED.

$FR_3 = 0$

C.1.4. 6.27x10^7 cycles of 20 M/sec wind, No Lift.
(Atkins Rept. Fig 5)

$f_{average} = 5.125^{ksi}$ (L.C.4)

$$f_b = \frac{0.7434\left(\frac{20}{10}\right)^2}{1 - \frac{0.909}{63.373}} = 3.02 \text{ ksi.}$$

$f_{min} = 5.125 - 3.02 = 2.105$ ksi

$f_{max} = 5.125 + 3.02 = 8.145$ ksi $= 56.12$ N/mm²

$\frac{f_{min}}{f_{max}} = 0.258$

$f_8 = 140.29$ N/mm², $f_7 = 172.61$ N/mm²

$$Log_{10} N = 8 + \frac{Log\,140.29 - Log\,56.12}{Log\,172.61 - Log\,140.29} = 12.419$$

$N = 2.626 \times 10^{12}$

$$FR_4 = \frac{6.27}{2.626} \times 10^{-5} \times 50\text{yrs} = 1.19 \times 10^{-3}$$

C.1.5 3.98x10^5 cycles/yr of 30 M/sec wind gust.
(Atkins, Fig 5)

$f_{average} = 5.125$ ksi.

$$f_b = \frac{0.7434\left(\frac{30}{10}\right)^2}{1 - \frac{0.909}{63.373}} = 6.786 \text{ ksi}$$

$f_{min} = 5.125 - 6.786 = -1.661$, $f_{max} = 5.125 + 6.786 = 11.911$ ksi. $= 82.07$ N/mm²

$\frac{f_{min}}{f_{max}} = \frac{-1.661}{11.911} = -0.139$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 42 OF

CLIENT TOTAL OIL MARINE JOB NO TC-102-

SUBJECT FRIGG FIELD, MPX, CRANE PEDESTALS

BASED ON DRAWING NO.

COMPUTER KARSAN CHK'D. BY [initials] APP'D BY DATE MAY-13-1975

$f_6 = 110.36.$ $f_7 = 136.01$

$\log N = 8 + \frac{\log 110.36 - \log 82.07}{\log 136.01 - \log 110.36} = 9.417$

$N = 2.614 \times 10^9$

$FR_5 = \frac{3.98}{2.614} \times 10^{-4} \times 50 yrs = 0.761 \times 10^{-2}$

C.1.6 313 cycles/yr. of 40 M/sec Wind.

$f_{average} = 5.125$ Ksi

$f_b = \frac{0.7434 \left(\frac{40}{10}\right)^2}{1 - \frac{0.909}{63.375}} = 12.064$ ksi

$f_{min} = 5.125 - 12.064 = -6.939$ ksi

$f_{max} = 5.125 + 12.064 = 17.189$ ksi $= 118.43$ N/mm^2

$\frac{f_{min}}{f_{max}} = -\frac{6.939}{17.189} = -0.404$

$N = 10^7$ cycles

$FR_6 = 0.313 \times 10^{-4} \times 50 yrs = 0.157 \times 10^{-2}$

C.1.7 10 cycles of 53 M/sec Gust. (for 50yrs)

$f_{average} = 5.125$ Ksi

$f_b \approx \frac{0.7434}{1 - \frac{0.909}{63.375}} \left(\frac{53}{10}\right)^2 = 21.18$ ksi

$f_{min} = -16.05$ ksi $f_{max} = 26.30$ ksi $= 181.21$ N/mm^2

$\frac{f_{min}}{f_{max}} = -0.610$

$f_5 = 162.81 \ N/mm^2 \qquad f_6 = 138.61$

$$\log N = 5 - \frac{\log f - \log f_5}{\log f_5 - \log f_6} = 5 - \frac{\log 181.21 - \log 162.81}{\log 162.81 - \log 138.61} = 4.334$$

$N = 2.162 \times 10^4$

$$FR_6 = \frac{1}{2.162} \times 10^{-3} = 0.462 \times 10^{-3}$$

CUMMULATIVE FATIGUE RATIO AT PEDESTAL PIPE

$$= 0.428 \times 10^{-3} + 1.066 \times 10^{-2} + 0.119 \times 10^{-2} + 0.761 \times 10^{-2} + 0.157 \times 10^{-2} + 0.426 \times 10^{-3} = 0.022 < 1 \text{ OK.}$$

No Fatigue Problem present (in general)

SECTION. 5

SECTION 5 - EVALUATE STATIC AND DYNAMIC STRESSES AT BASE CONNECTION AND MAN HOLES, STUDY FATIGUE.

STEP C – Evaluate Static and Dynamic Stresses at Base connection and Man Holes.

C.1. Check The Man-Hole stresses.

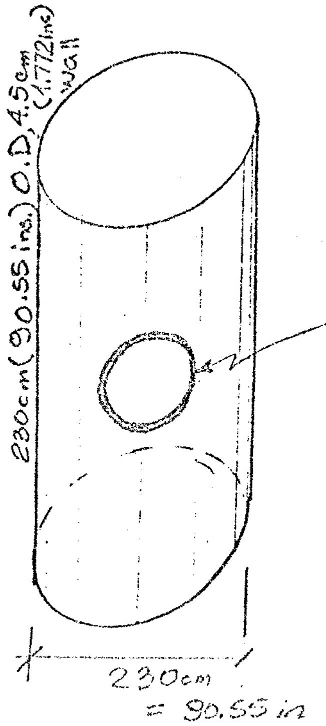
Analyse the stress case where

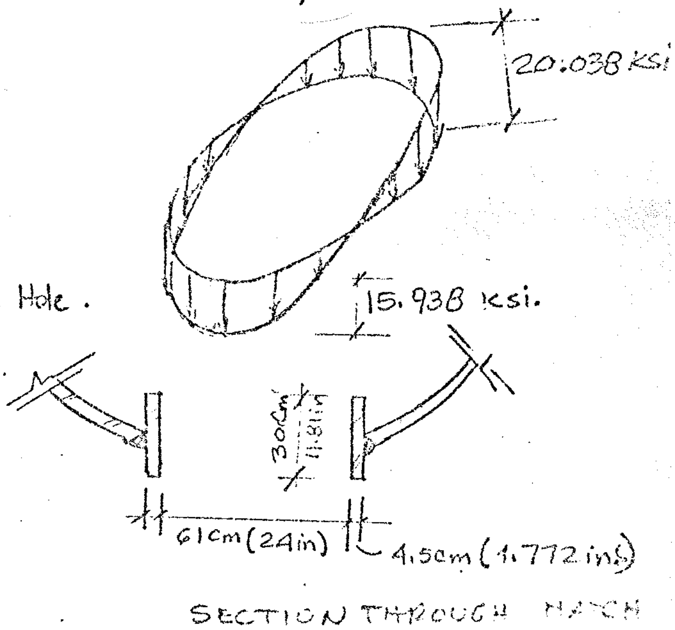
$f_a = 2.05\,ksi$ (compression)
$f_b = 17.988\,ksi$
} Load Condition 2.

△A

$M_b = 17.988 \times 10\,559.76 = 1.899 \times 10^5$ k-in.

$A = 2.05 \times 494.142 = 1013.0$ kips.





CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 45 OF ___

CLIENT TOTAL OIL MARINE — JOB NO TO-102-0

SUBJECT FRIGG FIELD, CRANE PEDESTALS

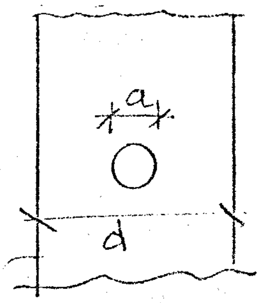
BASED ON ___ DRAWING NO ___

COMPUTER KARSAN. CHK'D. BY RRP APP'D BY ___ DATE MAY 13 1975

Study stress intensification factors

Assume the case of a infinite plate with a circular hole.

k = Stress intensification factor



$$= \frac{3d}{a+d}$$

R.J. Roarke: Formulas for Stress and Strain, McGraw Hill & Co. PP. 384. Formula 5

assuming $a = 24$

$d \cong \frac{\pi \times 91}{2} = 142.2$ in — for bending

$$k \approx \frac{3 \times 142.2}{142.2 + 24} = 2.57$$

(A) $f_b = 2.57 \times 17.988 = 46.23$ ksi.

for axial load $d \cong \pi \times 91 = 285.9$ in

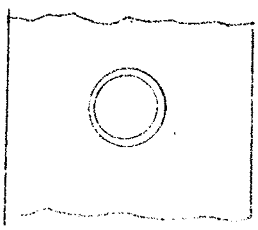
$$k = \frac{3 \times 285.9}{24 + 142.2} = 2.77$$

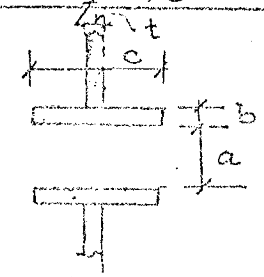
$f_a = 2.77 \times 2.05 = 5.68$ ksi.

$$f_c = 5.68 + \frac{46.23}{1 - \frac{8.105}{63.38}} = 53.50 \text{ ksi} \text{ — unacceptable.}$$

The stress intensification will probably lower than above due to poissons ratio effect and tube stiffener at the mouth of ...

Study the effect of tube stiffener.





$t = 1.772$ ins.
$c = 11.88$ ins.
$b = 1.772$ ins.
$a = 24$ ins.

CP BR 21
FORM D—1A

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ENGINEERING DEPARTMENT

SHEET No. 46 OF ____

CLIENT TOTAL OIL MARINE JOB NO TO-102-

SUBJECT FRIGG FIELD, CRANE PEDESTALS

BASED ON ____ DRAWING NO ____

COMPUTER KARSAN CHK'D. BY ____ APP'D BY ____ DATE MAY 16 1975

Bead Area = $A_b = b(c-t) = 1.772\,(11.888 - 1.772) = 17.926$ in

Hole Area = $A_h = at = 24 \times 1.772 = 43.339\ in^2$

$\frac{A_b}{A_h} = 0.413$

RJ Roark. Pp. 385 Formula 7

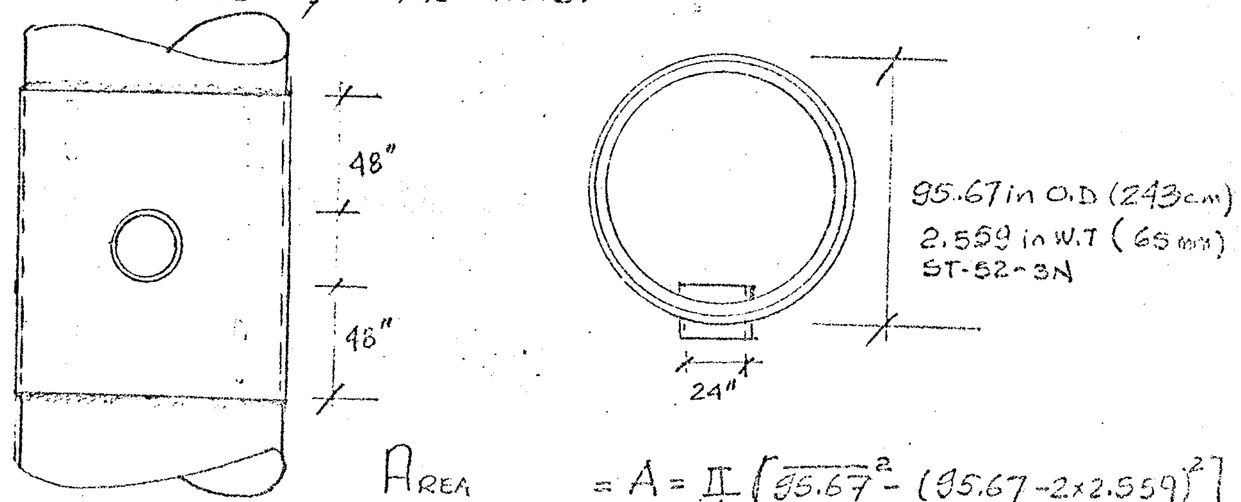
$K = 1.67$

Thus, intensified stress $\approx 1.67 \times 20.038 = 33.46$ ksi
$= .65 F_y$

(A)

Use a wrap plate to cut down the intensified stress.

Consider a 20mm (0.7874 in) wrap plate welded to the outside face of the pedestal pipe. Extend this by 2a (48 in) to both sides of the hole.



$\text{Area}_{\text{combined}} = A = \frac{\pi}{4}\left[\overline{95.67}^2 - (95.67 - 2 \times 2.559)^2\right]$
$= 748.55$

$I_{comb} = I_c = \frac{\pi}{64}\left(\overline{95.67}^4 - (95.67 - 2 \times 2.559)^4\right]$
$= 811822.45\ in^4$

$S_{comb} = 16971.30\ in^3$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 47 OF

CLIENT TOTAL OIL MARINE — JOB NO TO-102-

SUBJECT FRIGG FIELD, CRANE PEDESTALS

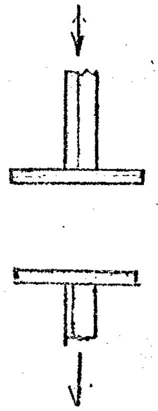
BASED ON — DRAWING NO

COMPUTER KARSAN CHK'D. BY DRP APP'D BY — DATE MAY 16 1975

$$f_a = \frac{1013.0}{748.55} = 1.353\,ksi$$

$$f_b = \frac{1.899\times10^5}{16971.30} = 11.189\,ksi$$

$$f_c = 1.353 + \frac{11.189}{1-\frac{2.05}{63.38}} = 12.916\,k$$



$t = 2.559\,in$

$\therefore\; A_b = 1.772\,(11.888-2.559) = 16.531$

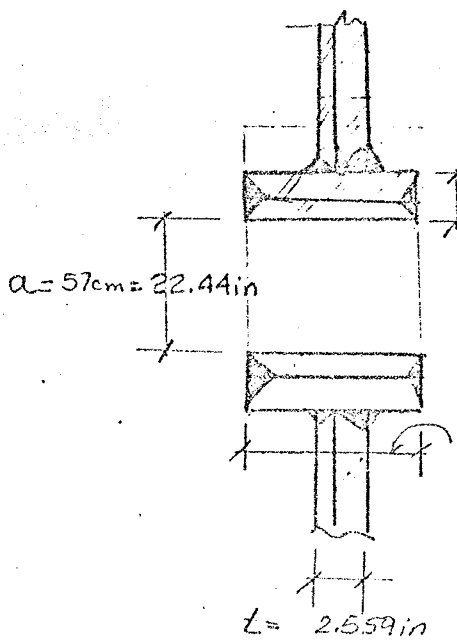
$A_h = 24\times2.559 = 61.416$

$\frac{A_b}{A_h} = 0.269$

$K = 1.98$

Intensified Stress $= 1.98\times12.92 = 25.57\,ksi$
$= .50\,F_y$, maybe acceptable

Increase thickness of bead to 65mm (2.559in) for added safety



$A_b = 2.559\,(11.88-2.559) = 23.852$

$A_h = 22.44\times2.559 = 57.423$

$\frac{A_b}{A_h} = 0.415$

$K = 1.66$

Intensified Stress $= 1.66\times12.92 = 21.45\,ksi$
$= .42\,F_y$

F.S. Against Yield $= 2.36$ OK.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 48 OF

CLIENT TOTAL OIL MARINE LTD JOB NO TO - 010

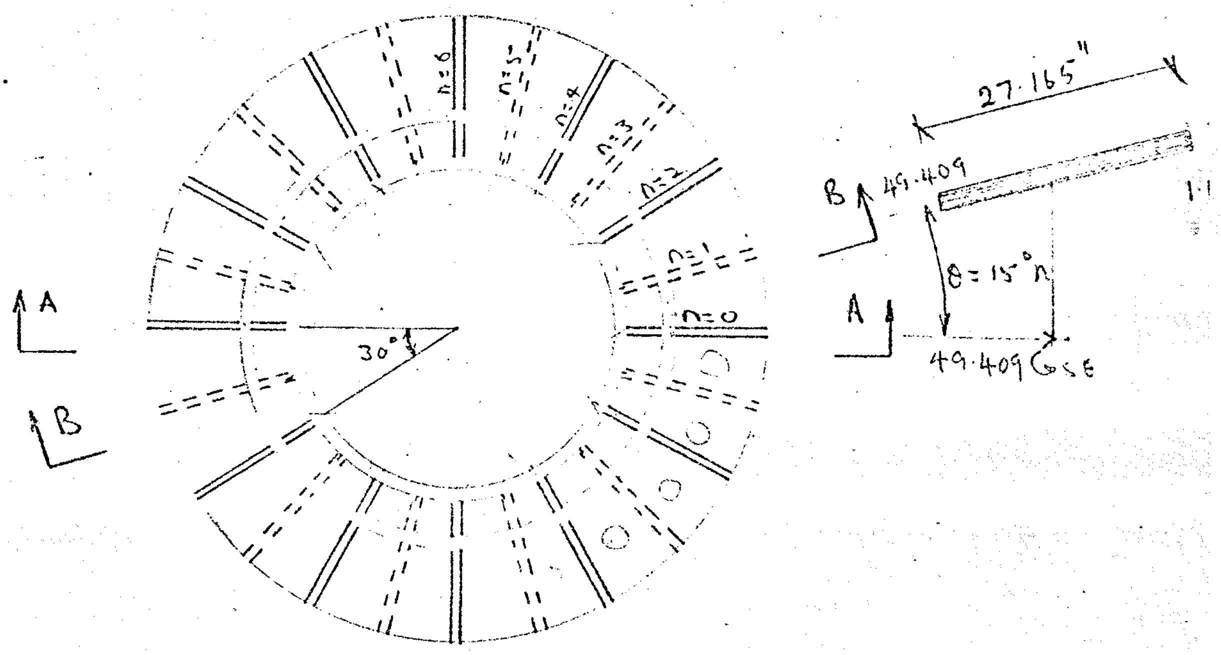
SUBJECT FRIGG FIELD CRANE PEDESTAL

BASED ON DRAWING NO

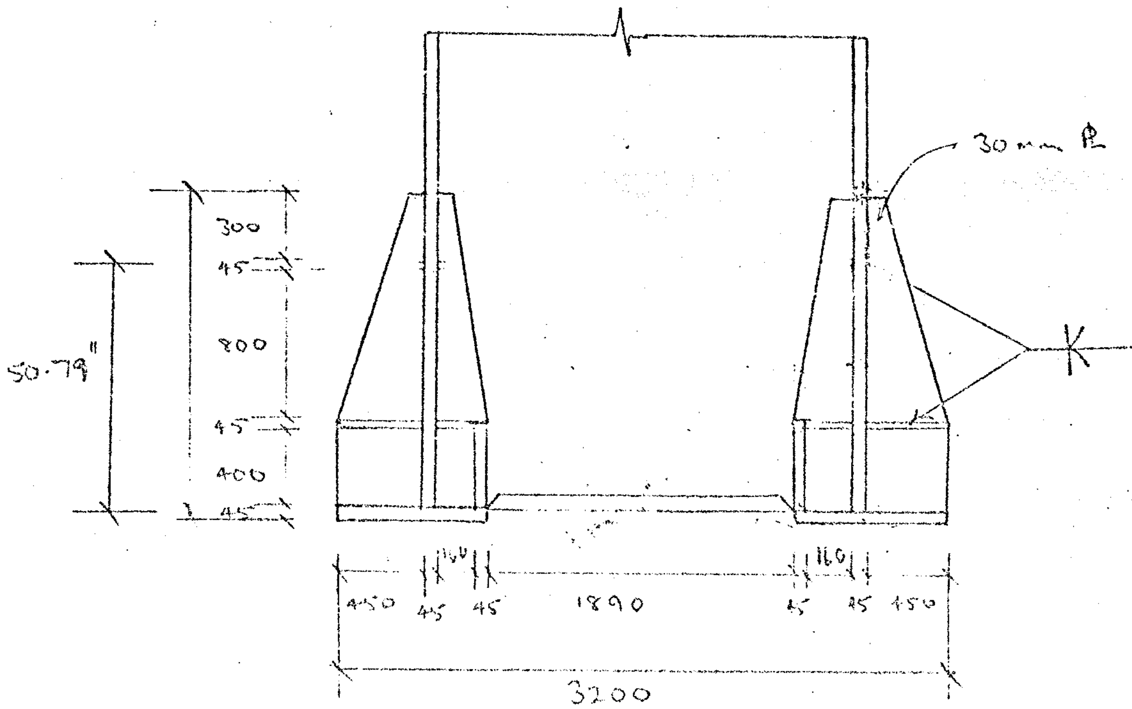
COMPUTER FORBES CHK'D. BY APP'D BY DATE AUG 1975

CHECK BASE CONNECTION STRESSES.

USE LOAD CONDITION 1 WITH THE FOLLOWING CONFIGURAT



PLAN



SECTION AA
1" = 40"

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

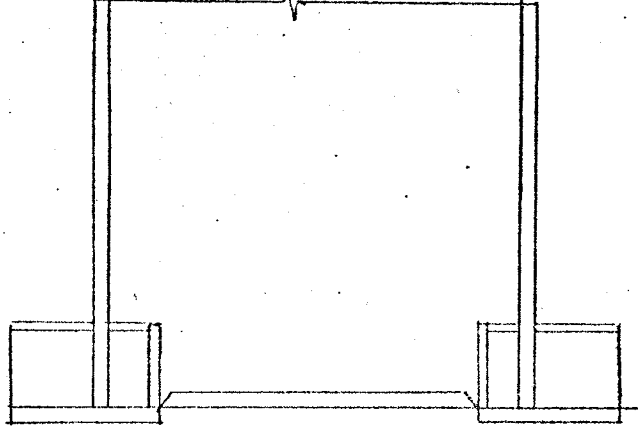
SHEET No. 49 OF

CLIENT Total Oil Marine Ltd. JOB NO TO-010

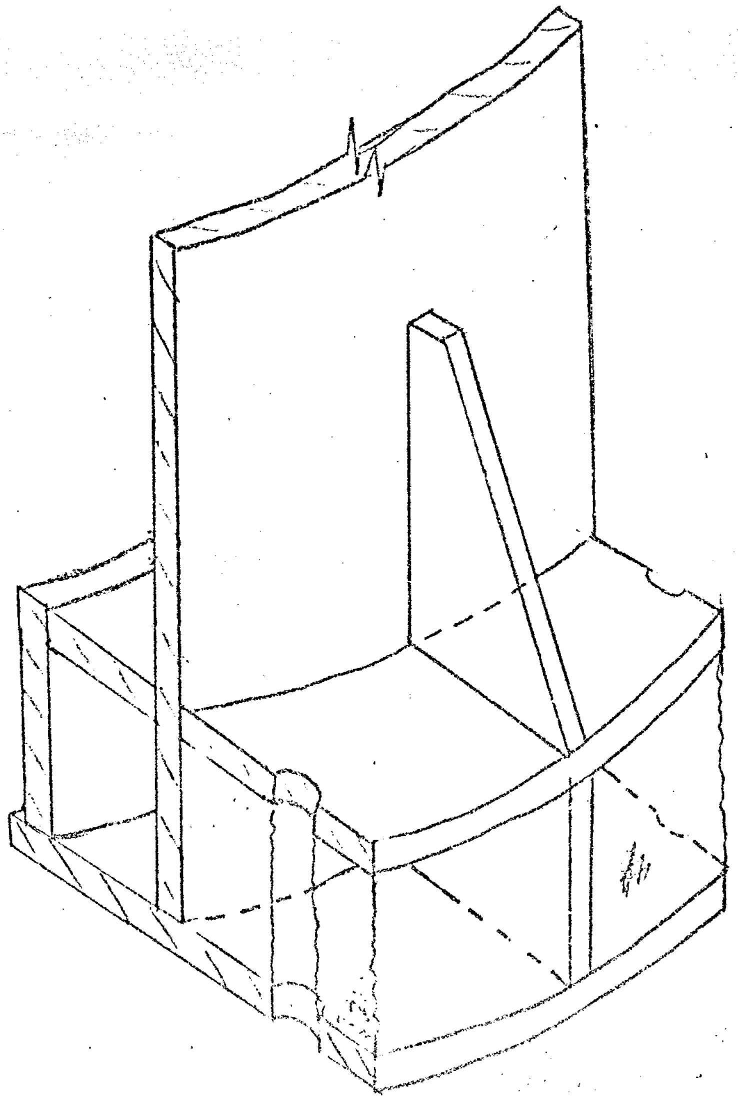
SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY [illegible] APP'D BY DATE Aug 1975



Section BB



Sketch of Stiffener.

CP BR 21
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BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 50 OF

CLIENT Total Oil Marine Ltd JOB NO TO-010

SUBJECT Frigg Field Crane Pedestals

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY DPP APP'D BY DATE Aug 1975

Calculate moment of Inertia of Stiffeners.

$I_{x_1} = \frac{1}{12} \; 1.1811^3 \times 27.165 = 3.73 \text{ in}^4$

$I_{y_1} = \frac{1}{12} \times 27.165^3 \times 1.1811 = 1972.87 \text{ in}^4$

$A = 32.0846 \text{ in}^2$

Moment of Inertia for one stiffener ..

$I_n = \frac{1}{2}(3.73 + 1972.87) - \frac{1}{2}(3.73 - 1972.87)\cos(30n) + 32.0846 \times [illegible] \cos^2 15n$

$= 988.3 + 984.57 \cos(30n) + 98570.632 \cos^2(15n)$

$I_0 = 80543.502 \text{ in}^4$

$I_1 = 75148.360 \text{ in}^4$

$I_2 = 60408.559 \text{ in}^4$

$I_3 = 40273.616 \text{ in}^4$

$I_4 = 20138.673 \text{ in}^4$

$I_5 = 5398.871 \text{ in}^4$

$I_6 = 3.73 \text{ in}^4$

Moment of Inertia of tubular area:

$t_{eq} = \frac{494.142 - 24 \times 1.1811 \times 1.7717}{494.142} \times 1.7717 = 1.5916$

$I_T = \frac{\pi}{64}\left[90.551^4 - (90.551 - 1.5916 \times 2)^4\right] = 440157.743 \text{ in}^4$

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 51 OF

CLIENT TOTAL OIL MARINE LTD. JOB NO TO-010

SUBJECT FRIGG FIELD - CRANE PEDESTAL

BASED ON DRAWING NO

COMPUTER FORBES CHK'D. BY [signature] APP'D BY DATE AUG 19 75

Total Moment of Inertia.

$$I_{TOTAL} = 440157.743 + 2I_0 + 4I_1 + 4I_2 + 4I_3 + 4I_4 + 4I_5 + 2I_6$$

$$= 1,406,724.523 \text{ in}^4$$

Section Modulus.

$$S_o = \frac{I_{TOTAL}}{62.992} = 2233.1 \text{ in}^3$$ (Outside fibres)

$$S_{o_I} = \frac{I_{TOTAL}}{35.827} = 39264.368 \text{ in}^3$$ (Inside fibres)

$$\text{Area} = 24 \times 32.0846 + 494.142 - 24 \times 1.1811 \times 1.7717$$

$$= 1213.95 \text{ in}^2$$

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 52 OF

CLIENT Total Oil Marine Ltd JOB NO TO-010

SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY [illegible] APP'D BY DATE 1 Aug 1975

Stress in Column Wall. – Section "BB"

– Consider stresses caused by axial load and moment from column.

– thus prestressing does not combine with these loads to cause moment in the column wall.

Stress outside of base ring – excluding prestress.

$$f_{c_o} = \frac{1040.32}{1213.95} + \frac{15474.4 \times 12}{22331.796} = 9.172 \text{ ksi}$$

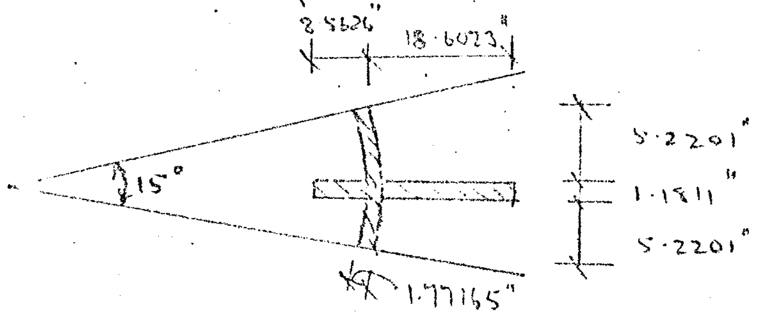
Stress in tubular wall – average.

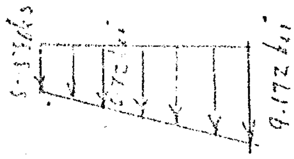
$$f_{c_t} = \frac{1040.32}{1213.95} + \frac{15474.4 \times 12}{1406724.523} \times 44.389 = 6.72 \text{ ksi}$$

Stress inside base ring

$$f_{c_i} = \frac{1040.32}{1213.95} + \frac{15474.4 \times 12}{39264.398} = 5.586 \text{ ksi}$$

Consider a cruciform element at base.





CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 53 OF ___

CLIENT: TOTAL OIL MARINE LTD — JOB NO: TO - 0167

SUBJECT: FRIGG FIELD CRANE PEDESTAL

BASED ON ___ DRAWING NO ___

COMPUTER: FORBES CHK'D. BY: DRP APP'D BY: ___ DATE: 3 AUG 1975

Total Force on the cruciform = F

$$F = \left(\frac{9.172 + 5.586}{2}\right) 1.1811 \times 27.1649 + 2 \times 6.72 \times 1.77165 \times 5.22$$

$$= 236.751 + 124.296 = 361.047 \text{ kips.}$$

Point of Application $\bar{x}$:

$$X = \frac{5.586 \times \frac{27.165^2}{2} \times 1.1811 + (9.172 - 5.586)\frac{2}{3} \times 27.165^2 \times 1.1811 + 6.72 \times 11.6212\ldots}{361.047}$$

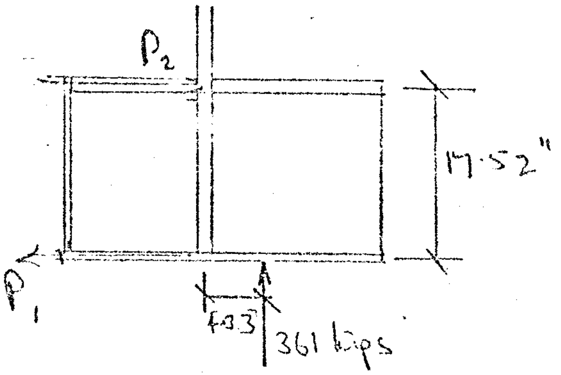
$= 12.896$ from inside base ring.

$\bar{x} = 12.896 - 8.5626 = 4.334$ from tub wall centre

Assume this moment is applied as two equal loads on tub wall.

$P_1 = P_2$

$P_2 = 361.047 \times \frac{4.334}{17.520} = 89.31$ kips



Force P_1 goes to tendon bolts as shear.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 54 OF

CLIENT TOTAL OIL MARINE LTD. JOB NO. TJ-0107

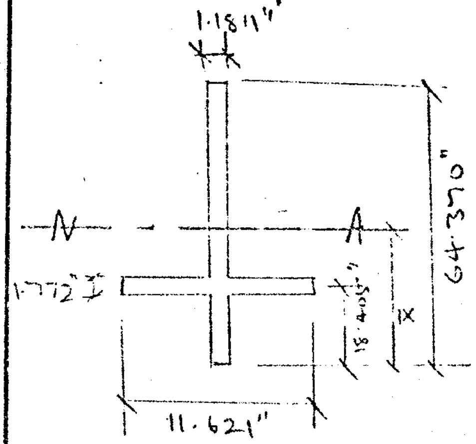
SUBJECT FRIGG FIELD CRANE PEDESTAL

BASED ON DRAWING NO.

COMPUTER FORBES CHK'D. BY PRM APP'D BY DATE AUG 19 75

Stress in Column Wall - Section "AA".

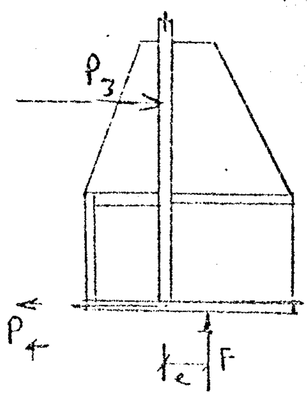
Position of Neutral Axis of Stiffener and Annulus.



$$\bar{X} = \frac{1.1811 \times \frac{64.37^2}{2} + 1.772 \times 11.620 \times 18.405}{1.1811 \times 64.37 + 1.772 \times 11.620}$$

$$\bar{X} = 29.248''$$

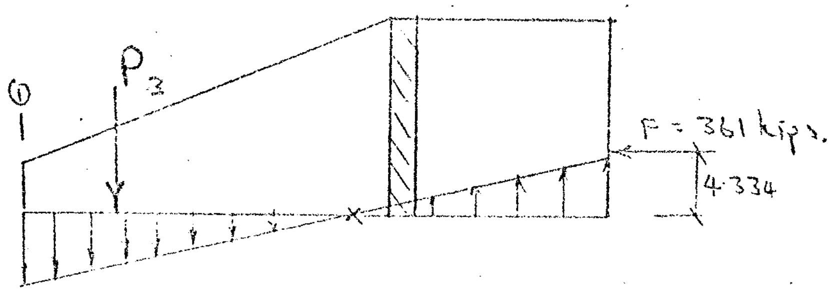
$$A = 96.62 \text{ in}^2$$



Assume moment (F.e) is applied as two equal loads on tub wall.

$P_3 = P_4$

Find stress distribution on tub wall due to this moment and thus calculate P



F = 361 kips.

e = 4.334 in.

M = Fe = 1564.57

Moment of Inertia

$$I_{NA} = \frac{1.1811 \times 64.370^3}{12} + 1.1811 \times 64.370 \left(\frac{64.370}{2} - 29.248\right)^2$$

$$+ \frac{11.621 \times 1.772^3}{12} + 11.621 \times 1.772 \left(29.249 - 18.40\right.$$

$$I_{NA} = 29333.9 \text{ in}^4.$$

Stress at ①

$$\sigma_① = \frac{My}{I} = \frac{1564.574\ (64.37 - 29.248)}{29333.9} = 1.87 \text{ ksi}$$

$$P_3 = \frac{1.87}{2}\ (64.37 - 29.248)\ 1.1811 = 38.8 \text{ kips}.$$

P_4 goes to tendon bolts as shear.

Point of application of P_3

$$Y = \frac{(64.370 - 29.248)}{3} = 11.707'' \text{ from ①}$$

$$\bar{Y} = 64.370 - 11.707 = 52.66'' \text{ from base.}$$

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 56 OF ___

CLIENT: TOTAL OIL MARINE LTD — JOB NO: TO-010

SUBJECT: FRIGG FIELD CRANE PEDESTAL

BASED ON: ___ — DRAWING NO: ___

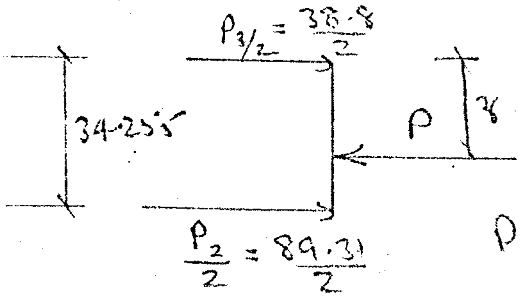
COMPUTER: FORBES — CHK'D. BY: P.?? — APP'D BY: ___ — DATE: AUG 1975

STRESS IN COLUMN WALL – TOTAL SECTION.

Resultant force P due to forces P_2 and P

P_2 is force on tub wall for section BB

as shown on page 68.



$$P = \frac{38.8}{2} + \frac{89.31}{2}$$

$$= 64.055 \text{ kips.}$$

Point of Application

$$\bar{y} = \frac{\frac{89.31}{2} \times 34.255}{64.055} = 23.88''$$

Use "ROARKE" – Formulaes for Stress and Strain – pp 293 – 317

$$q = \frac{64.055}{45.276} \times \frac{360^\circ}{2\pi \times 15^\circ} = 5.404 \text{ kip / linear in.}$$

$$\lambda = \sqrt[4]{\frac{3(1-\nu^2)}{R^2 t^2}} = \sqrt[4]{\frac{3(1-0.3^2)}{45.726^2 \times 1.7765^2}} = 0.14281 \text{ /in}$$

Load q will act over a circumferential band of width 34.255 inches.

$$\therefore b = 17.127$$

$$M_{max} = \frac{q}{2\lambda^2} e^{-b\lambda} \sin b\lambda$$

$$= \frac{5.404}{2 \times 0.14281^2} e^{(-17.127 \times 0.14281)} \sin (17.127 \times 0.1428$$

$$= 0.490 \text{ k / in}^2$$

Add this to existing stresses' - Load Condition 1 p 32

$f_c = 0.490 + 17.585 + 2.105 = 20.18$ ksi

$F_y = 52$ ksi

$$\frac{f_c}{F_y} = \frac{20.18}{52} = 0.39$$

Factor of Safety = 2.57

Check for local buckling in Stiffeners.

$$\frac{D}{T} = \frac{17.72}{1.1811} = 15 < \frac{3300}{F_y} = 63.4$$

$\therefore$ No local buckling problem exists in Stiffeners.

Check shear in tendons.

Area of tendons $= \frac{\pi}{4} \times 4.724^2 = 17.527$ in^2

Force = 89.31 kips

$$F_v = \frac{89.31}{17.527} = 5.10 \text{ ksi} < 0.4 F_y$$

$\therefore$ O.K.

CP BR 21
FORM D–IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 58 OF

CLIENT Total Oil Marine Ltd. JOB NO TO-0102

SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY [illegible] APP'D BY DATE Aug 19 75

Check Base Connection Stresses.

Use Load Condition 1

Bending Moment = 15474.4 kip - ft

Axial Force = 1040.32 kip

Shear Force = 9.323 kip

Torsion Moment = 10815 kip - ft

Analyse section by assuming prestressing in tendons is low so all the tension is taken by tendons, compression is taken by steel box sections.

Simulate the effect of steel box shape by considering it as a circular tube of equal area

Total x sectional area,

$A = 24 \times 27.165 \times 1.1811 + 494.142 - 24 \times 1.1811 \times 1.7717$
$= 1215.013 \text{ in}^2$

$X = 47.691''$

$t = X_1 - X_2 = \frac{A}{\pi(X_1 + X_2)} \doteq \frac{A}{2 \times \pi} = \frac{1215.013}{2 \times 47.691 \times \pi} = 4.055''$

$O.D = 47.691 + 4.055 = 99.437''$

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 59 OF ____

CLIENT: TOTAL OIL MARINE LTD JOB NO: TO - 0102

SUBJECT: FRIGG FIELD CRANE PEDESTAL

BASED ON ______ DRAWING NO ______

COMPUTER: FORBES CHK'D. BY: [initials] APP'D BY ______ DATE: 20 JULY 1975

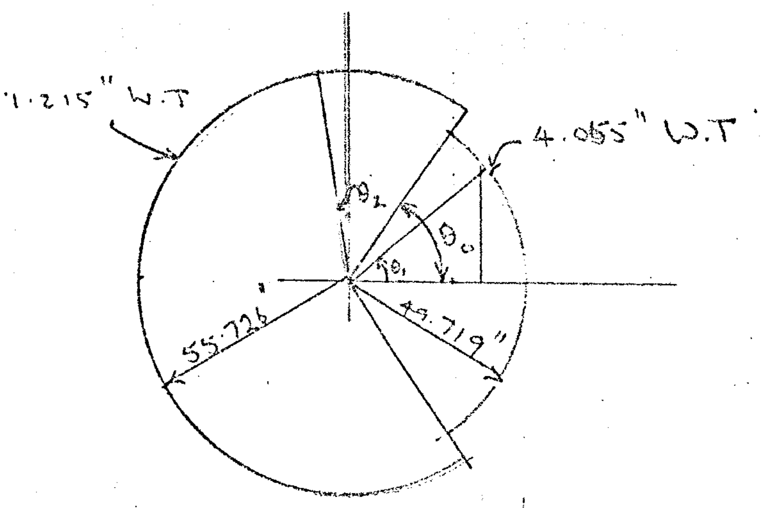
Tensile – simulate the effect of tendons also as a circular section.

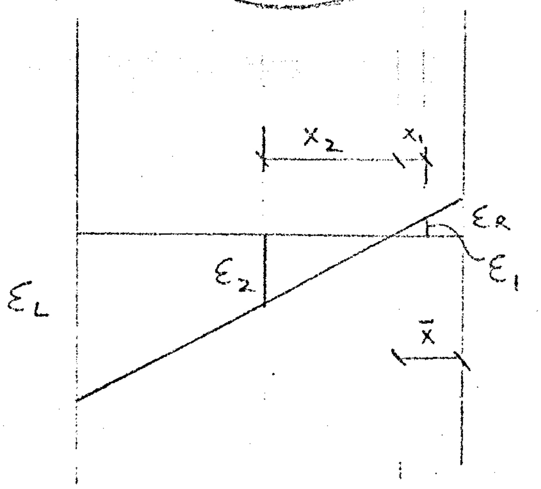
ϕ tendons = 120 mm = 4.724 in.

$$\text{Area} = 24 \times 4.724^2 \times \frac{\pi}{4} = 420.72 \text{ in}^2$$

$$\bar{\bar{t}} = \frac{420.72}{110.236\,\pi} = 1.215''$$

$$O\bar{\bar{D}} = 110.236 + 1.215 = 111.415$$





$$\varepsilon_1 = \varepsilon_R \frac{x_1}{\bar{x}}$$

$$\varepsilon_2 = \varepsilon_R \frac{x_2}{\bar{x}}$$

$$\therefore P_1 = \varepsilon_R \frac{x_1}{\bar{x}} E \times 4.055$$

$$P_2 = \varepsilon_R \frac{x_2}{\bar{x}} E \times 1.215$$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 60 OF

CLIENT Total Oil Marine Ltd JOB NO TO-0103

SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY APP'D BY DATE 30 July 19 75

Since force in compression = Force in tension

$\Sigma F = 0$

Integrate from 0 to 2π

$$\cancel{2}\int_0^{\theta_0} 47.6915 \cancel{\varepsilon_e} \frac{x_1}{\cancel{x}} \cancel{E} \times 4.055 \, d\theta = \cancel{2}\int_0^{\pi-\theta_0} 55.1185 \cancel{\varepsilon_e} \frac{x_2}{\cancel{x}} \cancel{E} \times 1.215$$

$$\int_0^{\theta_0} 47.6915 \times 4.055 \, x_1 \, d\theta_1 = \int_0^{\pi+\theta_0} 55.1185 \times 1.215 \times x_2 \, d\theta_2$$

$$x_1 = 49.6415 (\cos\theta_1 - \cos\theta_0)$$
$$x_2 = 55.1185 (\cos\theta_2 + \cos\theta_0)$$

$$\int_0^{\theta_0} 49.6415 (\cos\theta_1 - \cos\theta_0) \, d\theta_1 = \int_0^{\pi+\theta_0} 0.34665 \times 55.1185 (\cos\theta_2 + \cos\theta_0)$$

$$\Big|_0^{\theta_0} -\sin\theta_1 - \theta_1\cos\theta_0 \Big| + 0.38490 \Big|_0^{\pi+\theta_0} -\sin\theta_2 + \theta_2\cos\theta_0 \Big|$$

$$-\sin\theta_0 - \theta_0\cos\theta_0 = 0.38490 \left(-\sin(\pi+\theta_0) + (\pi+\theta_0)\cos\theta_0 \right)$$

$$1.20920 \cos\theta_0 + 1.38490 \sin\theta_0 + 1.38490\,\theta_0\cos\theta_0 = 0$$

$$1.3849 \tan\theta_0 + 1.38490\,\theta_0 + 1.2092 = 0$$

$$\tan\theta_0 + \theta_0 + 0.87313 = 0.$$

Let $\theta_0 = -25^\circ$ $\quad 0.9036 \neq 0.87313$

Let $\theta_0 = -24^\circ$ $\quad 0.86410 \neq 0.87313$

Let $\theta_0 = -24.3^\circ$ $\quad 0.8750 \simeq 0.87313$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 61 OF

CLIENT Total Oil Marine Ltd JOB NO TO - 0107

SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY APP'D BY DATE 30 July 19 75

Area in compression has an arc of 48.6°

Area of Steel in Comp = $\frac{2\pi}{360}$ 48.6 x 49.719 x 4.055 = 171.01 in

Area of Steel in Tension = $\frac{2\pi}{360}(360-48.6)$ x 55.726 x 1.215 = 367.99 in

$\bar{x} = R_c(1 - \cos 24.3°)$

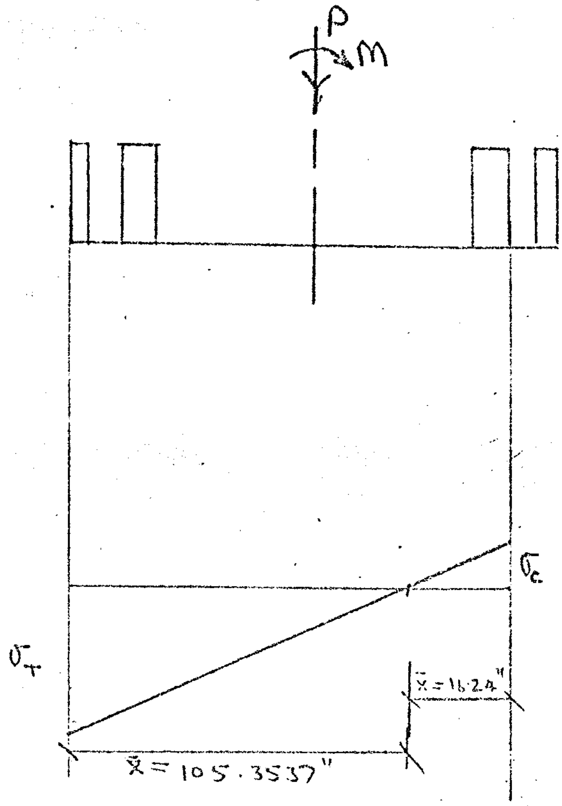
$= 49.6415(1 - \cos 24.3°)$

$\bar{x} = 16.24'$

$\bar{\bar{x}} = R_T(1 + \cos\theta_0)$

$= 55.1185(1 + \cos 24.3°)$

$\bar{\bar{x}} = 105.3537$ in



$\sigma = \frac{P}{A} \pm \frac{My}{I}$

CP BR 21
FORM D–1A

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ENGINEERING DEPARTMENT

SHEET No. 62 OF ____

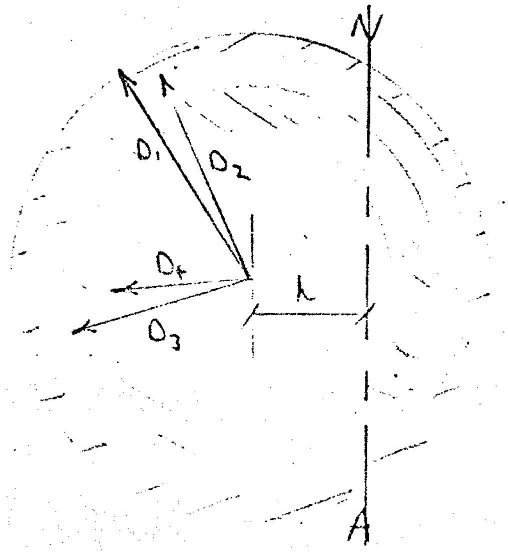
CLIENT: TOTAL OIL MARINE LTD   JOB NO. TO - 0167

SUBJECT: FRIGG FIELD CRANE PEDESTAL

BASED ON ____   DRAWING NO. ____

COMPUTER: FORBES   CHK'D. BY: [illegible]   APP'D BY: ____   DATE: 30 JULY 1975

Calculate moment of Inertia about N.A.



$$I_{NA} = \frac{\pi d^4}{64} + A h^2$$

$$= \frac{\pi}{64}\left[(D_1^4 - D_2^4) + (D_3^4 - D_4^4)\right] + A h^2$$

$$= \frac{\pi}{64}\left[(111.415^4 - 110.200^4) + (99.437^4 - 95.382^4)\right] + \frac{\pi}{4}[\quad]33\ldots$$

$$= 1988997.7 \text{ in}^4$$

area of Steel $= 831.93 \text{ in}^2$

CP BR 21
FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 63 OF

CLIENT Total Oil Marine Ltd JOB NO TO-0107

SUBJECT Frigg Field Crane Pedestal

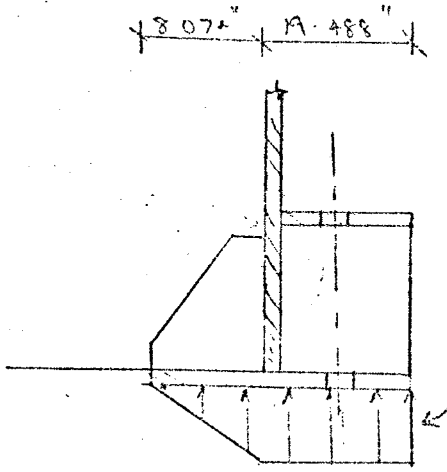
BASED ON DRAWING NO

COMPUTER Forbes. CHK'D. BY DRP APP'D BY DATE 31 July 1975

Initial tensile load in tendons is 244 tons

Stress in tendon $= \dfrac{244 \times 2.24}{\frac{\pi}{4} \times 4.724^2} = 31.18$ ksi

Stress on base due to tendon load

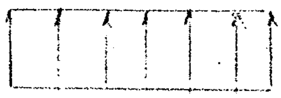


Base plate O.D = 125.984 in

Base plate I.D = 70.860 in

$\sigma_{TB} = \dfrac{244 \times 2.24 \times 24}{\frac{\pi}{4}(125.984^2 - 78.934^2)} = 1.732$ ksi

Stress at base.



$\sigma_{TB} = \dfrac{244 \times 2.24 \times 24}{\frac{\pi}{4}(125.984^2 - 70.860^2)} = 1.539$ ksi.

Stress on base due to axial load.

$\sigma_{AB} = \dfrac{1040.32}{1213.95} = 0.875$ ksi

Total Stress on base $= \sigma_{TB} + \sigma_{AB} = 2.607$ ksi

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FORM D–1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 64 OF

CLIENT Total Oil Marine JOB NO. DH0701

SUBJECT Engineering Design, Deck Modules, Crane Pedestals

BASED ON DRAWING NO

COMPUTER DRP CHK'D. BY DIK APP'D BY DATE Aug 19 73

The load in the tendons is given by.

Area × ($f_p - f_a \pm f_b$) where f_p = prestress
f_a = stress due to Axial Lo
f_b = stress due to bending

From G Forbes Calcs f_p = 31.18 ksi

Load Case 3 – The worst Case at the Base Max Lift + Wind Along Boom.
Axial Load = 1040.32 Kips

Bending = 18869.03 Kip – ft.

Area of Steel in Simulation of Base page 62.

A = 831.93 in²

⇒ f_a = 1040.32 / 831.93 = 1.250 ksi

I for Simulation = 1988997.7 in⁴. page 62.

∴ $f_b = \frac{M}{I} \times r$ r on Tensile side = 105.35"

∴ $f_b = \frac{18869.03 \times 105.35 \times 12}{1988997.7}$ = 11.993 ksi

∴ Final Stress at Full Load Case 3: Worst Case ie bending producing tension.
= 31.18 + 11.993 – 1.250 = 41.923 ksi. (≡ 328 tons)

Allowable Stress = $\frac{305 \times 2.24}{\pi/4 \times 4.724^2}$ = 38.930 ksi (≡ 305 tons)
∴ Tendon will yield.

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FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 65 OF

CLIENT Total Oil Marine Ltd JOB NO.

SUBJECT Crane Pedestal

BASED ON DRAWING NO.

COMPUTER DRP CHK'D. BY T.S. APP'D BY DATE 19

Ultimate Plastic Solution

Upward and downward (compressive) forces must be equal

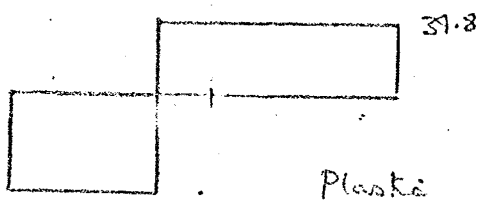
$\therefore \; 52.1 \times \pi \times 99.437 \times 4.055 \times \dfrac{360 - 2\theta_0}{360} = 38.9 \times \pi \times 111.415 \times 1.215 \times$

Compression Yield 52.1 Ksi Tension Yield 38.9 Ksi

$$\Rightarrow \quad 65997.35 \left(1 - \frac{\theta_0}{180}\right) = 16543.2 \, \frac{\theta_0}{180}$$

$$\therefore \quad \theta_0 = 180 \left(\frac{65997.35}{16543.2 + 65997.35} \right) = 143.92^\circ .$$

$$\cos 143.92^\circ = -0.81$$

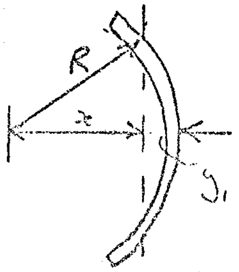


Plastic Stress Distribution.

To find N.A. = axis of areas

From Roark P76

For a thin sector of an annulus



$x = R - y_1$

$y_1 = R\left(1 - \dfrac{\sin\alpha}{\alpha}\right) \quad \Rightarrow \quad x = \dfrac{R\sin\alpha}{\alpha}$

$\therefore$ Tension Side $x = 13.07"$ Compression $x = 46.5"$

CP BR 21
FORM D—1A

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 66 OF

CLIENT Total Oil Marine JOB NO

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DPP CHK'D. BY T.S. APP'D BY DATE 19

$\therefore$ Ultimate Moment $= 6496.68 \times \left(\frac{13.07 + 46.5}{12} \right)$

$= 32249.81$ kip-ft.

$\therefore$ Safety Factor for Collapse $= \frac{32249.81}{18869.03} = 1.72$

$\therefore$ The base Tendons will not fail.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 67 OF

CLIENT TOTAL OIL MARINE LTD JOB NO TO - 0107

SUBJECT FRIGG FIELD CRANE PEDESTAL

BASED ON DRAWING NO

COMPUTER FORBES CHK'D. BY RBP APP'D BY DATE AUG 19 78

C.4. Check base connection for fatigue.

Following the report prepared by Atkins R + D and probable lifting history of crane.

Similar loadings will be used as per D. Karran's fatigue study C.3. pp 37 - 43.

C.4.1 One 40k lift every day for 30 years = 10950 cycles plus 5 m/sec wind vibration at 1 c.p.s. for a ten minute lift period 600 × 10950 = 6570000 cycles.

a) Minimum Stress at base, no wind, no lift. - L.C.4 p

$$f_c = f_a + f_{b_{ampl}}^{*} = 0.909 + \frac{4.156}{1 - \frac{0.909}{63.378}} = 5.125$$

b) Maximum Stress at base, no wind, 40 k lift.

- See page 37

$$f_c = 1.087 + \frac{10.98}{1 - \frac{1.087}{63.378}} = 12.257 \text{ ksi}$$

c) Stresses superimposed due to 5 m/sec wind.

- see page 38

$f_c = 0.159$ ksi.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 68 OF

CLIENT Total Oil Marine Ltd JOB NO TO - 010

SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY [illegible] APP'D BY DATE Aug 19 7[illegible]

Using B.S 153 Parts 3B + 4 : 1972 Class B. table 2 p

assume full rotation $\frac{f_{min}}{f_{max}} = -1$

$f_{max} = 12.257$ ksi $= 84.45\ N/mm^2$

10950 cycles.

$$\log_{10} N = 8 - \frac{\log 84.45 - \log 74.7}{\log 91.9 - \log 74.7} = 7.41$$

$N = 2.558 \times 10^7$ cycles.

Fatigue ratio$_1$ = FR1 = $\frac{1.095}{2.558} \times 10^{-3} = 0.428 \times 10^{-3}$

<u>6.57 x 10⁵ cycles of 5 m/sec wind.</u>

$$\frac{f_{min}}{f_{max}} = \frac{12.257}{12.257 + 0.159} = 0.987$$

$f_{max} = 12.416$ $f_8 = 432$ $f_7 = 430$

$\log_{10} N = 350$

∴ Negligible Effect.

C.4.2 <u>One full capacity lift every week for 30 years</u>

= 1560 cycles, no wind.

$f_a = 2.105$ ksi , $f_b = 18.499 + 0.490 = 18.989$ ksi – L.C.

$$f_{min} = 2.105 - \frac{18.989}{1 - \frac{2.105}{63.373}} = -17.536 \text{ ksi}$$

$$f_{max} = 2.105 + \frac{18.989}{1 - \frac{2.105}{63.373}} = 21.746 \text{ ksi}$$

$$\frac{f_{min}}{f_{max}} = -\frac{17.536}{21.746} = -0.806$$

$f_{max} = 21.746$ ksi $= 149.92$ N/mm²

$$\log_{10} N = 6 - \frac{\log 149.92 - \log 127.5}{\log 149.7 - \log 127.5} = 5.009$$

$N = 1.021 \times 10^5$ cycles.

$$\text{Fatigue Ratio}_2 = F.R._2 = \frac{1.560}{1.021} \times 10^{-2} = 0.01528$$

C.4.3 : <u>9.94×10^9 cycles of 10 m/sec wind with no load</u>. (Atkins – report fig 5)

$f_{average} = 5.125$ ksi (L.C.4)

Amplitude of Vibratory stresses.

$$f_b = \frac{0.734}{1 - \frac{0.409}{63.373}} = 0.754 \text{ ksi}$$

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 70 OF

CLIENT TOTAL OIL MARINE LTD JOB NO. TO-010

SUBJECT FRIGG FIELD CRANE PEDESTAL

BASED ON DRAWING NO.

COMPUTER FORBES CHK'D. BY DRP APP'D BY DATE AUG 1975

$f_{min} = 5.125 - 0.754 = 4.371$ ksi

$f_{max} = 5.125 + 0.754 = 5.879$ ksi $= 40.51\ N/mm^2$

$$\log_{10} N = 8 + \frac{\log 240.19 - \log 40.51}{\log 277.5 - \log 240.19} = 20.324$$

$N = 2.122 \times 10^{20}$ cycles.

$FR_3 = \frac{9.94}{2.122} \times 10^{-11} = 4.68 \times 10^{-11}$ — Neglect this value

C 4.4. <u>6.27×10^7 cycles of 20 m/sec wind no lift</u>

See p 41

$FR_4 = 1.19 \times 10^{-3}$

C 4.5 <u>3.98×10^5 cycles of 30 m/sec wind</u>

See p 41 $FR_5 = 0.761 \times 10^{-2}$

C 4.6 313 cycles of 40 m/sec

See p 42 $FR_6 = 0.157 \times 10^{-2}$

C 4.7 <u>10 cycles of 53 m/sec gust (50 years)</u>

See p 42 $FR_7 = 0.462 \times 10^{-3}$

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 71 OF

CLIENT Total Oil Marine Ltd JOB NO. 73-010

SUBJECT Frigg Field Crane Pedestal

BASED ON DRAWING NO.

COMPUTER Forbes CHK'D. BY RCC APP'D BY DATE Aug 1975

Cumulative Fatigue Ratio at base connection.

$$FR = 0.428 \times 10^{-3} + 1.528 \times 10^{-2} + 0.761 \times 10^{-2} + 0.157 \times 10^{-2} + 0.426 \times 10^{-3}$$

$$= 0.0253 < 1$$

∴ No fatigue problem exists.

SECTION 6.

SECTION 6 - ANALYSE DETAIL ELEMENTS.

Check Platform Support Struts

Weight of Materials.

Handrails - 2·7 lb/ft

Handrail Mesh - 2 lb/ft^2

Flooring Mesh - 10th Pl - 20 lb/ft^2

Struts - 4" OD x 0.375 W.T - 16.52 lb/ft

- 5½" OD x 0·375 WT - 20·78 lb/ft.

Channels - 200 mm - 20 lb/ft

Toe Plates - 4 lb/ft

Weight of Ladder.

Stringers L65 x 7 - 5 lb/ft

Rungs 20 ϕ - 1.65 lb/ft

Top + Bottom Hoops 100 x 6 Pl - 2 lb/ft

Intermediate Hoops 50x6 Pl - 1 lb/ft

Vertical Straps 40 x 6 Pl - 1 lb/ft

Total Weight of ladder 6·933 m long = 570 lb.

CP BR 21
FORM D—IA

BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 73 OF

CLIENT: Total Oil Marine Ltd — JOB NO: TO-010

SUBJECT: Frigg Field Crane Pedestal

BASED ON — DRAWING NO

COMPUTER: Forbes — CHK'D. BY: [illegible] — APP'D BY — DATE: Aug 1975

Platform - Elevation 126·645 m

Total Dead Weight = 1980 lb say 2000 lb

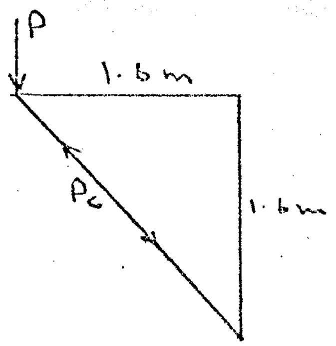
Live load - 3 kN/m² for stairway landings

- 60 lb/ft²

L.L = 2000 lb

Total load on Strut $= \frac{1410}{4} + 570 + \frac{2000}{4}$

P = 1420 lb.



$P_c = \frac{1}{\cos 45°} 1420 \simeq 2010$ lb.

Actual Stress $\sigma_c = \frac{P_c}{A} = \frac{2010}{4.86} = 413$ psi

Allowable Stress

Effective length $l = 0.7L = 0.7 \times 7.415 = 5.2$ ft

$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{10.42}{4.86}} = 1.46$

Slenderness Ratio $\frac{l}{r} = 43$

$\sigma_A = 8.79$ tonf/in² — BS 449 table 17

$\sigma_A = 19700$ psi.

$\sigma_c < \sigma_A$ ∴ O.K.

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ENGINEERING DEPARTMENT

SHEET No. 74 OF

CLIENT Total Oil Marine Ltd JOB NO. TO - 01

SUBJECT Frigg Field Crane Pedestal

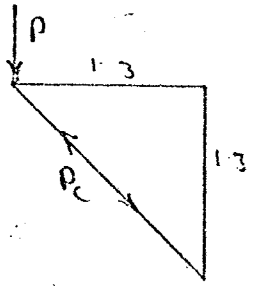
BASED ON DRAWING NO

COMPUTER Forbes CHK'D. BY DRP APP'D BY DATE Aug 19 75

Platform - Elevation 143.640 m.

Check strut 4" O.D x 0.375" W.T x 6.032 ft

Total load on strut = 1560 lb = P



$P_c = 1560 / \cos 45 \doteq 2210$ lbs

Stress $= \frac{P_c}{A} = 452$ psi $= \sigma_c$

Allowable Stress.

$l = 0.7L = 4.22$ ft

$r = \sqrt{\frac{I}{A}} = 1.46$

$\frac{l}{r} = 35$

Allowable Stress $\sigma_A = 9.02$ tsi $= 20200$ psi

$\sigma_c < \sigma_A$ ∴ O.K.

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BROWN & ROOT, (UK) LTD.

ENGINEERING DEPARTMENT

SHEET No. 75 OF

CLIENT TOTAL OIL MARINE LTD JOB NO TO-010

SUBJECT FRIGG FIELD CRANE PEDESTAL

BASED ON DRAWING NO

COMPUTER FORBES CHK'D. BY [illegible] APP'D BY DATE AUG 19 75

Platform - Elevation 148.699 m

Check strut 4" O.D × 0.375 W.T × 9.52 ft

Load = P = 3000 lb.

$P_c = 3000/0.724 \approx 4144$ lb.

$\sigma_c = \frac{P_c}{A} = 614$ psi

$l = 0.7L = 6.664$

$\frac{l}{r} = 95.2$

$\sigma_A = 5.36$ tsi $= 12000$ psi

$\sigma_c < \sigma_A$ ∴ OK.

Check strut $5\frac{1}{2}$" O.D × 0.375 W.T × 12.8 ft.

$P = 4500$ lb $\Rightarrow P_c = 6270$ lb.

$\sigma_c = \frac{6270}{6.11} = 1026$ psi.

$l = 0.7L = 8.96$ ft

$\frac{l}{r} = 58$

$\sigma_A = 8.13$ tsi $= 18200$ psi.

$\sigma_c < \sigma_A$ ∴ O.K.

∴ All struts on platforms on East and West Pedestals are satisfactory.

SECTION.7

SECTION 7 - SAFETY FACTORS FOR COLLAPSE

6.1 Impact Factors

Static Analysis of all sections of the Crane Pedestal and Base have been carried out. The true forces applied by the hook load are not static forces in general but a combination of dynamic and static loads. These loads have been converted to an equivalent static system by multiplying the static hook load by an Impact Factor.

Brown & Root Engineering judgement suggested that a good conservative estimate would be an Impact Factor of 2. This value is used for most of the calculations.

Lloyd's of London said that they would approve a value of Impact Factor = 1.2. Calculations of Safety Factors are presented for this value.

American Hoist have used a value of 1 in their calculations of failure loads and so for comparison calculations of Safety Factors for Impact Factors = 1 are also presented.

6.2 Crane Safety Factors

Failure loads for the 11750 Pedestal Crane are shown in Table 6.2.1. These figures are from the 'American Hoist 11750 Mode of Failure' report. These figures are the Static Hook Loads to cause failure at the points listed. Thus, the implied Impact Factor is 1.

Safety Factors have been calculated by dividing the failure loads by the maximum allowable lifted load for the different radii and are shown in Table 6.2.2.

The critical section for all loads is the Deck at Change in Section. The lowest Safety Factor is 1.55 for the maximum load lifted at 40' radius.

Table 6.2.1 - Hook Load (kips) to cause failure.

SUMMARY TABLE FOR MODE OF FAILURE*

RADIUS (FEET) / COMPONENT	BOOM	PENDANT CONN. AT BOOM POINT	PENDANTS	OUTER BAIL	BOOM HOIST ROPE	INNER BAIL	RETRACTABLE A-FRAME	BACKLEG	STANDARD A-FRAME	DECK AT BACKLEG CONN.	DECK AT CHANGE IN SECTION	DECK AT BOOM CONNECTION	TURNTABLE BEARING	TURNTABLE BOLTS
28	1200	1449	1278	1570	1861	1242	2698	855.0	4542	1350	493	1992	1098	1098
30	1180	1337	1180	1449	1718	1146	2379	781.6	4009	1235	449.5	1932	1033	1013
40	1132	974.2	859.3	1056	1254	833.9	1424	541.3	2406	860.7	310.6	1698	796	729
50	782.8	771.1	678.9	836.5	994.6	659.3	961.4	411.0	1630	656.9	234.4	1538	646	567
60	679.0	639.7	562.8	694.3	825.6	546.6	696.5	329.4	1185	529.3	186.3	1425	543	463
70	600.3	546.8	480.6	593.7	706.7	466.5	529.1	273.3	904.5	442.9	153.4	1345	467	390
80	537.4	476.0	418.0	517.1	616.1	405.7	415.2	233.3	713.4	378.9	129.5	1289	410	337
90	484.9	419.6	368.2	456.1	543.9	357.2	333.8	202.6	576.6	330.9	111.3	1253	364	295
100	437.1	373.8	327.7	405.3	483.7	317.9	272.4	178.7	473.7	293.4	96.90	1238	327	263
110	390.9	332.0	290.7	361.3	431.7	281.9	225.2	159.6	394.3	263.4	85.53	1244	297	236
120	348.8	295.7	258.7	322.0	385.3	250.8	187.0	144.0	330.2	239.0	76.13	1278	272	214
130	308.7	261.8	228.7	285.3	341.8	221.7	155.2	131.3	276.6	219.0	68.19	1345	250	195
140	268.1	228.1	198.9	248.8	298.6	192.7	127.3	120.9	232.0	202.7	61.76	1275	231	180
150	220.9	189.6	164.9	207.1	249.1	159.6	100.0	113.3	183.6	138.1	56.35	1125	215	166

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ENGINEERING DEPARTMENT

SHEET No. 76 OF

CLIENT Total Oil Marine Ltd

JOB NO [illegible]

SUBJECT Crane Base and Pedestal

BASED ON

DRAWING NO

COMPUTER D.R.P. CHK'D. BY T.S. APP'D BY DATE Aug 1975

Radius of Lift (ft)	Boom	Pendant Conn. at Boom Pt.	Pendants	Outer Bail	Boom Hoist Rope	Inner Bail	Retractable 'A' Frame	Back Leg	Standard 'A' Frame	Deck at Backleg Connection	Deck at Change in Section	Deck at Boom Connection	Turntable Bearing	Turntable Bolts
28	4·04	4·88	4·30	5·28	6·26	4·18	9·08	2·88	15·3	4·54	1·66	6·70	3·70	3·70
30	4·26	4·83	4·26	5·23	6·20	4·14	8·59	2·82	14·5	4·46	1·62	6·98	3·73	3·66
40	5·66	4·87	4·30	5·28	6·27	4·17	7·12	2·71	12·0	4·30	1·55	8·49	3·98	3·65
50	5·43	5·35	4·71	5·80	6·90	4·57	6·67	2·85	11·31	4·56	1·63	10·67	4·48	3·93
60	6·22	5·85	5·16	6·36	7·57	5·01	6·38	3·02	10·86	4·85	1·71	13·06	4·98	4·24
70	6·90	6·29	5·53	6·83	8·13	5·37	6·09	3·14	10·40	5·09	1·76	15·47	5·37	4·49
80	7·53	6·67	5·86	7·25	8·64	5·69	5·82	3·27	10·00	5·31	1·82	18·1	5·75	4·72
90	8·05	6·96	6·11	7·57	9·03	5·93	5·54	3·36	9·57	5·49	1·85	20·8	6·04	4·90
100	8·49	7·26	6·36	7·87	9·39	6·17	5·29	3·47	9·20	5·70	1·88	24·0	6·35	5·11
110	8·77	7·45	6·52	8·10	9·68	6·32	5·05	3·58	8·84	5·91	1·92	27·9	6·66	5·29
120	8·93	7·58	6·63	8·26	9·88	6·43	4·79	3·69	8·47	6·13	1·95	32·8	6·97	5·49
130	8·97	7·61	6·65	8·29	9·94	6·44	4·51	3·82	8·04	6·37	1·98	39·1	7·27	5·67
140	8·72	7·42	6·47	8·09	9·71	6·27	4·14	3·93	7·55	6·59	2·01	41·5	7·51	5·86
150	8·06	6·92	6·02	7·56	9·09	5·82	3·65	4·14	6·70	5·04	2·06	41·1	7·85	6·06

Table 6·2·2:-

Safety Factors defined as Failure Load / Max Lift Allowable Load.

Lift Load from Rating Chart B as this gives the lower Safety Factors.

6.3 Pedestal and Base Collapse Safety Factors

The Safety Factors against failure are shown in Table 6.3. The worst load condition at each location is considered with Impact Factors 1, 1.2 and 2.

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SHEET No. 77 OF

CLIENT Total Oil Marine JOB NO [illegible]

SUBJECT Crane Pedestal and Base

BASED ON DRAWING NO

COMPUTER DRP CHK'D. BY T.S. APP'D BY Mitchell DATE Aug 1976.

Impact Factor.	MODE OF FAILURE.					
	Pedestal Bending	Pedestal Wrinkling	Pedestal Buckling	Pedestal Base	Stiffner Buckling	Manhole Collapse
1	9·40	5·31	5·69	4·98	4·23	4·04
1·2	7·38	4·21	4·57	4·10	4·23	3·59
2.	3·93	2·35	2·52	2·40	4·23	2·11

Table 6·3

Safety Factors against Failure of Pedestal and Base Components. Figures are for the worst Load Condition at each Location.

6.4 Pedestal and Base Yield Safety Factors

The principal stress points have been checked to give Factors of Safety aginst yield. These are shown in Table 6.4.

Impact Factor	Stress Pt A	Stress Pt B
1	2·83	3·07
1·2	2·34	2·52
2.	1·64	1·47

Table 6·4
Factor of Safety against Yield at Stress Points A and B.

Stress Pt A is at the Base of the Pedestal.
Stress Pt B is 17' above the Base of the Pedestal.

6.5 Base Tendon Stresses

Although not a Brown & Root design responsibility, the base connection tendon stresses have been checked against yield and ultimate collapse. The Safety Factors are shown in Table 6.5.

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SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DRB CHK'D. BY T.S. APP'D BY DATE Aug 19 76.

Impact Factor	Safety Factor Yield	Safety Factor Collapse
1	1.10	3.27
1.2	1.04	2.77
2	0.93	1.72

Table 6.5
Safety Factors against Yield and Collapse in the Base Tendons.

6.6 <u>Detailed Failure Analysis of Components</u>

All the critical components are analysed for Impact Factors of 1, 1.2 and 2.

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CLIENT Total Oil Marine Ltd. JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DGP CHK'D. BY T.S. APP'D BY DATE Aug 1976.

Max Operating Lift + Dead Load from Crane:-

Impact Factor 1

O.T. Moment = 6417.61 kip ft.
Axial Load = 557.10 kips.
Swing Force = 9.323 Kips at 10.33 Ft High from Tub Top, 11.60 Ft from Tub ℄ towards load.

Impact Factor 1.2

OT Moment = 8205.39 kip-ft.
Axial Load = 619.76 kips.
Swing force as before

From Pages 6–10 Calcs.

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SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DRP CHK'D. BY T.S. APP'D BY DATE Aug 19 76

Load Condition	Impact Factor.	Axial Load (Kips) P	Shear (Kips) Q	Torsion Moment (Kip - ft) T	Bending Moment (Kip - ft) N
1	1	557.1	9.323	108.15	6417.61
	1.2	619.76	9.323	108.15	8205.39
	2.0	871.24	9.323	108.15	15356.52
3	1	557.1	37.67	108.15	6892.47
	1.2	619.76	37.67	108.15	8680.25
	2.0	871.24	37.67	108.15	15831.38

Forces and Moments at pedestal top for Load Conditions 1 and 3 for different Impact Factors.

For load condition 3 Wind load on Pedestal Pipe

W = 0.105 Kips/ft.

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SHEET No. 82 OF

CLIENT Total Oil Marine Ltd JOB NO

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER D.R.D. CHK'D. BY T. S. APP'D BY DATE Aug 1976

Load Condition	Impact Factor	Stress Point A						Stress Point B					
		f_a Kips	f_b Ksi	f_v Ksi	τ ksi	Interaction Ratio	S.F	f_a Ksi	f_b Ksi	f_v Ksi	τ Ksi	Interaction Ratio	SF
1	1	1.47	7.35	0.03	0.06	0.35	2.83	1.41	7.87	0.03	0.06	0.33	3.07
1	1.2	1.60	9.37	0.03	0.06	0.43	2.34	1.54	9.89	0.03	0.06	0.40	2.52
1	2	2.11	17.59	0.03	0.06	0.61	1.64	2.05	18.01	0.03	0.06	0.68	1.47
3	1	1.47	8.51	0.12	0.06	0.26	3.82	1.41	10.46	0.11	0.06	0.31	3.27
3	1.2	1.60	10.54	0.12	0.06	0.32	3.17	1.54	12.48	0.11	0.06	0.36	2.78
3	2	2.11	18.67	0.12	0.06	0.53	1.89	2.05	20.60	0.11	0.06	0.57	1.74

From Calc. pages 28 et. seq.

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CLIENT Total Oil Marine Ltd, JOB NO

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DLD CHK'D. BY T.S. APP'D BY DATE 19

Load Case	Impact Factor	Axial Load (Kips)	Shear (Kips)	Torsion Moment (Kip-ft)	Bending Moment (Kip-ft)
1	1	726·18	9·323	108·15	6470·53
	1·2	788·84	9·323	108·15	8246·85
	2	1040·32	9·323	108·15	15378·51
3	1	726·18	38·79	108·15	9849·17
	1·2	788·84	38·79	108·15	11631·62
	2	1040·32	38·79	108·15	18771·57

Forces and Moments at pedestal base for Load Conditions 1 and 3 for different Impact Factors.

From pages 28 et. seq.

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CLIENT Total Oil Marine Ltd. JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DRP CHK'D. BY T.S. APP'D BY DATE Aug 19 76

<u>Overall Safety Factors</u> — based on pp 33 et seq.

<u>Axial Buckling:-</u>

Amplified bending stress (Load Condition 1).

Impact factor = 1. $f^*_b = \dfrac{7.35}{1 - \frac{1.47}{63.378}} = 7.52$ ksi

∴ Combined Stress $f_c = 7.52 + 1.47 = 8.99$

∴ <u>Safety Factor = 51.2/8.99 = 5.69</u>

Impact factor = 1.2 $f^*b = \dfrac{9.37}{1 - 1.6/63.38} = 9.61$

∴ $f_c = 9.61 + 1.60 = 11.21$

∴ <u>Safety Factor = 4.57.</u>

Impact factor = 2 $f^*_b = \dfrac{17.59}{1 - 2.11/63.38} = 18.20$

$f_c = 18.20 + 2.11 = 20.31$

<u>Safety Factor = 51.2/20.31 = 2.52.</u>

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CLIENT Total Oil Marine Ltd JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO.

COMPUTER DRB CHK'D. BY T.S. APP'D BY DATE Aug 19 76.

<u>Ultimate Wrinkling</u>

Safety factor = 47.72 / f_c (page 34)

Impact	Factor	1	Safety Factor = 5.31
"	"	1.2	" " = 4.21
"	"	2	" " = 2.35

<u>Combined Failure</u> (page 36.

Safety Factor = 69.12 / f_b

Impact	Factor	1	Safety Factor = 9.40
"	"	1.2	" " = 7.38
"	"	2	" " = 3.93

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SHEET No. 56 OF

CLIENT Total Oil Marine Ltd. JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER [illegible] CHK'D. BY T.S. APP'D BY DATE Aug 19 76

Stresses at Manholes pages 44 et seq.

Load Condition	Impact Factor	M (kip-in)	A (kips)	f_a (ksi)	f_b (ksi)	f_c (ksi)	Safety Factor
1	1	8.311×10^4	696.74	0.93	4.90	5.90	5.23
	1.2	1.044×10^5	760.98	1.02	6.15	7.27	5.02
	2	1.902×10^5	1012.99	1.35	11.21	12.80	2.41
3	1	1.105×10^5	696.74	0.93	6.51	7.63	4.04
	1.2	1.318×10^5	760.98	1.02	7.77	8.60	3.59
	2	2.175×10^5	1012.99	1.35	12.82	14.60	2.11

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SHEET No. 87 OF

CLIENT Total Oil Marine Ltd, JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO.

COMPUTER ... CHK'D. BY T.S. APP'D BY DATE Aug 19 76

<u>Pedestal Base</u> – see G. Forbes Calculations pp 52 et seq

<u>Load Condition 1</u>
<u>Impact Factor = 1.</u> Thus using the same notation

$$f_{co} = \frac{726.18}{1213.95} + \frac{6470.53 \times 12}{22331.796} = 4.08 \text{ ksi}$$

$$f_{cT} = \frac{726.18}{1213.95} + \frac{6470.53 \times 12}{1406724.523} \times 44.389 = 3.05 \text{ ksi}$$

$$f_{ci} = \frac{726.18}{1213.95} + \frac{6470.53 \times 12}{39264.398} = 2.58 \text{ ksi}$$

Thus force on Cruciform Element

$$F = \left(\frac{4.08 + 2.58}{2}\right) 1.1811 \times 27.165 + 2 \times 3.05 \times 1.772 \times 5.22$$

$$= 163.27 \text{ kips,}$$

$$\text{And } \bar{x} = \left\{ 2.58 \times \frac{27.165^2}{2} \times 1.1811 + (4.08 - 2.58)\tfrac{2}{3} \times 27.165^2 \times 1.1811 + 3.05 \times 11.62 \times 1.772 \right\} \div 163.27$$

$$= 12.61$$

$$\therefore \bar{x} = 12.61 - 8.563 = 4.047 \text{ from Tub wall centre.}$$

$$\text{Thus } P_1 = P_2 = 163.27 \times \frac{4.047}{17.52} = 37.71 \text{ kips,}$$

$$M = 163.27 \times 4.047 = 660.75 \text{ kip-in.}$$

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SHEET No. 88 OF

CLIENT Total Oil Marine Ltd, JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO.

COMPUTER DRP CHK'D. BY T.S. APP'D BY DATE Aug 19 76

$$\sigma_1 = \frac{My}{I} = \frac{660.75 \times (64.37 - 29.248)}{29333.9} = 0.791 \text{ ksi}.$$

$$\therefore P_3 = \frac{0.791}{2}(64.37 - 29.248) = 13.893 \text{ kips}$$

Resultant $P = \frac{13.893}{2} + \frac{37.71}{2} = 25.801$ kips

$$\text{at } z = \frac{89.31}{2} \times \frac{13.893}{37.71} = 16.45''$$

$$\therefore q = \frac{25.801}{45.276} \times \frac{360^\circ}{2\pi \times 15^\circ} = 2.177 \text{ kips/in}^2$$

Thus the max bending stress $= M_{max} = 0.197$ kips/in².

$$\therefore f_c = 0.197 + 7.35 + 1.47 = 9.017 \text{ ksi}$$

$$\therefore \text{Safety Factor} = \frac{51.2}{9.017} = 5.68$$

Load Condition 1
Impact Factor 1·2

$$f_{co} = \frac{788.84}{1213.95} + \frac{8246.85 \times 12}{22331.796} = 5.08 \text{ ksi}$$

$$f_{cr} = \frac{788.84}{1213.95} + \frac{8246.85 \times 12}{1406724.523} \times 44.389 = 3.77 \text{ ksi}$$

$$f_{ci} = \frac{788.84}{1213.95} + \frac{8246.85 \times 12}{39264.398} = 3.17 \text{ ksi}$$

$$\therefore F = \frac{(5.08 + 3.17)}{2} \times 1.1811 \times 27.165 + 2 \times 3.77 \times 1.772 \times 5.22$$

$$= 202.09 \text{ kips}$$

$$X = \frac{\left\{3.17 \times \frac{27.165^2}{2} \times 1.1811 + (5.08 - 3.17) \times \frac{2}{3} \times 27.165^2 \times 1.1811 + 3.77 \times 11.62 \times 1.772\right\}}{202.09}$$

$$X = 12.71$$

$$\bar{x} = 12.71 - 8.563 = 4.15'$$ from Tub wall Centre.

Thus $$P_1 = P_2 = 202.09 \times \frac{4.15}{17.52} = 47.835 \text{ kips}$$

$$M = 202.09 \times 4.15 = 838.067 \text{ kip-in.}$$

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SHEET No. 90 OF

CLIENT Total Oil Marine Ltd. JOB NO

SUBJECT Crane Pedestals

BASED ON DRAWING NO

COMPUTER DRP CHK'D. BY T.S. APP'D BY DATE Aug 1976

$$\sigma_1 = \frac{My}{I} = \frac{838.067 \times (64.37 - 29.248)}{29333.9} = 1.003 \text{ ksi}$$

$$\therefore P_3 = \frac{1.003}{2}(64.37 - 29.248) = 17.62 \text{ kips.}$$

$$\therefore P = \frac{17.62}{2} + \frac{47.84}{2} = 32.728 \text{ kips}$$

$$\text{at } z = \frac{89.31}{2} \times \frac{17.62}{47.84} = 16.45 \text{ ins.}$$

$$q = \frac{32.728}{45.276} \times \frac{360}{2\pi \times 45} = 2.761 \text{ kips/in}^2.$$

Thus $M_{max} = 0.25$ ksi

$$f_c = 0.25 + 9.37 + 1.60 = 11.22 \text{ ksi}$$

$$\therefore \text{Safety Factor} = \frac{51.2}{11.22} = 4.56.$$

Load Condition 1.
Impact Factor = 2

As before Safety Factor = 2.57

Load Condition 3
Impact Factor = 1.

$$f_{co} = \frac{726.18}{1213.95} + \frac{9849.17 \times 12}{22331.796} = 5.89 \text{ ksi}$$

$$f_{cT} = \frac{726.18}{1213.95} + \frac{9849.17 \times 12}{1406724.523} \times 44.389 = 4.33 \text{ ksi}$$

$$f_{ci} = \frac{726.18}{1213.95} + \frac{9849.17 \times 12}{39264.389} = 3.61 \text{ ksi}$$

$$F = \left(\frac{5.89 + 3.61}{2}\right) \times 1.1811 \times 27.165 + 2 \times 4.33 \times 1.772 \times 5.22 =$$

$$= 232.48 \text{ kips}$$

$$X = \frac{\left\{3.61 \times \frac{27.165^2}{2} \times 1.1811 + (5.89 - 3.61)\frac{\times 2}{3} \times 27.165^2 \times 1.811 + 4.33 \times 11.62 \times 1.772\right\}}{232.48}$$

$$= 12.85''$$

$\bar{X} = 12.85 - 8.563 = 4.29''$ from Tub Wall Centre.

$$\therefore \quad P_1 = P_2 = 232.48 \times \frac{4.29}{17.57} = 56.89 \text{ kips}$$

$$M = 232.48 \times 4.29 = 996.642 \text{ kip-in.}$$

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SHEET No. 92 OF

CLIENT Total Oil Marine Ltd JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO.

COMPUTER DRD CHK'D. BY T.S. APP'D BY DATE Aug 19 76

$$\sigma_1 = \frac{My}{I} = \frac{996.642\ (64.37 - 29.248)}{24333.9} = 1.193 \text{ ksi}$$

$$\therefore\ P_3 = \frac{1.193}{2}(64.37 - 29.248) = 20.955 \text{ kips}$$

$$\therefore\ P = \frac{20.955}{2} + \frac{56.89}{2} = 38.923 \text{ kips}$$

$$\text{at } z = \frac{89.31}{2} \times \frac{20.955}{56.89} = 16.45''$$

$$\tau = \frac{38.923}{45.276} \times \frac{360^\circ}{2\pi \times 15^\circ} = 3.284 \text{ ksi}$$

Max Bending Stress = 0.298

$$\therefore\ f_c = 0.298 + 8.51 + 1.47 = 10.278$$

Safety Factor = 4.98

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Load Condition 3
Impact Factor 1.2.

$$f_{co} = \frac{788.84}{1213.95} + \frac{11631.62 \times 12}{22331.796} = 6.90$$

$$f_{cr} = \frac{788.84}{1213.95} + \frac{11631.62 \times 12}{1406724.398} \times 44.389 = 5.05$$

$$f_{ci} = \frac{788.84}{1213.95} + \frac{11631.62 \times 12}{39284.398} = 4.20.$$

Thus $F = \left(\frac{6.90 + 4.20}{2}\right) \times 1.1811 \times 27.165 + 2 \times 5.05 \times 1.772 \times 5.22$

$= 271.57$ kips

$$X = \frac{\left\{4.20 \times \frac{27.165^2}{2} \times 1.1811 + (6.90 - 4.20) \times \frac{2}{3} \times 27.165^2 \times 1.1811 + 5.05 \times 11.62 \times 1.772\right\}}{271.57}$$

$X' = 12.903$

$\bar{X} = 12.903 - 8.563 = 4.34$, from Tub Wall centre.

Thus $P_1 = P_2 = 271.57 \times \frac{4.34}{17.52} = 67.272$ kips.

$M = 271.57 \times 4.34 = 1178.614$ kip-in.

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SUBJECT Crane Pedestal

BASED ON DRAWING NO.

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$$\sigma = \frac{My}{I} = \frac{1178.61(64.37 - 29.248)}{29333.9} = 1.411 \text{ ksi.}$$

$$P_3 = \frac{1.411}{2}(64.37 - 29.248) = 24.782 \text{ kips}$$

$$P = \frac{24.782}{2} + \frac{67.27}{2} = 46.027 \text{ kips}$$

$$\text{at } z = \frac{89.31}{2} \times \frac{0.040}{0.109} = 16.39''$$

$$q = \frac{46.027}{45.276} \times \frac{360}{2\pi \times 15} = 3.883 \text{ ksi.}$$

$$M_{max} = 0.352 \text{ ksi}$$

$$\therefore f_c = 0.352 + 10.54 + 1.60 = 12.492$$

$\therefore$ Safety Factor = 4.10

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SUBJECT Crane Pedestal

BASED ON DRAWING NO.

COMPUTER DRB CHK'D. BY T.S. APP'D BY DATE Aug 19 76

Load Condition 3
Impact Factor 2

$$f_{co} = \frac{1040.32}{1213.95} + \frac{18771.57 \times 12}{22331.796} = 10.944.$$

$$f_{cT} = \frac{1040.32}{1213.95} + \frac{18771.57 \times 12}{1406724.523} \times 44.389 = 7.965$$

$$f_{ci} = \frac{1040.32}{1213.95} + \frac{18771.57 \times 12}{39264.348} = 6.594$$

$$\therefore F = \left(\frac{10.944 + 6.594}{2}\right) \times 1.1811 \times 27.165 + 7.965 \times 2 \times 1.772 \times 5.22$$

$$= 428.70$$

$$\text{and } x = \frac{\left\{6.59 \times \frac{27.165^2}{2} \times 1.1811 + (10.944 - 6.594) \times \frac{2}{3} \times 27.165^2 \times 1.1811 + 7.965 \times 11.62 \times 1.772\right\}}{428.70}$$

$$x = 12.977.$$

$$\bar{x} = 12.977 - 8.563 = 4.414 \text{ in from Tub wall centre.}$$

$$P_1 = P_2 = 428.70 \times \frac{4.414}{17.52} = 108.018 \text{ kips}$$

$$M = 428.70 \times 4.414 = 1892.47 \text{ kip-in.}$$

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SHEET No. 96 OF

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SUBJECT Crane Pedestal

BASED ON DRAWING NO

COMPUTER DPD CHK'D. BY T.S. APP'D BY DATE Aug 19 76

$\sigma_1 = \frac{My}{I} = \frac{1892.47\,(64.37 - 29.248)}{29333.9} = 2.266$ ksi

$P_3 = \frac{2.266}{2}\,(64.37 - 29.248) = 39.791$ kips

$\therefore P = \frac{39.791}{2} + \frac{108.018}{2} = 73.905$ kips

at $z = \frac{89.31}{2} \times \frac{39.791}{108.018} = 16.45''$

$\Sigma = \frac{73.905}{45.276} \times \frac{360}{2\pi \times 15} = 6.235$

$\therefore M_{max} = 0.565$ ksi

$\therefore f_c = 0.565 + 18.67 + 2.11 = 21.345$

$\therefore$ Safety Factor = 2.40.

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SHEET No. 97 OF

CLIENT Total Oil Marine Ltd JOB NO.

SUBJECT Crane Pedestals

BASED ON DRAWING NO.

COMPUTER DFP CHK'D. BY T.S. APP'D BY DATE Aug 1975

Tendon Stresses in base:-

From page 64

Load Condition 1
Impact Factor 1

$f_a = \frac{726.18}{831.93} = 0.87 \text{ ksi}$

$f_b = \frac{6470.53}{1573.33} = 4.11 \text{ ksi}$

$f_t = 31.18 + f_b - f_a$

$f_t = 34.42$ ⇒ Safety Factor = 1.13

Load Condition 1
Impact Factor 1.2

$f_a = \frac{788.84}{831.93} = 0.95 \text{ ksi}$

$f_b = \frac{8246.85}{1573.33} = 5.24 \text{ ksi}$

$f_t = 35.47$ ⇒ Safety Factor = 1.10.

Load Condition 1
Impact Factor 2

$f_a = \frac{1040.32}{831.93} = 1.25 \text{ ksi}$

$f_b = \frac{15378.51}{1573.33} = 9.77 \text{ ksi}$

$f_t = 39.90 \text{ ksi}$ ⇒ Safety Factor = 0.98

Load Condition 3
Impact factor = 1.

$f_a = \frac{726.18}{831.93} = 0.87$ ksi

$f_b = \frac{9849.17}{1573.3} = 6.26$ ksi

$\therefore f_c = 36.57$ ksi $\Rightarrow$ **Safety Factor = 1.10.**

Impact factor = 1.2

$f_a = \frac{788.84}{831.93} = 0.95$ ksi

$f_b = \frac{11631.62}{1573.33} = 7.39$ ksi

$f_c = 37.12$ ksi **Safety Factor = 1.04**

Impact Factor = 2.

$f_a = \frac{1040.32}{831.93} = 1.25$

$f_b = \frac{18771.57}{1573.33} = 11.93$

$f_c = 41.86$ ksi $\Rightarrow$ **Safety Factor = 0.93**

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ENGINEERING DEPARTMENT

SHEET No. 99 OF

CLIENT Total Oil Marine Ltd. JOB NO.

SUBJECT Crane Pedestal

BASED ON DRAWING NO.

COMPUTER DPP CHK'D. BY T.S. APP'D BY DATE Aug 1978

Tendons Plastic Collapse:- (pages 65 – 66)

Safety Factor = Ultimate Moment / Applied Moment = 32249·81 / Applied Moment.

∴ Safety Factors:-

Load Condition 1	1	S.F =	4·98
	1·2	=	3·91
	2·0	=	2·10
Load Condition 3	1	=	3·27
	1·2	=	2·77
	2·0	=	1·72.

6.7 Conclusions

Under static loading (Impact Factor = 1), the lowest safety factor on the crane is 1.55 at the change in deck section. Under the same conditions, the lowest safety factor on the pedestal and base is 4.04 for local collapse at the manholes. This is 62% higher than that for the crane.

For an Impact Factor of 1.2, recommended by Lloyds, the lowest safety factor is 3.59 for local collapse at the manholes.

For an Impact Factor of 2, recommended by Brown & Root, the lowest safety factor is 2.11 for local collapse at the manholes.

Thus the pedestal and base are safe, even with an Impact Factor of 2. The pedestal and base are stronger than the crane.

SECTION 8.1

APPENDIX

- "A Study of Wind Effects on Crane Pedestals for Frigg Field Intermediate Platform". Atkins Research and Development Co.
- "Total Marine Platform - Crane Pedestals". Dr. T. A. Wyatt.
- Miscl. Crane Data by American Hoist and Derrick Co.

A Report for Brown & Root (U.K.) Ltd.,
acting on behalf of Total Marine.

A STUDY OF WIND EFFECTS ON CRANE PEDESTALS FOR FRIGG FIELD INTERMEDIATE PLATFORM

Atkins Research and Development
Parkside House
Ashley Road
EPSOM
Surrey.

April 1975.

CRANE PEDESTALS - A STUDY OF WIND-INDUCED EFFECTS

1. INTRODUCTION

There are three main mechanisms by which elastic structures may be excited dynamically. All structures are subjected to turbulence of the wind which may contain a significant amount of energy at the natural frequency of the structure. A simplified procedure for calculating response has been devised by Davenport[1] and is used in many codes of practice, e.g. the Canadian and Danish codes. This procedure takes into account the relevant properties of the structure and ground environment. The definition of the design wind speed in terms of its averaging period is of paramount importance to this calculation.

A second form of excitation particularly relevant to tall slender structures of unchanging cross-section can result from vortex shedding. The frequency at which pairs of vortices are shed equals the frequency of the fluctuating cross-wind or lift force. This is represented by the Strouhal number

$$S = \frac{\eta D}{V}$$

where η is lift frequency

D is cross-section dimension

and V is wind speed.

For a circular cylinder the value of Strouhal number is approximately 0.2 under all usual realistic conditions. Dynamic response can occur when the shedding frequency coincides with the natural frequency of the structure, i.e. $\eta = N$. The wind speed at which this occurs is called the critical wind speed and is usually quite low. The critical wind speed is determined only by S, η and D. The way in which dynamic response is related to wind speed and structural properties has been described by Wootton[2], and by Wootton and Scruton[3] for circular cylinders vibrating in test conditions.

Continued ... ...

A third form of dynamic response which is highly dependent on body shape is called galloping. This does not occur with circular sections and so is not considered further.

In calculating wind effects it is important to consider the different construction stages; a perfectly stable final structure may be aerodynamically unstable during its erection. For this crane pedestal the worst case for turbulent forcing occurs when the structure is complete, i.e. when the crane is in place. However, the worst case for vortex shedding response could occur before the crane is in position because the mass to be excited will be smaller (an unimportant consideration in Davenport's turbulent theory). For the same reason, modes of vibration higher than the fundamental have to be considered for vortex shedding response, provided the critical wind speeds are within the design range. Higher modes are not important to turbulent forcing as the fundamental mode gives the greatest dynamic response. Only the 27m pedestal is considered as this will suffer greater wind loads than the 23m pedestal.

2. RELEVANT WIND SPEEDS

The design wind speed is specified as 53 m/s. This is for a 3-second gust. The Department of Energy's 'Guidance on the Design and Construction of Offshore Installations' recommends a gust size of 5 seconds with a power-law exponent of 0.08 for structures the size of this crane pedestal. The variation of this gust speed with height above the sea is shown in Fig. 1. The base of the pedestal is 31m above low-tide sea level and during storm conditions wave heights of 30m are likely. The wave lengths will be large, around 500m, and thus the maximum effective height of the pedestal above the sea will be approximately 46m.

Continued ... ...

3. STEADY WIND LOADING

The drag on a circular cylinder is dependent on Reynolds number Re, defined as VD/ν where ν is kinematic viscosity. The maximum Reynolds numbers of this study are about 10^7 and the corresponding drag coefficient C_D (drag per metre length/$\frac{1}{2}\rho V^2 D$) is 0.6 (Wootton and Scruton[3]). The crane eliminates any 'tip-flow effects' which cause high local drags (Gould, Raymer and Ponsford[4]) so that $C_D = 0.6$ is assumed over the total length of the circular section.

The drag coefficient of the crane and boom/jib cannot be specified accurately, but values of C_D = 1.5 and 0.3[5] respectively are thought to be safe. The latter is for a square lattice structure with round sections and a solidity ratio of 0.4. The maximum wind loading over the circular section is shown in Fig. 2 and the total load on the crane in the position giving greatest loading is shown as lumped to act at the cabin centre. The overall wind load from the boom/jib in its raised position (the worst case) is also shown in Fig. 2. This value is in approximate agreement with that specified by the manufacturers.

4. THE INFLUENCE OF TURBULENCE

Davenport defines a gust factor G as the extent by which turbulence magnifies steady loads.

$$C_{D\,max} = G.C_{D\,mean}$$

where $G = 1 + gr.\sqrt{B + R}$

$R = SF/\beta$

and $\beta = \delta/2\pi$

g is peak factor

r is roughness factor

B is excitation by background turbulence

R is excitation by turbulence resonant with structure

F is gust energy ratio

S is size reduction factor

β is damping factor

δ is logarithmic decrement.

Continued ... ...

a) g is dependent on the fundamental natural frequency N and the gust size. A transfer matrix method gives N = 0.99 and the gust size is 5 seconds. This gives g = 3.0.

b) maximum height of structure 240 ft., hence r = 0.20.

c) B = 1.4

d) $R = \dfrac{S.F.2\pi}{\delta}$

$S = .26$

$F = .078$

$\delta = 0.01$

$\delta = 0.01$ is probably the smallest value recorded for a structure of this type (Scruton and Flint[6]) and is therefore a conservative estimate. This gives

$R = 12.7$

Hence

$G = 3.25$

The maximum loading distribution is thus given by Fig. 2 with the forces magnified by 3.25 and oscillating at 0.99 Hz. The maximum tip deflection for such a loading is about 80mm.

5. DYNAMIC RESPONSE TO VORTEX SHEDDING

5.1 With the Crane in Position

The natural frequency of the fundamental model is 0 99 Hz and that of the second mode is 14.2 Hz (using the transfer matrix method). The critical wind speed in the second mode is above the design wind speed and thus precludes response of this mode. The dynamic response is dependent on $\bar{m}/\rho D^2$ and δ where $\bar{m}$ is given by

$$\bar{m} = \frac{\int_0^H m f(\overset{2}{y})\,dy}{\int_0^H f(\overset{2}{y})\,dy}$$

H is height of structure

m is mass/unit length

f(y) is mode shape

y is height above base.

f(y) is assumed to be parabolic, i.e. $f(y) = \alpha y^2$

Thus $\bar{m}$ = 27300kg/m

$$\frac{\bar{m}}{\rho D^2} = 4300$$

Taking $\delta = 0.01$

$$\frac{\bar{m}}{\rho D^2}.\delta = 43 \quad \text{and} \quad \frac{\bar{m}}{\rho D^2}\sqrt{\delta} = 430$$

It is clear from Wootton's work[2] that there will be no significant dynamic response due to vortex shedding.

5.2 Without Crane in Position

The natural frequency of the fundamental mode is 2.9 Hz assuming that only the crane platform is in position

$\bar{m}$ = 3360kg/m

$\frac{\bar{m}}{\rho D^2}$ = 529 and again assume δ = 0.01 (safe)

For response $V = 5ND$

$= 33.3$ m/s

and $Re = 5 \times 10^6$

For Wootton's paper

$$\frac{\bar{m}}{\rho D^2}\delta = 5.29 \quad \text{and} \quad \frac{\bar{m}}{\rho D^2}\sqrt{\delta} = 52.9$$

Figs. 8 and 14 in this paper imply the RMS reduced amplitude will be 0.01, i.e. an absolute amplitude of 32mm. Thus the construction stage is also safe from dangerous vortex shedding excitation.

6. DESIGN PARAMETERS

Fig. 2 gives the greatest possible mean loading distribution for the 5-second gust speed which occurs once in 50 years. This should be multiplied by a gust factor of 3.25 to give the amplitudes of dynamic load fluctuating at 0.99 Hz.

For fatigue considerations the sea is always assumed to be at mid-tide level and V_M is the 5-second gust speed at 10m above this level. The distribution of drag/metre on the circular section is shown in Fig. 3 as a function of V_M^2 together with the overall loading due to the crane and the boom/jib. The gust factor G is plotted against V_M in Fig. 4.

Continued ... ...

Thus the amplitudes of dynamic load at the fundamental structural frequency of 0.99 Hz are known at all wind speeds as

$$C_{D\ max} = G.C_{D\ mean}.$$

To quantify fatigue the probability of a certain wind speed occurring needs to be known. This is shown in Fig. 5 as the number of cycles of 0.99 Hz which exceed a certain wind speed in one year. This line is based on wind data from a sea area including the Frigg Field. It will be noticed that the design gust speed of 53 m/s occurring once in 50 years fits on this curve. The fluctuating stresses at a given wind speed can be calculated from Figs. 3 and 4. Thus fatigue resulting from turbulence can be calculated.

Vortex shedding induces a fluctuating side force or lift on the circular section but not on the crane and boom. At the Reynolds numbers for this circular section the RMS lift coefficient $C_{L\ rms}$ is approximately equal to 0.4. The corresponding distribution of lift/m is shown in Fig. 6 as a function of V_M^2. The frequency at which it acts is equal to 0.09V, where V is the velocity at a given section. (This means there will be a small range of lift frequencies across the span). The exceedance diagram for wind speed, shown in Fig. 5, has to be modified as frequency is dependent on wind speed. In doing this the mean spanwise frequency is assumed for a given value of V_M. The resulting exceedence diagram is shown in Fig. 7. The fluctuating stresses can be calculated from Fig. 6. Thus fatigue resulting from fluctuating forces due to vortex shedding can also be calculated.

Continued ... ...

7. REFERENCES

1. Davenport, A.G., Gust Loading Factors. Proc. A.S.C.E. Vol. 93 1967.
2. Wootton, L.R., The Oscillations of Large Circular Stacks in Wind. Proc. I.C.E. Vol. 43 1968.
3. Wootton, L.R., and Scruton, C., Aerodynamic Stability. Proc. C.I.R.I.A. Seminar June 1970.
4. Gould, R.W.F., Raymer, W.G., and Ponsford, P.J., Wind Tunnel Tests on Chimneys of Circular Section at High Reynolds Numbers. NPL Aero Report 1266 1968.
5. The Polish Wind Loading Code.
6. Scruton, C., and Flint, A.R., Wind Excited Oscillations of Structures. Proc. I.C.E. Vol. 57 April 1964.

FIG.1

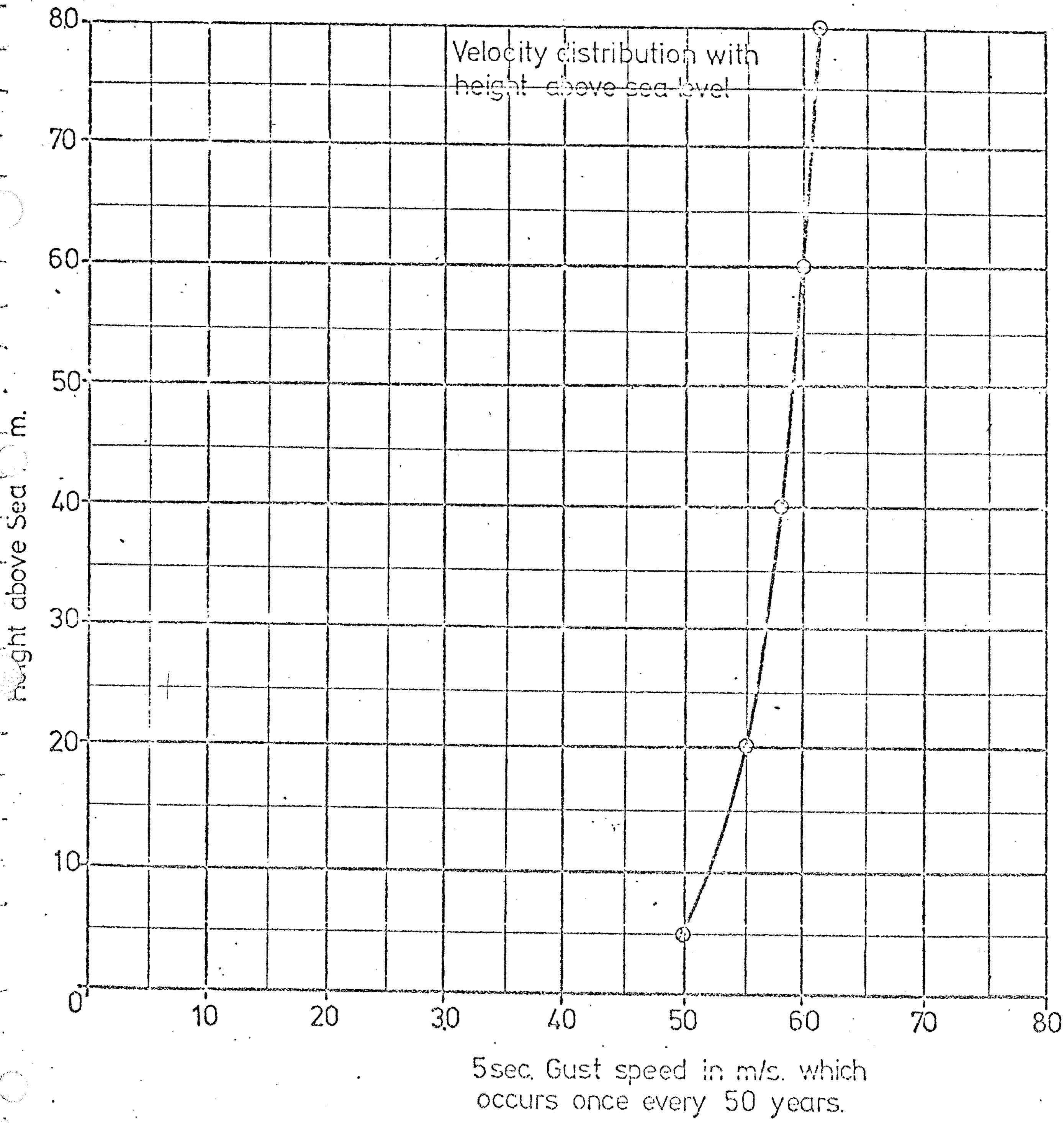
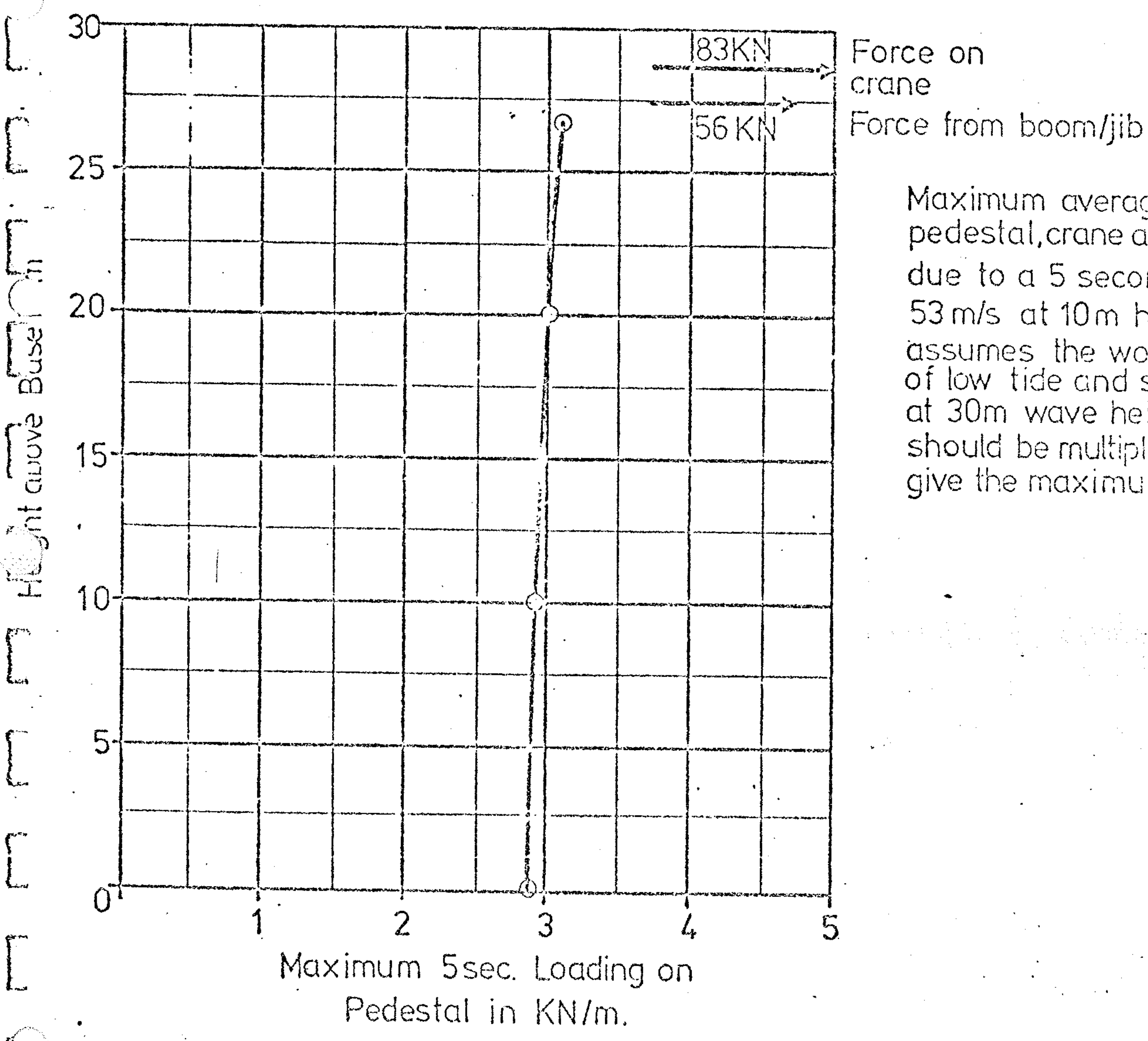
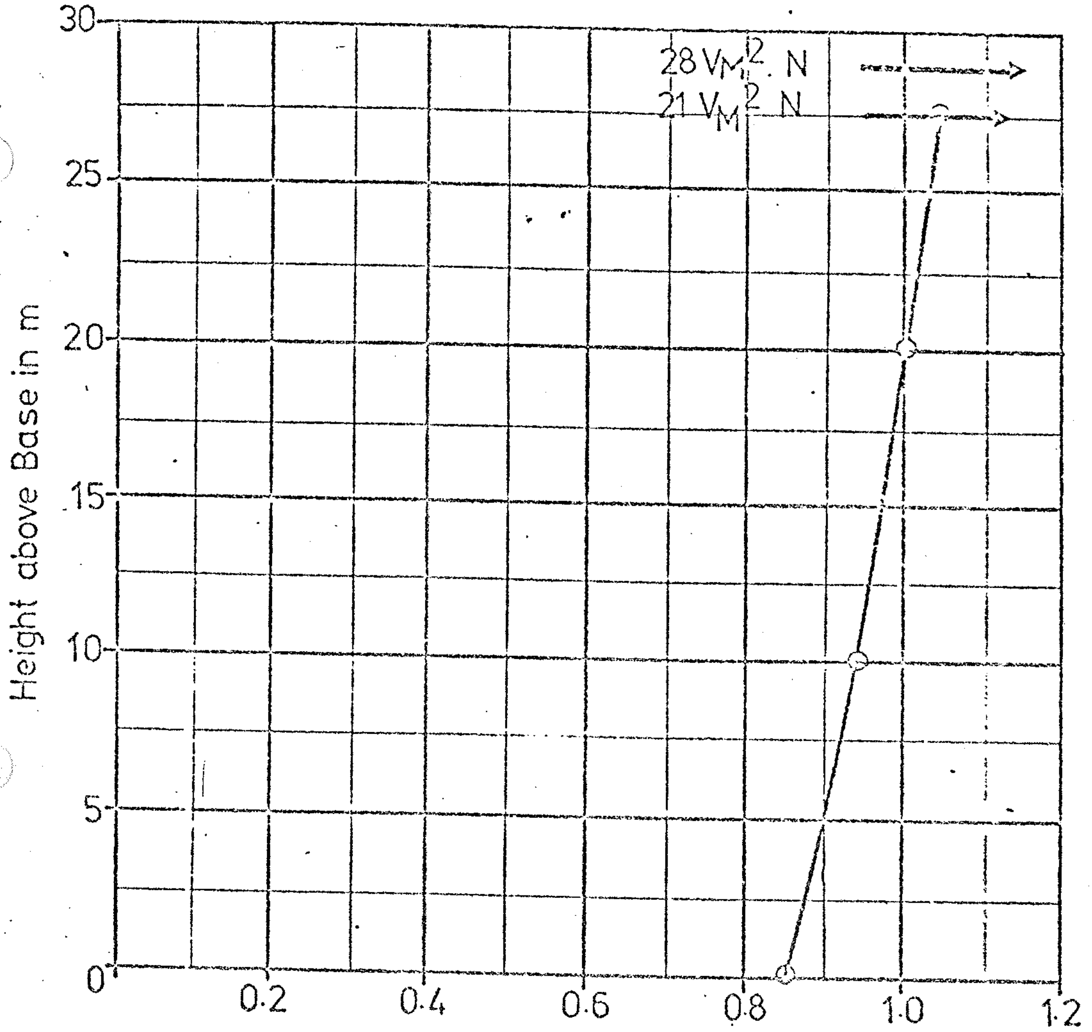

Velocity distribution with height above sea level
Height above Sea m.
5sec. Gust speed in m/s. which occurs once every 50 years.
0
10
20
30
40
50
60
70
80

FIG. 2



Maximum average loading on the pedestal, crane and boom/jib due to a 5 second gust of 53 m/s at 10 m height. This assumes the worst condition of low tide and storm waves at 30m wave height. These VALUES should be multiplied by 3·25 to give the maximum GUST LOADING.

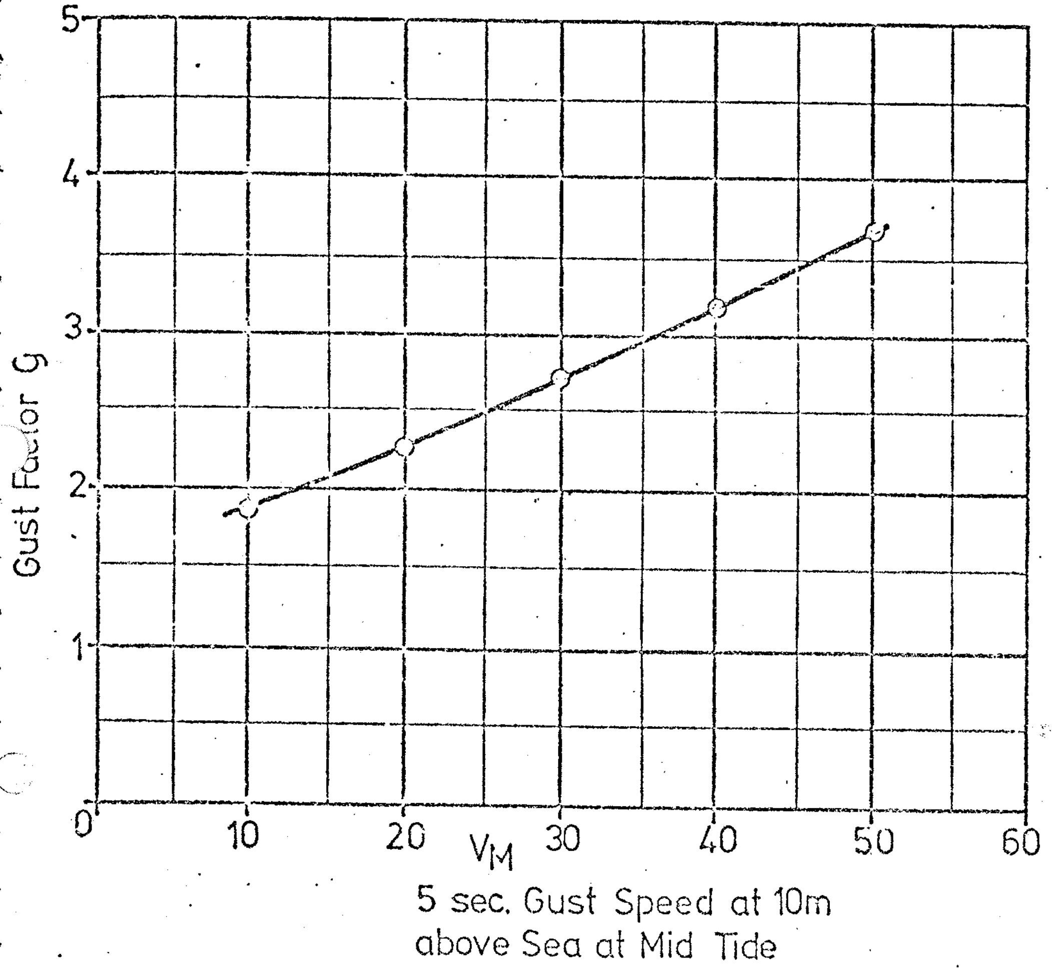
FIG.3



Loading on crane, boom/j and pedestal in terms of V_M (the 5 sec. gust speed at 10m above mid tide level). This is the average loading.

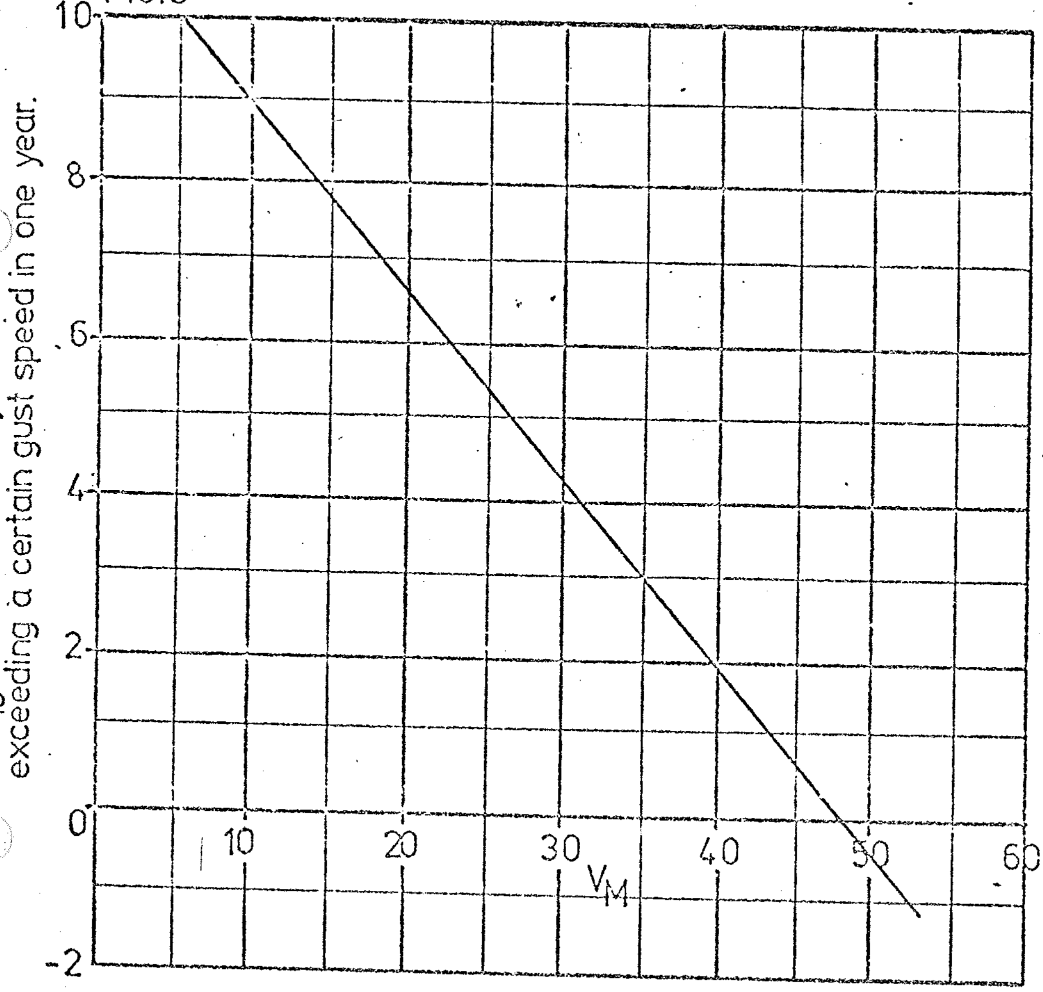
Load on Pedestal
at Mid Tide in N/m × V_M^2.
(V_M is 5sec. Gust speed at 10m above sea at Mid Tide)

FIG. 4



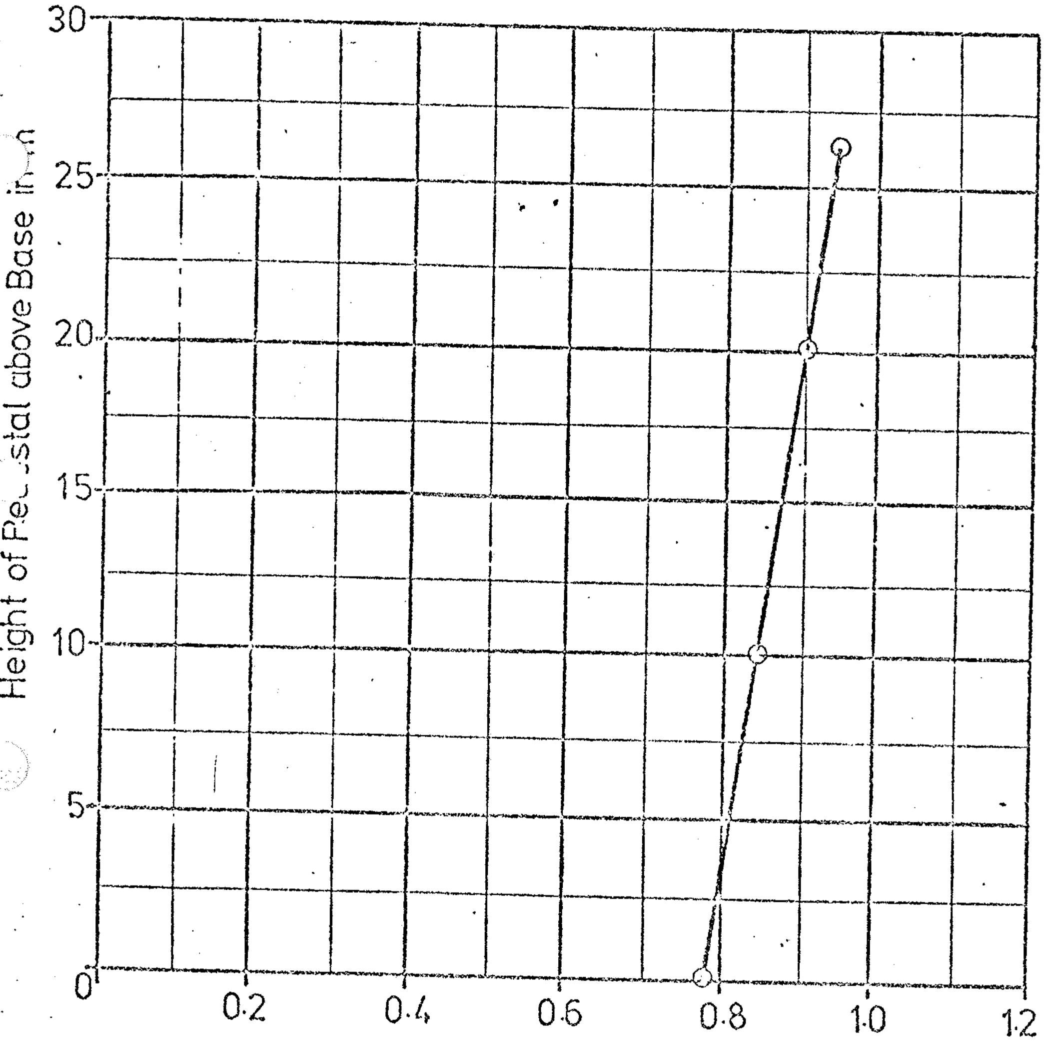
Amplification Factor to give Gust Loading with natural structural frequency of 0.99 Hz.

FIG.5



Exceedance Diagram for Turbulence Forces. V_M is 5sec. gust speed at 10m above sea at mid-tide

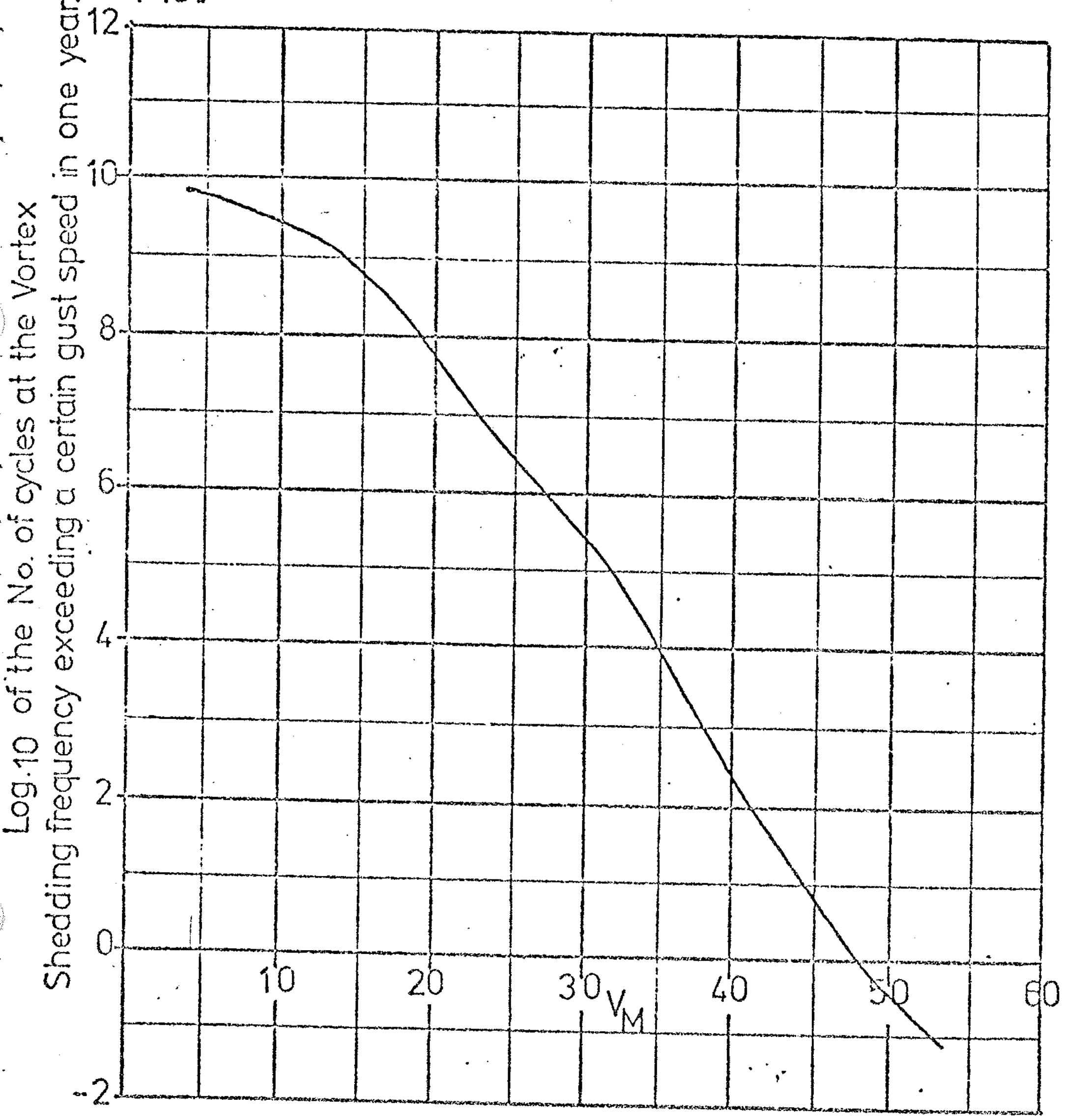
FIG. 6



Lift Amplitudes on Pedestal at Mid Tide in N/m × V_M^2 (V_M is Gust speed 10m above Sea at Mid Tide)

Fluctuating side force on pedestal due to vortex shedding in terms of V_M.

FIG 7



Exceedance Diagram for Vortex Shedding Forces. V_M is 5sec. gust speed at 10m above sea at mid-tide.

SECTION 8.2

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Department of Civil Engineering
Imperial Institute Road, London SW7
Telephone: 01-589 5111 Telex: 261503

25 February 1975.

Dear Peter,

Total Marine Platform - Crane Pedestals

This is to confirm my telephone report that I am convinced that there is no significant risk of wind-induced oscillation of the crane pedestals. I do not think that any practicable test programme would add much to this conclusion.

The reason for the security of the structure is primarily the high mass. The significant parameter is $m\delta/\rho D^2$ (or possibly $m'\delta/\rho D^2$) where m is the effective mass per unit length of cylinder, δ is the natural damping logarithmic decrement, ρ is the density of air, and D is the diameter. The 'effective' mass must take account of any superimposed mass that must participate in an oscillation - in this case, the crane. I show in my calculations that the effective mass here is of the order of ten times the value for a concrete chimney, thirty times the typical value for a steel chimney. Even with the relatively low damping possible with your base mounting, safety seems assured. Damping is unlikely to be abnormally low, however, because any shaking of the crane is likely to cause damping.

I personally normally use a rather lower value of the coefficient of alternating lift than Mr. Kapsan - or preferably use the experimental results of Wooton (Proc. ICE 43 Aug. 1969). Wooton's results predict an amplitude significantly less than 1% of the diameter, in which event the vortex shedding at these high Reynolds numbers would be very poorly correlated over the height and the effective lift coefficient much lower than either the value I tried in my calculation or Mr. Kapsan's.

I have not felt it necessary to investigate the combined effect of bending and torsion, as Mr. Kapsan has shown the effect of this to be fairly small. The approach made in my calculations of finding a modal stress coefficient (page 2) which is then applied to the modal response calculations should be followed if you require to do so in any future case, as the relative magnitude of dynamic response in torsion will not be the same as in bending. Here bending predominates in the dynamic response - torsion would arise mainly from the eccentricity of the crane centroid from the pedestal axis. I have also made an order-of-magnitude check on possible gust-induced motion, and this too is small.

I enclose my calculations because they may perhaps prove of assistance in considering any future similar cases, although I cannot hope they will be easy to follow since I have made no effort to write them up for your benefit. For the service condition it is important to include the rotary inertia (second moment of mass) of the crane. In the event, the first mode frequency proves similar to your estimate, as I do not feel it necessary to include allowance for any suspended load. The second mode

.../

is considerably different, but still corresponds to a high critical wind speed and is not serious.

For the tethered condition, although the tethers would not effectively prevent sideways movement, they are certainly intended to relieve the crane of the jib, and the effective rotary inertia would be very much reduced. The second mode frequency is then high enough to carry the critical speed well out of the design range.

The main remaining shortcoming in my frequency calculations is that no allowance has been made for flexibility of the crane itself. This is likely to be important, particularly in stretch of the luffing ropes and flexure of the jib, but I can foresee no way in which this would greatly alter the overall conclusions.

I enclose my account, and hope it will also be possible to keep in touch.

Yours sincerely,

Tom Wyatt

T.A. Wyatt.

Dr. P.M.Roberts,
Brown & Root (U.K.) Ltd.,
30 St. Georges Road,
London SW19.

BROWN & ROOT – TOTAL MARINE

CRANE PEDESTAL

FIRST MODE PROPERTIES

Consider 27m pedestal with dimensions as B&R Sheet 1, Nov 21/74.
The concrete support stiffness is taken as Sheet 9, Nov 22/74,
namely 16×10^{11} kg cm/rad $= 0.16 \times 10^{9}$ kNm/rad → flex. at 28.75m: 55×10^{-6}, 170×10^{-6}, 6.25×10^{-6}

For pedestal 2300 φ, 45t, $EI = 42.5 \times 10^{6}$ kNm²

∴ to centroid of crane, $l = 28.75$m,

translational stiffness $3EI/l^3 = 5.6 \times 10^{3}$ kN/m, flex. 176×10^{-6} m/kN

rotation/lin stiffness $2EI/l^2 = 102 \times 10^{3}$ kN, 9.8×10^{-6} /kN

rotational stiffness $EI/l = 1.48 \times 10^{6}$ kNm, 0.675×10^{-6} /kNm

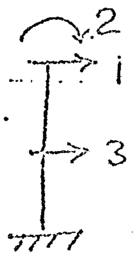
→ The flexibility of the crane itself under load will be considerable, *in fact prob. very important consideration*.
So consider first <u>unloaded</u>. The rotary inertia of the crane should be included.

Crane – point mass 292,000 lb = 133 t   rotary inertia: body 66.5 t, 5 m², 3… ; cwt 50 t, 27 m², 13.5… ; jib 16.5 t, 700 m², 11500 ; total 13,200

¼ of shaft @ 27kg/km = 27 t
160 t

Half mass of shaft = 54 t to be placed at half height.

Thus:



mass matrix ⌈160 t, 13200 t m², 54 t⌋

flexibility matrix

191×10^{-6} m/kN	10.0×10^{-6} m/kN	60.8×10^{-6} m/kN
10×10^{-6} rad/kN	0.631×10^{-6} rad/kNm	2.54×10^{-6} m/kN
60.8×10^{-6}	2.54×10^{-6}	29.5×10^{-6}

Thus, in units of 100 t, 1000 kN, 10 m we have
(i.e. consistent in that 1000 kN gives acc. 100 t @ 10 m/s²)

$$M = \begin{bmatrix} 1.60 & & \\ & 1.32 & \\ & & 0.54 \end{bmatrix}, \quad F = \begin{bmatrix} 1.91 & 1.00 & 0.608 \\ 1.00 & 0.63 & 0.254 \\ 0.608 & 0.254 & 0.295 \end{bmatrix} \times 10^{-2}$$

The equation of motion (undamped free oscillation) is $M\ddot{y} = -Ky$, which in flexibility form is clearly, for periodic sol^n ω (radians/sec)

$$[I - \omega^2 FM]\, y = 0 \quad , \text{ so, for non-zero soln}$$
$$\det \left| \frac{1}{\omega^2} I - FM \right| = 0$$

For the model sketched on page 1, evaluate FM and write $\frac{10^2}{\omega^2} = C$,

$$\det \begin{vmatrix} 3.06-C & 1.32 & 0.328 \\ 1.600 & 0.898-C & 0.137 \\ 0.973 & 0.335 & 0.132-C \end{vmatrix} = 0$$

i.e. sum of $\left\{ \begin{matrix} (3.06-C)(0.898-C)(0.132-C) \\ 1.600 \times 0.335 \times 0.328 \\ 0.973 \times 1.32 \times 0.137 \end{matrix} \right\} - \left\{ \begin{matrix} (3.06-C)\ 0.335\ 0.137 \\ 0.973\,(0.898-C)\ 0.328 \\ 1.600\ \ 1.32\ \ (0.132-C) \end{matrix} \right\} = 0$

leading to $(3.06-C)(0.898-C)(0.132-C) + 2.48C - 0.353 = 0$

First mode solution $C = 3.89$ $\quad \omega^2 = 25.7$ $\quad n = 0.81$ Hz.

This is virtually identical with previous solution – but here we assume zero load on hook. Previously 100 kip = 45t to by mass of boot.

Thus the rotary motion reduces frequency by about 12%.

Mode shape 1, 0.0545 rad, 0.31.

Generalised mass $160 + 39 + 5 = 204$ t (rotary, shape)

Generalised stiffness $= 5250$ kN/m } on unit displt at centroid of crane

Equivalent length of cylinder considered at $\mu = 1$ $= 0.37H$ neglecting top res.

$= 0.12H$ or, considering top 3.5m as inactive $= 0.27H = 7.8$ m.

Thus for $C_L = 0.4$ and $\delta = 2\pi\gamma = 0.03$, $\frac{M\delta}{\rho D^2 l_e} = \frac{204 \times 0.03}{0.0012 \times 2.3^2 \times 7.8} = 120$

steady amp. $= \frac{D}{8\pi} \times \frac{\rho l_e D^2}{M\delta} \times \frac{C_L}{S^2} = \frac{2300 \quad 0.4}{8\pi \quad 120 \quad 0.19^2} = 8.5$ mm

– Strouhal No $= 0.19$

This is << 1% D, so won't happen anyway in hypercritical turbulent flow (Wootton)

Base moment influence coefficient $= 14.3$ kNm per mm amplitude

∴ for 8.5 mm, moment amplitude $= 1220$ kNm

and as $Z \doteq \pi D^2 t/4 \doteq 0.21\,m^3$, stress amp $6\ N/mm^2 = 0.9$ ksi

This stack is effectively [illegible] as long as a concrete [illegible]

Second mode solution $C = 0.185$ $\omega^2 = 540$ $n = 3.7$ Hz.

critical wind speed $5.2 \times 3.7 \times 2.3 = 44$ m/s.

Note this is for oscillation in plane of jib: i.e. only significant if jib f...

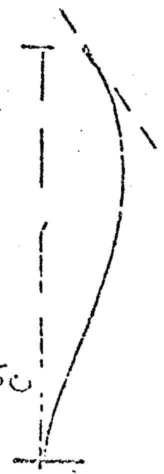
Mode would be $1.0, \; -0.26, \; 1.9$ (rad)

Generalised mass $160 + 900 + 200 = 1260$ t (rotary, shaft)

Generalised stiffness 0.68×10^6 kN/m

Equiv. length (discarding top 3.5m) $= 1.2H = 34$ m

Thus for $C_L = 0.4$ and $\delta = 0.06$, $\frac{M\delta}{\rho D^2 L_e} = \frac{1260 \times .06}{.0012 \times 2.3^2 \times 34} = 350$



Steady amplitude 3.0 mm

As before, this is much less than 1% D.

Base moment influence coefficient 1450 kNm/mm

Stress amplitude 20 N/mm^2 $= 3$ ksi.

As the crane is stowed when extreme storms are predicted, and the combination of cradle inlet and shelter is such that oscillation is likely to be significant only perpendicular to the jib direction, consider also zero rotary inertia (jib is alone 90° of ...

With the very crude model obtained by simply omitting coordinate (2),

$$\begin{vmatrix} 3.06 - C & .329 \\ 0.973 & 0.132 - C \end{vmatrix}$$

gives $C = 3.16$ $n = 0.53$ Hz, mode 1, .32

& $C = 0.027$ $n = 9.5$ Hz, mode 1, −9.2

Improving the mode 2 approximation by energy, the actual KE for distributed mass according to shape drawn thro' shape above {1, −9.2} proves to agree closely with the 2-mass approx, so approx. $n = 9.5$ Hz is probably good enough. This gives critical speed well out of range.

There would appear no cause for fitting strakes.

Gust forcing

A quick check on the maximum gust response can be obtained by comparing σ_y in design wind $\bar{V} = 40$ m/s with resonant $\hat{y}$ predicted due to vortex excitation at $V \doteq 10$ m/s.

Ratio is

$$\frac{\sigma_y}{\hat{y}} = \sqrt{2\delta} \; J \; \frac{\sigma_v}{\bar{V}} \sqrt{\frac{n_0 S(n_0)}{\sigma_v^2}} \left(\frac{\text{design } \bar{V}}{\text{resonant } V}\right)^2 \left(\frac{A C_D}{A C_L}\right)$$

- $\sqrt{2\delta}$: approx $\frac{1}{4}$ for $\delta = .03$
- J: take as 1
- $\frac{\sigma_v}{\bar{V}}$: take as 0.11
- $\left(\frac{\text{design } \bar{V}}{\text{resonant } V}\right)^2$: approx 16
- $\left(\frac{A C_D}{A C_L}\right)$: approx 12

for the design $\bar{V} = 40$, $n_0 = 0.3$ Hz, $\sqrt{\frac{n_0 S(n_0)}{\sigma_v^2}} = \sqrt{0.07} = 0.27$

$\therefore$ the ratio $\frac{\sigma_y}{\hat{y}} \doteq 1.4$ approx

The dynamic response (say $4\sigma_y$) would be combined (by adding squares) with the static gust response, and added to the hourly mean given by $\bar{V}$. In view of the low stress levels corresponding to $\hat{y}$ (bottom of p2), and the low turbulence intensity for the full marine exposure (static gust response $\doteq$ 0.8 × hourly mean or 0.44 × "design" value from static calc. basis), this seems to be no problem.

SECTION 8.3

AMERICAN HOIST AND DERRICK COMPANY
63 SOUTH ROBERT STREET
ST. PAUL, MINNESOTA 55107
TELEPHONE 612-228-4321

PROPOSAL

NO. S-3464 **PAGE NO.** 1 **OF** **DATE** 11-1

TO: Brown & Root (UK) Ltd.
Ashville House
Alexandra Road
Wimbledon, London, SW 19, England

Subject: AMERICAN Model 11750 Pedestal Cranes

Enclosed are corrected copies of the rating charts A & B which were sent on October 23, 1974. Due to computer error, the correction is in the parts of line when the radius is at 28, 30, 35 and 40 feet.

Rating chart A, which applies to the 11750 Pedestal Crane with No. 15 jib in place with 150' of boom is now identified as rating chart 1170.07. Rating chart B, which applies to the 11750 Pedestal Crane with only 150' of main boom, no jib in place, is now identified by the rating chart No. 11750.08.

Sincerely,

Michael T. Mooney
Sales Department

/lm

Enc.

AMERICAN MODEL 11750 PEDESTAL CRANE RATINGS

Rating Chart A
11750.07

150 Ft. 94" Heavy Duty Boom
6-Sheave Offset Boom Point
No. 15 Jib, 30 Ft. with 0-5 ft. offs

Radius in Feet	Boom Angle Degrees	Rating in U. S. Tons (2000 lbs.)	Rating in British Tons (2240 lbs.)	Distance in Feet-Boom Point to Boom Foot	Minim Parts Line
28	82.1	146.56	130.85	149	9
30	81.3	136.46	121.83	148	8
35	79.4	114.3	102.05	147	7
40	77.5	98.0	87.5	146	6
45	75.5	83.36	74.42	145	5
50	73.5	70.07	62.56	143	5
55	71.5	60.3	53.84	142	4
60	69.5	52.55	46.92	140	4
65	67.4	46.55	41.56	138	3
70	65.3	41.47	37.03	136	3
75	63.2	37.25	33.25	133	3
80	61.0	33.67	30.06	131	3
85	58.8	30.78	27.48	128	2
90	56.5	28.13	25.11	125	2
95	54.1	25.8	23.03	121	2
100	51.7	23.75	21.2	117	2
105	49.2	21.93	19.58	113	2
110	46.6	20.29	18.12	109	2
115	43.9	18.82	16.8	104	2
120	41.1	17.5	15.62	98	2
125	38.0	16.29	14.54	92	2
130	34.8	15.2	13.57	85	2
135	31.2	14.3	12.76	77	1
140	27.2	13.37	11.93	68	1
145	22.5	12.5	11.16	57	1
150	16.7	11.7	10.45	43	1

Net lifting capacity over the 30 ft. jib is 10 British tons (22,400 lbs.) with maximum 5 ft. offset to 150' radius.

Load ratings are in tons. Safe loads depend on boom length, radius of operation and proper handling, all of which must be taken into consideration by user. Ratings are based on strength of material rather than stability and must not be exceeded. Minimum rope safety factors are:

Boom hoist 4.88:1 static, 4.5:1 dynamic; pendants 3.5:1, load line 5.1:1 static, 4.5:1 dynamic. Lifting is approved only at those radii for which ratings are shown in the chart. "Radius in feet" is the horizontal distance at crane base, level from center pin to a vertical line through the center of gravity of the suspended load. Blocks, slings, buckets, magnets and other load carrying devices are considered part of the load. Designed and rated to comply with the American Petroleum Industry and ANSI Code B30.5 requirements.

The bail load line (boom line) is 1" diameter 6 x 26, WS, FW, RAL, IWRC, EIPS wire rope with a minimum breaking strength of not less than 103,400 pounds.

The main load line is 1-1/4" diameter 6 x 49 (Scale) preformed RRL, EIPS, IWRC, Specification S67/71 Bridon Ind. wire rope with a minimum breaking strength of not less than 175,500 pounds.

The Whip Line is 1-1/4" diameter 18 x 7 non-spin, EIPS wire rope with a minimum breaking strength of not less than 130,200 pounds.

AMERICAN MODEL 11750 PEDESTAL CRANE RATINGS

Rating Chart B
11750.08

150 Ft. 94" Heavy Duty Boom
6-Sheave Offset Boom Point

Radius In Feet	Boom Angle Degrees	Rating In U. S. Tons (2000 lbs.)	Rating In British Tons (2240 lbs.)	Distance In Feet-Boom Point To Boom Foot	Minimum Parts of Line
28	82.1	148.56	132.63	149	9
30	81.3	138.46	123.61	148	8
35	79.4	116.3	103.83	147	7
40	77.5	100.0	89.28	146	6
45	75.5	85.36	76.20	145	5
50	73.5	72.07	64.34	143	5
55	71.5	68.3	55.62	142	4
60	69.5	54.55	48.70	140	4
65	67.4	48.55	43.34	138	3
70	65.3	43.47	38.81	136	3
75	63.2	39.25	35.03	133	3
80	61.0	35.67	31.84	131	3
85	58.8	32.78	29.26	128	2
90	56.5	30.13	26.89	125	2
95	54.1	27.8	24.81	121	2
100	51.7	25.75	22.80	117	2
105	49.2	23.93	21.36	113	2
110	46.6	22.29	19.90	109	2
115	43.9	20.82	18.58	104	2
120	41.1	19.5	17.40	98	2
125	38.0	18.29	16.32	92	2
130	34.8	17.2	15.35	85	2
135	31.2	16.3	14.54	77	1
140	27.2	15.37	13.71	68	1
145	22.5	14.5	12.94	57	1
150	16.7	13.7	12.23	43	1

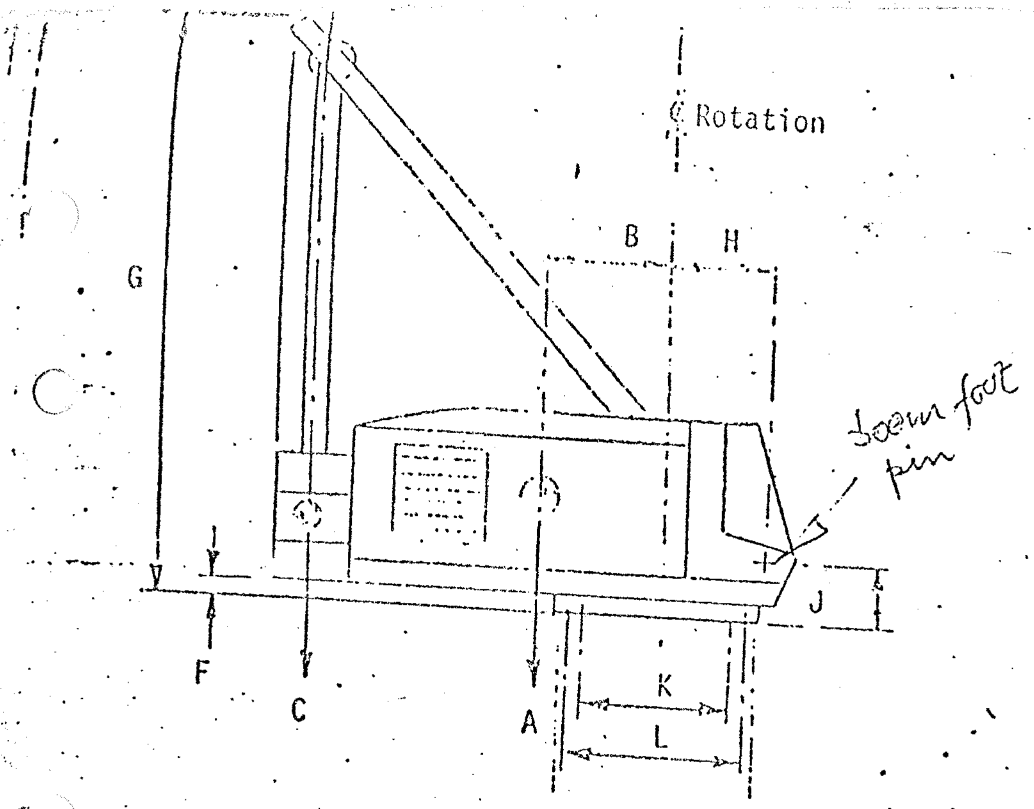
Load ratings are in tons. Safe loads depend on boom length, radius of operation and proper handling, all of which must be taken into consideration by user. Ratings are based on strength of material rather than stability and must not be exceeded. Minimum rope safety factors are:

Boom hoist 4.88:1 static, 4.5:1 dynamic; pendants 3.5:1, load line 5.1:1 static, 4.5:1 dynamic. Lifting is approved only at those radii for which ratings are shown in the chart. "Radius in feet" is the horizontal distance at crane base, level from center pin to a vertical line through the center of gravity of the suspended load. Blocks, slings, buckets, magnets and other load carrying devices are considered part of the load. Designed and rated to comply with the American Petroleum Industry and ANSI Code B30.5 requirements.

Rating Chart B
11750.08

The bail load line (Boom line) is 1" diameter 6 x 26, WS, FW, RAL, IWRC, EIPS wire rope with a minimum breaking strength of not less than 103,400 pounds.

The main load line is 1-1/4" diameter 6 x 49 (Seale) preformed RRL, EIPS, IWRC, Specification S67/71 Bridon Ind. wire rope with a minimum breaking strength of not less than 175,500 pounds.



ORDER NO.
A - 9189F; A-9190F
DATE 10-17-1974

BY Dennis Kruse

ENGINEERING DEPARTMENT
AMERICAN HOIST & DERRICK CO.

CORRECTED: 10-23-1974

MODEL:	11750
BOOM TYPE:	94 Heavy Duty
BOOM LENGTH:	150 Ft.
RATING CHART:	11750.07

A = Weight of Upper --
B = C Rotation to C.G. of Upper Deck-------------------------- 132,000 lbs.
C = Weight of Counterweight------------------------------------ 4.76 ft.
D = C Rotation to C.G. of Counterweight--------------------- 110,800 lbs.
E = Tail Swing-- 16.92 ft.
F = Clearance from Bottom Turntable Bearing to Bottom of ------ 19.0 ft.
Counterweight--
G = Height Over Raised A-Frame ---------------------------------- 7.25 inch.
H = C Rotation to C. Boom Foot---------------------------------- 33.1667 ft.
J = Height of Boom Foot from Bottom Turntable Bearing----------- 5.833 ft.
K = Pitch Diameter of Bull Gear (1.25 D.P.) ------------------- 1.739 ft.
L = Lower Mounting Bolt Circle Diameter ------------------------ 100.00 inch
M = .3 Path Roller Bearing Drawing No.--------- 718482 105.00 inch
N = Maximum Allowable Net Overturning Moment Based on Swing Bearing-9,500,000 ft. lbs.
P = Maximum Swing Torque Available-------------------------------- 430,000 ft. lbs.
Q = Side Load, for Working Condition, No Wind, 150 Ft. Boom,
No Load and based on Full Swing Torque (P)----------------------
R = Thrust with Maximum Rating with 150 Ft. Boom.--------------- 17,200 lbs.
558,300 lbs.

NOTE: N; P; Q; and R do not necessarily occur simultaneously.

For maximum moment condition with 150 ft. boom, and load at 30 ft. radius, the forces occurring simultaneously are:

N = 6,333,600 ft. lbs.
P = 430,000 ft. lbs.
R = 543,120 lbs.
Q = 16,889 lbs (inclusive wind load of 55 MPH. Affect of wind on load not included.)

THESE SPECIFICATIONS APPLY ONLY TO MACHINE AS SHOWN ABOVE.

OCTOBER 23, 1974
AHI-0868

ATTN: MR. PETER ROBERTS

SUBJECT: TELEPHONE CONV. OF 10-22-74
TWO MODEL 11750 PEDESTAL CRANES.

1) SIDE LOAD DUE TO STORM NON WORKING CONDITION. 59,800 LBS IS THE SIDE LOAD IMPOSED ON THE PEDESTAL CRANE DUE TO WIND VELOCITY MEASURED AT 53 M/SEC, 10M ABOVE SEA LEVEL WIND ACTING PERPENDICULAR TO LONGITUDINAL AXIS OF CRANE AND IS APPLIED 3.75 FT ABOVE BOOM FOOT PIN CENTER LINE, AND 46.67 FT AHEAD OF CENTER LINE ROTATION.

2) SIDE LOAD ''Q'' AS GIVEN ON SPEC SHEET 10-17-74 IS NOT APPLICABLE TO THE CRANES IN QUESTION AND ARE AS FOLLOWS:

A) SIDE LOAD Q FOR WORKING CONDITION AND NO WIND IS 17,207 LBS BASED ON FULL SWING TORQUE OF 430,000 FT.LBS AND 150 FT BOOM NO LOAD.

B) SIDE LOAD Q WITH 272,920 LBS LOAD AT 30 FT RADIUS IS 9,323 LBS.

C) SIDE LOAD Q FOR WORKING CONDITION WITH 55 MPH WIND AND NO LOAD IS 7,566 LBS.

3) N EQUALS 9,500,000 FT.LBS IS THE MAXIMUM ALLOWABLE NET OVERTURNING MOMENT IN REGARD TO THE SLEWING BEARING FOR WORKING CONDITION, HOWEVER MAXIMUM OVERTURNING MOMENT FOR THIS CRANE IS 6,333,600 FT.LBS. (SEE NO. 5)

4) THRUST ''R''

A) R EQUALS 590,000 LBS IS THE THRUST LOAD WITH MAXIMUM RATING WITH 120 FT BOOM.

B) FOR 150 BOOM, THE MAXIMUM THRUST LOAD IS R EQUALS 558,300 LBS.

5) UNDER THE MAXIMUM MOMENT CONDITION THE FOLLOWING FORCES WILL OCCUR SIMULTANEOUSLY. (150 FT BOOM, 272,920 LBS AT 30 FT RAD)
N EQUALS 6,333,600 FT LBS
R EQUALS 543,120 LBS
Q EQUALS 16,889 LBS (COMPOSED OF 9,323 PLUS 7,,566 LBS FROM 55 MPH WIND - AFFECT OF WIND ON LOAD NOT INCLUDED).

6) PEDESTAL ADAPTOR, WILL ACHIEVE OPTIMUM LOAD DIFFUSION WHEN INSTALLED PROPERLY AND BOLTS TORQUED TO SPECIFICATION AS SHOWN ON 719228.

7) NOTE: THIS INFORMATION APPLIES TO THE CRANE EQUIPPED WITH 150 FT BOOM AND RATING CHART 11750.07

REGARDS
E. BURG / W. BEER

AMER SALES STP

BROWNROOT LDN

PETER R. (4)

NC
M

U
CD816.10
BROWNROOTSG LDN
KEY+230297432+
RCA0334-25
AMER SALES STP

BROWNROOTSG LDN

TO: AMERICAN HOIST U.S.A. 297432
ATTN: W.BEER

CC: AMERICAN HOIST LONDON. TELEX NO.28401
ATTN: A.SULLIVAN

FROM: BROWN AND ROOT, ST GEORGES ROAD. TELEX NO.283734

URGENT

SUBJECT:- 11700 PEDESTAL DESIGN DATA

A) YOUR TELEX RECIEVED THIS AM. MANY THANKS

B) REQUEST CONFIRMATION THAT:-
1. 'Q' 'N' AND 'R' IN POINT 2-3 OF YOUR TELEX ALL ACT ON AXIS OF ROTATION CENTRE LINE AT BASE OF DATUM 1,750FT BELOW BEAM FOOT PIN. SOME CONFUSION STILL EXISTS ABOUT MOMENTS DUE TO SIDE LOADS SINCE WIND AND SLEWING [illegible] VALUES PRESUMABLY DO NOT ACT IN SAME PLACE IN FIRST INSTANCE.

2. FULL SWING TORQUE 450,000FT LBS IS INDEPENDANT OF LOAD HOOK AND THEREFORE ACTS WITH NR AND Q IN POINT 3 OF YOUR TELEX.

C) FOR SUCHHIGH PEDESTAL WE SHOULD INVESTIGATE MAX SIDE FORCE CONDITION IN ADDITION TO MAX MOMENT CONDITION. PLEASE CAN YOU STATE WORST COMBINATION OF NR AND Q FOR THIS CRITERION.

D) DO FIGURES FOR STORM LOAD IN POINT I ASSUME A BOOM CRADLE IN USE OR A CONSERVATIVE ASSUMPTION OF NO CRADLE.

E) OUR SPECIFICATION CALLS FOR''PEDESTAL ADAPTOR EXTENTION'' AND RECENT MEETINGS WITH AH AND B LONDON CONFIRM THAT TRUNCATED C CONICAL STEEL WORK BETWEEN ADAPTOR AND PEDESTAL FORMS THIS ADAPTOR EXTENTION. EXTENT OF EXTENTION VERTICALLY DOWNWARDS DETERMINED BY AH AND B PROVIDE FULLY ''SMOOTHED'' LOAD INPUT TO TOP OF PEDESTAL. DRAWINGS WILL BE PROVIDED IN TWO WEEKS TIME AS DISCUSSED IN TELECON BURG/BEER-ROBERTS OF 10/22-74.

F) WHAT ARE VERTICAL FORCES AND MOMENTS ASSOCIATED WITH STORM WIND LOADING DUE TO WEIGHT OF CRANE AND BOOM?

G) CRANE LOAD RADIUS CHART.
WE REQUIRE IMMEDIATE DETAILS OF CRANE LOAD RADIUS CHART FOR 150FOOT BOOM WITH 30 FOOT FIXED PIN JIB.

BEST REGARDS
WEBB/ROBERTS/MOCKRIDGE

CC:
J.DUNLAP
N.POPOFF
J.KILGORE
L.TRAMMELL
J.BOSTOCK

ENDS.........

AMER SALES STP

BROWNROOTSG LDN

BROWNROOTSG LDN
AMHOIST LONDON

Mr Roberts

TELEX NO. 40-1
28 OCTOBER 1-74

ATTENTION : MR.MOCKRIDGE

AS REQUESTED BY TELEPHONE, HERE IS A RELAY OF THE TELEX SENT TO YOU BY OUR ST PAUL OFFICE, USING YOUR TELEX NO. 928784:

QUOTE:

OCTOBER 25, 1974
AHI-0957

SULLIVAN, FOLLOWING JUST TELEXED T BROWN AND ROOT, ATTN. MR. PETER ROBERTS.

SUBJECT: 11/50 PEDESTAL DESIGN DAT .

REFERENCE: YOUR TELEX OCT 25, 1974

B1) "N" AND "R" ACT ON AXIS OF ROTATION CENTERLINE NOT BASE OF DATUM 1.75 FT BELOW BOOM FOOT PIN. "Q" ACTS AT DIFFERENT POINTS FOR WIND AND FOR SLEWING. WE WILL HAVE THESE VALUES TELEXED TO YOU BY OCT 30.

B2) SIDE LOAD DUE TO ACCELERATION OR DECELERATION DEPENDS ON LOCATION OF MASS CENTER. MAS CENTER CHANGES WITH CHANGE OF HOOK LOAD.

C) NO 5 & FROM OUR TELEX OCT 23, 74 REPRESENTS WORST CONDITION. HOWEVER, AS STATED, THE WIND EFFECT ON THE LOAD HAS NOT BEEN CONSIDERED SINCE SIZE AND SHAPE NOT KNOWN.

D) FIGURES FOR STORM ASSUME NO CRADLE. HOWEVER, WE WILL TELEX SIDE FORCES ON CRADLE BY OCT 30.

E) WE MAILED YOU OUR PEDESTAL BASE WELDMENT 717700 ON OCT 17. WE ASSUME IT WILL CLEAR UP THIS POINT.

F) OUR ENG SPEC SHEET 10/17/74 WAS MAILED 10-17-74 WILL GIVE YOU VERTICAL FORCES AND MOMENT DUE TO WEIGHT OF CRANE.

THE WIND LOADING IS GIVEN IN OUR TELEX OF 10-23-74 POINT1, ASSUMES THE BOOM IN THE HORIZONTAL POSITION.

G) RATING CHART 11750.07 BEING SENT BY AIRMAIL.

H) WE WILL CALL YOU MONDAY OCT 28 AT 9 AM OUR TIME FOR FURTHER DISCUSSION OF THIS MATTER.

REGARDS,
ED BURG / W. BEER

- END QUOTE -

PARA B2) PLS READ- MAS S CENTER CHANGES

PLEASE NOTE: PARA. F) ON OUR COPY OF TELEX WAS GARBLED AND WE HAVE HAD TO OMIT NEARLY TWO LINES. HAVE TELEX ST. PAUL FOR CLARIFICATION OF THIS PARAGRAPH, AND WILL TELEPHONE COPY THROUGH TO YOU IMMEDIATLY ON RECEIPT OF AN ANSWER. HOWEVER, IF THEY ARE TELEPHONING YOU, IT IS PSSIBLE YOU MAY BE ABLE TO ASCERTAIN FULL TEXT OF THIS PARAGRAPH BEFORE WE RECEIVE A REPLY TELEX.

REGARDS,

PP. A. J. SULLIVAN

WELL RECEIVED ??

MOM PLS

This should complete all info on max moment design condition

Mr Roberts

(6)

TMK.

BROWNROOTSG LDN

RCA

AMER SALES STP

AMER SALES STP

NOVEMBER 5, 1974
AHI-1248

ROBERTS / MCCKRIDGE

SUBJECT: 11750 PEDESTAL DESIGN DATA

REFERENCE: OUR TELEX AHI-0956 OF 10/25/74

HERE IS PROMISED ADDITIONAL INFORMATION:

B1) ''Q'' SIDE LOAD FROM SLEWING APPLIED 11.6 FT FORWARD OF CENTER ROTATION AND 7.28 FT ABOVE BOOM FOOT PIN CENTER LINE.

D) 17,970 LBS IS THE HORIZONTAL FORCE AT THE CRADLE WITH THE SWING BRAKE RELEASED, WITH APPLIED WIND STORM FORCE OF 59,800 LBS., 3.75 FT ABOVE BOOM FOOT PIN CENTER LINE AND 46.67 FT AHEAD OF CENTER LINE ROTATION.

WE ARE AIRMAILING CORRECTED PEDESTAL DESIGN INFORMATION DATED 10-23-74. ALSO INCLUDED WILL BE RATING CHART 11750.07 WHICH APPLIES.

REGARDS,
WRIGHT / BURG

....
MER SALES STP

BROWNROOTSG LDN.....

P. Roberts

(8)

COMMITTEE LDN
BROWNROOTSG LDN

TO: LLOYDS REGISTER-TLX NO. 880379, OCEAN ENGINEERING

FROM: BROWN AND ROUT, ST GEORGES ROAD-TLX NO-926784

SG323 12/2/75 WL

ATTENTION: MR. ALFORD-FRIGG FIELD INTERMEDIATE MANIFOLD PLATFORM

FOLLOWING TELEPHONE CONVERSATION THIS AFTERNOON HOLLANDS/ROBERTS WE REQUEST CONFIRMATION THAT AN IMPACT FACTOR OF 20% APPLIED TO LIFTED LOAD IS APPROPRAITE TO 90 FOOT HIGH CRANE PEDESTALS WITH 150 TONS REVOLVING CRANES.

REGARDS

WEBB, ROBERTS

ENDS......

COMMITTEE LDN
BROWNROOTSG LDN

P. Roberts

(9) 687

M
BROWNROOTSG LDN
COMMITTEE LDN
13/2/75.
UR
TO BROWN AND ROOT ATTENTION WEBB/ROBERTS WIMBLEDON
OUR REF OSG/590/3000/GA/1086
YOUR REF SG323
SUBJECT FRIGG FIELD INTERMEDIATE MANIFOLD PLATOEEE MANIFOLD PLATFORM

CONFIRM IMPACT FACTOR OF 20 PERCENT APPLIED TO THE LIFTED LOAD IS IN ORDER FOR YOUR 90 FOOT HIGH CRANE PEDESTAL (150 TON REVOLVING CRANE) PROVIDED THE EFFECT OF WIND AND SLEWING FORCES WILL BE ALLOWED FOR AND ACCEPTABLE WORKING STRESS LEVELS ADOPTED. YOUR TELEX 12.2.75 REFERS.

LLOYDS REGISTER LONDON/TLX 888379=

SENT 13/1526.FGH=

BROWNROOTSG LDN
COMMITTEE LDN

RCA
AMER SALES STP
AMER SALES STP

FEBRUARY 7, 1975
AHI-4554

MICKRIDGE, FOLLOWING IS ANSWERS TO YOUR TELEX MESSAGES SG241 AND 266 RE TOTAL OIL PEDESTAL CRANES:

TELEX SG241 DATED 1/31/75

WE CONFIRM POINT 1 IS CORRECT.
OVERTURNING MOMENT N EQUALS 6,333,600 FT LBS
INCLUDES STATIC AND DYNAMIC LOAD Q EQUALS 9,323 LBS AND
Q ACTING 11.6 FT FORWARD AND 7.28 FT ABOVE BOOM FOOT PIN

POINT 2) SERVICE CONDITION (WITH 55 MPH WIND).
N EQUALS 6,333,600 FT LBS WITH NO WIND.
N EQUALS 6,362,000 FT LBS WITH WIND FROM SIDE.
N EQUALS 6,933,000 FT LBS WITH WIND FROM REAR.

R EQUALS 543,120 LBS (NOT FT LBS)
Q EQUALS 9,323 LBS. 11.6 FT FORWARD, 7.28 FT ABOVE PIN PLUS 7,566 LBS WIND LOAD WITH BOOM AT 81 DEGREE ANGLE, 45.855 FT ABOVE BOOM FOOT PIN AND 4.263 FT FORWARD OF CENTER ROTATION.

WE AGREE WITH YOUR ASSUMPTION OF WINDFORCE ON LOAD OF 12,000 - 7,566 EQUALS 4,434 LBS CONCENTRATED AT A HEIGHT OF 58.44 FT ABOVE BOOM FOOT PIN. THIS SIDE LOAD DUE TO WIND WILL AFFECT THE RESULTING OVERTURNING MOMENT [illegible] AS FOLLOWS:
WIND PERPENDICULAR TO LONGITUDIONAL AXIS OF CRANE
N EQUALS 6,362,000 FT LBS
WIND FROM REAR (CONSERVATIVELY ASSUMED SAME AREA)
N EQUALS 6,933,000 FT LBS.

FURTHER, YOU ARE CORRECT, THE FORCE N, R AND Q DO NOT INCLUDE IMPACT FACTORS. HOWEVER WE AGAIN WANT TO POINT OUT THAT THE RATING CHART 11750.07 IS PER API CODE IN ALL STRUCTURAL MEMBERS EXCEPT FOR WIRE ROPES. SEE NOTE ON RATING CHART). ACCORDING TO API SECTION 3.1 ALL REVOLVING CRANE STRUCTURES SHALL BE SUBJECTED TO DEAD LOAD PLUS 1.33 TIME THE RATED LOAD, WHILE THE FOUNDATION SHALL BE DESIGNED FOR DEAD LOAD PLUS 2.0 TIMES THE RATED LOAD.

WE RECOMMEND TO FOLLOW THE API CODE AND USE AN IMPACT FACTOR OF 2.0 ON THE RATED LOAD FOR THE REMAINING PART OF THE CRANE FOUNDATION.

WITH IMPACT FACTOR OF 1.33 INCLUDED THE FOLLOWING FORCES SHALL BE CONSIDERED AT THE SLEWING BEARING.
(SEE API FIGURE 1.1 ITEM 7)
N EQUALS 9,634,908 FT LBS
R EQUALS 633,184 LBS

WITH IMPACT FACTOR OF 2.0 THE FOLLOWING FORCES SHALL BE CONSIDERED AT THE CRANE FOUNDATION.
(SEE API FIGURE 1.1 ITEM 11)
N EQUALS 15,120,600 FT LBS
R EQUALS 816,040 LBS.

WE CONFIRM POINT 3 AND 3C IS CORRECT. CRADDLE LOCATED 155.83 FT FORWARD CENTER ROTATION.

PLEASE NOTE: RATING CHART NO. 11750.07 IS WITH 30 FT JIB MOUNTED ON BOOM AND RATING AT 30 FT RADIUS IS 134.46 SHORT TONS AND RATING CHART 11750.06 IS THE RATING WITHOUT THE JIB MOUNTED AND THE RATING AT 30 FT IS 133.46 SHORT TONS. OUR CALCULATIONS ARE MADE WITH JIB MOUNTED AND THEREFORE, WE USED RATING CHART 11750.07.

TELEX SG-266 DATED 2/4/75

POINT 1) (PARA. 2)A) SIDE LOAD Q FOR WORKING CONDITION AND NO WIND IS 17,207 LBS BASED ON FULL SWING TORQUE OF 430,000 FT LBS AND 150 FT BOOM AT 81 DEGREE ANGLE AND NO LOAD. SIDE LOAD APPLIED AT MASS CENTER (BECAUSE IT IS DYNAMIC) 6.851 FT BEHIND CENTER LIN ROTATION AND 11.07 FT ABOVE BOOM FOOT.

N EQUALS -1,867,000 FT LBS
R EQUALS 270,200 LBS
Q EQUALS 17,207 LBS

POINT 2) SIDE LOAD OF 14,300 LBS. THIS SIDE LOAD WILL EXIST AND NEARLY ALL OF IT WILL HAVE TO BE APPLIED TO THE BOOM POINT WHEN THE LOAD HAS SUCH A LARGE AREA THAT THE FORCE DUE TO WIND BLOWING FROM THE SIDE COUNTERBALANCES THE FULL SWING TORQUE SO THAT THE CRANE UPPER DOES NOT SWING. IF THIS LOAD HAPPENS TO BE 273,000 LBS THEN YOU ARE CORRECT IN SAYING IN THIS CASE THAT THIS REPRESENTS A 5.2 PCT SIDE LOAD.

IN CONCLUSION.

REVIEWING THE EFFECT OF WIND AND SWING ACCELERATION ON THE CRANE, STRUCTURE IN REGARD TO OVERTURNING MOMENTS AND SIDE LOADS IN COMPARING THEM TO THE MOMENTS AND THRUST LOADS TO BE USED WITH THE API IMPACT FACTORS YOU WILL AGREE WITH US THAT THE MOMENTS AND FORCES DUE TO WIND AND ACCELERATION ARE NEGLIGABLE, AND THAT A CRANE DESIGNED TO THE API SPECIFICATIONS WILL MORE THAN ADEQUATELY COVER THE EFFECTS OF WIND AND DYNAMIC FORCES WITHIN THE RATED

AMHOIST LONDON
BROWNROOTSG LDN31

TO: AMERICAN HOIST-UDERRICK-U.S.A.TELEX NO.297432
ATTN: ED.BURG/L.WRIGHT

CC: AMERICAN HOIST-LONDON-TLX NO-20491
ATTN: A.SULLIVAN

(11)

FROM: BROWN AND ROOT, ST GEORGES ROAD-TLX NO-928784

SG241 31/1/75 WL

SUBJECT: FRIGG INTERMEDIATE PLATFORM 11750 PEDESTAL CRANES.

A) THE FOLLOIWNG DATA IS A SUMMARY OF DESIGN FORCES FOR THE CRANE PEDESTAL SUPPLIED BY AH AND D.
YOU ARE REQUESTED TO CONFIRM IT IS CORRECT.

1) SERVICE CONDITION. (NO WIND) MOST SEVERE DESIGN CONDITION FOR PEDESTAL IE. LOAD OF 138.46 SHORT TONS AT 30FT.

OVERTURNING MOMENT N=6,333,600 FT LBS
VERTICAL REACTION R= 543,120 LBS
SLEWING SIDE LOAD Q= 9,323 LBS

Q ACTING 11.6 FT FORWARD AND 7.28 FT ABOVE BOOM FOOT PIN CENTRELINE.

2) SERVICE CONDITION (WITH 55MPH WIND) LOAD OF 138.46 ST AT 30FT MOST SEVERE CASE FOR PEDESTAL LIFTING IN WIND.

N=6,333,600 FT LBS
R= 543,120 FT LBS
Q= 9,323 LBS 11.6 FT FORWARD 7.28FT ABOVE PIN PLUS
7,566 LBS WIND LOAD AT A POSITION UNSPECIFIED BY AH AND D.
ALLOWING FOR ARBITRARY SIZE LOAD ON HOOK AN EXTRA WIND COMPONENT OF Q HAS BEEN ASSUMED OF 12,000 LBS ACTING 20FT FORWARD OF AND 50FT ABOVE BOOM FOOT PIN.
THIS FIGURE INCLUDES THE 7,566 LBS ON CRANE ALONE BUT IS ADDITIONAL TO THE 9,323 LBS SLEWING LOAD.

IN CASES A1 AND A2 WE ASSUME YOU HAVE NO ALLOWANCE INCLUDED FOR IMPACT ON THE LOAD. PLEASE CONFIRM OR EXPLAIN IMPACT ALLOWANCE INCLUDED.

IF NO IMPACT ALLOWANCE MADE PLEASE EXPLAIN WHY CONSIDERED UNECESSARY OR SUGGEST/RECOMMEND A FACTOR AND PRECISELY TO WHAT IT SHOULD BE APPLIED.
PLEASE COMMENT ON SUGGESTION TO INCLUDE IMPACT ALLOWANCE IN PEDESTAL OF 20% IE. AN EXTRA LOADING IN CASES A1 AND A2 OF:-

ADDITIONAL N OF 0.2 X 138.46 X 2000 X30
= 1,661,520 FT LBS
ADDITIONAL R OF 0.2 X 138.46 X 200
= 55,384 LBS.

3) STORM WIND CONDITION BOOM HORIZONTAL SQUARE TO WIND. NO CRADLE.

SIDE LOAD ON CRANE AND BOOM Q=59,800 LBS
Q APPLIED 3.74 FT ABOVE AND 46.67 FT AHEAD OF CENTRE LINE OF ROTATION.

B) COMPLETED PEDESTAL DRAWINGS ARE BEING POSTED TO YOU FOR INFORMATION AND COMMENT AS DISCUSSED ROBERTS/BURG ON 22OCTOBER LAST.

C) PLEASE CONFIRM CRADLE SIDE FORCE IS 17,970 LBS.

BEST REGARDS

WEBB/ROBERTS/MOCKRIDGE

CC: J.DUNLAP
N.POPOFF
J.KILGORE
J.PLANT
B.BOSTOCK
J.COKER

P. Roberts (13)

TO: AMERICAN HOIST-U.S.A.-TELEX NO:297432
ATTN: ED BORG

CC: AMERICAN HOIST LONDON-TELEX NO:28491
ATTN: A.SULLIVAN

FROM: BROWN AND ROOT, ST GEORGES ROAD-TLX NO-928784

SG217 28/1/75 WL

SUBJECT: PEDESTAL MOUNTED CRANES
TOTAL OIL MARINE

WE HAVE RECIEVED THE FOLLOWING TELEX FROM LLOYDS.

QUOTE''

IT IS FOR A H AND D TO SPECIFY THE CAPACITY OF THE SLEWING GEAR AND THE MAXIMUM TORQUE IT WILL APPLY TO JIB HEEL. IF THE GEAR IS CAPABLE OF RESISTING A TORQUE FROM 2 DEGREES HEEL PLUS 3 PERCENT SIDE FORCE PLUS WIND ONLY THEN THIS IS THE MAXIMUM TRANVERSE LOADING WHICH THE JIB IS SUBJECTED TO AND OUR EXAMINATION WILL BE BASED UPON THESE FIGURES. THE FIGURE FOR SLEWING FORCES APPEARS TO US TO BE SMALL BUT IS DEPENDANT UPON BRAKING CAPACITY OF THE SLEW GEAR.
2 DEGREE HEEL IS EQUIVALENT TO 3.5 PERCENT TRANVERSE FORCE. FOR YOUR FURTHER INFORMATION THESE JIBS ARE EXTREMELY SENSITIVE TO TRANVERSE FORCES AND IT IS IMPORTANT THAT SLEWING DECELERATION FORCES AND HEEL (OR LOAD SWING) ANGLES ARE CLEARLY SPECIFIED.

FOR CERTIFICATION PURPOSES A H AND D MUST PROVIDE SEVEN COPIES OF CALCULATIONS AND PLANS OF ALL MAIN STRUCTURAL ITEMS.
(JIB, A FRAME, PLATFORM, PEDESTALS, RIGGING ETC).
THESE MUST BE SUBMITTED TO AVOID POSSIBLE DELAYS IN APPROVAL.

PLEASE EXPEDITE

WEBB/KETTLE/MOCKRIDGE

CC: N.POPOFF
J.KILGORE
J.WOOD
P.ROBERTS
R.LUCAS
J.COKER
J.PLANT-ASHVILLE HOUSE

ENDS.....

J. Mockridge

P Roberts

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RCA
AMER SALES STP

AMER SALES STP

FEBRUARY 3, 1975
AHI-4369

MOCKRIDGE RE PEDESTAL CRANES TOTAL OIL MARINE URTLX SG217 OF JANUARY 28.

THE MAXIMUM TORQUE DEVELOPED BY THE SWING MECHANISM AND TRANSMITTED TO THE BOOM BY SWING ACCELERATION OR DECELERATION IS 430,000 FT LBS.
THIS IS EQUIVALENT TO A SIDE FORCE OF:
430,000 / 30 EQUALS 14,300 LBS SIDE FORCE
AT THE BOOM HEAD (SHEAVE AXLE) OR:
14,300 / 273,000 X 100 EQUALS 5.2-PCT OF RATED LOAD.

FOR ANY WORKING CONDITION WHERE THE SWING SYSTEM IS EMPLOYED, THE EFFECTS OF WIND LOAD AND CRANE LIST MUST BE CONSIDERED AS INCLUDED IN THE SWING TORQUE VALUE. THIS IS TO SAY THAT IN THE ABOVE CONDITION THAT IT IS NOT POSSIBLE TO INDUCE MORE SIDELOADING ON THE BOOM THAN THAT CAUSED BY SWING TORQUE.

IF HOWEVER, PROPER LIFTING PROCEDURES ARE NOT FOLLOWED, AND THE POSITIVE SWING LOCK IS ENGAGED WHILE HANDLING A LOAD IT IS POSSIBLE TO INDUCE HIGHER SIDE LOADS ON THE BOOM. THIS WOULD BE APPLICABLE ON A BARGE MOUNTED PEDESTAL WHERE THE EFFECTS OF LIST AND WIND ARE COMPOUNDED.

SINCE MACHINES ARE OPERATING ON OFFSHORE DRILLING PLATFORMS, RATINGS ARE SUPPLIED WHICH COMPLY WITH THE API SPECIFICATIONS FOR OFFSHORE CRANES. API STATES THAT STRESSES SHALL BE CALCULATED WHEN (THE MACHINE IS) SUBJECT TO DEADLOAD PLUS 1.33 TIME THE RATED LOAD PLUS 2.7 PERCENT OF THE RATED LOAD APPLIED AS A HORIZONTAL SIDE FORCE. WHILE 2.7 PERCENT SIDELOAD IN ITSELF CERTAINLY DOES NOT COMPENSATE FOR SWING TORQUE EFFECTS MUCH LESS THOSE FROM WIND AND LIST IF THE SWING IS LOCKED. THE USE OF A 1.33 OVERLOAD AT THIS CONDITION AMPLIFIES THE EFFECT OF THE SIDELOAD. IT WAS ON THESE CRITERIA THAT THE RATINGS WERE DEVELOPED.

COMMENTS CONCERNING CALCULATION DATA REQUESTED TO FOLLOW.

REGARDS,
WRIGHT / BURG

CORRECTION: PARA5 LINE 4 WORD 8 SHD READ TIMES

AMER SALES STP

F 150 (15)

J. Mockridge

JBDQ13.51
BROWNROOTSG LDN
KEY+230297432+
0848 EST
AMER SALES STP

BROWNROOTSG LDN

TO: AMERICAN HOIST-U-S-A-TLXNO:297432

FROM: BROWN AND ROOT, ST GEORGES ROAD-TLX-928704, LONDON

SG266 4/2/75 WL

ATTENTION: ED BURG/L.WRIGHT

SUBJECT: PEDESATAL CRANES
TOTAL INTERMEDIATE PLATFORM.

1. REF TELEX 22-10-74.

PARA 2)A) SIDE LOAD Q FOR WORKING CONDITION AND NO WIND IS 17,207 LBS BASED ON FULL LOAD SWING TORQUE OF 430,000 LBS AND 150' BOOM NO LOAD, IMPLYING 17207/273,000 X 100=6.3 PCT.

2. REF TELEX 3-2-75

SIDE LOAD 14300 LBS

14300/273,000 X 100=5.2 PCT RATED LOAD

PLEASE EXPLAIN AND CONFIRM THAT CASE 2 NOW APPLIES.

REGARDS

WEBB/KETTLE/MOCKRIDGE

CC: J.DUNLAP
N.POPOFF
J.KILGORE
J.WOOD
P.ROBERTS
R.LUCAS
J.COKER
J.PLANT

ENDS......

AMER SALES STP

BROWNROOTSG LDN

LSLH 16

American Hoist & Derrick Limited,
63 South Robert Street,
St. Paul,
Minnesota 55107,
U.S.A.

6th Feburary 1975.

Frigg Field to Scotland Pipeline
Intermediate Manifold Platform

Subject: CRANE PEDESTAL

Attention: Mr. E. Burg/L. Wright

Gentlemen:

Please find enclosed drawings numbered:-

A1-MP/M-248-1
249-1
250-1

These detail crane pedestals. As discussed by telephone. Robert/Burg on 22nd October and referenced in our telex SG 241 of 31st January 1975. We should be most grateful for your evaluation and comments on the pedestals.

The pedestal base is post-tensioned to a concrete beam with an in-service tendon force of 180 metric tonnes per tendon.

Design forces have already been submitted for confirmation in the above referenced telex. We estimate maximum static deflection at the top of the pedestal to be 3.11" under 55 m.p.h lift condition. We estimate the first mode vibration period as 1.25 Hz and the second mode as 0.24 Hz. These correspond roughly with wind speeds of 22 and 112 m.p.h. respectively. You may wish to satisfy yourselves that these figures are realistic and to comment on any possible dynamic interaction between structural oscillation and crane system characteristics.

We look forward to your comments and will be happy to further discuss any points arising.

Yours very truly,
BROWN & ROOT (UK) LTD

L. A. Webb
Project Engineer

b.c.c. N. Popoff
J. Dunlap
J. Mockridge
J. Plant

LAW/PMR/JCP

P. Roberts

(18)

5th February 1975

K. H. BROUGHTON
PETER M. ROBERTS

CRANE PEDESTALS

Enclosed please find one copy of:

Drawings A1-MP/M-248-1
249-1
250-1

These show East and West Crane Pedestals. Also enclosed is a copy of our basic calculations and the relevant extract from the Design Criteria.

As discussed previously, you are requested to have these documents reviewed, an assessment made of what further analysis is required and have such work as is needed put in hand.

Dr. T. Wyatt at Imperial College is presently studying the aerodynamics of the structure with a view to possible incorporation of spoilers and to make recommendations about how a fatigue analysis might be approached. Stress levels and limitations on stress levels arising from Dr. Wyatt's work will be sent to you.

You will note that in our calculations we have allowed for 20% impact. We are currently negotiating suitability of this figure with Lloyds and the crane manufacturers.

Particular areas of concern to me are the stress levels in the base fixing around manholes and any possible interaction between them. The post-tensioning force at each flange hole is 240 mt initially relaxing to 180 mt (figures to be confirmed by C G Doris). You will note that the top flange will collapse under this load. C G Doris are considering placing concrete between the flanges. Alternatively we shall insert short lengths of heavy wall pipe.

Any analysis resulting from this request will be required for our design report.

P M Roberts

P. M. Roberts

c.c. N. Popoff
L. A. Webb
J. Kilgore

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RCA
AMER SALES STP

AMER SALES STP

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ATTN: ROBERTS / MOCKRIDGE

FOLLOWING SAFETY FACTORS OR STRENGTH MARGINS APPLY ON 11750 PEDESTAL CRANE WITH 150 FT 94H BOOM, OFFSET TIP AND 30FT NO. 15 JIB IN PLACE, CRANE EQUIPPED WITH 110,000 LBS COUNTERWEIGHT. BOOM STRENGTH SAFETY FACTORS INCLUDE ALLOWANCE FOR A SIDE FORCE DUE TO A 57.5 MPH WIND ON BOOM AND JIB EFFECTIVE AREA ONLY. NO WIND FORCE ON LOAD ITSELF TAKEN INTO CONSIDERATION.

COMPONENTS	SAFETY FACTORY
BOOM POINT SHEAVE	7.28
PENDANTS	4.11
BOOM HOIST LINE	5.95
150 FT BOOM	5.41
OUTER BAIL FRAME	8.76
OUTER BAIL SHEAVE AXLES	5.49
A-FRAME	2.10
BACKLEG PINS	2.89
TURNTABLE BEARING	5.86

NOTE - EACH OF ABOVE ARE THE MINIMUM VALUES INVESTIGATED FOR THE WORST CONDITIONS AS PER RATING CHART 11750.07.

REGARDS,
WRIGHT / BURG

AMER SALES STP

BROWNROOTSG LDN.......

P. Roberts

5H 20

AMHOIST LONDON
BROWNROOTSG LDN

TO: AMERICAN HOIST.U.S.A.TLX NO.297432
ATTN: E.BURG

CC: AMERICAN HOIST-LONDON-TELEX NO.28491
ATTN: A.SULLIVAN

FROM: BROWN AND ROOT, ST GEORGES ROAD-TELEX NO.928784

SG568 19/3/75 WL

SUBJECT: TOTAL FRIGG 11750 PEDESTAL CRANES.

A)WE WISH TO ESTABLISH THAT IN EVENT OF SEVERE OVERLOAD, FAILURE MODE OF COMPLETE PEDESTAL/CRANE ASSEMBLY IS NOT CATASTROPHIC I.E.PREFERRED ULTIMATE STRENGTH HIERARCHY IS A-FRAME, BOOM, BOOM FOOT PIN, ROLLER PATH CONNECTION, PEDESTAL, DECK BEAM CONNECTION DECK BEAM.(OR SIMILAR SEQUENCE IN WHICH DANGER TO OPERATOR IS MINIMISED).

B) WE THEREFORE REQUEST YOUR BEST ESTIMATE OF ABSOLUTE MAXIMUM FAILURE LOAD VS RADIUS CURVE TOGETHER WITH NOTE OF WHAT FAILS AT EACH RADIUS. FOR THESE PURPOSES WE WOULD INCLUDE ANY HYDRAULIC RELIEF VALVE ACTUATION WHICH EFFECTIVELY DROPPED THE LOAD BUT NOT ANY WARNING DEVICE REQUIRING OPERATOR ACTION.

REGARDS-WEBB/ROBERTS/MOCKRIDGE

CC: N.POPOFF
B.KETTLE
B.LUCAS
J.COKER
J.PLANT
F.GOOD

ENDS...
AMHOIST LONDON
BROWNROOTSG LDN

SECTION 8.4

AMERICAN HOIST
& DERRICK COMPANY
ST. PAUL, MINNESOTA 55107

AMERICAN

11750 PEDESTAL CRANE
MODE OF FAILURE

GS 17438 A-9189
GS 17440 A-9190

AMERICAN 11750 PEDESTAL CRANE
SUMMARY OF MODE OF FAILURE CALCULATIONS

The attached calculations have been performed to determine the magnitude of loads which will produce failure of critical structural components on the 11750 Pedestal Crane. The configuration involved is that of machines GS-17438 and GS-17440 equipped with 150 ft. boom. The critical hook loads shown represent the failure of components under loadings in the principal lifting plane only without regard for conditions of sideload. All strength margins, safety factors and fatigue considerations common to design have been removed. Under no circumstances should these loads be used to arrive at allowable capacities for these machines. Only those capacities shown in American Hoist and Derrick Rating Chart No. 11750.08 are valid for machine operation.

A computer program was used to expedite the determination of various component loads. A copy of this program has been included to provide additional background for the calculations.

11750 PEDESTAL CRANE

GS 17488 A-9189

GS 17440 A-9190

SUMMARY TABLE FOR MODE OF FAILURE

RADIUS (FEET) / COMPONENT	BOOM	PENDANT CONN. AT BOOM POINT	PENDANTS	OUTER BAIL	BOOM HOIST ROPE	INNER BAIL	RETRACTABLE A-FRAME	BACKLEG	STANDARD A-FRAME	DECK AT BACKLEG CONN.	DECK AT CHANGE IN SECTION	DECK AT BOOM CONNECTION	TURNTABLE BEARING	TURNTABLE BOLTS
28	1200	1449	1278	1570	1861	1242	2698	855.0	4542	1350	493	1992	1098	1098
30	1180	1337	1180	1449	1718	1146	2379	781.6	4009	1235	449.5	1932	1033	1013
40	1132	974.2	859.3	1056	1254	833.9	1424	541.3	2406	860.7	310.6	1698	796	729
50	782.8	771.1	678.9	836.5	994.6	659.3	961.4	411.0	1630	656.9	234.4	1538	646	567
60	679.0	639.7	562.8	694.3	825.6	546.6	696.5	329.4	1185	529.3	186.3	1425	543	463
70	600.3	546.8	480.6	593.7	706.7	466.5	529.1	273.3	904.5	442.9	153.4	1345	467	390
80	537.4	476.0	418.0	517.1	616.1	405.7	415.2	233.3	713.4	378.9	129.5	1289	410	337
90	484.9	419.6	368.2	456.1	543.9	357.2	333.8	202.6	576.6	330.9	111.3	1253	364	295
100	437.1	373.8	327.7	405.3	483.7	317.9	272.4	178.7	473.7	293.4	96.90	1238	327	263
110	390.9	332.0	290.7	361.3	431.7	281.9	225.2	159.6	394.3	263.4	85.53	1244	297	236
120	348.8	295.7	258.7	322.0	385.3	250.8	187.0	144.0	330.2	239.0	76.13	1278	272	214
130	308.7	261.8	228.7	285.3	341.8	221.7	155.2	131.3	276.6	219.0	68.19	1345	250	195
140	268.1	228.1	198.9	248.8	298.6	192.7	127.3	120.9	232.0	202.7	61.76	1275	231	180
150	220.9	189.6	164.9	207.1	249.1	159.6	100.0	113.3	183.6	138.1	56.35	1125	215	166

SHOWN CAPACITIES IN KIPS

PARTS OF LOAD LINE	LOAD LINE	BOOM POINT AXLE	DEAD END
2	350.0	392.3	274.8
4	700.0	784.5	549.7
6	1050	765.0	824.5
8	1400	1020	1099
10	1750	1275	1374
12	2100	1530	1649

THESE ITEMS ARE NOT AFFECTED BY THE RADIUS

INDEX OF CALCULATIONS

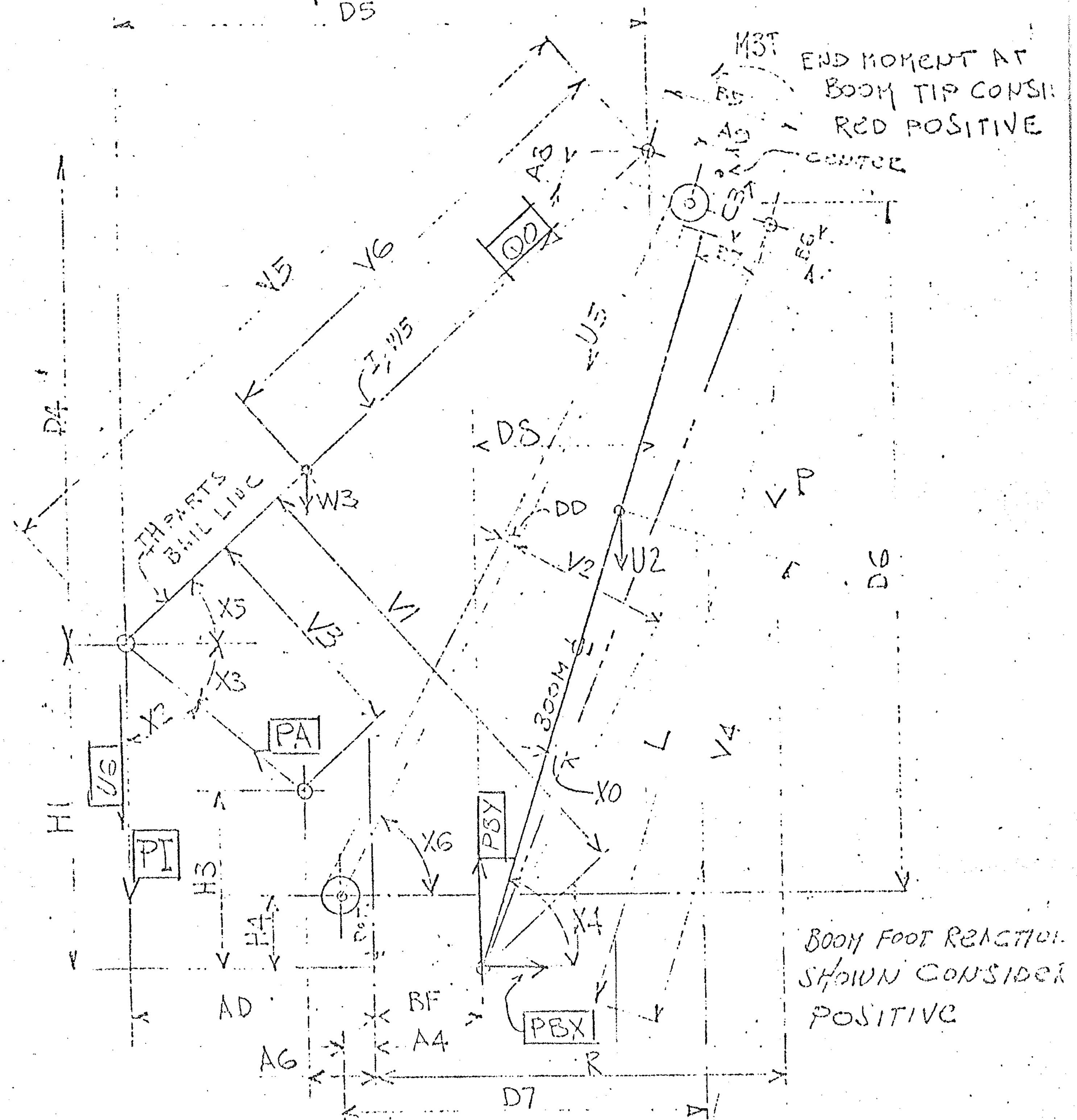
Item	Subject
1	American Program for Forces on Principle Structural Members
2	Boom
3	Pendant Connections at Boom Point 1.) Maximum Allowable Force 2.) Hook Load causing failure
4	Pendants 1.) Hook Load causing failure
5	Outer Bail 1.) Maximum Allowable Force 2.) Hook Load causing failure
6	Boom Hoist Rope 1.) Hook Load causing failure
7	Inner Bail 1.) Maximum Allowable Force 2.) Hook Load causing failure
8	Retractable A-Frame (Gantry) 1.) Maximum Allowable Force 2.) Hook Load causing failure
9	Backleg 1.) Maximum Allowable Force 2.) Hook Load causing failure
10	Standard A-Frame 1.) Maximum Allowable Force 2.) Hook Load causing failure
11	Deck of Backleg Connection 1.) Maximum Allowable Force 2.) Hook Load causing failure
12	Deck at Change in Section
13	Deck at Boom Connection
14	Turntable Bearing & Bolts
15	Load Line, Dead End & Boom Point Axle 1.) Maximum Allowable force on Dead End 2.) Maximum Allowable force on Boom Point Axle

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

AH0154B

DATE 11-3-75 El.

PROBLEM: FORCES ACTING ON PRINCIPAL STRUCTURAL MEMBE[RS] OF 1100 CRANE AS LINEAR FUNCTIONS OF HOOK LOAD FOR GIVEN BOOM L AND SELECTED HOOK LOAD RADIUS.



NOTES: 1. WEIGHT OF LOAD LINE AND SERVICE BLOCK CONSIDERED PART OF HOOK LOAD. 2. WEIGHTS OF HOIST LINE TO HOIST DRUM (ONE ROPE RETRACTABLE A-FRAME, INNER BAIL & TELESCOPING LEGS ARE DISREGARDED BY THE NUMBER OF PARTS FOR LOAD LINE (DATA NORM) IS THE MIN [illegible] FOR SELECTED BOOM [illegible]

AMERICAN HOIST & DERRICK CO.
SAINT PAUL, MINNESOTA

AH0154B

Definition of Data Terms

AD	Distance from CL Rotation to Upper Axle of Retr. Frame	(Ft.)
BF	Distance from CL Rotation to Boom Foot	(Ft.)
H1	Height from Boom Foot to Upper Axle of Retr. Frame	(Ft.)
H3	Height from Boom Foot to Lower Axle of Retr. Frame	(Ft.)
H4	Height from Boom Foot to Hoist Drum Axle	(Ft.)
A6	Horizontal distance between Centerline Rotation and Lower Axle of Retr. Frame	(Ft.)
A4	Horizontal distance between Boom Foot and Hoist Drum Axle	(Ft.)
DD	Average Radius of Rope Layer on Hoist Drum	(Ft.)
HO	Boom Structure Weight Constant	(Kips)
SO	Boom Structure Weight Rate	(Kips/Ft.)
S1	Boom Structure Weight location factor	
B5	Distance between Pendant Connection and CL of Sheave	(Ft.)
B6	Distance between Splice Pin Plane and CL Sheave	(Ft.)
B7	Distance between CL of Boom and CL of Sheave	(Ft.)
C3	Distance from Boom Point to Pendant Connection along Boom Axis	(Ft.)
IH	Number of Parts of Bail Line	
A9	From CL Boom — Location Dimensions for Guide Sheave Axis	(Ft.)
A8	From Boom Point along Boom Axis — Location Dimensions for Guide Sheave Axis	(Ft.)
IP	Number of Pendants	
W3	Weight of Outer Bail	(Kips)
W5	Weight of Pendant (One) including Sockets	(Kips/Foot)
A3	Distance from Boom Foot to Outer Bail	(Ft.)

SELECTIVE DATA

L - Boom Length
T1 - Number of Parts for Hoist Line
Input Data for Selected Boom Length:

R P

from given Capacity Chart for Crane Model

```
X0 = ATAN([illegible] (L+B[illegible]))
X2 = ATAN(AD-AG)/(HI-H3))
X3 = ATAN((HI-H3)/(AD-AG))

X4 = X0 + ATAN(SQRT((L-BG)**2 + B7**2 - (R-BF)**2)/(R-BF))        BOOM ANGLE
D4 = L+C3 [illegible] X4 - [illegible] *COS(X4) - HI
D5 = (L+C3)*COS(X4) - [illegible] *SIN(X4) + BF + AD
X5 = ATAN(D4/D5)
D6 = (L+A8 * SIN(X4) + A9 * COS(X4) - A4
D7 = (L+A8 *COS(X4) - A9 * SIN(X4) + A4
X6 = ATAN(D6/D7)
V1 = [illegible] + (AD+BF)*SIN(X5)
V2 = [illegible] X6 + ([illegible] SIN X6)
V3 = (HI-H3)*COS(X5) + (AD-AG)*SIN(X5)
DD = D5 - AD - BF
V5 = SQRT(D4**2 + D5**2)
V6 = L+C3 - A3        ← (A3 DISTANCE FROM B.I TO OUTER BAIL)
U2 = H0 + S0*L
* V4 = L/S1
U3 = IP + [illegible] * V5 * [illegible] * (1 - SIN(X5))        [illegible] AT BOOM TIP [illegible] PART OF [illegible] WEIGHT AT B.T
U4 = U3*(V5-V6+V6*SIN(X5))/V5
U5 = P/TI

√Q0 = (P*(R-BF) + U2*V4*COS(X4) + (U3+U4)*D3 - U5*(V2+DD))/V1
√U6 = (Q0/IH)*2
√PI = (Q0*V3/(AD-AG)) - U6
√PA = Q0*COS(X3+X5) + (PI+U6)*[illegible](X2)

MBT = Q0*COS(X4-X5)*(B5-B7) + U[illegible]*[illegible] (X4+[illegible])*(A9+DD) -
      -P*SIN(X4)*B7 + P*COS(X4)*B[illegible]        (KFT)

√PBY = Q0*SIN(X5) + U6*SIN[illegible] + U[illegible] + P + (MBT/(L+C3))*COS(X4)
√PBX = Q0*COS(X5) + U[illegible]*COS(X6) - (MBT/(L+C3))*SIN(X4)
```

√ FORCES TO BE PRINTED (OUTPUT)

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

A11015 4B

DATE 11-3-75 EL

SUBJECT: MODE OF OUTPUT FOR 11250 CRANE

FOR PROGRAM EXECUTION.

A. SELECTIVE DATA INPUTS:

BOOM 94SR , L=150 FT.
NUMBER OF PARTS OF HOIST LINE TI=12
NUMBER OF PARTS OF BOOM LINE IH=14

USE STD. WORKING RANGE FOR 11250 CRANE & STD. INCREMENT FOR WORKING RADIUS.

B. PRINT: QO , PI , PA, (PI+UG), PBY, PBX, UG
(FORCES IN KIPS, MOMENTS IN K-FT).

- FOR TWO WORKING CONDITIONS

1) EMPTY BOOM P = 0

2) HOOK LOAD P = 1.0 [illegible] UNIT).

FORCES ACTING ON MEMBERS AS FUNCTION OF HOOK LOAD.

11750 CRANE (

GS-17438, GS-17440

BOOM LENGTH= 150 (BOOM MODEL: B94BR)

RADIUS	BACKLEG FORCE (P1)	MAST FORCE (PA)	BACKLEG + LUFF (P1+U6)	BOOM VERTICAL (PBY)	BOOM HORIZONTAL (PBX)	SUSP. FORCE (Q0)	LUFF FORCE (U6)
20.0	20.054	6.297	23.199	56.390	5.403	17.956	2.565X
20.0	21.517	6.652	24.192	58.203	5.654	18.724	2.675XX
30.0	22.690	9.455	25.464	57.624	6.107	19.559	2.794
30.0	23.654	9.657	26.507	59.692	6.449	20.390	2.913
40.0	32.961	16.027	36.874	64.365	10.518	27.252	3.893
40.0	34.553	16.694	38.406	66.508	10.981	28.365	4.055
50.0	43.258	23.809	48.192	69.969	15.691	34.535	4.934
50.0	45.040	24.789	50.177	72.331	16.368	35.957	5.137
60.0	53.463	32.710	59.420	74.665	21.625	41.552	5.936
60.0	55.675	34.050	61.654	77.210	22.547	43.255	6.179
70.0	63.018	42.665	70.557	78.465	28.289	48.428	6.918
70.0	66.220	44.430	73.421	81.160	29.408	50.408	7.201
80.0	73.624	53.727	81.520	81.372	35.660	55.278	7.897
80.0	76.653	55.924	84.655	84.161	37.185	57.538	8.220
90.0	83.455	65.675	92.344	85.290	43.824	62.223	8.869
90.0	86.671	68.572	96.124	86.157	45.669	64.770	9.255
100.0	95.059	79.222	102.973	84.140	52.784	69.402	9.915
100.0	96.879	82.475	107.201	87.042	55.007	72.251	10.322
110.0	102.365	93.947	113.365	83.746	62.652	76.999	11.000
110.0	106.564	97.820	118.038	86.635	65.328	80.174	11.453
120.0	111.269	110.371	123.454	81.009	73.740	85.280	12.184
120.0	115.662	114.946	128.572	84.623	76.865	88.824	12.689
130.0	119.600	129.117	133.136	77.771	86.382	94.748	13.535
130.0	124.596	134.510	136.697	80.422	90.061	98.706	14.101
140.0	127.005	151.599	142.206	70.394	101.574	106.425	15.204
140.0	132.562	157.997	146.208	72.742	105.936	110.917	15.845
150.0	132.550	182.037	150.054	55.545	122.006	123.886	17.090
150.0	138.032	190.470	156.489	57.204	127.944	129.199	18.457

NOTES: 1. PROGRAM AHOISAB
2. UPPER LINE (X) - EXECUTION FOR HOOK LOAD P=0
LOWER LINE (XX) - EXECUTION FOR HOOK LOAD P=1 (KIP)

MODE OF FAILURE

11750 Pedestal Crane
11/21/75 BR

GS 17438
GS 17440

Hook Load Causing Boom Failure

The hook load causing failure of the boom is found from the boom strength program.

Boom Model B94BR
Length 150′

Within the boom strength program, all possible failure criteria are checked and the limiting value in each particular case is chosen. The criteria, along with a brief explanation of how each is utilized in the determination of final capacity follows:

1. Boom Axial Force adds the dimension of nonlinearity to the solution of this beam-column problem. Due to this nonlinearity, boom/deflections under side load must be calculated using a tangent function. If excessive axial force is present, the value of the tangent will approach infinity, thereby indicating instability of the column. To prevent this from occurring, the boom axial force is limited to that value which corresponds to the tangent of 1.53 radians.

2. Boom Deflection is calculated under a side load equalling two percent of the rated load.* The magnitude of the boom tip deflection for this condition must not exceed two percent of the boom length. This criteria is in compliance wherever possible with actual test results.

3. Elastic Buckling of the Boom as an Overall Column is a critical factor for long booms. This check prevents the stresses in the boom from reaching the point where elastic (Euler) buckling of the whole boom occurs. This check is valid only for large values of the boom L/R.**

4. Inelastic Buckling of the Boom as an Overall Column is an improbable criteria. It prevents the boom stresses from exceeding those which correspond to the inelastic (short column) buckling of the whole boom.

5. Local Buckling of the Boom Unsupported Chord as an Inelastic Member is the factor which usually governs the capacity of short booms. This criteria limits the total stress in any one boom chord to a value below that which would lead to local buckling of the chord between lacing points.***

6. Local Buckling of the Boom Unsupported Chord as an Elastic Member is a rather improbable phenomina. It is prevented from occurring by this check which is identical to the preceding check except that the Euler buckling criteria is used.

7. Failure of the Splice Joints. The critical force for these joints are calculated on the attached sheets.

In addition to the loadings imposed by a hook load, the boom strength subroutine of the program has the capability (though for this application it is not used) of analyzing the effects of listing the machine a specified amount. The results of the additional loading due to the list is reflected in increased boom tip deflection and additional chord stresses which are checked per the above outline. This feature allows us to provide rating charts for any degree of list that may be required.

NOTES:

* For this application the side load has been set equal to zero.

** The effective length ratio for the boom as an overall column is computed by the Swedish Method.

Ref: ACTA POLITECHNICA SCANDINAVICA ME 27.

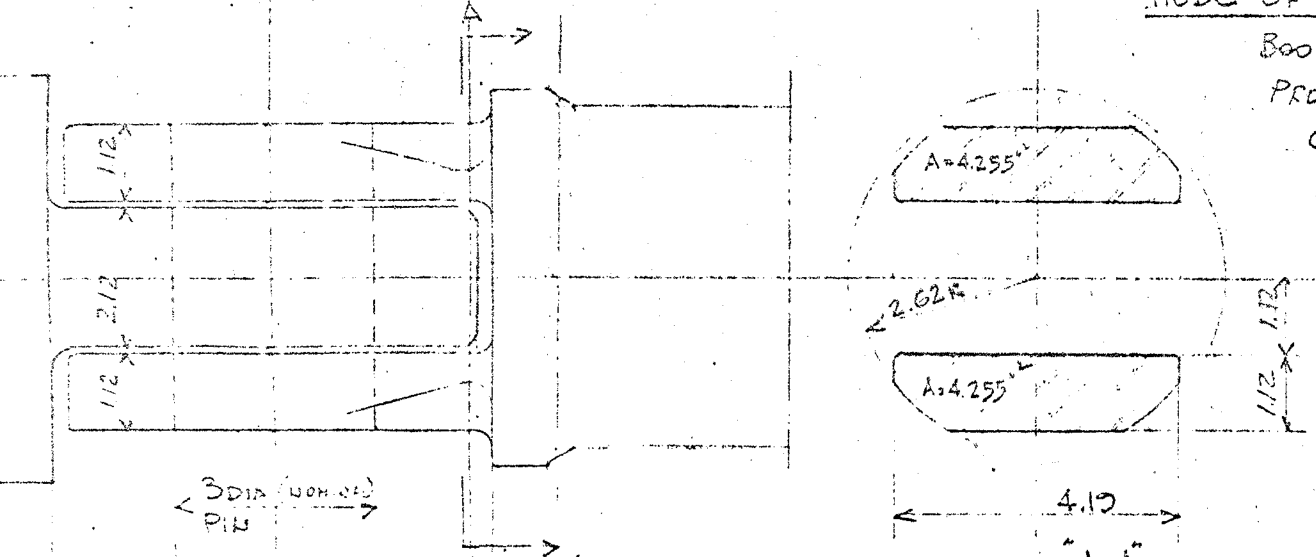
*** The location of unbraced chords and the specification of details (per working drawings) are picked by the computer according to the 150 foot boom assembly data.

A-9189 GS-17438
A-9190 GS-17440

11750 CRANE (PEDESTAL)

MODE OF FAILURE —

BOOM (STRUCTURE) ASSEMBLY 94BR.-150' LONG
PROBLEM: THE COMPRESSIVE FORCE ON REAR CHORD OF BOOM TIP SECTION (721586) CAUSING THE FAILURE AT SPLICE JOINT.



SECTION "A-A"
TOTAL AREA = 2×4.255 = 8.51"²

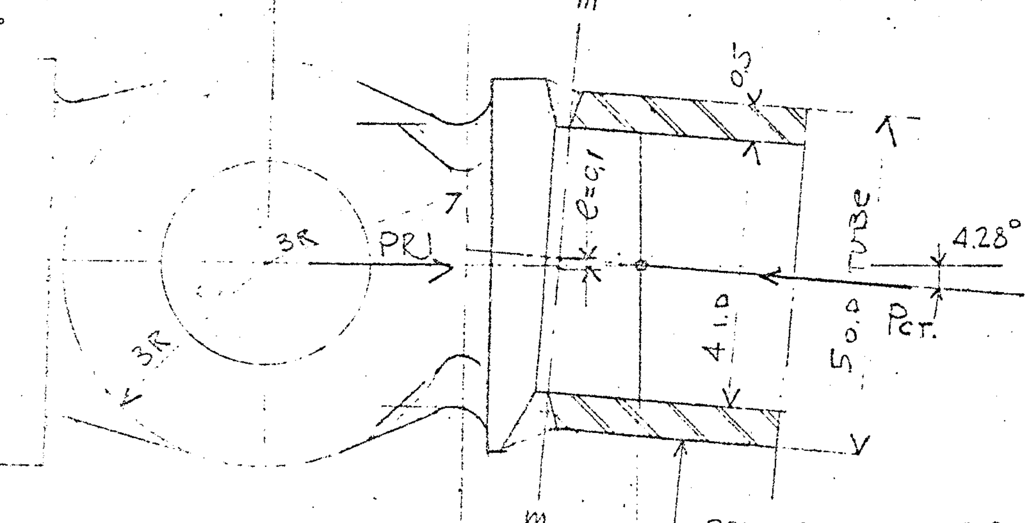
1. FOR UNBRACED REAR CHORD OF BOOM TIP WELDMENT:

$L = 38.85$ TUBE: 5 OD @ ½ WALL, $F_y = 100$ KSI
CROSS SECTION AREA = 7.0688 $r = 1.6$
SECTION MODULUS $S = 7.245^3$
CRITICAL BUCKLING STRESS

$$F_{CR} = F_y - \frac{F_y^2}{4\pi^2 E}\left(\frac{KL}{r}\right)^2 ; \quad \frac{KL}{r} = \frac{1.0 \times 38.85}{1.6} \simeq 25 \qquad E = 29\times10^3 \text{ KSI}$$

$$F_{CR} = 100 - \frac{100^2 \times 25^2}{4\times\pi^2\, 29\times10^3} = 100 - 5.46 = 94.54 \text{ KSI}$$

CRITICAL FORCE FOR TUBE = P_{CT} = 94.54×7.0688 = 668^K
CRITICAL FORCE PER SPLICE JOINT PRJ = 668×Cos 4.28° = 666^K



TUBE SECTION 50'

REAR CHORD TUBE OF BOOM TIP WELDMENT DRWG 721586

2. FORCE PRJ, CAUSING FAILURE OF WELDING JOINT AT m-m
CROSS SECTION AREA = 7.0688"² SECTION MODULUS S = 7.245"
MATERIAL: SAME AS SPLICE CASTING SG7, 255 TO 302 BHN
F_y = 90 KSI.

$$F_y = 90 = \frac{PRJ}{7.0688} + \frac{PRJ \times 0.10}{7.245} \simeq PRJ(0.155269)$$

$$PRJ = \frac{90}{0.155269} \simeq 580 \text{ KIPS} \quad \text{(GOVERNING)}$$

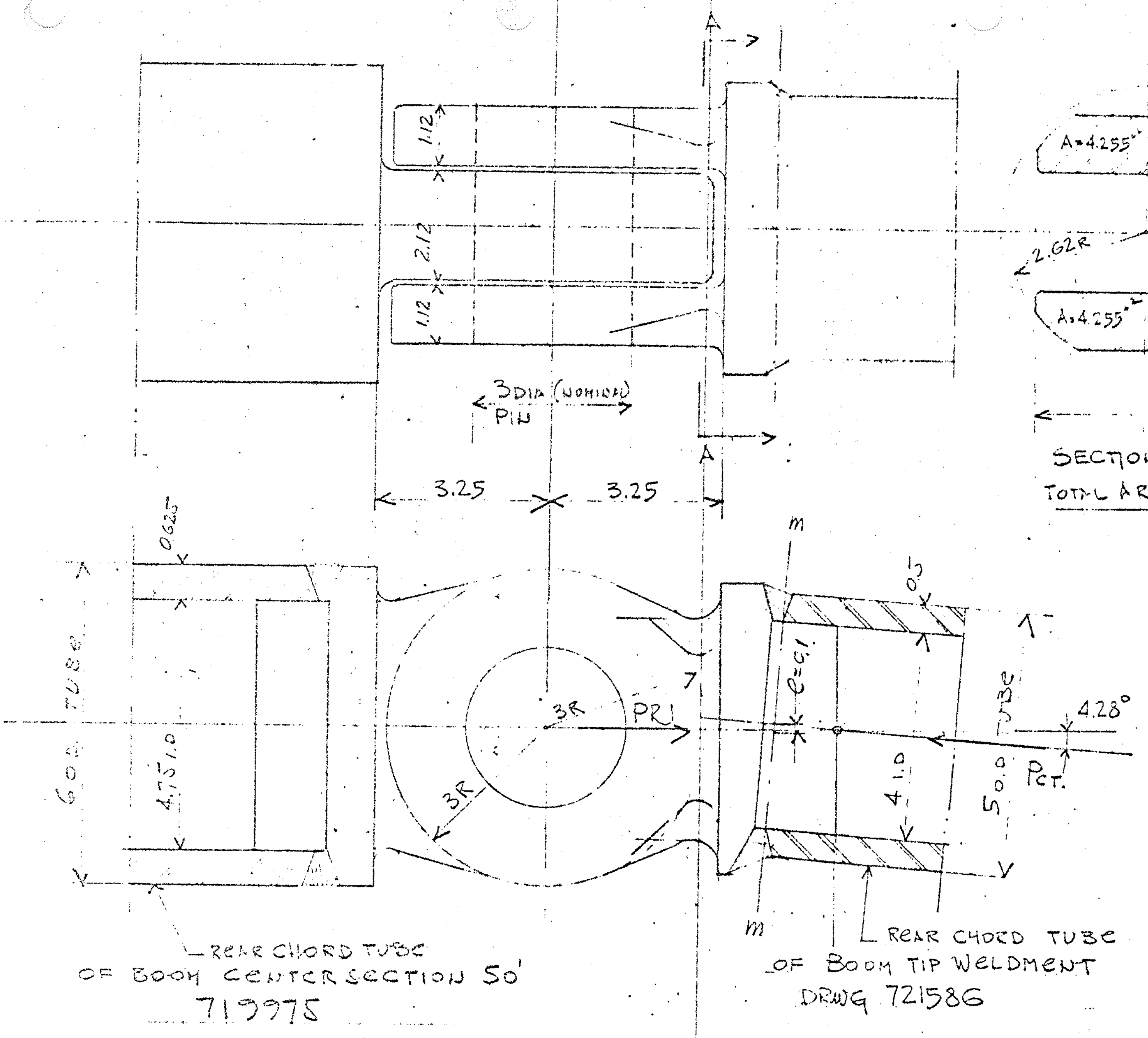
— cut line

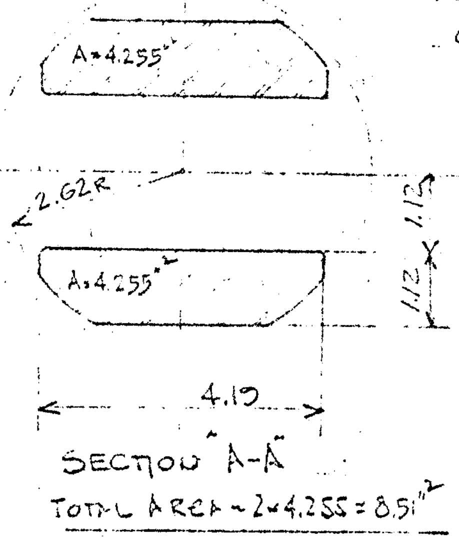
A-5170 GS-17440

MODE OF FAIL...E –

BOOM (STRUCTURE, ...

PROBLEM: THE COMP...
CHORD OF B...
CAUSING THE FA...





1. FOR UNBRACED ...
TIP WELDMEN...
L = 38.85 ...
CROSS SECTIO...
SECTION ...
CRITICAL ...

$F_{CR} = F_y - \frac{F_y^2}{4\pi^2 E}\left(\frac{KL}{r}\right)^2 \; ; \quad \frac{KL}{r} = ...$

$F_{CR} = 100 - \frac{100^2 \times 25^2}{4 \times \pi^2\, 29 \times 10^3} = 100 - ...$

CRITICAL FORCE FOR TUBE = F...

CRITICAL FORCE PER SP...

2. FORCE PRJ, CAUSING FAILURE ...

CROSS SECTION AREA = 7.0...

MATERIAL: SAME AS SP...

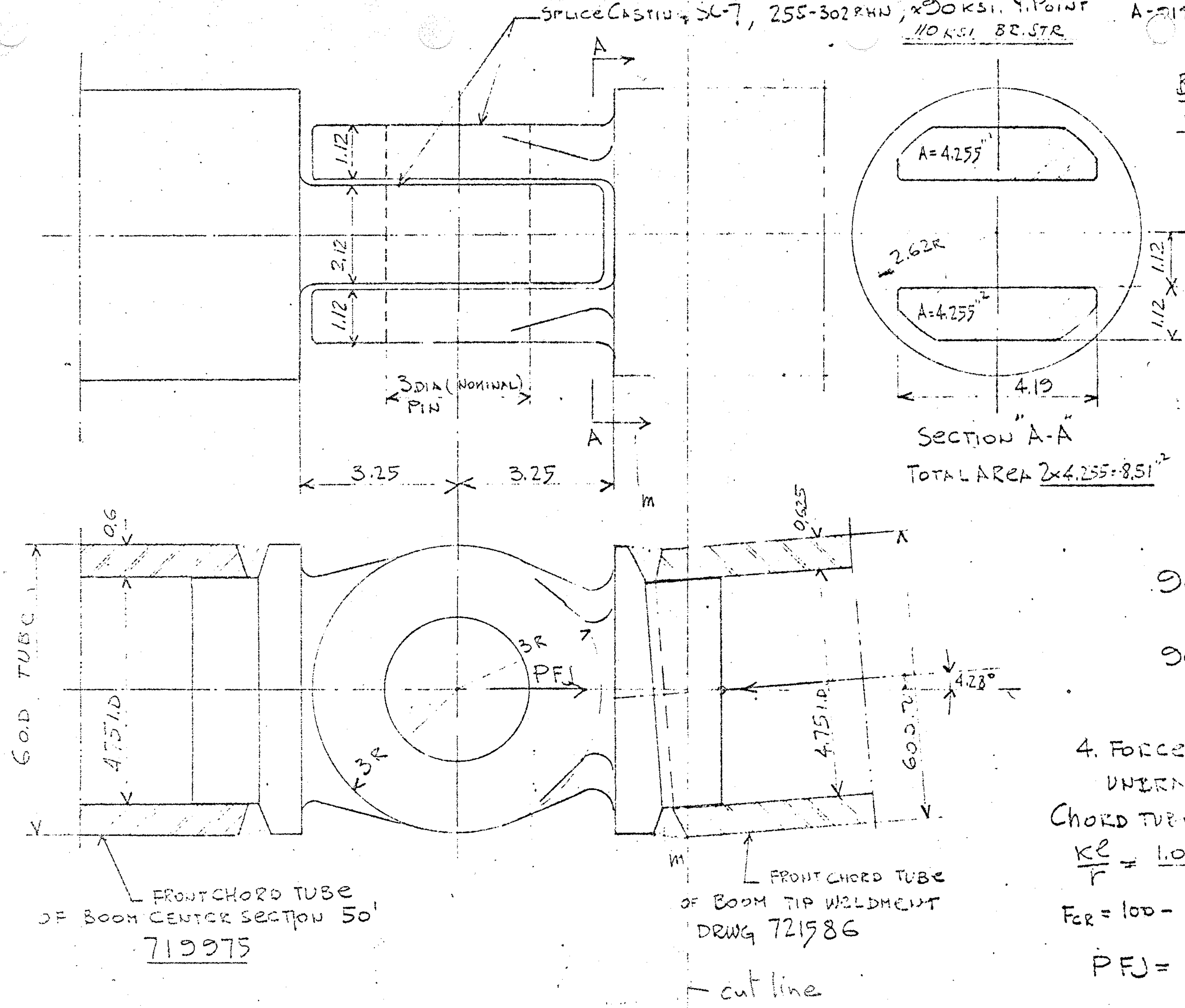
$F_y = 90$ KSI

$F_y = 90 = \frac{PRJ}{7.0688} + \frac{PRJ \times ...}{7.245...}$

$PRJ = \frac{90}{0.155269} \cong 580...$

– cut line

A-5190 GS-17440



• MODE OF F...

BOOM (STRUCTURE) ...

PROBLEM: THE COMP... CHORD CA...

1. FORCE PFJ ... BEARING -

$PFJ = 90 \times 8$...

2. FORCE PFJ CAU... (IN COMPRESSION...

$PFJ = 90 \times 8$...

3. FORCE PFJ ... OF BUTT WELDING ...

$90\,KSI = \frac{PFJ}{A} + \frac{PFJ\ldots}{S}$

$90 \approx PFJ\left(\frac{1}{10.554} + \ldots\right)$

$PFJ = 877^{K} >$

4. FORCE PFJ CAUSING TH... UNBRACED CHORD OF BOO...

CHORD TUBE: 6 OD × 0.625 ...

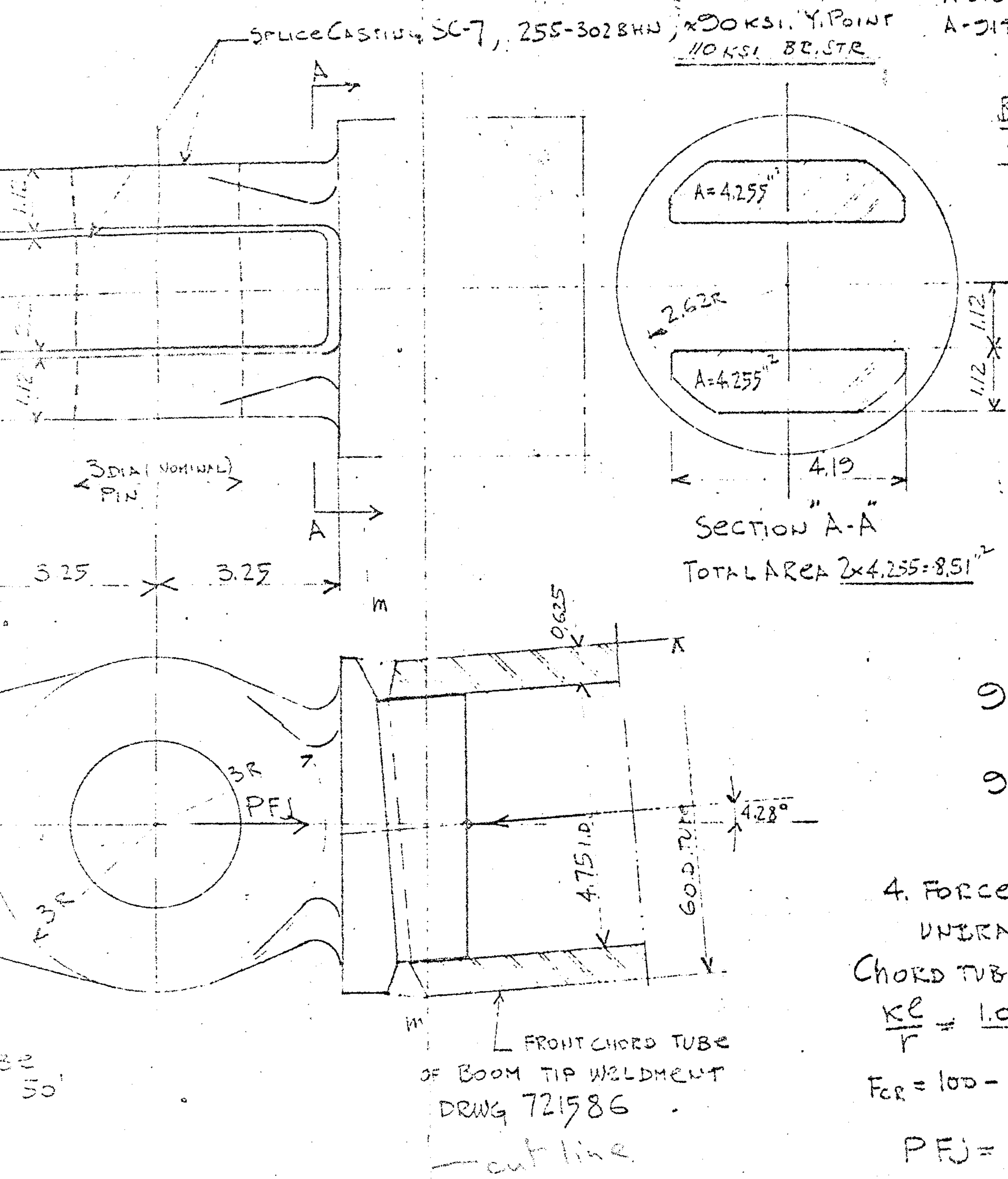
$\frac{Kl}{r} = \frac{1.0 \times 97.3}{1.91} \cong 51$ $F_{CR} =$

$F_{CR} = 100 - \frac{100^2 \times 51^2}{4\pi^2 \times 29 \times 10^3} = 100 - 2\ldots$

$PFJ = 77.28 \times 10.554 = 815\ldots$

A-9189 - GS-17438
A-9190 GS-17440

11750 CRANE (PEDESTAL)



MODE OF FAILURE

BOOM (STRUCTURE) ASS'Y 94BR - 150' LONG

PROBLEM: THE COMPRESSIVE FORCE IN FRONT CHORD CAUSING THE FAILURE AT SPLICE JOINT

1. FORCE PFJ CAUSING THE FAILURE IN PIN BEARING -

$$PFJ = 90 \times 3 \times 2.125 \approx 580^K \text{ (GOVERNING)}$$

2. FORCE PFJ CAUSING THE FAILURE (IN COMPRESSION) AT SECTION A-A

$$PFJ = 90 \times 8.51 = 766^K > 580^K$$

3. FORCE PFJ CAUSING THE FAILURE OF BUTT WELDING JOINT m-m

$$90\text{ KSI} = \frac{PFJ}{A} + \frac{PFJ \times e}{S}$$

$e = 0.10$ (ECCENTRICITY)
$A = 10.554"$
$S \approx 12.876"^3$

$$90 \approx PFJ\left(\frac{1}{10.554} + \frac{0.10}{12.876}\right)$$

$$PFJ = 877^K > 580$$

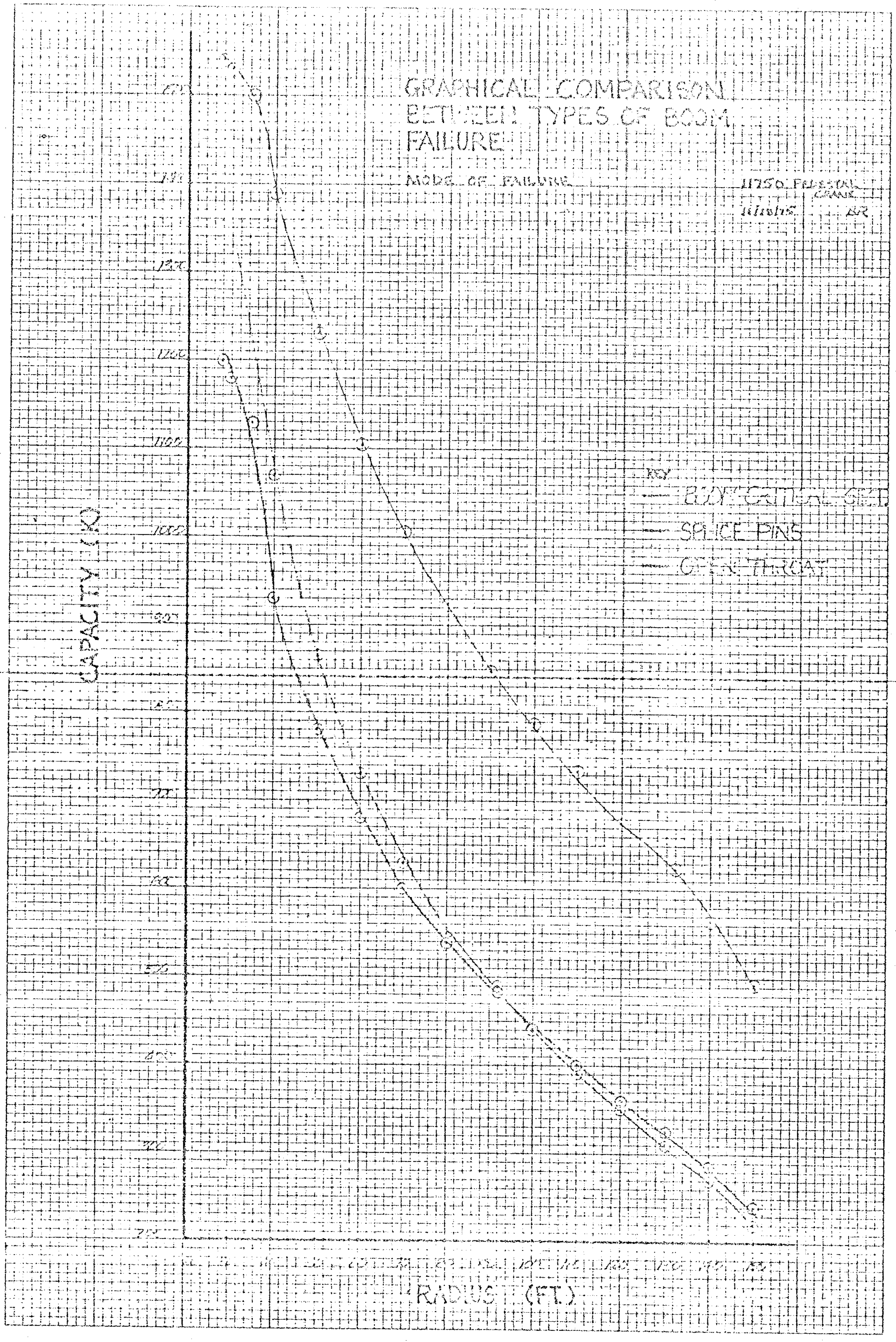
4. FORCE PFJ CAUSING THE FAILURE (BUCKLING) OF UNBRACED CHORD OF BOOM CENTER SECTION 719975

CHORD TUBE: 6 OD × 0.625 WALL AREA 10.554"² $r \approx 1.91$ $F_y = 100$ KSI

$$\frac{K\ell}{r} = \frac{1.0 \times 97.3}{1.91} \approx 51 \qquad F_{CR} = F_y - \frac{F_y^2}{4\pi^2 E}\left(\frac{KL}{r}\right)^2$$

$$F_{CR} = 100 - \frac{100^2 \times 51^2}{4\pi^2 \times 29 \times 10^3} = 100 - 22.7 = 77.28 \text{ KSI}$$

$$PFJ = 77.28 \times 10.554 = 815K > 580K$$

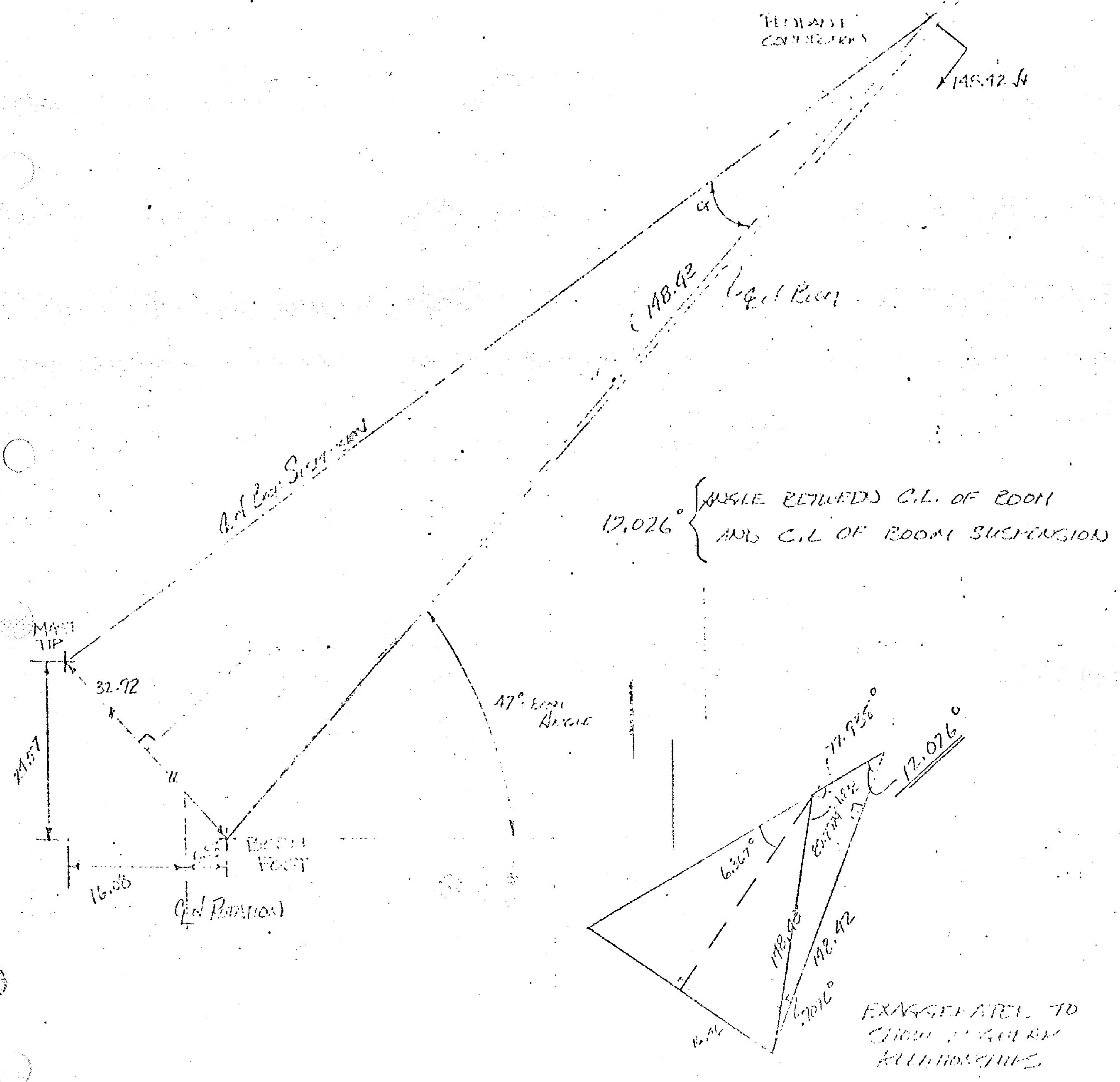

GRAPHICAL COMPARISON
BETWEEN TYPES OF BOOM
FAILURE
MODE OF FAILURE
11750 PEDESTAL CRANE
KEY
SPLICE PINS
OPEN THROAT
CAPACITY (K)
RADIUS (FT.)

47 0703

⊘ MAXIMUM ALLOWABLE FORCE ON PENDANT CONNECTION AT BOOM POINT

(1151 K)

ASSUME: THE WORST CONDITION ON THE PENDANT CONNECTION IS WHEN THE ANGLE BETWEEN THE PENDANTS AND CENTER LINE OF THE BOOM IS THE GREATEST.



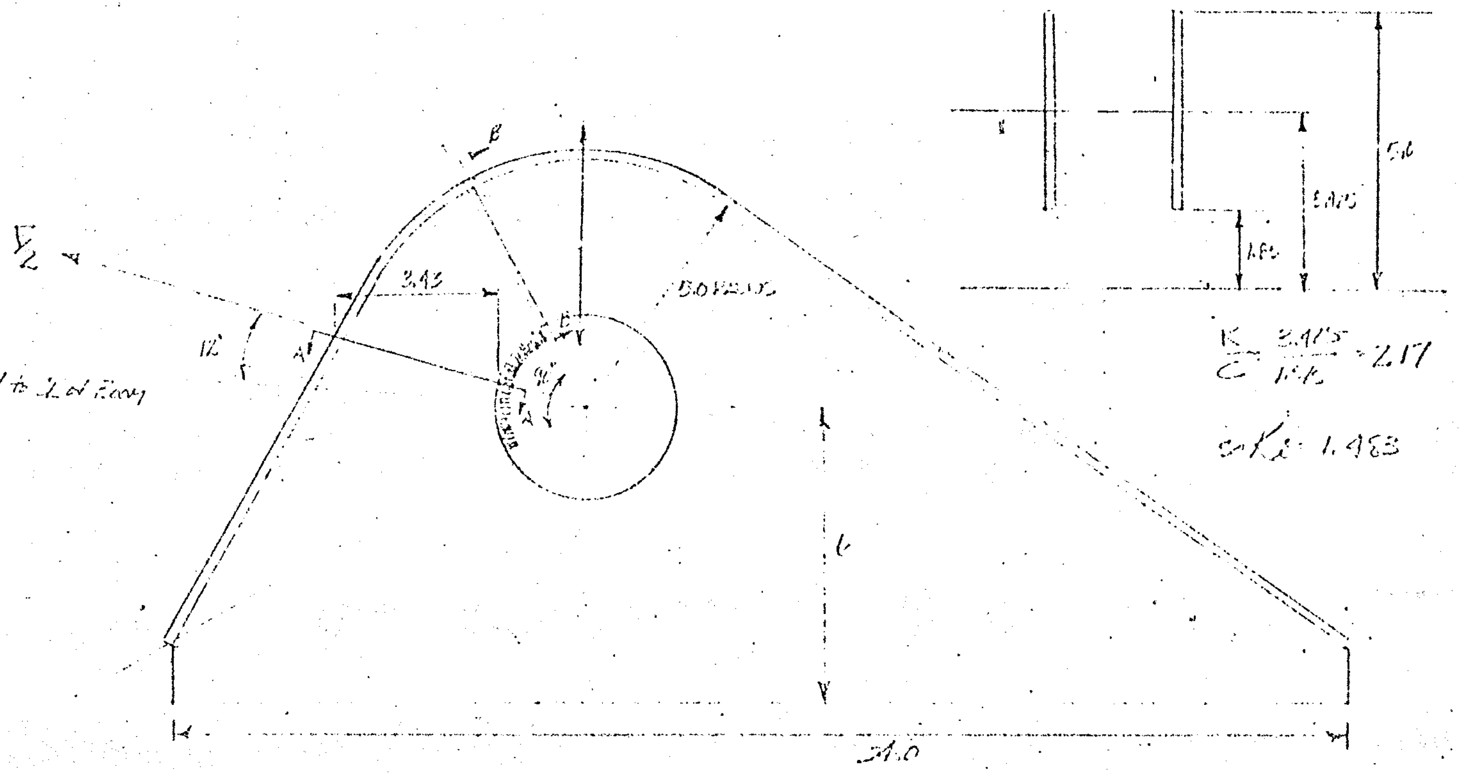
AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

SUBJECT [illegible]

PIN [illegible]

DATE 11/ [illegible]

CHECK STRESS IN PLATE (USING ROARK: FORMULAS FOR STRESS AND STRAIN pg 164)



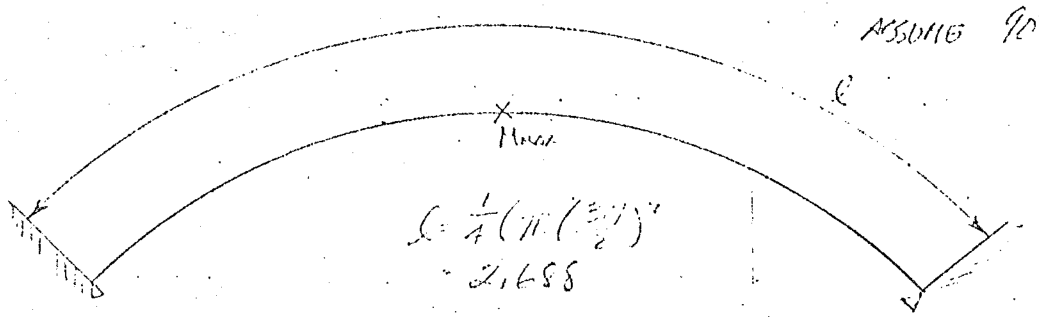
$\frac{K}{C} = \frac{3.475}{1.6} = 2.17$

so $K_i = 1.483$

TREAT AS CURVED BEAM

LOAD IS UNIFORMALLY DISTRIBUTED OVER THE CONTACT AREA OF THE PIN

ASSUME 90° contact angle (conservative)



$\ell = \frac{1}{4}(\pi(\ldots))$

$= 2.688$

ASSUME SUPPORTS 50% FIXED

SECTION A-A – CHECK FOR BENDING

so $M_{max} = \frac{1}{10} w \ell^2$; $w = \frac{F/2}{\ell}$

$M_{max} = \frac{1}{10}\left(\frac{F}{2}\right) \times \ell$

$= .1344\,F$

AT M_{max} $S = \frac{[illegible]}{6} = \frac{[illegible]}{6} = 1.96$

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

[illegible] [illegible] ([illegible])

Mode of Failure

DATE [illegible]

FOR FAILURE - [illegible] Fu = 115 ksi

$$115\ ksi = \frac{.1344F}{1.96} \times 1.493$$

Force 1131 K [illegible]

SECTION B-B - [illegible] FOR SHEAR

$$V = \frac{1}{2}\left(\frac{F}{2}\right) = \frac{F}{4}$$

$$A = 3(.5(5+1.1)) = 5.15\ in^2$$

$$F_v = .6(100\ ksi) = 60\ ksi$$

$$60\ ksi = \frac{.25F}{5.15}$$

Force 1243 K [illegible]

CHECK BEARING PRESSURE

$$F_b = 100\ ksi = F_y$$

$$A = 2(.5)(3.7\ in) = 3.7\ in^2$$

$$F_y = 100\ ksi = \frac{F/2}{3.7}$$

Force = 740 K

THIS DOESN'T REALLY CAUSE FAILURE.

CHECK WELD - CHECK WELD FOR 1131^K FORCE
1/2" FILLET

$$M = \frac{1131^K}{2}(\cos 15^\circ)(6") = 3315.9\ K\text{-}in$$

$$S = \frac{t(l^2)}{6} = \frac{1(24)^2}{6} = 192\ in^3$$

$V = \frac{113.1^K}{2} \cos(12°) = 553.14^K$

$Tension = \frac{113.1^K}{2}(\sin 12°) = 117.5^K$

$f_B = \frac{3318.9 \text{ K-in}}{192 \text{ in}^2} = 17.29 \text{ K/in}$

$f_T = \frac{117.5^K}{1(24) \cdot 2 \text{ in}} = 2.448 \text{ K/in}$ $f_{TOTAL} = 19.733 \text{ K/in}$

$f_V = \frac{553.14^K}{2 \cdot 1(24 \text{ in})} = 11.5 \text{ K/in}$

$f_{COMB\ BEND} = \frac{19.733}{2} + \sqrt{\left(\frac{19.733}{2}\right)^2 + (11.5)^2} = 25.04 \text{ K/in}$

REQUIRED WELD = 25.04 K/in = (100 KSI)(.707)(WELD SIZE)

WELD SIZE = .354 in < .5 in. OK

$f_{COMB\ SHEAR} = \sqrt{\left(\frac{19.733}{2}\right)^2 + (11.5)^2} = \quad \text{K/in}$

REQUIRED WELD = 15.15 = (.6)(100 KSI)(.707)(WELD SIZE)

WELD SIZE = .357 in < .5 in OK

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

Hook at Failure

11750 Crane (Revised)

DATE [illegible]

Hook Load Causing Failure of Pendant-Boom Connection

Radius (ft)	Force (K) = a + b(P)	Hook Load (kips)
25	1131 = 17.956 + .745 P	1449
30	1131 = 19.[illegible] + [illegible] P	1337
40	1131 = [illegible] + 1.1[illegible] P	974.2
50	1131 = 24.535 + 1.422P	771.1
60	1131 = 41.552 + 1.703 P	639.7
70	1131 = 48.47[illegible] + 1.98 P	546.8
80	1131 = 55.278 + 2.26P	476.0
90	1131 = 62.223 + 2.541 P	419.6
100	1131 = 69.402 + 2.84 P	373.8
110	1131 = 76.999 + 3.175 P	332.0
120	1131 = 85.268 + 3.536 P	295.7
130	1131 = 94.748 + 3.998 P	261.8
140	1131 = 106.425 + 4.492P	228.1
150	1131 = 123.886 + 5.313 P	189.6

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

[illegible] G-11440 . [illegible]

Hook of Failure DATE [illegible]

HOOK LOAD CAUSING FAILURE OF PENDANTS

* TYPE 1.5" ϕ AAA – 4 PARTS 250k = B.S.

ALLOWABLE FORCE = 1000k

RADIUS (FT)	EQUATION : a + L(P)	HOOK LOAD (KIPS)
28	1000 = 17.956 + .768 P	1278
30	1000 = 19.557 + .831 P	1180
40	1000 = 27.252 + 1.133 P	859.3
50	1000 = 34.535 + 1.422 P	678.9
60	1000 = 41.552 + 1.703 P	562.8
70	1000 = 48.428 + 1.98 P	480.6
80	1000 = 55.278 + 2.26 P	418.0
90	1000 = 62.223 + 2.547 P	368.2
100	1000 = 69.402 + 2.84 P	327.7
110	1000 = 76.999 + 3.175 P	290.7
120	1000 = 85.288 + 3.536 P	258.7
130	1000 = 94.748 + 3.958 P	228.7
140	1000 = 106.425 + 4.492 P	198.9
150	1000 = 123.886 + 5.313 P	164.9

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

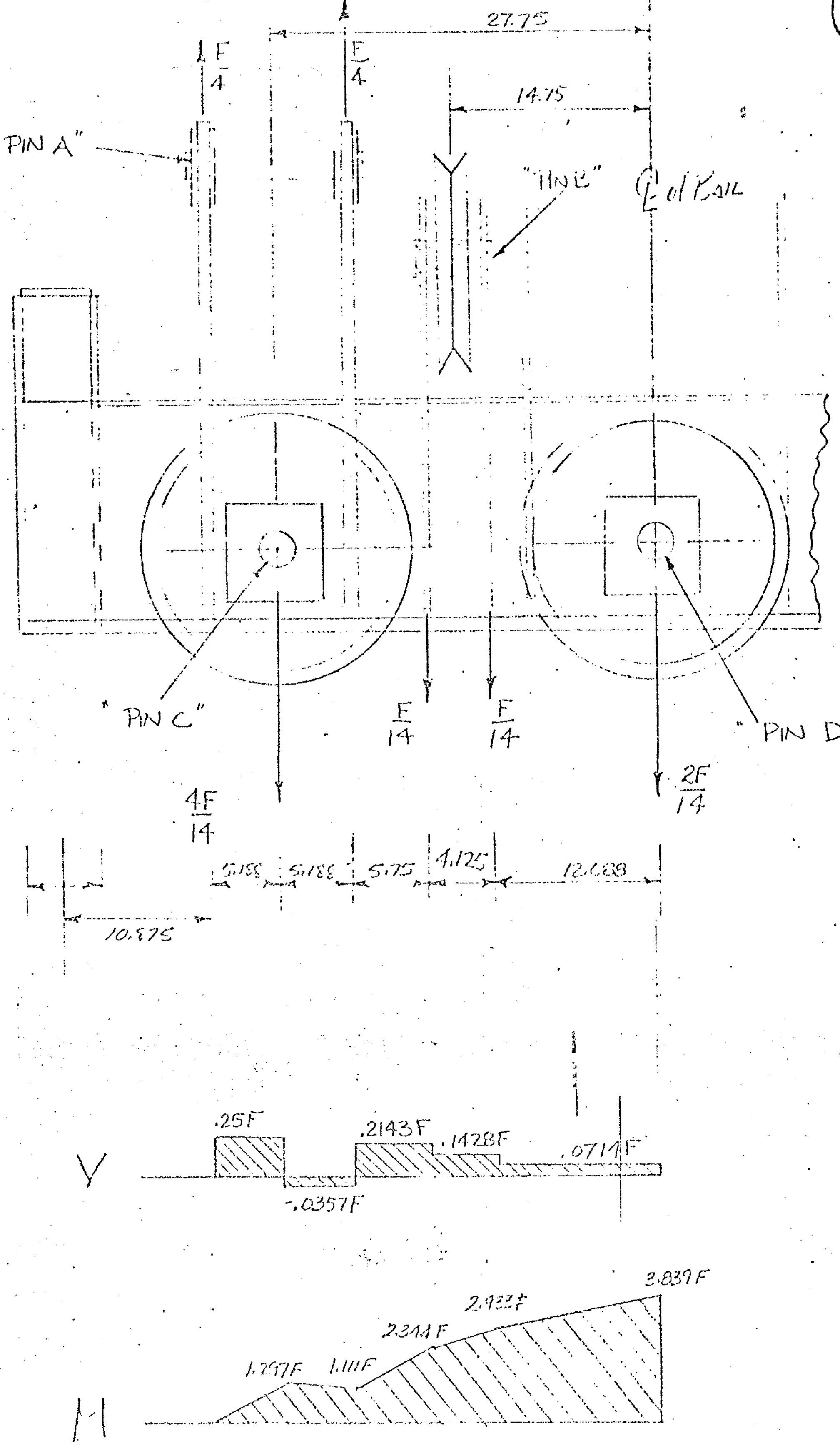
11750 Crane

Mode of Failure

DATE 10/23/75

Maximum Allowable Force on Outer Bail

1224 K



AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

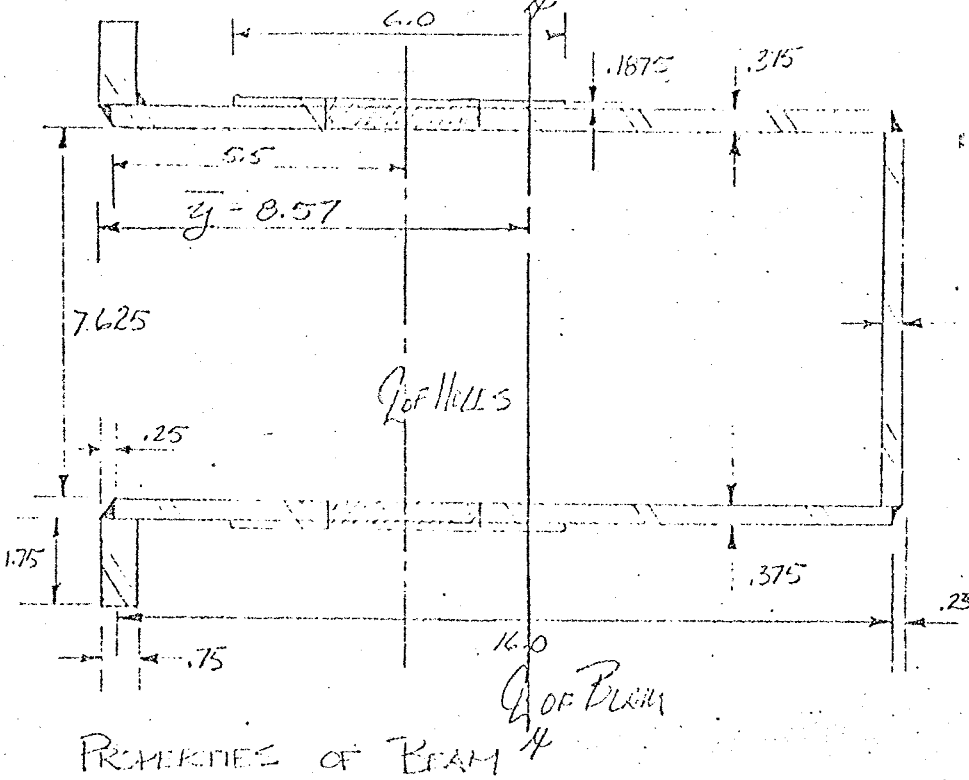
Mode of Failure

1150 Crane (Pile ...)

DATE 10/30/75 PR

GS 11438
GS 11440

Outer Bail - Main Beam



MATL: A62

F_{UTS} = 115 KSI

$F_{COMP} = \left[1 - \frac{(Kl/r)^2}{2C_c^2}\right] F_y$

l = 8.0 in

Properties of Beam

$$\text{Area} = (16)(.375)(2)+(7.625)(.375)+(2)(1.75)(.75)+6(.1875)(2)-(2)(3)(.5625)$$
$$= 12 + 2.859 + 2.625 + 2.25 - 3.375$$
$$= 16.359 \text{ in}^2$$

$$\bar{y}_1 = \frac{8.25(12) + .1875(2.859) + 2.625(16.125) + 10.75(2.25 - 3.375)}{16.359}$$

$= 7.933$ in

$$I_{xx} = (8.195)^2(2.625) + (.32)^2(12) + \tfrac{1}{12}(.375)(16^3) + (3.07)^2(2.25) - (3.07)^2(3.375) + (7.7425)^2(2.859)$$

$= 466.32 \text{ in}^4$

$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{466.32}{16.359}} = 5.339$

$\frac{Kl}{r} = \frac{88(1.0)}{5.339} = 16.48$

$$\therefore F_{comp} = \frac{(3.839 \times \text{FORCE})\, 8.57 \text{ in}}{466.32 \text{ in}^4} = \left[1 - \frac{(16.48)^2}{2(76.7)^2}\right] 100 = 97.63$$

FORCE = 1384 K

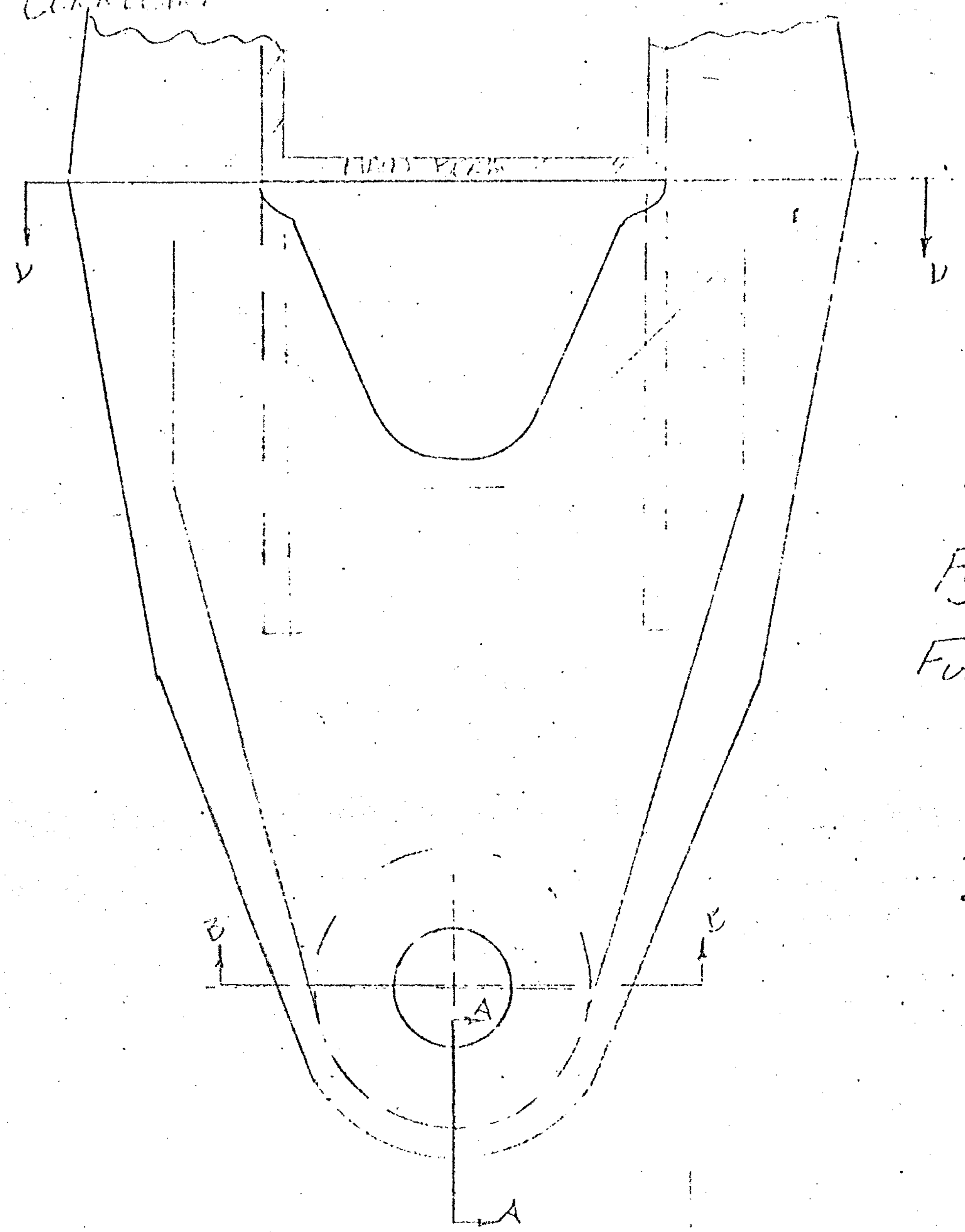
AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

DATE 10/7/75 PR

PENDANT CONNECTION

GS 17438
GS 17440



Mat'l A62

F_y 100 KSI

F_{UTS} = 115 KSI

SECTION A-A

AREA = (3.38)(.75) + (3)(.75) + (.75) = 7.035 in²

115 KSI = F/A / 7.035 in²   FORCE = 3236 K

SECTION B-B

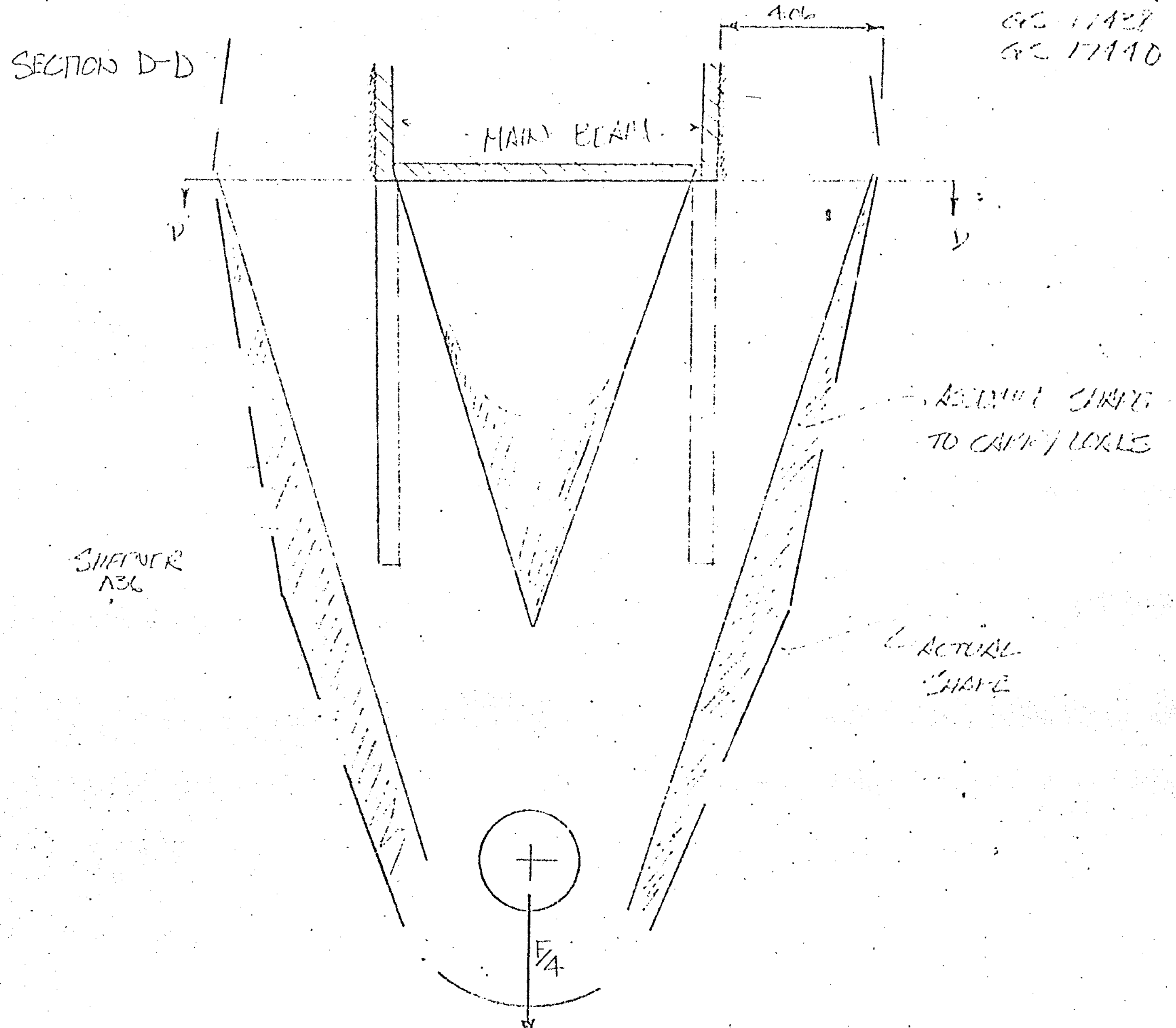
AREA = (6.00 - 2.0)(.75)2 + (6.75).75 = 11.063

115 KSI = F/A / 11.063 in   FORCE = 5089 K

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

11750 [illegible]

DATE 10/21/75



NOTE: IGNORE INNER PLATE AND CALCULATE STRESS AT D-D FROM FORCE TRANSFERED FROM WELD AT MAIN BEAM AT SECTION D-D

* PLATE AND STIFFNERS WILL DIVIDE LOAD SO BOTH ARE STRESSED TO ULTIMATE SIMULTANEOUSLY

AREA OF PLATE = 4.06 × .75 = 3.046 in²

AREA OF STIFFNER = 3.0 × .375 = 1.125 in²

TOTAL = 4.172 in²

LET PLATE TAKE 57.3 %

STIFFNER TAKE 42.7 %

[illegible]
GC 1990

Mode of Failure

11250 Crane ([illegible])

DATE 10/1/85 [illegible]

PLATE STRESS

$$S_{PLATE} = \frac{(.75)(4.06)^2}{6} = 2.06\ in^3$$

$$115_{KSI} = \frac{1}{2}\left(\frac{F/4}{3.046}\ .573\right) + \frac{(\frac{1}{2}\frac{F}{4})(2.03)}{2.06}(.573)$$

$$115_{KSI} = .0235\,F + .0706\,F$$

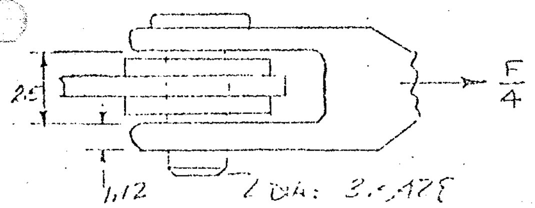
FORCE = 1222 K

STIFFNER STRESS

$$58 = \frac{1}{3}\left(\frac{\frac{F}{4}}{1.125}(.427)\right) = .111\,F\,(.427)$$

FORCE = 1224 K   MAXIMUM ALLOWABLE FORCE ON OUTER BAIL

PIN A



$$M = F\left(\tfrac{1}{3}(2.25 + 1.12) + .125\right)$$
$$= F\,(1.248)$$

$$S = .098175\,D^3$$
$$= 4.366$$

$F_{UTS} = 125$ KSI

$$125_{KSI} = \frac{M}{S} = \frac{F/4\,(1.248)}{4.366}$$

FORCE = 1749 K

DOUBLE SHEAR

$F_Y = 100$ KSI $F_V = 60$ KSI

$$60_{KSI} = \frac{.20F}{\pi\,(3.5478/2)^2 \cdot 2}$$

[illegible] 4.[illegible]

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

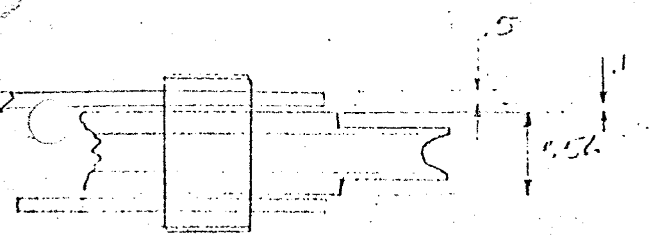
GS 17440

Mode of Failure

[illegible] Crane ([illegible])

DATE [illegible]

Pin B



DIA = 3.5128

BENDING

$F_{UK} = 125$ KSI

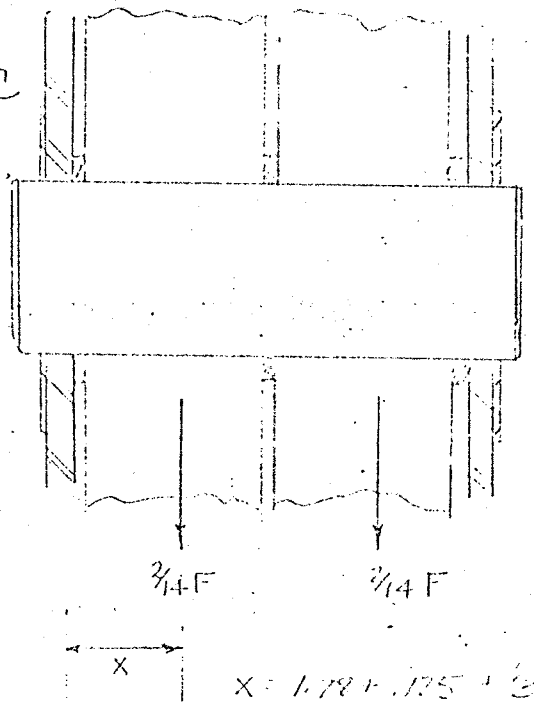
$M = F/8 \left(\frac{1}{3} (.5 + 3.56) + .1 \right)$

$= .1817\ F$

$125\ KSI = \frac{.1817F}{4.366}$ FORCE = 3004 K

SHEAR $60\ KSI = \frac{.1428F}{19.72}$ FORCE = 8282 K

Pin C



X = 1.78 + .125 + 1/3 (.38)

= 2.03

BENDING

$M = F/7\ (2.03)$

$= .29\ F$

$S = 4.366$

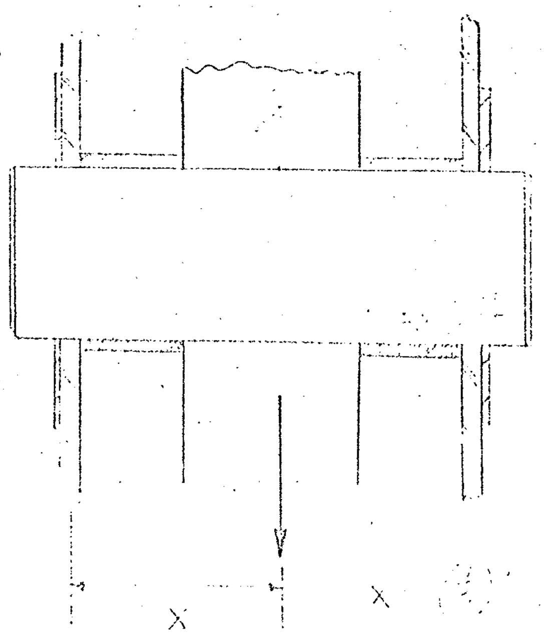
$125\ KSI = \frac{.29F}{4.366}$

FORCE = 1882 K

SHEAR $60\ KSI = \frac{.286F}{19.72}$

FORCE = 4141

Pin D



X [illegible]

$M = F/7\ (3.872)\ \frac{1}{2}$

$= .2766\ F$

$S = 4.366$

$125\ KSI = \frac{.2766F}{4.366}$

FORCE = 1973 K

$60\ KSI = \frac{.2857F}{19.72}$

FORCE = 4141 K

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

GS 1143
GS 11440

MODE OF FAILURE

1175 Cl. Const. (Revised)

DATE 11/10/75 PK

HOOK LOAD CAUSING FAILURE OF OUTER BAIL

RADIUS (FT)	EQUATION : a + L(P)	HOOK LOAD (KIPS)
28	1224 = 17.956 + .768 P	1570
30	1224 = 19.559 + .831 P	1449
40	1224 = 27.252 + 1.133 P	1056
50	1224 = 34.535 + 1.422 P	836.5
60	1224 = 41.552 + 1.703 P	694.3
70	1224 = 48.428 + 1.98 P	593.7
80	1224 = 55.278 + 2.26 P	517.1
90	1224 = 62.223 + 2.547 P	456.1
100	1224 = 69.402 + 2.849 P	405.3
110	1224 = 76.999 + 3.175 P	361.3
120	1224 = 85.288 + 3.536 P	322.0
130	1224 = 94.748 + 3.958 P	285.3
140	1224 = 106.425 + 4.492 P	248.8
150	1224 = 123.886 + 5.313 P	207.1

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

Mode of Failure

[illegible] Crane ([illegible])

DATE [illegible]

Hook Load Causing Failure of Boom Hoist Rope

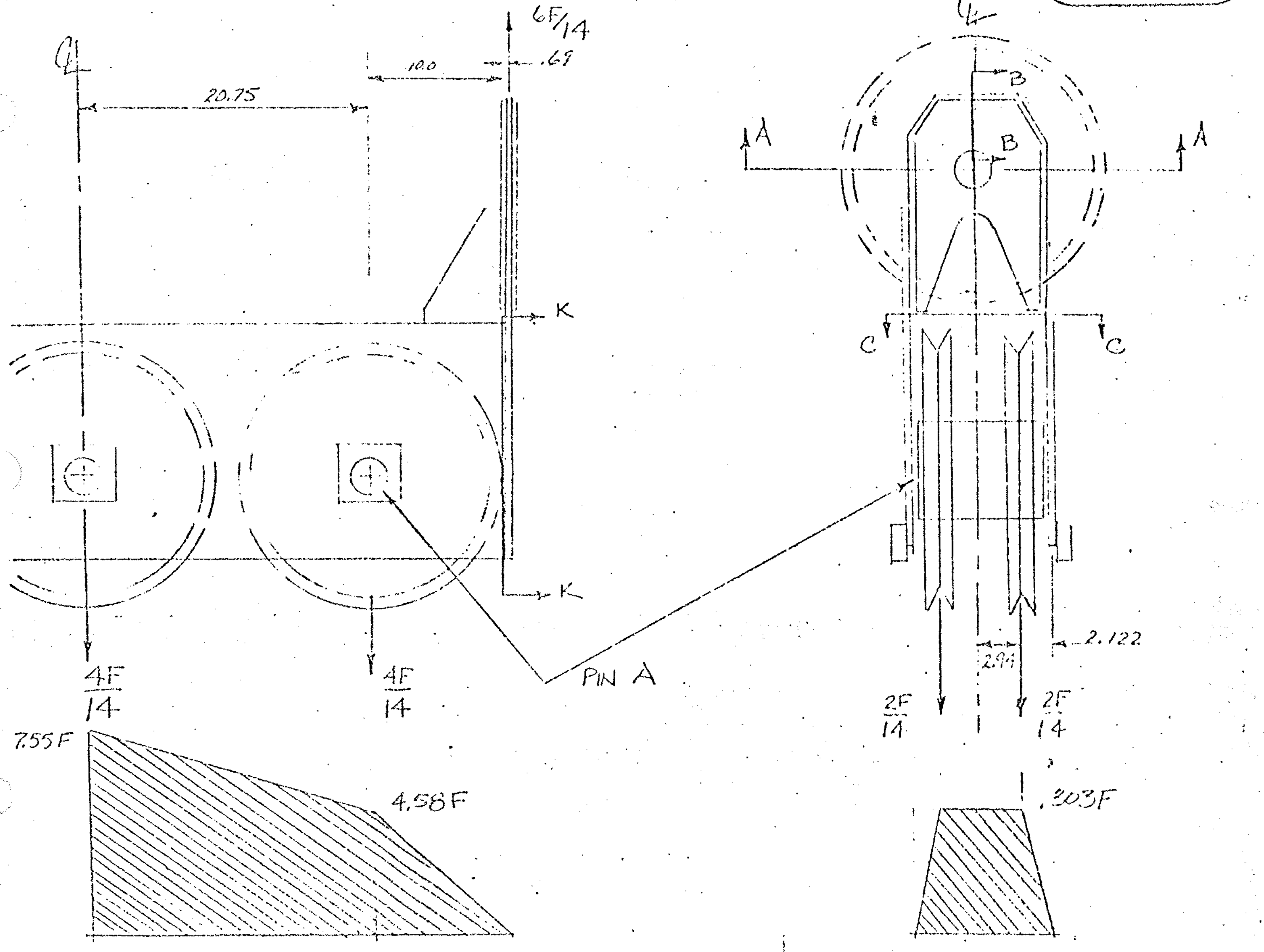
* TYPE 1" ϕ EIPS - 14 PARTS 103.4K - B.S.

Allowable Force = 1447.6K

Radius (FT)	Equation: $a + b(P)$	Hook Load (KIPS)
28	$1447.6 = 17.956 + .768P$	1861
30	$1447.6 = 19.559 + .831P$	1718
40	$1447.6 = 27.252 + 1.133P$	1254
50	$1447.6 = 34.535 + 1.422P$	994.6
60	$1447.6 = 41.552 + 1.703P$	825.6
70	$1447.6 = 48.428 + 1.98P$	706.7
80	$1447.6 = 55.278 + 2.26P$	616.1
90	$1447.6 = 62.223 + 2.547P$	543.9
100	$1447.6 = 69.402 + 2.849P$	483.7
110	$1447.6 = 76.999 + 3.175P$	431.7
120	$1447.6 = 85.288 + 3.536P$	385.3
130	$1447.6 = 94.748 + 3.956P$	341.8
140	$1447.6 = 106.425 + 4.492P$	298.6
150	$1447.6 = 123.556 + 5.313P$	249.1

■ Maximum Allowable Force on Tower Rail

972.1k



■ Pin A　　A54　　$F_{UTS} = 125$ ksi　　$F_y = 100$ ksi

$S = (0.098)(3.54)^3 = 4.35\ in^3$

Bending

$125\ ksi = \frac{.303\ F}{4.35\ in^3}$

Force = 1795 K

Double Shear

$60\ ksi = \frac{.143\ F}{\frac{\pi (3.54^2)}{4}}$

Force = 4129 K

■ Weld at Joint K-K

Special A-62 weld　$F_y = .6(100\ ksi)\ 60\ ksi$

$.707(3/8)60k = \frac{.4286\ F}{15.81(2)}$　　F... 1174 K

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

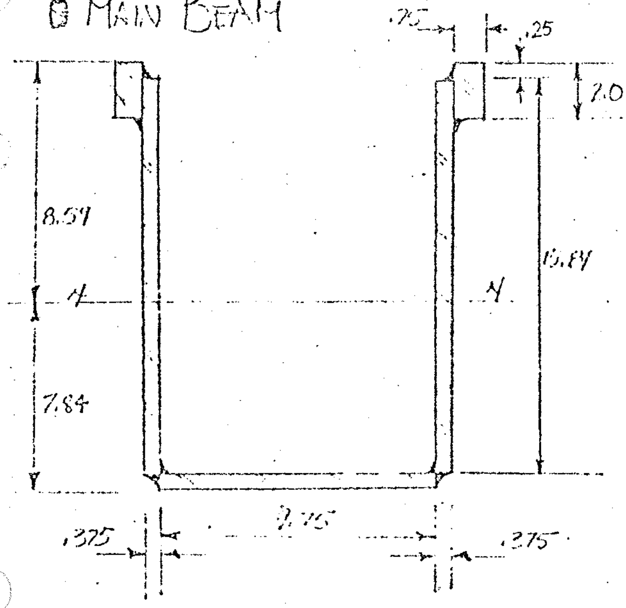
Mode of Failure

1150 Crane (...)

DATE 11/3/75 RK

GS 17438
GS 17440

⊕ Main Beam



Properties

$$(2.0)(.375)(15.81) = 11.85\ in^2 \times 8.28\ in = 98.12$$
$$(.375)(9.75) = 3.65\ in^2 \times .19\ in = .684$$
$$(2.0)(.75)(2.0) = \underline{3.0\ in^2} \times 15.935 = \underline{46.305}$$
$$18.5\ in^2 \qquad 145.109$$

$$y_1 = \frac{145.109}{18.5} = 7.84 \qquad y_2 = 8.57$$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{633.65}{18.5}} = 5.85$$

$$I_{xx} = \frac{2(.375)(15.81)^3}{12} + (3.0)(7.595)^2$$
$$+ (3.65)(7.65)^2 = 633.65\ in^4$$

$$\frac{KL}{r} = \frac{1.0(62.85)}{5.85} = 10.75$$

A62 Mat'l $\qquad F_{UTS} = 115\ ksi$

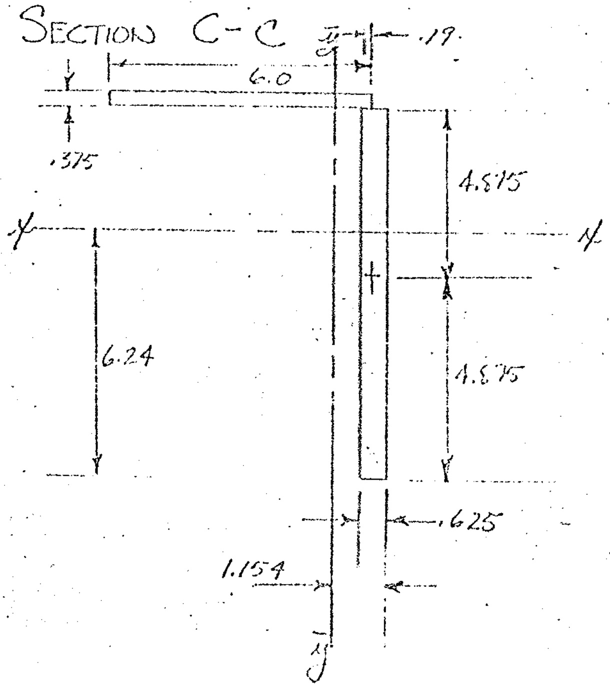
$$F_{comp} = \left[1 - \frac{(10.75)^2}{2(151)^2}\right]100 = 99.5\ ksi$$
(see A-Frame)

$$99.5\ ksi = \frac{(7.55 F)(8.59)}{633.65\ in^4}$$

Force = 972.1 K

* Maximum Allowable Force

⊕ Section C-C



Mat'l A62 $\qquad F_{UTS} = 115$

Properties

$$(9.75)(.625) = 6.094\ in^2 \times 4.875 = 29.71$$
$$(6.0)(.375) = \underline{2.25\ in^2} \times 9.9375 = \underline{22.36}$$
$$8.344\ in^2 \qquad 52.071$$

$$\bar{y} = \frac{52.07\ in^3}{8.344\ in^2} = 6.24\ in$$

$$6.094(.3125) = 1.904$$
$$2.25(3 + .435) = \underline{7.729}$$
$$9.633\ in^2$$

$$\bar{x} = \frac{9.633}{8.344} = 1.154$$

$I_{x-x} = \frac{1}{12}(.625)(9.75)^3 + (1.365)^2(6.094) + (3.698)^2(2.25)$
$= 48.27 + 11.354 + 30.77$
$= 90.40 \text{ in}^4$

$I_{y-y} = \frac{1}{12}(6)^3(.375) + (2.281)^2(2.25) + (.8415)^2(6.094)$
$= 6.75 + 11.71 + 4.32$
$= 22.77 \text{ in}^4$

$115 \text{ KSI} = \frac{.4286 F}{8.344} + \frac{(.4286 F)(.8415)}{22.77} + \frac{(.4286 F)(1.365)}{90.40}$

$115 \text{ KSI} = .0514 F + .0158 F + .00647 F$

$115 \text{ KSI} = (.07371 F)$ FORCE = 1560 K

SECTION A-A   MAT'L A62 + A56 F_{UTS} = 115 KSI

$\text{AREA} = (9.75 - 4.62)(.625) + (9.25 - 4.62)(.5625)$
$= 5.82 \text{ in}^2$

$115 \text{ KSI} = \frac{.4286 F}{5.82}$ FORCE 1561 K

SECTION B-B

$\text{AREA} = (5.5 - 2.31)(.625) + (5.25 - 2.31)(.5625)$
$= 3.6475 \text{ in}^2$

$115 \text{ KSI} = \frac{.4286 F}{3.6475}$ FORCE = 978.7 K

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

[illegible] 11250 Crane ([illegible])

Mode of Failure DATE 11/12/[illegible] [illegible]

□ HOOK LOAD CAUSING FAILURE OF INNER BAIL

RADIUS (FT)	EQUATION : a+b(P)	HOOK LOAD (KIPS)
28	972.1 = 17.956 + .768 P	1242
30	972.1 = 19.559 + .831 P	1146
40	972.1 = 27.252 + 1.133 P	833.9
50	972.1 = 34.535 + 1.422 P	659.3
60	972.1 = 41.552 + 1.703 P	546.4
70	972.1 = 48.428 + 1.98 P	466.5
80	972.1 = 55.278 + 2.26 P	405.7
90	972.1 = 62.223 + 2.547 P	357.2
100	972.1 = 69.402 + 2.84 P	317.9
110	972.1 = 76.999 + 3.175 P	281.9
120	972.1 = 85.288 + 3.536 P	250.8
130	972.1 = 94.748 + 3.958 P	221.7
140	972.1 = 106.425 + 4.492 P	192.7
150	972.1 = 123.556 + 5.313 P	159.6

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

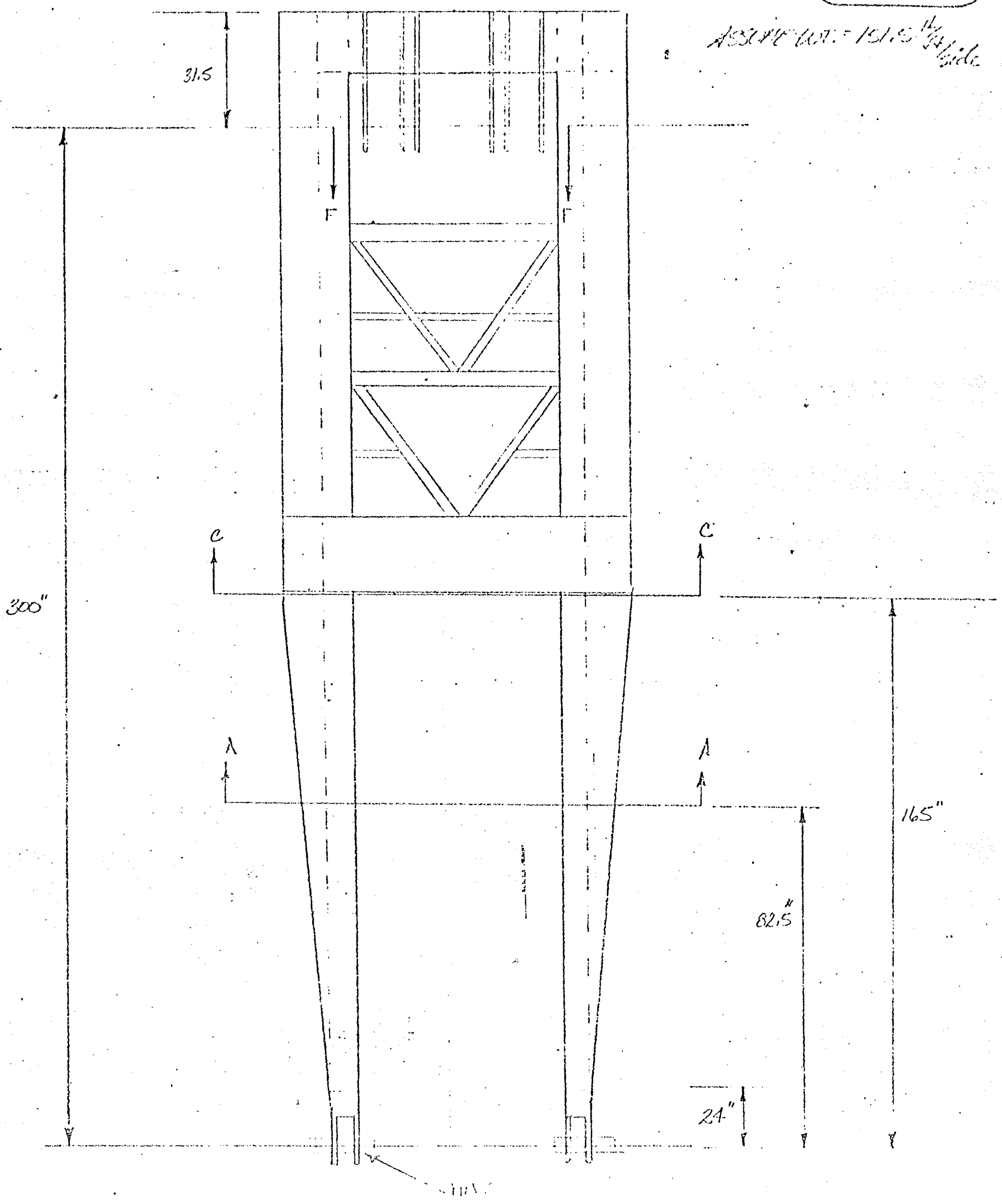
11750 CRANE
DATE 10/29/75

MODE OF FAILURE

MAXIMUM ALLOWABLE FORCE ON A-FRAME (KIPS)

966 K

ASSUME WT = 151.5 K/side



TO FIND MAX ALLOWABLE FORCE USE AISC COMBINED STRESS EQUATION BUT ELIMINATE ALL SAFETY FACTORS. THIS APPROACH WILL BE USED THROUGHOUT ALL CALCULATION'S UNLESS NECESSARY

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}} \leq 1.0$$

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = 126.1 \quad \text{FOR A36}$$

$K = 1.0 \quad l = 200\text{ in} \quad r_{xx} = 3.82\text{ in}$

$$\frac{Kl}{r} = 78.5$$

NORMALLY

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right] F_y}{\frac{5}{3} + \frac{3(Kl/r)}{8C_c} + \frac{(Kl/r)^3}{8C_c^3}}$$

where $\frac{5}{3} + \frac{3(Kl/r)}{8C_c} + \frac{(Kl/r)^3}{8C_c^3}$ is SAFETY FACTOR

NOW USE

$$F_a = \left[1 - \frac{(Kl/r)^2}{2C_c^2}\right] F_y = 29.024\text{ ksi}$$

NORMALLY

$$F'_e = \frac{12\pi^2 E}{23(Kl_b/r_b)^2}$$

where $12/23$ is SAFETY FACTOR

NOW USE

$$F'_e = \frac{\pi^2 E}{(Kl_b/r_b)^2} = 46.46\text{ ksi}$$

NORMALLY

$$F_b = \left[\begin{matrix}\text{SOME FACTOR} \\ \text{BASED ON } l/r\end{matrix}, \text{but} < .6\right] F_y$$

NOW USE $F_y = 36\text{ ksi}$

LET $C_{mx} = 1.0$ [illegible]

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

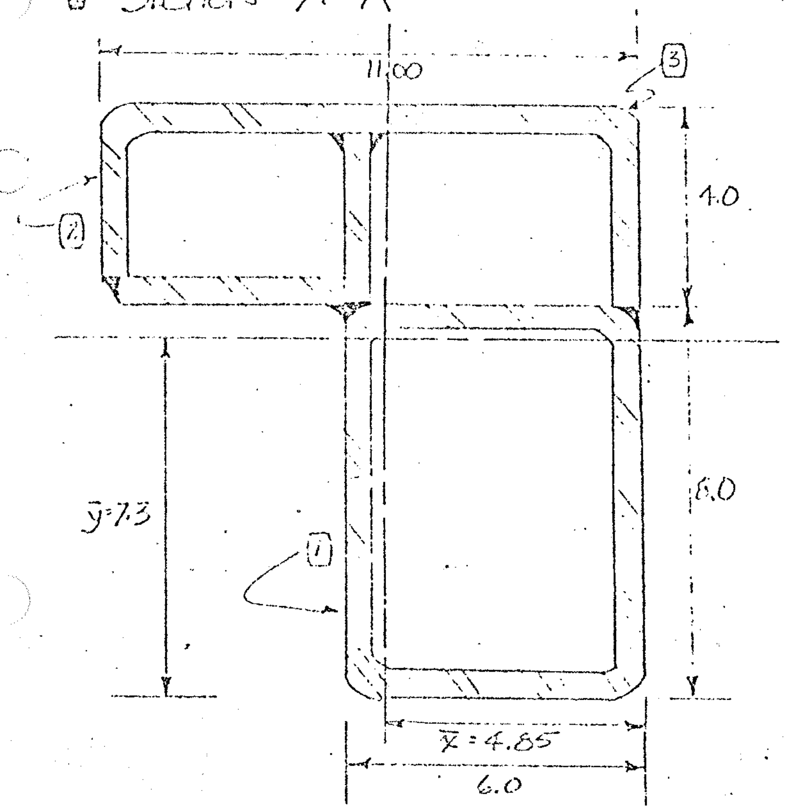
Mode of Failure

11750 : Crane ([illegible])

DATE 10/29/75 BK

GS 17148
GS 17140

Section A-A



Properties of Section

Assume ② to be 6x4x½ tube
③ to be 4x4x½ tube

$$\text{Area} = 11.9 + 8.4 + 3.75 = 23.79 \text{ in}^2$$

$$\bar{y} = \frac{4(11.9) + 10(8.14) + 10.8(3.75)}{23.79} = 7.3 \text{ in}$$

$$\bar{x} = \frac{3(11.9) + 10(8.14) + 1.22(3.75)}{23.79} = 4.85 \text{ in}$$

$$I_{x\text{-}x} = 96.2 + (11.9)(3.3)^2 + 17.6 + (8.14)(2.7)^2 + 1.97 + (3.75)(3.5)^2 = 348.4 \text{ in}^4$$

$$r_{xx} = \sqrt{\frac{I}{A}} = \sqrt{\frac{348.4}{23.79}} = 3.83 \text{ in}$$

$$\frac{\dfrac{P}{23.79\text{ in}}}{29.024\text{ ksi}} + \frac{1.0\left(\dfrac{.1515\text{ K/ft}\,(82.5\text{ in})(300\text{ in} - 82.5\text{ in})\,7.3\text{ in}}{2 \times 12\text{ in/ft}\quad 348.4\text{ in}^4}\right)}{\left(1 - \dfrac{\frac{P}{23.79\text{ in}^2}}{46.46\text{ ksi}}\right) 36\text{ ksi}} = 1.0$$

$$1.448\times10^{-3}\,P + \frac{2.3733}{(1 - 9.047\times10^{-4}\,P)\,36} = 1.0$$

TRY P = 574 K $\qquad$ .860 + .142 = 1.002

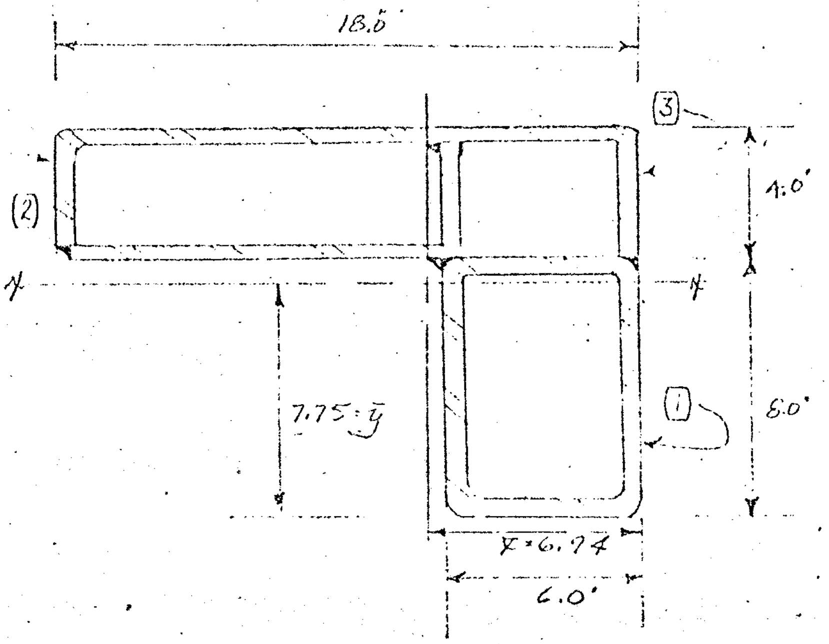
Force = 574 K

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

MODE OF FAILURE

11750 : CRANE (PEDESTAL)
DATE 10/29/75 PP
GS 17438
GS 17496

● SECTION C-C



PROPERTIES OF SECTION

ASSUME (2) TO BE A 12 x 4 x ½ TUBE
(3) TO BE A 6 x 4 x ½ ANGLE

AREA = 11.9 + 13.9 + 4.75
= 30.55 IN²

$$\bar{y} = \frac{11.9(4.0) + 13.9(10.0) + 4.75(10.0)}{30.55}$$

= 7.75 IN

$$\bar{x} = \frac{(11.9)(3) + (13.9)(12.0) + (4.75)(12.0)}{30.55}$$

$\bar{x}$ = 6.94 IN

$$I_{x\text{-}x} = 96.2 + (11.9)(3.75)^2 + 35.2 + (13.9)(2.25)^2 + 17.4 + (4.75)(2.25)^2$$
$$= 436.8 \text{ IN}^4$$

$$r_{x\text{-}x} = \sqrt{\frac{I}{A}} = \sqrt{\frac{436.8}{30.55}} = 3.75 \text{ IN}$$

ASSUME : (1) & (3) ONLY RESIST AXIAL FORCE AND NEGLECT ECCENTRICITY OF N.A. AND AXIAL FORCE. EFFECTS BALANCE

$$\frac{\frac{P}{19.5}}{29.024} + \frac{1.0\left(\frac{.1515\ K/ft\ (165\ in)(300-165)\ in\ 7.75\ in}{2 \times 12\ in/ft \quad 436.8\ in^4}\right)}{\left(1 - \frac{\frac{P}{19.5\ in^2}}{46.46\ KSI}\right) 36} = 1.0$$

$$1.767 \times 10^{-3} P + \frac{2.495}{(1 - 1.104 \times 10^{-3} P) 36} = 1.0$$

TRY P = 483 K .8535 + .1485 = 1.002

FORCE = 483 K

● MAXIMUM A-FRAME FORCE = 966 K TOTAL

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

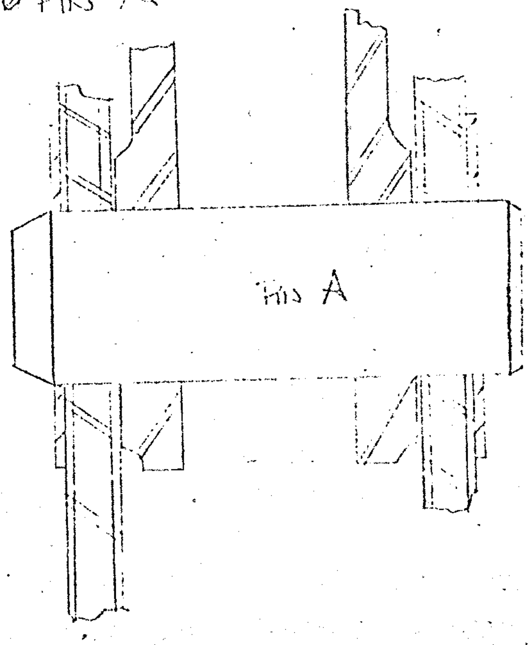
Mode of Failure

11750. Crane (Pedestal)

DATE [illegible]

GS 17438
GS 17440

Pin A



Mat'l A-54

Dia = 3.497 in

$A = \pi D^2/4 = 9.60\ in^2$

CHECK FAILURE IN DOUBLE SHEAR

$F_v = .6(F_y) = 60\ ksi$

$60\ ksi = \dfrac{F}{2 \times 9.60}$

Force = 1152 K /LEG

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

[illegible]

DATE [illegible]

⑧ HOOK LOAD CAUSING FAILURE OF A-FRAME (MAST)

RADIUS (FT)	EQUATION : (in kips)	HOOK LOAD (KIPS)
28	966 = 8.297 + .355 P	2696
30	966 = 9.455 + .402 P	2379
40	966 = 16.027 + .667 P	1424
50	966 = 23.809 + .98 P	961.4
60	966 = 32.710 + 1.34 P	696.5
70	966 = 42.685 + 1.745 P	529.1
80	966 = 53.727 + 2.197 P	415.2
90	966 = 65.875 + 2.697 P	333.8
100	966 = 79.222 + 3.255 P	272.4
110	966 = 93.947 + 3.8[illegible] P	225.[illegible]
120	966 = 110.371 + 4.575 P	187.0
130	966 = 129.117 + 5.393 P	155.2
140	966 = 151.599 + 6.3[illegible] P	127.30
150	966 = 182.637 + 7.8[illegible] P	100.0

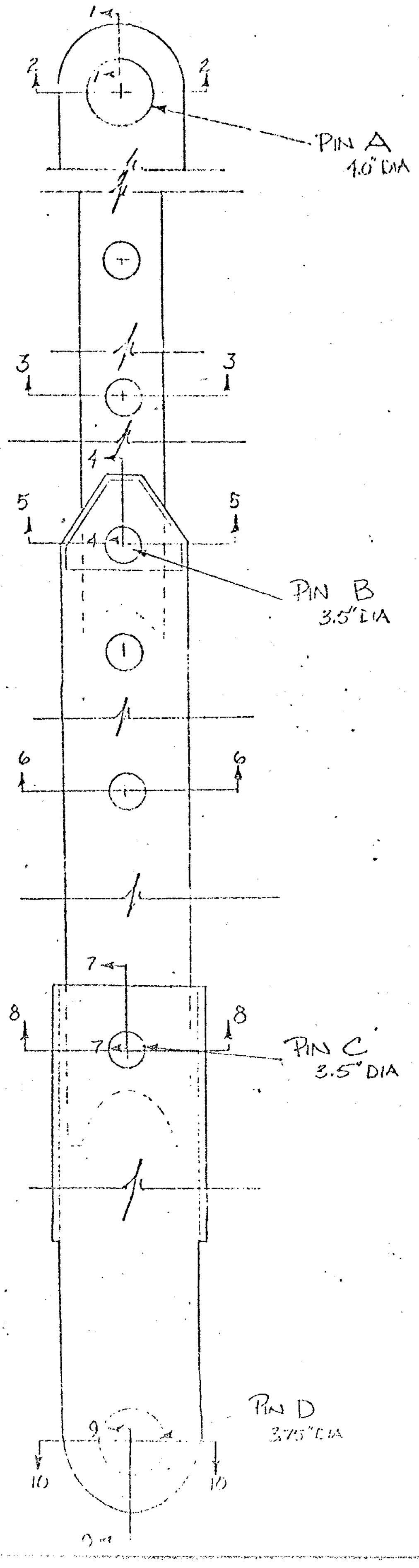
AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

[illegible] 1175[illegible] CRANE ([illegible])

DATE 10/21/75 R.R.

M[illegible] OF FR[illegible]

■ MAXIMUM ALLOWABLE FORCE ON BACKLEG (KIPS) — 577.3 K



■ PIN A   A-54   UTS = 125 KSI

BENDING   Y.P. = 100.0 KSI

$S = (0.098)\,4^3 = 6.27\ in^3$

$f_B = 125\ KSI = \frac{M}{S}$ so $M = 627\ K\text{-}in$

$627\ K\text{-}in = \frac{F}{4}(.817)$

FORCE = 3837 K

SHEAR $F_v = .6(F_y)$

$f_v = 60\ KSI = \frac{F}{A}$ FORCE = 754 K

■ PIN B   A-54   UTS = 125 K

BENDING   Y.P. = 100.0 KSI

$S = (0.098)\,3.5^3 = 4.2\ in^3$

$f_B = 125\ KSI = \frac{M}{S}$ so $M = 525\ K\text{-}in$

$525 = \frac{F}{4}(.58)$

FORCE = 3621 K

SHEAR

$f_v = 60\ KSI = \frac{F}{A = 9.62\ in^2}$

FORCE = 577.3 K

■ PIN C   A-54   UTS = 125 KSI

BENDING   Y.P. = 100.0 KSI

$S = 4.2\ in^3$ $A = 9.62\ in^2$

$f_B = 125\ KSI = \frac{M}{S}$ so $M = 525\ K\text{-}in$

$525\ \frac{F}{4}(.58)$

F[illegible] 3621 K

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

Hole of Failure — DATE 11/8/75 — 11750 Crane (Version) — BR

GS 17413
GS 17490

SHEAR $f_v = 60\text{ KSI} = \frac{F}{9.62\text{ in}^2}$ FORCE = 577.2 K

Pin D — A 54 — Y.P. = 100 KSI — UTS = 125

$S = (.098)\,3.75^3 = 5.168\text{ in}^3$

$f_B = 125\text{ KSI} = \frac{M}{S}$; so $M = 646$ K-in

$646 = (F/4)(.878)$

FORCE = 2943 K

$f_v = 60\text{ KSI} = \frac{F}{A = 11.04\text{ in}^2}$

FORCE = 662.7 KSI

NOTE: IN CHECKING PIN HOLES IN TENSION THE FOLLOWING ASSUMPTIONS ARE MADE

1) NO STRESS CONCENTRATION FACTORS (SEE STEEL DESIGN PG 30 McCORMAC)
2) ULTIMATE TENSILE STRENGTH IS ALLOWABLE

THESE ASSUMPTIONS ARE BASED ON THE FOLLOWING FACTS

1) AROUND HOLES ONCE FIBERS STRESSED TO YEILD PT. THEY WILL YELD WITHOUT FURTHER STRESS INCREASE RESULTING IN A REDISTRIBUTION OR BALANCING OF STRESSES.
2) A 62 AND SC7 ARE DUCTILE ENOUGH THAT THE MATERIAL WILL YEILD IN AREAS OF HIGH STRESS CONCENTRATIONS. (DUCTILE > 5% ELONGATION : PEARSON)

SECTION 1-1 — SC-7 — $F_y = 100$ KSI — $F_{UTS} = 140$ KSI

AREA = $(0.76)(5-1.75) + .12(4.25-1.75) = 2.77\text{ in}^2$

$140\text{ KSI} = \frac{F}{2.77}$ FORCE = 357.8 K

* Hole at Keeper Plate

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

Mole of Triumph

11250 [illegible] (Pedestal)

DATE 10/28/15 PK

GS 17455
GS 17410

Section 2-2   SC-7 F_y = 100 ksi F_{UTS} = 140 ksi

$$\text{Area} = (.76)(9-3.5) + .12(8.5-3.5) = 4.78\ in^2$$

$$140\ ksi = \frac{F}{4.78\ in^2} \qquad \text{Force} = 669.2\ K$$

Section 3-3   A62 F_y = 100 ksi F_{UTS} = 115 ksi

$$\text{Area} = 2(.5)(8.0) - 2(3.5)(.5) = 4.5\ in^2$$

$$115\ ksi = \frac{F}{4.5} \qquad \text{Force} = 517.5\ K$$

Section 4-4   A62 F_{UTS} = 115 ksi

$$\text{Area} = .5(2)(4.7-1.75) + 2.0(.312)(4.3-1.75) + 2(.188)(4.2-1.75)$$
$$= 5.46\ in^2$$

$$115\ ksi = \frac{F}{5.46\ in^2} \qquad \text{Force} = 627.9\ K$$

Section 5-5   A-62 F_{UTS} = 115 ksi

$$\text{Area} = .5(2)(10.62-3.5) + 2(.312)(7.6-3.5) + 2(.188)(13.0-3.5)$$
$$= 14.48$$

$$115\ ksi = \frac{F}{14.48} \qquad \text{Force} = 1665.2\ K$$

Section 6-6   A-62 F_{UTS} = 115 ksi

$$\text{Area} = 2(.5)(10.36) - 2(3.5)(.5) = 6.86\ in^2$$

$$115\ ksi = \frac{F}{6.86\ in^2} \qquad \text{Force} = 788.9$$

Section 7-7   A-62 F_{UTS} = 115 ksi

$$\text{Area} = 2(4.8-1.75)(.5) + 2(.188)(4.3-1.75) = [illegible]\ in^2$$

$$115\ ksi = \frac{F}{3.96} \qquad \text{Force} = 455.4\ K$$

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

Mode of Failure

11750 Cable (Pendant)
DATE 10/28/75 RK

GS 17438
GS 17440

- Section 8-8 A-62 F_{UTS} = 115 KSI

$$\text{Area} = 2(10.44-3.5)(.5) + 2(.188)(9.44-3.5) = 9.16\ in^2$$

$$115_{KSI} = \frac{F}{9.16\ in^2} \qquad \text{Force} = 1053.4\ K$$

- Section 9-9 A-62 F_{UTS} = 115 KSI

$$\text{Area} = 2(5.22-1.88)(.5) + 2(4.72-1.88)(2(.188)) = 5.47\ in^2$$

$$115_{KSI} = \frac{F}{5.47} \qquad \text{Force} = 629.05\ K$$

- Section 10-10 A-62 F_{UTS} = 115 KSI

$$\text{Area} = 2(10.44-3.75).5 + 2(9.44-3.75)(2 \times .188) = 10.95\ in^2$$

$$115\ KSI = \frac{F}{10.95\ in^2} \qquad \text{Force} = 1259\ K$$

- Maximum Allowable Force is governed by Section 1-1

775.6 KIPS

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

[illegible]
GC 17440

11750 CRANE ([illegible])

DATE 11/7/75 [illegible]

Hook Load Causing Failure of Backleg

RADIUS (FT)	EQUATION: a+b(P)	HOOK LOAD (KIPS)
28	775.6 = 20.634+.883 P	855.0
30	775.6 = 22.69 + .964 P	781.0
40	775.6 = 32.981 + 1.372P	541.3
50	775.6 = 43.258 + 1.782P	411.0
60	775.6 = 53.483 + 2.192P	329.4
70	775.6 = 63.618 + 2.602 P	273.6
80	775.6 = 73.624 + 3.009P	233.3
90	775.6 = 83.455 + 3.416P	202.6
100	775.6 = 93.059 + 3.82 P	178.7
110	775.6 = 102.365 + 4.219P	159.6
120	775.6 = 111.269 + 4.613P	144.0
130	775.6 = 119.6 + 4.996P	131.3
140	775.6 = 127.003 + 5.362P	120.9
150	775.6 = 132.356 + 5.676 P	113.3

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE — 11250 CRANE (ROBERT) — DATE 11/1/75 — BR

■ MAXIMUM FORCE ON STD. A-FRAME (1621 K)

TREAT AS TWO HINGED ARCH AND ANALYZE USING MOHR-MAXWELL'S THEORY FOR VIRTUAL WORK, IGNORING NORMAL FORCES AND SHEAR FORCES THRU THE BODY. ASSUME THE WORK IS PRODUCED BY BENDING ONLY. ALSO ASSUME THE FRAME IS SYMMETRIC ABOUT THE DASHED CENTER LINE

SEE SKETCH ON LATER PAGE

■ ANALYSIS

1) REPLACE THE FIXED SUPPORT "B" BY TWO SUPPORT AND HORIZONTAL FORCE "H". DETERMINE THE VERTICAL REACTIONS AT "B" & "O" DUE TO F AT JOINT "A".

MOMENTS @ "O" $R_{BY} = \dfrac{F(\cos(48.02)) \times 33.5 - F(\sin 48.02) \times 19.25}{66.75}$

$= .1213\ F$

MOMENTS @ "B" $R_{OY} = \dfrac{F(\sin 48.02) \times 47.5 + F(\cos 48.02) \times 33.5}{66.75}$

$= .8647\ F$

2) FOR TWO-HINGED ARCH: $H * \delta_{HH} + \Delta H_P = 0$

WHERE $\delta_{HH} = \int_s \dfrac{\bar{M}_H^2}{EI} ds$ — HORIZONTAL DISPLACEMENT OF HINGE "B" UNDER UNIT FORCE $\bar{H}$

AND $\Delta H_P = \int_s \dfrac{\bar{M}_H * M_P}{EI} ds$ — HORIZONTAL DISPLACEMENT OF HINGE "B" UNDER MOMENTS OF UNIT FORCE AND ACTIVE FORCES

3) THE MOMENT OF INERTIA AT EACH CROSS SECTION (ASSUMED PLATES) $I = \dfrac{2b}{12} * h^3 = \text{CONST} \times h^3$

4) THE GENERAL EQUATION FOR ARCH WILL BE

$$H * \int_s \frac{(1*y)^2}{h^3} ds + \int_s \frac{1*y*M_P}{h^3} ds = 0$$

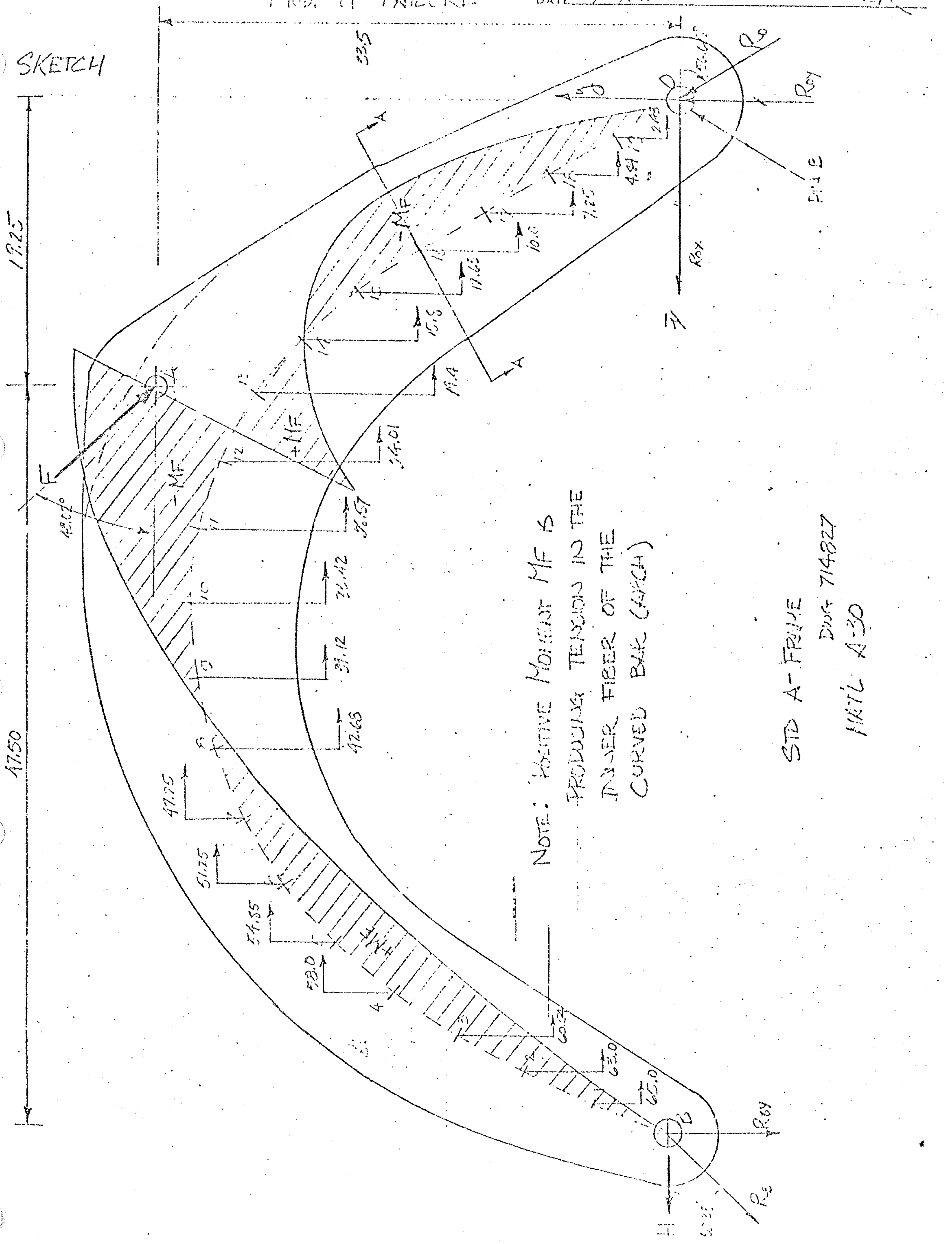
AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

Mode of Failure

11750 Crane (Pedestal)

DATE 11/5/75

SKETCH



AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

11750 CRANE (REDESIGN)

DATE 11/5/75 RK

SS 17438
SS 17440

5) REMAKING THE INTEGRATION BY SUMMATION USING SIMPSON'S RULE

$$\Sigma \cdot \frac{1}{3}\left[Z_0 + Z_n + 4(Z_1 + Z_2 + \cdots Z_n) + 2(Z_2 + Z_4 + \cdots Z_{n-1})\right]$$

SECTION	h (in)	h^3 (in³)	y (in)	y^2 (in²)	y^2/h^3 (1/in)	y/h^3 (1/in²)	M_F (K-IN)	$y*M_P/h^3$	FINAL MOMENT $M_F = M_P + H*y$ (K-in)
1	8.25	561	4.80	23	0.04100	0.008556	-.2143 F	-.00183 F	.26858 F
2	9.75	927	9.25	86	0.09277	0.009978	-.4562 F	-.00455 F	.47435 F
3	10.50	1157	13.50	182	0.15730	0.01167	-.7534 F	-.00879 F	.6047 F
4	10.75	1240	17.75	317	0.25564	0.0143	-1.061 F	-.01519 F	.72465 F
5	10.75	1240	21.50	462	0.37258	0.01734	-1.4445 F	-.0250 F	1.1019 F
6	11.00	1331	24.75	613	0.46055	0.0186	-1.880 F	-.0350 F	.7184 F
7	11.50	1521	27.50	756	0.49704	0.0181	-2.367 F	-.0428 F	.3995 F
8	12.0	1728	29.50	870	0.50347	0.0171	-2.920 F	-.0495 F	.0477 F
9	12.75	2073	30.50	930	0.44817	0.0147	-3.352 F	-.0493 F	-.2837 F
10	13.75	2600	31.00	961	0.36961	0.0119	-4.043 F	-.0482 F	-1.025 F
11	14.50	3048	30.60	936	0.30709	0.0100	-4.631 F	-.0465 F	-1.553 F
12	14.50	3048	29.40	864	0.28346	0.00965	-5.154 F	-.0500 F	-2.226 F
13	14.25	2900	27.20	740	0.25517	0.00938	-1.617 F	-.01519 F	1.117 F
14	13.75	2600	24.00	576	0.22154	0.00923	-2.390 F	-.0221 F	.0244 F
15	13.00	2197	20.40	416	0.18978	0.00929	-2.706 F	-.0251 F	-.65376 F
16	12.50	1953	16.60	275	0.14081	0.0085	-2.456 F	-.0209 F	-.7860 F
17	11.50	1521	12.25	150	0.09862	0.00805	-1.924 F	-.0155 F	-.69165 F
18	10.50	1157	8.25	68	0.05877	0.00713	-1.332 F	-.0095 F	-.5021 F
19	9.25	791	4.00	16	0.02023	0.00506	-.5735 F	-.0029 F	.1711 F
					$\Sigma = 4.774$			$\Sigma = -.1805$ F	

NOTE : $M_P = -R_{BY} * (66.75 - x)$ FOR SECT. 1-12

$M_P = -R_{BY} * (66.75 - x) - R_y(19.75 - x) + R_x(33.5 - y)$

6) THE GENERAL EQUATION BECOMES

$$H * \left[\Sigma \, y^2/h^3\right] + \left[\Sigma \, \frac{y * M_P}{h^3}\right] = 0$$

$$\Sigma \, y^2/h^3 = \tfrac{1}{3}\left[0 + 0 + 4(2.387) + 2(2.386)\right]$$

$= 4.774$

$$\sum \frac{y \ast Hp}{h^3} = \frac{1}{3}\left[0 + 0 + 4(.2329F) + 2(.25494F)\right]$$

$$= .4805F$$

So $H \ast 4.774 = .4805F$

$$H = .1006F$$

$$R_{ox} = .6689F - .1006F = .5683F$$

7) THE RESULTANT REACTION AT JOINT B

$$R_B = \sqrt{(.1006F)^2 + (.1213F)^2} = .1576F \qquad \tan\alpha = \frac{.1213}{.1006}$$

$$\alpha = 50.33°$$

8) THE RESULTANT REACTION AT JOINT O

$$R_o = \sqrt{(.5683F)^2 + (.8647F)^2} = 1.035F \qquad \tan\beta = \frac{.8647}{.5683}$$

$$\beta = 56.69°$$

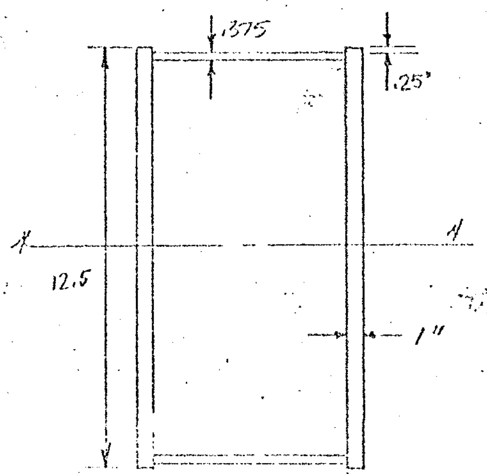
SECTION A-A (NODE 16)

$t = 1"$ $h = 12.5$

$M = .7860F$ $A_x = 1.035F$

AREA $= 2 \times t \times h = 25 \text{ in}^2$

$$S = \frac{2 \times t \times h^2}{6} = \frac{2 \times 12.5^2}{6} = 52 \text{ in}^3$$



ASSUME AVERAGE CROSS-SECTIONS AS SHOWN
THIS WILL BE USED TO FIND A, r SO
KL/r CAN BE FOUND AND FINALLY ALLOWABLE
COMPRESSIVE FORCE

$$I_{xx} = \frac{1}{12}(1)(12.5)^3 \times 2 + 6^2(6.25)(.375) \times 2$$

$$= 325.5 + 168.75$$

$$= 494.27 \text{ in}^4$$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{494.27}{25}} = 4.45$$

$$l = 39 \text{ in}$$

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

Mode of Failure

11750 Crane (Rotating)

DATE 11/5/75 PK

GS 17438
GS 17440

$$\frac{Kl}{r} = \frac{1.0 \times 39}{4.45} = 8.764 \qquad C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = 111.6$$

$$\text{so } F_a = \left[1 - \frac{(Kl/r)^2}{2C_c^2}\right] F_y \quad \text{where } F_y = 46 \text{ ksi (A-36)}$$

$$= \left[1 - \frac{(8.764)^2}{2(111.6)^2}\right] 46 \text{ ksi} = 45.8 \text{ ksi}$$

NEGLECTING SECONDARY STRESSES DUE TO DEFLECTION

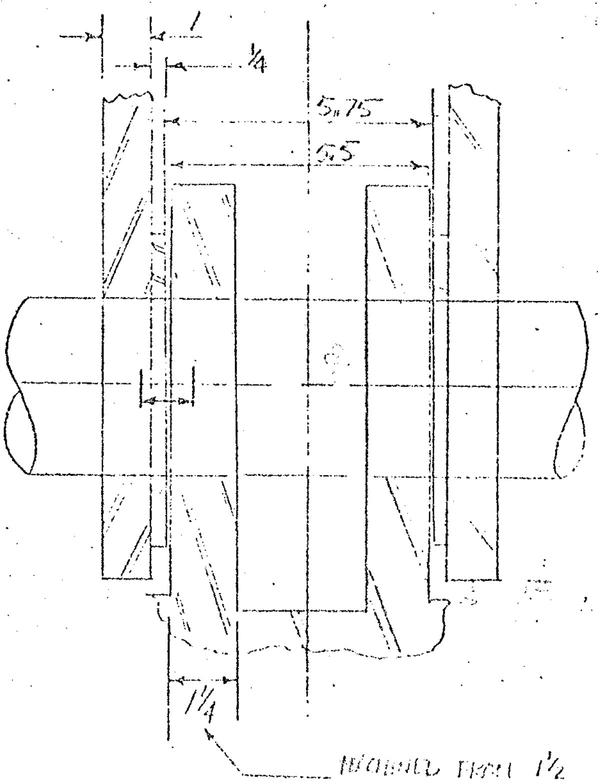
$$45.8 \text{ ksi} = \frac{1.035 F}{25 \text{ in}^2} + \frac{.7860 F\text{-in}}{52 \text{ in}^3}$$

$$45.8 \text{ ksi} = .0414 F + .0151 F$$

FORCE = 810.4 K / PER LEG OF A-FRAME
1621 K TOTAL

Maximum Force on Std A-Frame

Pin B



PIN B
3.496" DIA
Mat'l A-514
$F_v = .6(F_y)$
$= 60$ KSI

CHECK PIN IN DOUBLE SHEAR

$$A = \frac{\pi D^2}{4} = \frac{\pi (3.496)^2}{4}$$

$$= 9.6 \text{ in}^2$$

$$60 \text{ ksi} = \frac{F}{9.6 \text{ in}^2 \times 2}$$

FORCE = 1152 K / SIDE

(B) HOOK LOAD CAUSING FAILURE OF STD. A-FRAME

RADIUS	EQUATION: a+b(P)	HOOK LOAD (KIPS)
28	1621 = 8.297 + .355 P	4542
30	1621 = 9.455 + .402 P	4009
40	1621 = 16.0[illegible]7 + .667 P	2406
50	1621 = 23.809 + .93P	1630
60	1621 = 32.710 + 1.34P	1185
70	1621 = 42.685 + 1.745P	904.5
80	1621 = 53.727 + 2.197P	713.4
90	1621 = 65.875 + 2.697P	576.6
100	1621 = 79.222 + 3.2[illegible]P	473.7
110	1621 = 93.047 + 3.[illegible]P	394.3
120	1621 = 110.371 + 4.575P	330.2
130	1621 = 129.117 + 5.393P	276.6
140	1621 = 151.599 + 6.[illegible]P	232.0
150	1621 = 182.657 + 7.[illegible]P	183.6

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

11750 C HOISTAL CRANE

MODE OF FAILURE — DATE 11/6/75 — R.R.

Maximum Force on Deck at Backleg Connection

FORCE OF BACKLEG 1213.8 K

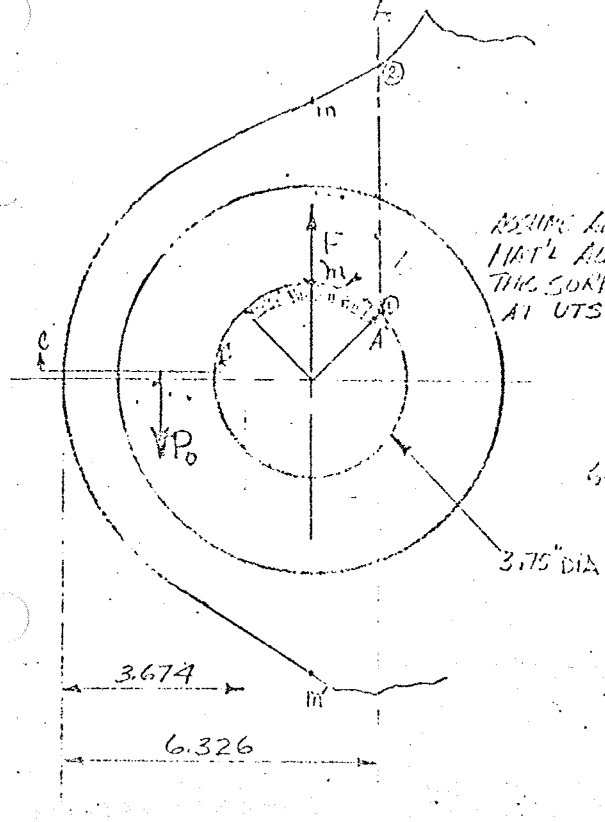
F = BACKLEG TENSION − STRUT / HOLE

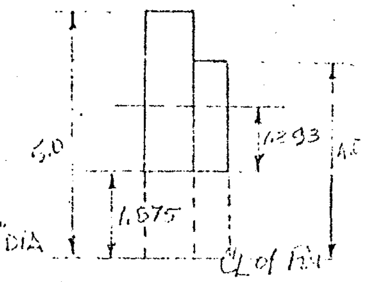
STRUT 110.83 K/4 = 27.71 K

TREATING AS CURVED BEAM ;

ROARK : FORMULAS FOR STRESS AND STRAIN

FOURTH EDITION − PAGE 16.4 CASE 1





$(5.0-1.875)1 = 3.125 \times \frac{3.125}{2} = 4.88$

$(4.0-1.875).75 = 1.594 \times 1.063 = 1.69$

$4.72 \qquad 6.57$

$\bar{x} = \frac{6.57}{4.72} = 1.393$

$R = 1.875 + 1.393 = 3.268$

$C = 1.393$

$\frac{R}{C} = 2.35 \qquad K_i \cong 1.443$

ASSUME FIBER STRESS AT m = UTS ∴ $f_m = 58$ KSI

Assisting Force P_o (Ignoring Restraining M)

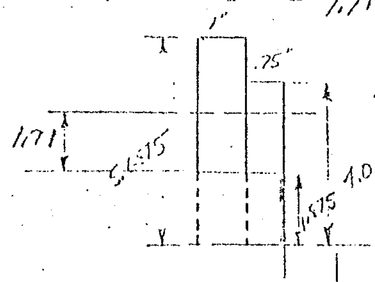
$f_m = \frac{P_o \times R}{S} K_i$

AND $P_o = \frac{S \times f_m}{K_i \times R}$

$P_o = \frac{3.88 \times 58}{1.443 \times 3.268}$

$= 47.72^K$

WHERE $S = \frac{I}{C} = \frac{6.63}{1.71} = 3.88$



$1(5.6875-1.875) = 3.94 \times \frac{3.94}{2} = 7.75$

$.75(4.0-1.875) = 1.594 \times 1.063 = 1.69$

$5.53 \qquad 9.44$

$\bar{x} = \frac{9.44}{5.53} = 1.71$

$I = \frac{1}{12}(1)(3.94)^3 + \frac{1}{12}(.75)(2.125)^3$

$+ (.26)^2(3.94) + (.648)^2(1.594)$

$= 6.63$

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

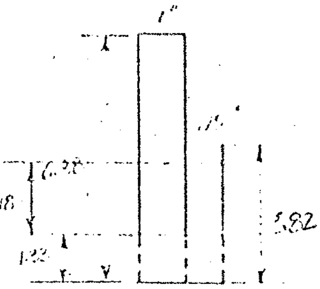
ESTIMATE 11150 SERIES PIN

MODE OF FAILURE

DATE 11/6/75

@ SECTION A-A - FAILS WHEN BOTH ① & ② AT UTS (f_{AVE} = UTS)

FIND FORCE NECESSARY TO BRING ② TO UTS



$1(6.38-1.33) = 5.05 \times \frac{5.05}{2} = 12.75$

$.75(3.82-1.33) = 1.87 \times \frac{2.49}{2} = 2.33$

$6.92 \qquad 15.075$

$\bar{y} = \frac{15.075}{6.92} = 2.18 \text{ in}$

$I = \frac{1}{12}(1)(5.05)^3 + \frac{1}{12}(.75)(2.49)^3 + (.935)^2(1.87) + (.345)^2(5.05)$

$= 10.73 + .965 + 1.634 + .601$

$= 13.93$

$S = \frac{I}{C} = \frac{13.93}{2.18} = 6.39 \text{ in}^3$

BENDING STRESS

$M = F(1.326) - 47.72(4.594) = 1.326F - 219.23$

$f_B = \frac{1.326F - 219.23}{6.39} \times .758 = .1573F - 26.00$

SHEAR STRESS

$A = 6.92 + [5.25 \times 1 + 2.375 \times .75] = 13.95 \text{ in}^2$

$f_V = \frac{F}{13.95} = .0717F$

COMBINED MAX BENDING STRESS

$f_{UTS} = 58\text{KSI} = \frac{f_b}{2} + \sqrt{\left(\frac{f_B}{2}\right)^2 + f_V^{\,2}}$

SOLVING FOR F YIELDS

FORCE = 429.26^K

COMBINED MAX SHEAR STRESS

$f_V = .6 \times 36\text{KSI} = 21.6 = \sqrt{\left(\frac{f_B}{2}\right)^2 + f_V}$

SOLVING FOR F YIELDS FORCE = 275.74

SHEAR. GOUGING - MAXIMUM FORCE $(275.74^K + 27.71^K)4 = 1213.8^K$

[illegible]

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

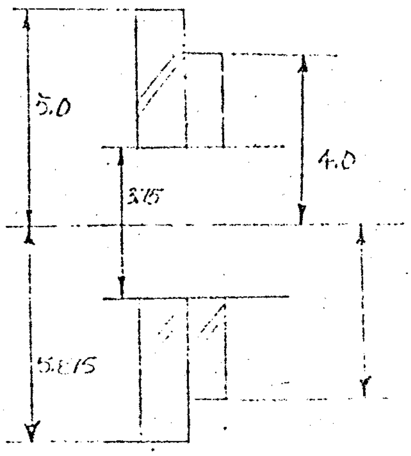
Hull or Fatigue

11750 [illegible] Pedestal

DATE 11/7/[illegible]

RC 17138
RC 17190

⊠ SECTION C–C – CHECK IN TENSION

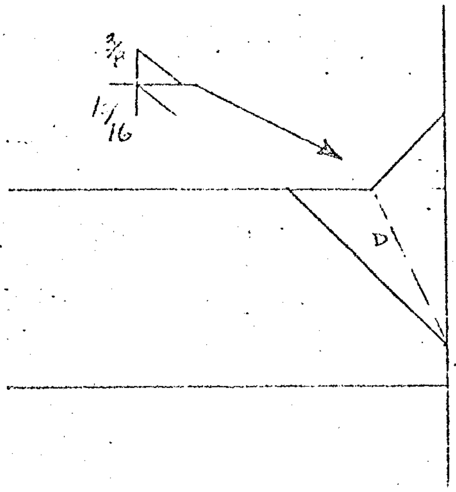


$AREA = (5.0 - 1.875) \times 1) - (4.0 - 1.875).75$
$= 4.72\ in^2$

$f_v = \frac{47.72^K}{4.72\ in^2} = 10.110\ ksi$

so F = 275.74 is OK

⊠ CHECK WELD AT CONNECTION TO DECK



CHECK IF WELD CAN TRANSFER PREVIOUS LIMITING FORCE

$FORCE = 237.65^K$

$T_e = D - \frac{1}{8} = 6/8$ AISC

$S_w = \frac{d^2 \times t}{6} = \frac{28^2 \times .75}{6} = 98\ in^3$

$A = .75 \times 28 = 21\ in^2$

$M = 237.65^K \times 9\ in = 2138.85\ k\text{-}in$

$V = 237.65^K$

$f_B = \frac{2138.85\ k\text{-}in}{98\ in^3} = 21.825\ ksi$

$f_v = \frac{237.65\ K}{21\ in^2} = 11.32\ ksi$

MAXIMUM PRINCIPLE BENDING $= \frac{21.825}{2} + \sqrt{\left(\frac{21.825}{2}\right)^2 + 11.32^2} = 26.64\ ksi < 58\ ksi$ UTS

MAXIMUM PRINCIPLE SHEAR $\sqrt{\left(\frac{21.825}{2}\right)^2 + 11.32^2} = 15.73\ ksi < .6(36) = 21.6\ ksi$ SHEAR [illegible]

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN

MODE OF FAILURE

11750 - CRANE PEDESTAL

DATE 11/

GS 17438
GS 17440

- CHECK PIN IN DOUBLE SHEAR

$AREA = \frac{\pi D^2}{4} = 11.027 \ in^2$ MATL A-54 $F_y = 100$

$F_v = .6(100 \ KSI) = 60 \ KSI$

$F_v = \frac{F}{2 \times A}$ SO $60 \ KSI = \frac{F}{2 \times 11.027}$

FORCE = 1323.2^K / BRACKET
661.6^K/HOLE

- CHECK BEARING PRESSURE

$58^K = \frac{F}{1.75^{in} \times 3.75^{in}}$

FORCE = 380.6^K

[illegible] 17450
GS 17440

MODE OF FAILURE

11750 CRANE (PEDESTAL)

DATE 11/7/75 RR

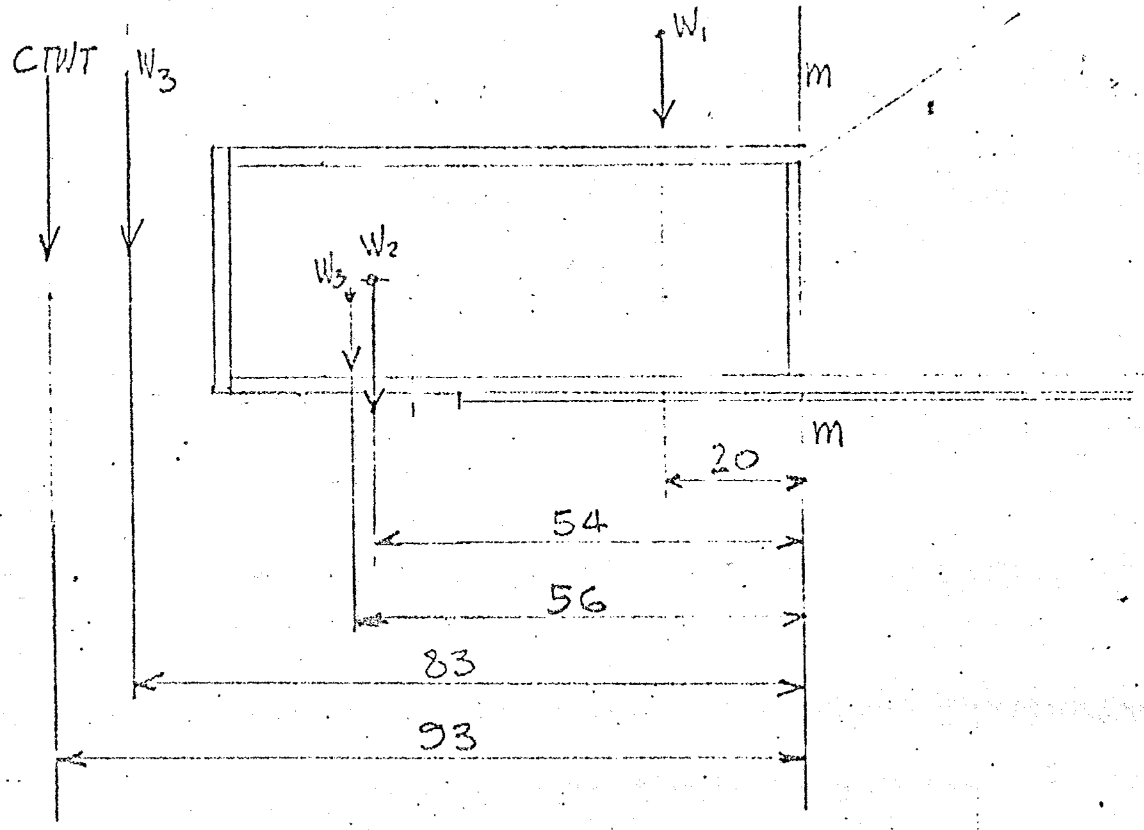
① HOOK LOAD CAUSING FAILURE AT BACKLEG CONNECTION TO DECK

RADIUS (FT)	EQUATION: a + b(P)	HOOK LOAD (KIPS)
28	1213.8 = 10.624 + .883 P	1350
30	1213.8 = 22.69 + .964 P	1235
40	1213.8 = 32.981 + 1.372 P	860.7
50	1213.8 = 43.259 + 1.782 P	656.9
60	1213.8 = 53.485 + 2.192 P	529.3
70	1213.8 = 63.618 + 2.602 P	442.0
80	1213.8 = 73.624 + 3.009 P	378.9
90	1213.8 = 83.456 + 3.416 P	330.9
100	1213.8 = 93.059 + 3.8[illegible] P	293.4
110	1213.8 = 102.365 + 4.219 P	263.4
120	1213.8 = 111.260 + 4.618 P	239.0
130	1213.8 = 119.6 + [illegible]	219.0
140	1213.8 = 127.003 + 5.362 P	202.7
150	1213.8 = 132.[illegible] + 7.8[illegible] P	138.1

110DC

AMERICAN HOIST & DERRICK CO. A-9189, GS-17438 — 11750 CRANE (PEDESTAL)
ST. PAUL, MINN — A-9190, GS-17440 — DATE

MODE OF FAILURE - REAR END OF MAIN BEAM OF CENTER BASE
REAR MOMENT OF DEAD LOADS ABOUT CRITICAL SECTION M-M



ENGINE INSTALLATION W_1	9.5×20	=	190 K"
BOOM HOIST DRUM ASSEMBLY W_2	5.5×54	=	297
REAR END OF CENTER BASE WGHT. W_3	7.25×56	=	406

TELESCOPING BACK LEGS 3.9^K 3.9^K
INNER BAIL ASS'Y 1.28 1.28
PART OF A-FRAME WELDMENT { $\frac{7.274 \times 21}{25}$ = 6.10

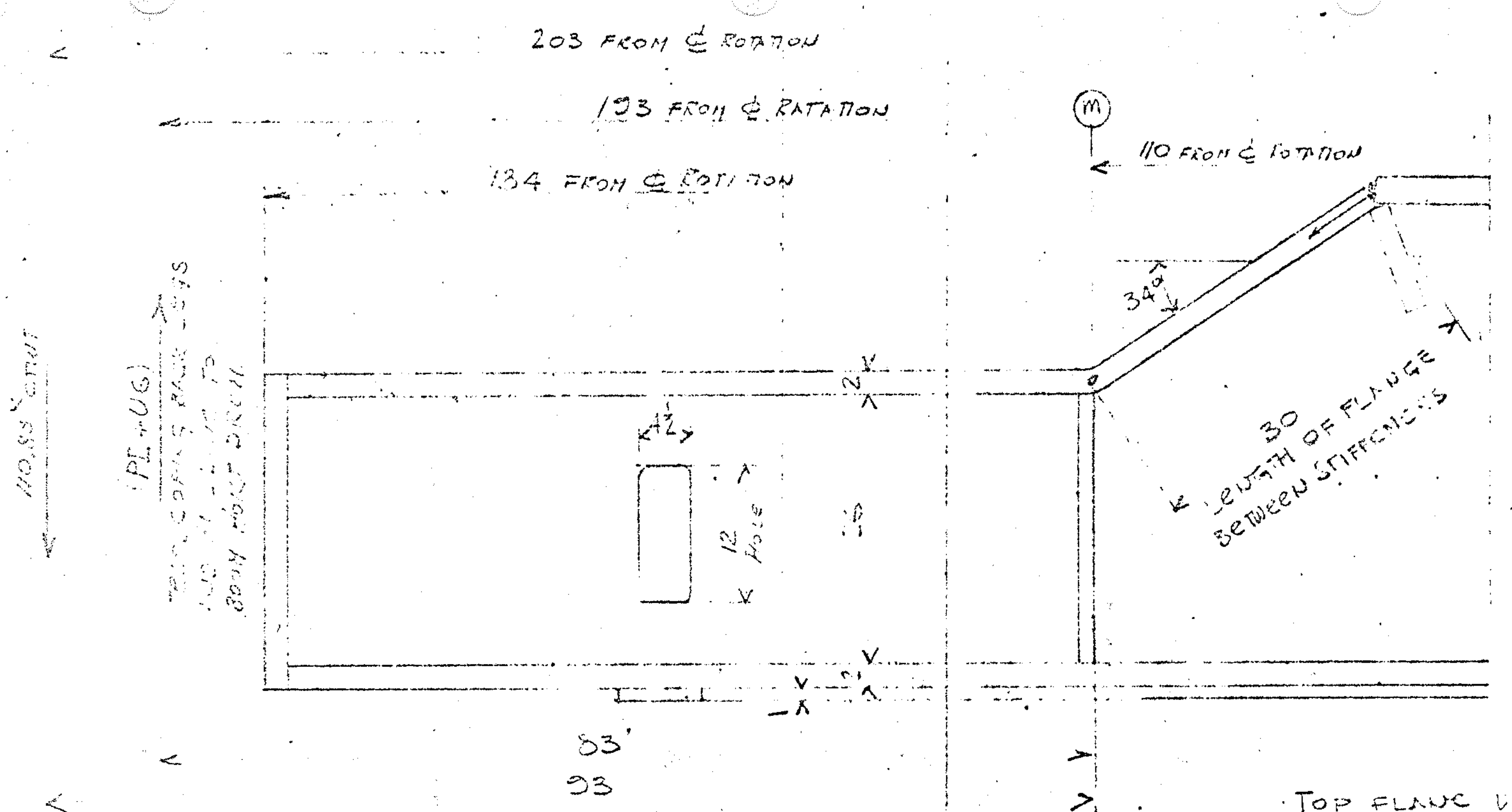
W_3 = 11.28^K — 11.28×83 = 936

COUNTERWEIGHT — 110.83×93 = 10307

MOMENT TOTAL 144 — 12136 K"

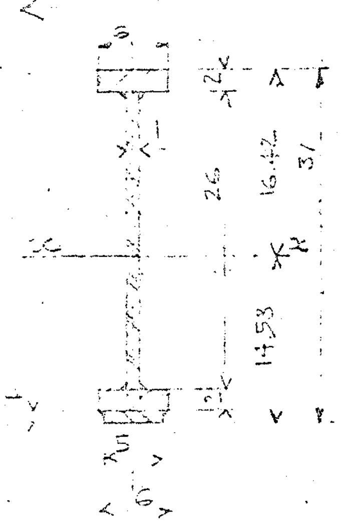
MOMENT ACTING ON SIDE BEAM = $M_D/2$

$= 12136/2 = 6068$ K"



R_{FT}	FORCE THRU TELESCOPE [illegible] PI	FOR [illegible] TO BOOM [illegible] UG
28	20.53 + [illegible].873 P	2.53 - [illegible] P
30	22.69 + 0.964	2.[illegible] + [illegible] P
40	32.[illegible]8 + 1.372	3.89 + [illegible] P
50	43.26 + 1.782 P	4.93 + [illegible]
60	53.48 + 2.193	[illegible].94 + [illegible] P
70	63.62 + 2.6[illegible]	6.92 + [illegible] P
80	73.62 + 3.00[illegible]	7.9 + [illegible] P
90	83.45 + 3.4[illegible]	8.89 + [illegible] P
100	93.06 + 3.82[illegible]	9.91 + [illegible] P
110	102.36 + 4.219	11.0 + 0.45 P
120	111.27 + 4.613	12.18 + 0.50 P
130	119.6 + 4.996	13.53 + 0.57 P
140	127.0 + 5.35[illegible]	15.2 + 0.64 P
150	132.3 + 5.676	17.7 + 0.76 P

← cutline



PROPERTIES OF CROSSSECTION m-m

Bottom Strip	5×1 =	5.0	× 0.5 =	[illegible].5
Bottom Flange	6×2 =	12.0	× 2.0 =	[illegible]
Web	1×26 =	26.0	× 16.0 =	[illegible]
Top Flange	6×2 =	12.0	× 30 =	3[illegible]
TOTAL		55.0		≈ 802

$y_{c1} = \frac{802}{55} \approx 14.58 \qquad y_{c2} = 31 - 14.58 = [illegible].42$

$I_x = \frac{1\times26^3}{12} + 26\times1.42^2 + 12\times15.42^2 + 12\times12.58^2 + 5\times14.0[illegible]^2 =$

$= 1464.67 + 52.43 + 2853.31 + 1899.08 + 991.23 \cong \underline{7260''^4}$

TOP FLANGE UNDER COMPRESSION

MAT. A-50 F_y = 42 KSI Y. POINT

ASSUME FLANGE FREE SUPPORTED BUCKL[illegible] IN SIDEWAY DIRECTION

$I = \frac{2\times6^3}{12} = 36''^4 \qquad r = \sqrt{\frac{36}{2\times6}} = 1.73$

$\frac{KL}{r} = \frac{1.0\times30}{1.73} \cong 18 \qquad C_c = \sqrt{\frac{2\pi^2E}{F_y}} = \sqrt{\frac{[illegible]\times10^3}{42}} \cong 116$

CRITICAL BUCKLING STRESS: $F_c = \left[1 - \frac{(KL/r)^2}{2C_c^2}\right]F_y = \left[1 - \frac{18^2}{2\times116^2}\right]\times42 = 41.4[illegible]$

CRITICAL BENDING MOMENT AT SECTION m-m

$M_{CR} = \frac{F_c \cdot I_x \times \cos 34^\circ}{y_{c2}} = \frac{41.49\times7260\times\cos 34^\circ}{[illegible].42} = [illegible]03$ KIP. INCH

A-9189, A-9190 GS-17438, GS-17440 11750 CRANE (PEDESTAL)

SUBJECT: MODE OF FAILURE

PROBLEM: HOOK LOAD P CAUSING THE FAILURE (IN BENDING) OF REAR END OF MAIN BEAMS OF CENTER BASE WELDMENT

R_{FT}	FORCE THRU TELESCOPING CA...LES PI (KIPS)	FORCE THRU ROPES TO BOOM HOIST DRUM UG (KIPS)	COMBINED FORCE PI+UG (KIPS)	HOOK LOAD F
28	20.53+0.883 P	2,55 + 0.11 P	23.2 + 0.993 P	493
30	22.69+0.964 P	2.79 + 0.12 P	25.48 + 1.084 P	449.5
40	32.98+1.372	3.89 + 0.16 P	36,87 + 1.532 P	310.5
50	43.26+1.782 P	4.93 + 0.20 P	48,19 + 1.982 P	234.4
60	53.48 + 2.193	5.94 + 0.24 P	59.4 + 2.433 P	186.3
70	63.62 + 2.602	6.92 + 0.28 P	70.54 + 2.832 P	153.4
80	73.62 + 3.009	7.9 + 0.32 P	81.52 + 3.329 P	129.5
90	83.45 + 3.416	8.89 + 0.36 P	92.34 + 3.776 P	111.3
100	93.06 + 3.820	9.91 + 0.41 P	102.47 + 4.23 P	96.9
110	102.36 + 4.219	11.0 + 0.45 P	113.36 + 4.664 P	85.53
120	111.27 + 4.613	12.18 + 0.50 P	123.45 + 5.113 P	76.13
130	119.6 + 4.996	13.53 + 0.57 P	133.13 + 5.566 P	68.19
140	127.0 + 5.35	15.2 + 0.64 P	142.2 + 5.799 P	61.76
150	132.3 + 5.676 P	17.7 + 0.76 P	150.0 + 6.436 P	56.35

← cut line

FOR SELECTED CROSS SECTION OF THE BEAM m-m

$$M_{CR} = 15208^{K''} = \left(\frac{PI+UG}{2}\right) \times 83 - \frac{M_D}{2}$$

$$M_{CR} = 15208^{K''} = (PI+UG)\,41.5 - 6068^{K''}$$

HENCE: $PI+UG = \dfrac{15208+6068}{41.5} = 512.7^{K}$

M_D - REAR MOMENT OF DEAD LOADS ABOUT "m-m" - SEE SEPARATE SHEET.

$(PI+UG) = a + bP$ (GENERAL EQUATION)

HERE:

a, b - PARAMETERS BASED ON HOOK LOAD RADIUS R

P - CRITICAL HOOK LOAD CAUSING THE FAILURE OF CENTER BASE BEAM AT SECTION "m-m"

CHECKING THE WEB AT SECTION THRU THE HOLE

NET AREA OF WEB = $(26-12) \times 1.0 = 14''^2$

SHEAR STRESS IN WEB WHEN CENTER BASE IS SUBJECTED TO CRITICAL FORCE $(PI+UG) \cong 513^{K}$

$$f_S = \left(513 - \frac{144}{2}\right)/14 \cong 13.2 \text{ KSI} < 25.2 \text{ KSI (NO PROBLEM)}$$

... FLANGE UNDER COMPRESSION

... REAR ... Y. POINT

... FLANGE FREE SUPPORTED ... BUCKLING

... DIRECTION

$= 32$ $r = \sqrt{\frac{32}{2 \times 6}} = 1.73$

$\frac{30}{1.73} \cong 18$ $C_c = \sqrt{\frac{2\pi^2 E}{F_Y}} = \sqrt{\frac{2\pi^2 \cdot 29 \cdot 10^3}{42}} \cong 116$

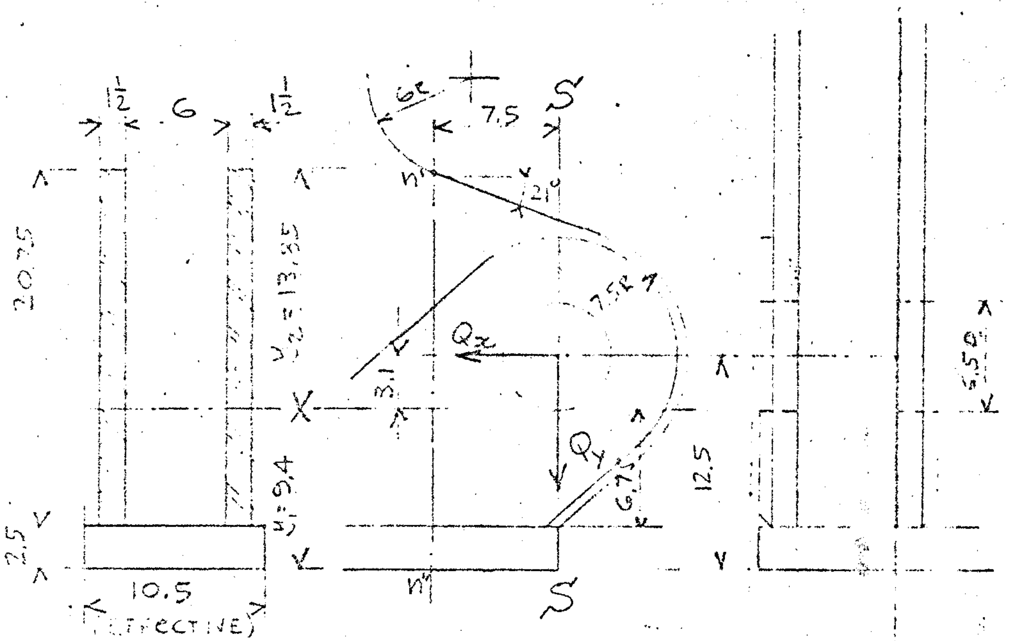
...BUCKLING STRESS $F_{CR} = \left[1 - \frac{(KL/r)^2}{2C_c^2}\right] F_Y = \left[1 - \frac{18^2}{2 \times 116^2}\right] \times 42 = 41.49 \text{ KSI}$

... BENDING MOMENT AT SECTION "m-m"

$F_Y \times CoL3Y'' = 41.49 \times 7... \times CoL3Y'' = ...93$ KP. INCH

PROBLEM: HOOK LOAD CAUSING THE [illegible] OF CENTER BASE WELDMENT

COMPONENTS OF BOOM FOOT REACTION PBY & PBX [illegible]



	COMPONENTS OF BOOM FOOT REACTION (KIPS) PBY ①	PBX ②	7.5 Q = = PBY×7.5 ③	[illegible]
28	56.39+1.813 P	5.40+0.251 P	211.46+[illegible] P	18 [illegible]
30	57.82+1.868 P	6.17+0.282 P	216.82+[illegible] P	[illegible]
40	64.39+2.123 P	10.52+[illegible] P	241.46+[illegible] P	[illegible]
50	[illegible].95+2.347 P	15.69+0.697 P	262.[illegible]	[illegible]
60	74.[illegible]+2.525 P	21.63+0.922 P	[illegible]	72 [illegible]
70	78.49+[illegible] P	28.29+1.190 P	294.3+9.031 P	
80	81.37+2.739 P	35.63+1.505 P	305.14+[illegible] P	
90	83.29+2.867 P	43.82+1.845 P	312.34+[illegible] P	
100	84.14+2.902 P	52.78+2.225 P	315.5[illegible] P	
110	83.[illegible]5+[illegible] P	62.68+2.[illegible] P	[illegible]	
120	81.31+2.514 P	73.74+3.123 P	306.7[illegible]+[illegible] P	
130	77.77+2.[illegible] P	86.58+3.[illegible] P	29[illegible]+[illegible] P	
140	70.39+2.348 P	101.57+4.362 P	263.[illegible]	
150	55.54+1.710 P	122.61+5.338 P	208.[illegible]+[illegible] P	

CRITICAL SECTION n'-n' (IGNORING REINFORCING [illegible])

2.5×10.5	=	26.25 in²	×1.25	≅ 32.8
20.75×2×1.5	=	62.25	×13.87	≅ 801.[illegible]
	AREA	88.5 in²		834

$y_1 = \frac{834}{88.5} = 9.4 \qquad y_2 = 20.75+2.5-9.4 = 13.85$

$I_x = \frac{2\times1.5\times20.75^3}{12} + 62.25\times[illegible]^2 + 26.25\times8.15^2 \cong 472[illegible] \text{ in}^4$

STRESS AT EXTREME FIBER:

$F_{n'} = +\frac{(7.5Q_y - 3.1Q_x)\,13.85}{I_x \cos 21°} - \frac{Q_x}{88.5} \qquad F_{n''} = -\frac{(7.5Q_y - 3.1Q_x)\times9.5}{I_x} - \frac{Q_x}{88.5}$

THEN FOR T1-PLATES WITH 115 KSI TENS. STRESS [illegible]

$(7.5Q_y - 6.7Q_x) = [illegible]$ (K-INCH) (FAILURE AT [illegible] $F_n = 115$ KSI)

$(7.5Q_y + 3.15Q_x) = 55623$ (K-INCH) (FAILURE AT [illegible] F_n 100 KSI, COMP.)

CRITICAL SECTION S-S' [illegible]

EFFECTIVE [illegible]

$2\times2.25\times6.75 = 30.38 \text{ in}^2$ [illegible]

CRITICAL SHEAR FORCE = (PBY) = [illegible]

(IGNORING ASSISTANCE OF [illegible])

ESTIMATED CRITICAL BOOM FO[illegible]

$P_{CR} = 100\times2.25\times2\times[illegible]$

SUBJECT: MODE OF FAILURE. A-9189, GS-17438 A-9190, GS-17440

11750 CRANE (HYDRAULIC ...)

PROBLEM: HOOK LOAD CAUSING THE FAILURE OF FRONT END OF MAIN BEAMS OF CENTER BASE WELDMENT

COMPONENTS OF BOOM FOOT REACTION PBY & PBX (AS FUNCTION OF HOOK LOAD) SEE SEPARATE SHEETS

	COMPONENTS OF BOOM FOOT REACTION (KIPS) PBY (1)	PBX (2)	$7.5Q_y = \frac{PBY \times 7.5}{2}$ (3)	FAILURE OF FIBER AT ...' $7Q_x = \frac{7 \cdot PBX}{2}$ (4)	LINE 3 LESS LINE 4 (5)	P' KIPS (6)	FAILURE OF FIBER AT 11" $3.18Q_x = \frac{3.18 \cdot PBX}{2}$ (7)	LINE (3) PLUS LINE (7) (8)	P'' KIPS (9)	P''' KIPS	BOOM FOOT REACTION $P_a = \sqrt{PBY^2 + PBX^2}$	P'''' KIPS	P KIPS
28	53.39+1.313P	5.40+0.251P	211.46+6.795P	18.90+.841P	193+5.158P	6119	8.59+0.319P	220+7.178P	7617	1992			1992
30	57.82+1.868P	6.17+0.282P	216.82+7.005P	[illegible]	196+6.06P	6015	9.81+0.448P	227+7.453P	7433	1932			1932
40	64.39+2.123P	10.52+0.443P	241.46+7.961P	36.82+1.551P	206+6.41P	5685	16.73+0.736P	258+8.697P	6366	1693			1698
50	69.95+2.341P	15.69+0.697P	262.45+8.712P	52.56+2.335P	210+6.447P	5652	24.95+1.108P	287+9.81P	5555	1538			1538
60	74.69+2.525P	21.63+0.922P	280.07+9.470P	72.0+3.087P	208+6.38P	5712	34.39+1.466P	314+10.935P	5058	1425			1425
70	78.49+2.675P	28.29+1.199P	294.34+10.031P				44.98+1.906P	339+11.937P	4651	1345			1345
80	81.37+2.789P	35.68+1.505P	305.14+10.459P				56.73+2.393P	362+12.852P	4300	1289			1289
90	83.29+2.867P	43.82+1.845P	312.34+10.751P				69.67+2.933P	382+13.684P	4037	1255			1253
100	84.14+2.902P	52.78+2.225P	315.52+10.88P				83.92+3.534P	399+14.416P	3880	1238	99.3+3.65P		1238
110	83.75+2.889P	62.68+2.646P	314.06+10.834P				99.66+4.207P	414+15.041P	3670	1244	104.6+3.9P		1244
120	81.81+2.814P	73.74+3.123P	306.79+10.552P				117.2+4.965P	424+15.517P	3557	1278	110.1+4.20P		1278
130	77.77+2.651P	86.58+3.679P	291.64+9.941P				137.3+5.850P	429+15.791P	3495	1345	116.2+4.53P	1394	1345
140	70.39+2.348P	101.57+4.362P	263.96+8.805P				161.5+6.935P	425+15.74P	3506	1522	123.5+4.95P	1275	1275
150	55.54+1.719P	122.61+5.338P	208.27+6.416P				194.9+8.487P			2088	134.6+5.6P	1125	1125

Note.

P' & P'' HOOK LOADS CAUSING THE FAILURE IN BENDING AT CRITICAL SECTION ...

P''' - HOOK LOAD CAUSING THE FAILURE IN SHEAR AT SECTION S-S

P'''' - HOOK LOAD CAUSING FAILURE IN COMPRESSION UNDER THE FOOT PINS

P - FINAL HOOK LOAD (FAILURE OF FRONT END BEAM OF CENTER BASE)

CRITICAL SECTION S-S FAILURE IN SHEAR.

EFFECTIVE ... WELDING ... PLATES

$2 \times 2.25 \times 6.75 = 30.38''^2$ TOTAL AREA (BOTH SIDES) $= 2 \times 30.38 = 60.75''^2$

CRITICAL SHEAR FORCE $= (PBY) = 0.6 \times 100 \times 60.75 = 3645^K$

(IGNORING ASSISTANCE OF UPPER BRIDGE)

ESTIMATED CRITICAL BOOM FOOT FORCE

$P_{BCR} = 100 \times 2.25 \times 2 \times 2 \times ...5 \times 1.1 = 6435_K$

CRITICAL FORCE CAUSING THE FAILURE OF BOOM FOOT PINS IN DOUBLE SHEAR

$P_{SCR} = 100 \times 0.6 \times 4 \times \pi 6.1^2 = 7364_K > 6435_K$

AMERICAN HOIST & DERRICK CO. A-9110, GS-17440 1175D CRANE (PEDESTAL)
ST. PAUL, MINN.

DATE

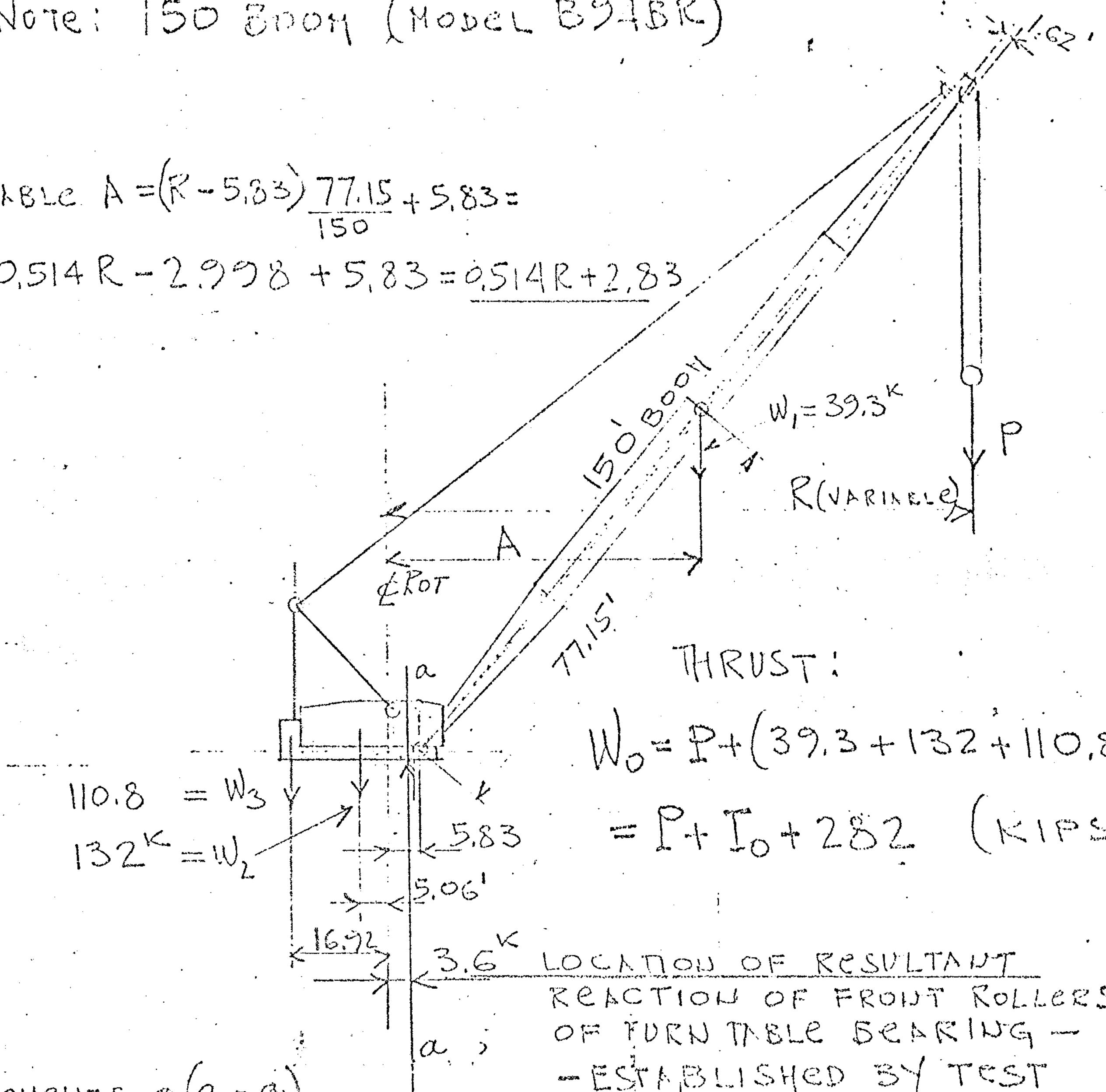
MODE OF FAILURE

FORWARD MOMENT & THRUST AS FUNCTIONS OF HOOK LOAD AND HOOK LOAD RADIUS – GENERAL FORMS

NOTE: 150' BOOM (MODEL B94BR)

VARIABLE $A = (R - 5.83)\frac{77.15}{150} + 5.83 =$

$= 0.514R - 2.998 + 5.83 = \underline{0.514R + 2.83}$



THRUST:

$W_0 = P + (39.3 + 132 + 110.8) + T_0$

$= P + T_0 + 282$ (KIPS)

3.6K LOCATION OF RESULTANT REACTION OF FRONT ROLLERS OF TURNTABLE BEARING – – ESTABLISHED BY TEST

MOMENTS @ (a – a)

L.LOAD	$P \times (R - 3.6)$	=	$P(R - 3.6)$
W_1	$39.3(0.514R + 2.83 - 3.6)$	=	$20.2R - 30.26$
W_2	$132.0(-5.6 - 3.6)$	=	-1214.4
W_3	$110.8(-16.92 - 3.6)$	=	-2273.6

$M_{R_{(a-a)}} = P(R - 3.6) + 20.2R - 3518$ (KIPS, FT)

(MOMENT IS RESISTED BY [illegible] ON REAR END OF TURNTABLE BEARING)

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

A-9189, GS-17438
A-9190, GS-17440

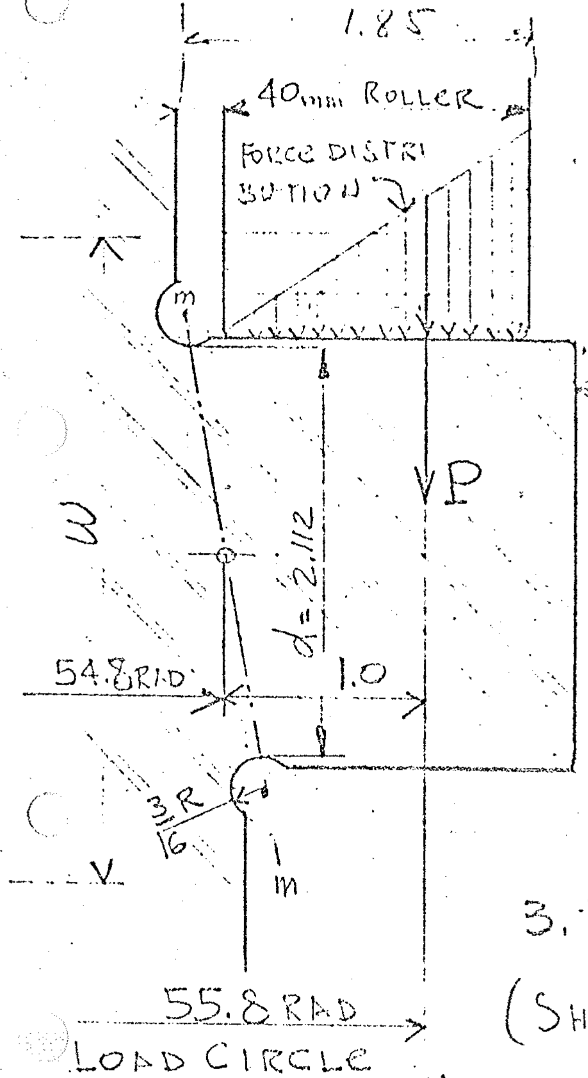
11750 CRANE (PEDESTAL)

DATE

MODE OF FAILURE

TURN TABLE ROLLER BEARING – ROTEX 3R13-111N4

PROBLEM: FORCE P PER ONE INCH OF LOAD CIRCLE CAUSING THE FAILURE (IN BENDING) OF THE FLANGE SUPPORTING THE LOAD (UPPER) ROLLERS



1. MATERIAL AISI-4140 WITH 250 TO 300 BHN, 130 KSI. BE. STRENGTH.

2. SECTION MODULUS AT "m-m"

$$S = \frac{bh^2}{6}; \quad h = 2.112$$

$$b = \frac{1.0 \times 54.8}{55.8} = 0.982$$

$$S = \frac{0.982 \times 2.112^2}{6} = 0.73$$

3. STRESS CONCENTRATION FACTOR AT m-m. (SHIGLEY, PAGE 614, FIG. A-12-4)

ASSUME $\frac{W}{d} = \infty$ (CONSERVATIVE

$r/d = 0.1875/2.112 \cong 0.09$ $\quad K_t = 2.3$

4. $F_{cr} = \frac{M_B \times K_t}{S} = \frac{P \times 1.0 \times 2.3}{0.73}$

$$P = \frac{130 \times 0.73}{1.0 \times 2.3} = 41.26 \text{ KIPS}$$

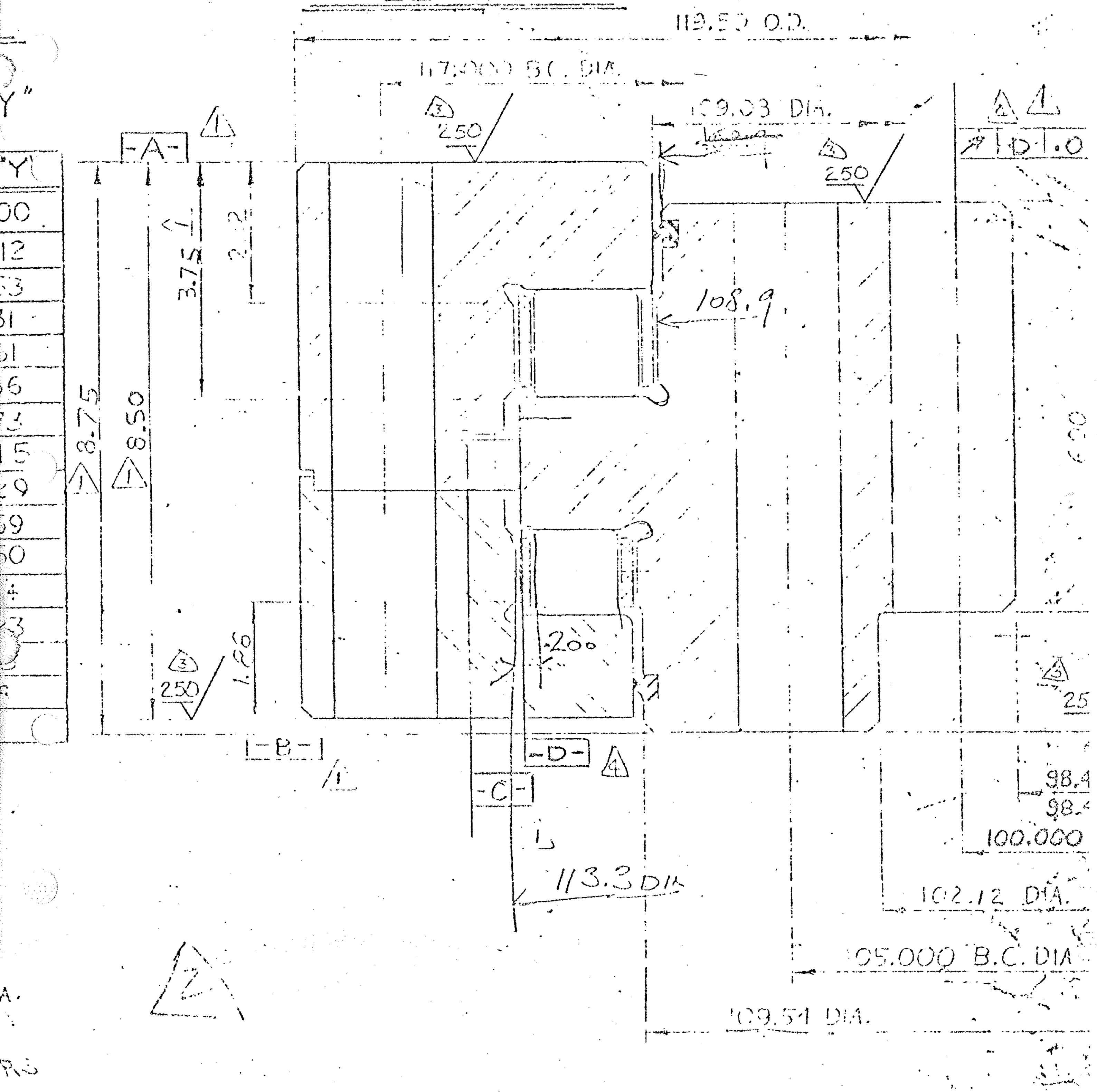
5. AVERAGE PER ONE INCH OF LOAD CIRCLE

$$P_a = 41.26/1.21 \cong 32^K$$

716182	4

SHEET 2 OF 2

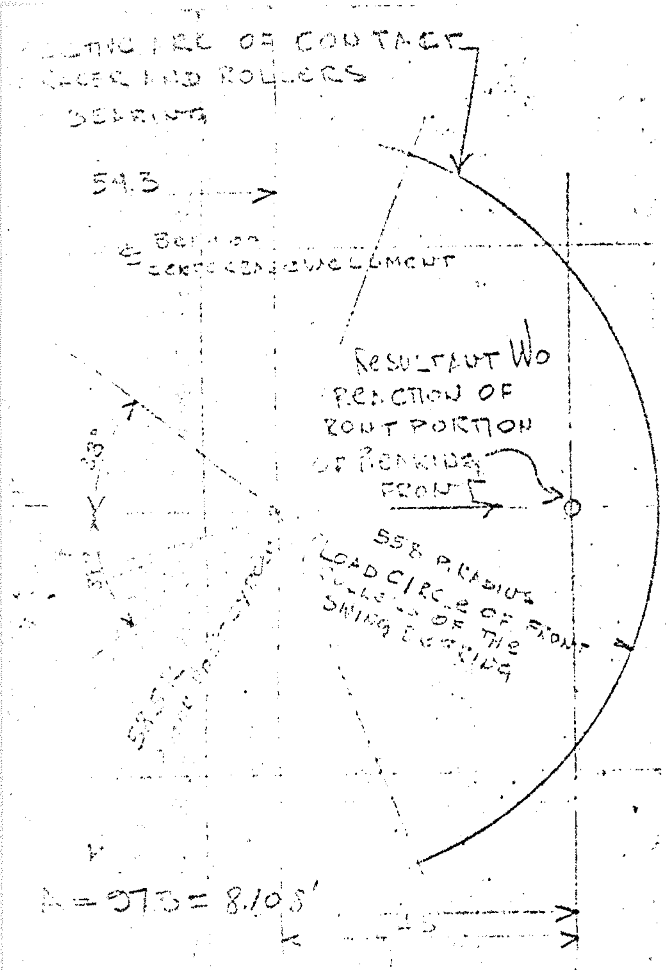
[illegible]
TURN TABLE BEARING
ROTEX 3R13-111N

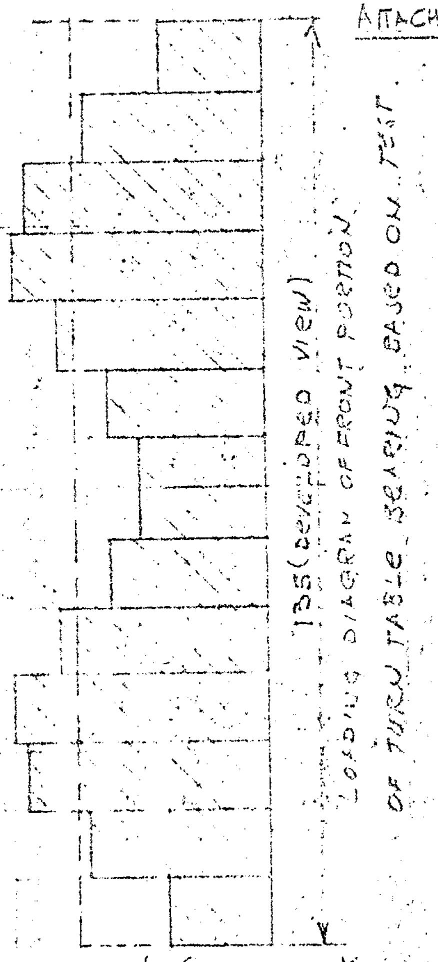


NOTE:

DIMENSIONS APPLIED TO INSIDE HOLES ONLY

ATTACHMENT 150' BOOM-394BR A-9107, GS-17439 A-9190, GS-17440 1750 ...





P_u (average) = 32^k

$P_{max} = P \times 1.29 = 41.26^k$

CRITICAL

MODE OF FAILURE

HOOK LOAD CAUSING THE FAILURE OF TURN TABLE ROLLER ...

P_T - CAUSING THE FAILURE OF ANCHOR BOLTS AT REAR

P_B - CAUSING THE FAILURE OF SUPPORTING FLANGE FOR FRONT LOAD ROLLERS

R	R-3.6 = B	HOOK LOAD CAUSING FAILURE OF ANCHOR BOLTS AT REAR		HOOK LOAD CAUSING FAILURE OF THE RACES AT THE FRONT	
		$P_T = \frac{27355 - 20.2R}{R-3.6}$ (KIPS)	RESULTANT: $W_o = P + T_o + 282$	$W_o = P(1+\frac{B}{8.108}) + 2.49R - 150$	P_B (KIPS)
28	24.4	1098	4320	4.009P - 80.28	1098
30	26.4	1013	4235	4.256P - 75.3	1033
40	36.4	729	3951	5.489P - 50.4	796
50	46.4	567	3789	6.723P - 25.5	646
60	56.4	463	3685	7.956P - 0.6	543
70	66.4	390	3612	9.189P + 24.3	467
80	76.4	337	3559	10.423P + 49.2	410
90	86.4	295	3517	11.656P + 74.1	364
100	96.4	263	3485	12.889P + 99	327
110	106.4	236	3458	14.123P + 123.9	297
120	116.4	214	3436	15.356P + 148.8	272
130	126.4	195	3417	16.589P + 173.7	250
140	136.4	180	3402	17.823P + 198.6	231
150	146.4	166	3388	19.056P + 223.5	215

$2P_1 \left[\int_0^{10.5} 1 \times 53.5\, dx + \int_0^{32°} 53.5^2 \cos\alpha\, d\alpha \right]$

$\ldots \sin 35° \Big] = 2P_1\, 3775 = 7550 P_1$

FOR ANCHOR BOLT $1\frac{1}{2} \times 6$ NC - A-490

TENSILE LOAD PER BOLT = 210^K MIN

CRITICAL UPLIFT FORCE $T_o = 210 \times 14 = 2940^K$

CRITICAL $M_R = 2940 \times 8.108 = 23837^{K\,FT}$

THEN $M_R = 23837 = P(R-3.6) + 20.2R - 3518$

CRITICAL HOOK LOAD = $\frac{27355 - 20.2R}{(R-3.6)}$

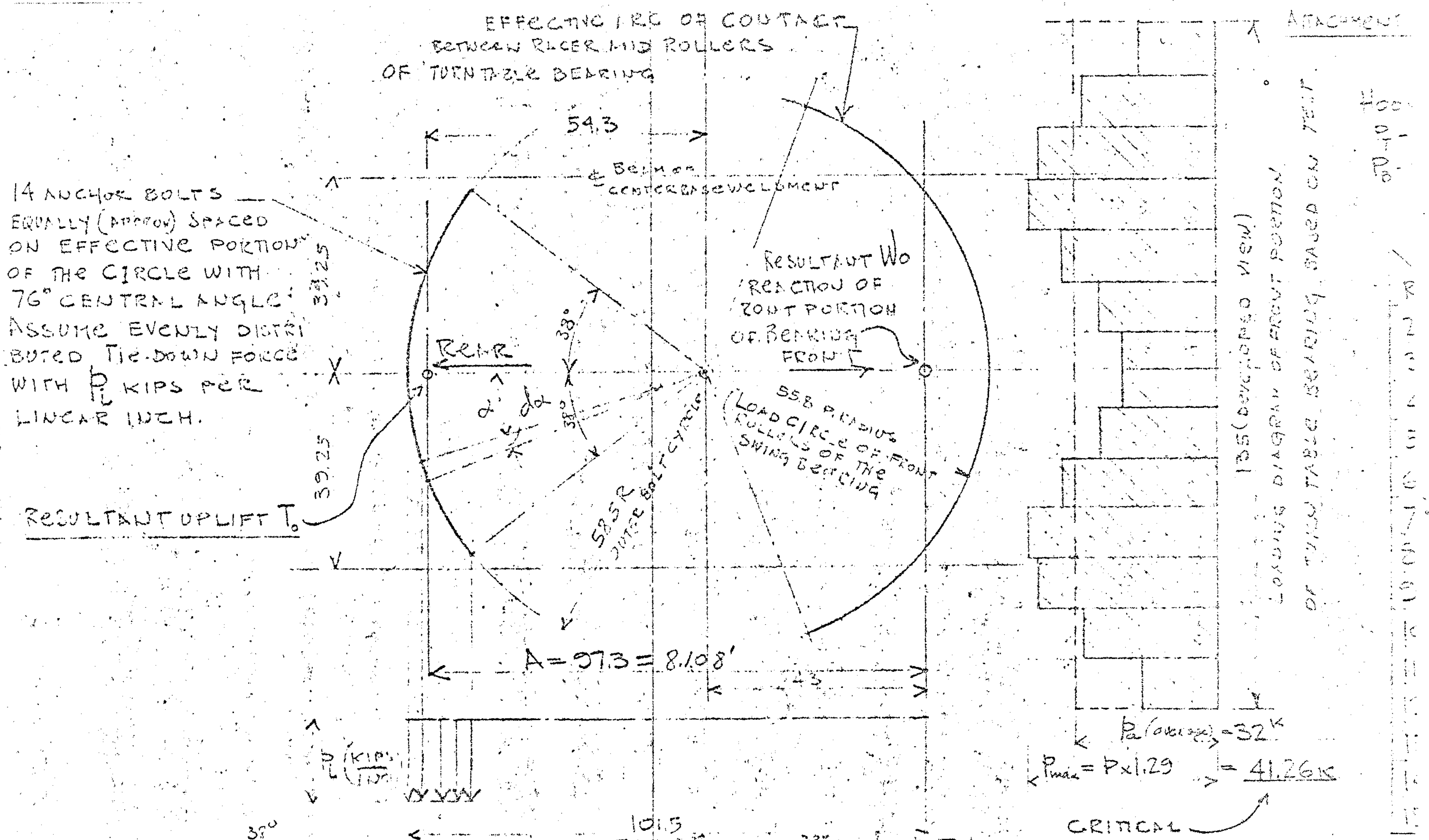
FOR CRITICAL THRUST $W_o = 32 \times 135 = 4320^K$

$W_o = P + T + 282$

$T = \frac{M}{A} = P\frac{(R-3.6)}{8.108} + \frac{20.2R}{8.108} - \frac{3518}{8.108}$

$W_o = P + P\frac{(R-3.6)}{8.108} + 2.49R - 432 + 282$

$W_o = P\left(1 + \frac{B}{8.108}\right) + 2.49R - 150$



$$M_R = 2\int^{38°} p_1\, 58.5\, d\alpha\,(43 + 58.5\cos\alpha) = 2p_1\left[\int_0^{38} 43 \times 58.5\, d\alpha + \int_0^{38°} 58.5^2 \cos\alpha\, d\alpha\right]$$

$$M_R = 2p_L\left[\frac{43 \times 58.5 \times 38 \times \pi}{180} + 58.5^2 \times \sin 38°\right] = 2p_1 3775 = 7550 P_1$$

OR $\underline{M_R = T_0 \times 8.108 \text{ KP.FT.}}$

FOR ANCHOR BOLT $1\frac{1}{2}$ x 6N

TENSILE LOAD PER BOLT

CRITICAL UPLIFT FORCE

CRITICAL M_R = 2940×8.1

THEN M_R = 23837 = P(R-3.

CRITICAL HOOK LOAD = 273

- HOOK LOAD CAUSING FAILURE OF LOAD LINE

  * TYPE 1¼" ∅ BRIDON - 12 PARTS 175 K BS.
  ALLOWABLE FORCE = 2100 K

  THE HOOK LOAD TO CAUSE FAILURE IS INDEPENDENT OF THE RADIUS (ASSUMING MAXIMUM OF 12 PARTS USED). BUT THE ALLOWABLE FORCE CAN BE VARIED BY CHANGING THE NUMBER OF PARTS TO ACHIEVE DESIRED SAFETY FACTORS.

  MAXIMUM HOOK LOAD FOR 12 PARTS **2100 K**

- HOOK LOAD CAUSING FAILURE OF DEAD END

  THE HOOK LOAD REQUIRED TO CAUSE FAILURE IS INDEPENDENT OF THE RADIUS BECAUSE THE FORCE IS TRANSFERED TO THE DEAD END BY THE LOAD LINE

  MAXIMUM HOOK LOAD FOR 12 PARTS **1149 K**

- HOOK LOAD CAUSING FAILURE OF BOOM POINT KNUCKLE

  THE HOOK LOAD REQUIRED TO CAUSE FAILURE IS INDEPENDENT OF THE RADIUS BUT VERY DEPENDENT ON THE NUMBER OF PARTS OF LOAD LINE. 12 PARTS IS THE WORST CONDITION

  MAXIMUM HOOK LOAD FOR 12 PARTS **1530 K**

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

GS 17440

11750 Crawl. (Special)

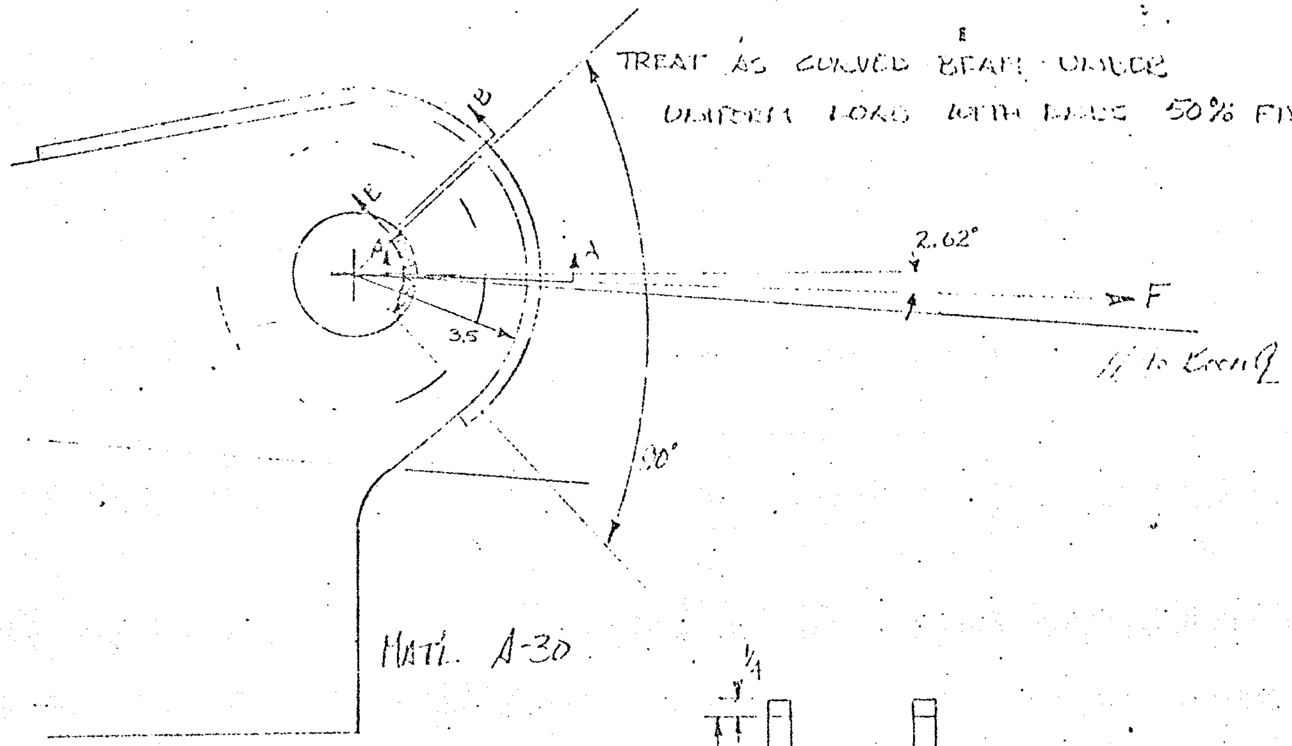
MOD. OF FAILURE

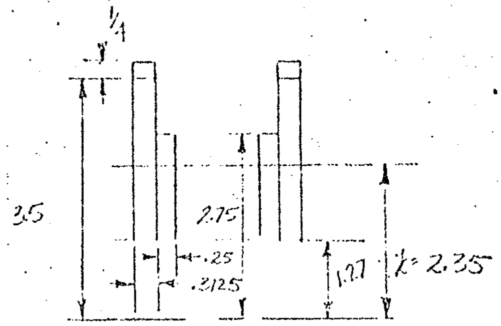
DATE 11/13/75

① MAXIMUM ALLOWABLE FORCE ON DEAD END

ASSUMING 12 PTS OF LOAD LINE

1649 K





$2([3.75-1.27]\times .3125) = 1.55 \times 2.51 = 3.89$

$2([2.75-1.27]\times .25) = \underline{.74} \times 2.01 = \underline{1.49}$

$2.29 \qquad 5.38$

$\bar{X} = \frac{5.38}{2.29} = 2.35$

$\frac{R}{C} = \frac{2.35}{1.08} = 2.176$

USING ROARK: FORMULAS FOR STRESS AND STRAIN PG 164 CASE 1

$K_i = 1.483$

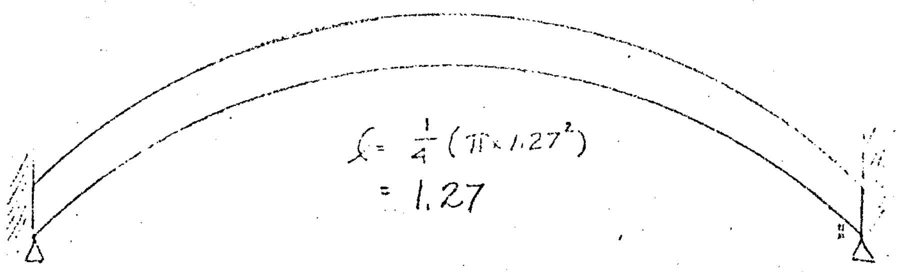
AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

65 11440

Mode of Failure

11750 Crane (Pedestal)

DATE 11/12/75 RK



$M_{max} = \frac{1}{10} w \ell^2 \qquad w = \frac{F}{\ell} \qquad V = \frac{1}{2} F = .5F$

$= \frac{1}{10} F \ell = .127 F$

Check Section A-A (Bending)

$S = \frac{I}{C} \qquad I = \frac{1}{12}(.3125)(2.48)^3 \quad .3972$

$+ \frac{1}{12}(.25)(1.48)^3 \quad .0675$

$+ .16^2(1.55) \quad .0397$

$+ .31^2(.74) \quad .0855$

$.590$

$C = 2.35 - 1.27 = 1.08$

$F_{UTS} = 70 \text{ KSI} = \frac{.127 F \times 1.08}{.590} \times 1.483$

Force = 203 K

Check Section B-B (Shear)

Area = 2.29 in

$F_v = .6(50) = \frac{.5F}{2.29}$

Force = 137.4 K

Check Bearing Pressure

$F_{br}: 70 \text{ KSI} = \frac{F}{(.25+.31)2.53}$

Force = 99.7 K — This doesn't cause failure

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

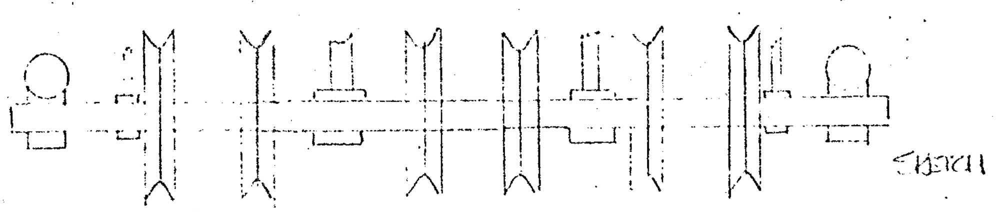
11750: CRANE (PEDESTAL)

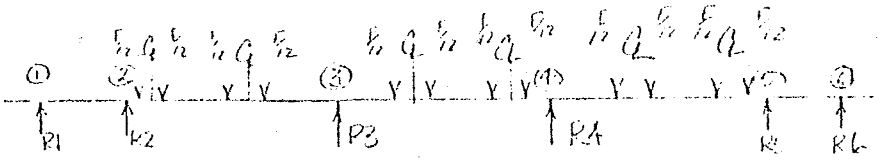
DATE 11/11/75 — RK

① MAXIMUM ALLOWABLE FORCE ON BOOM POINT AXLE

1530 K
12 PTS OF L.L.

② CHECK WITH 12 PARTS





USE THREE MOMENT EQUATION TO SOLVE FOR REACTIONS

END CONDITIONS

$M_1 = M_6 = 0$

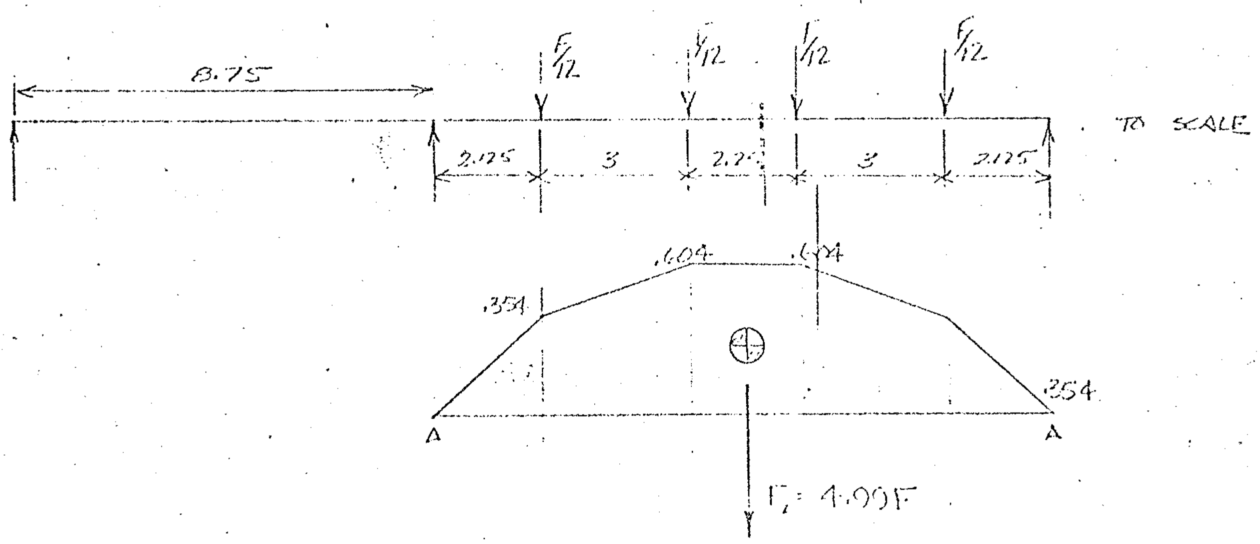
$M_2 = M_5$

$M_3 = M_4$

EQUATION

$$M_1 L_1 + 2M_2(L_1 + L_2) + M_3 L_2 = -\frac{6F_1 U_1}{L_1} + -\frac{6F_2 V_2}{L_2}$$

SPAN 1



AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

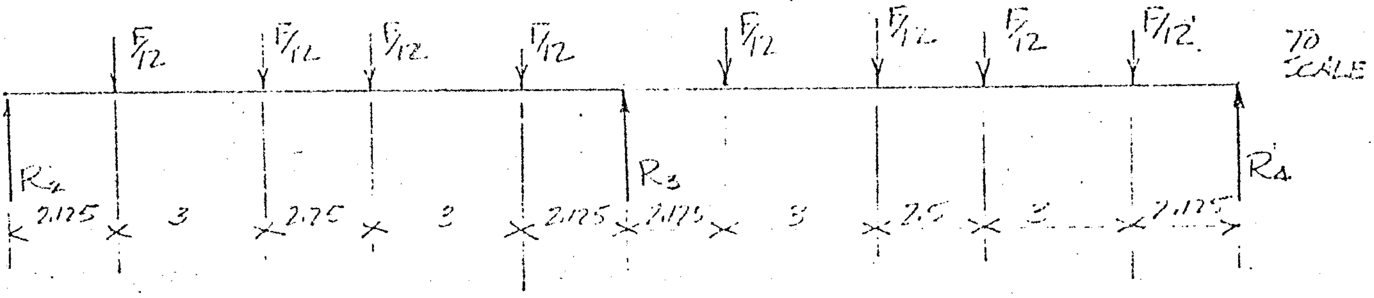
11750 · CRANE (CRITERIA)
DATE 11/4/75 RK

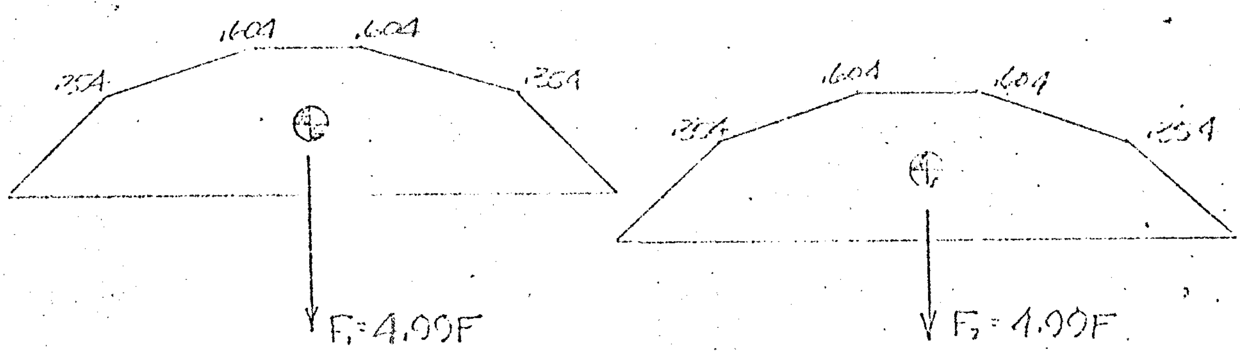
SPAN 1 EQUATION

$$0 + 2M_2(8.75+12.5) + M_3(12.5) = 0 - \frac{6(4.99)F(6.25)}{12.5}$$

$$43M_2 + 12.5M_3 = -14.97F$$

SPAN 2





SPAN 2 EQUATION

$$M_2(12.5) + 2M_3(2(12.5)) + M_4(12.5) = -2\left(\frac{6(4.99F)(6.25)}{12.5}\right)$$

$$12.5M_2 + 62.5M_3 = -29.94F$$

SOLVING YEILDS

$$M_2 = -.2216F \qquad M_3 = -.4352F$$

AND

$$.2216F = (R_1 \times 8.75) \qquad R_1 = .0253F$$

LET $X = R_1 + R_2$

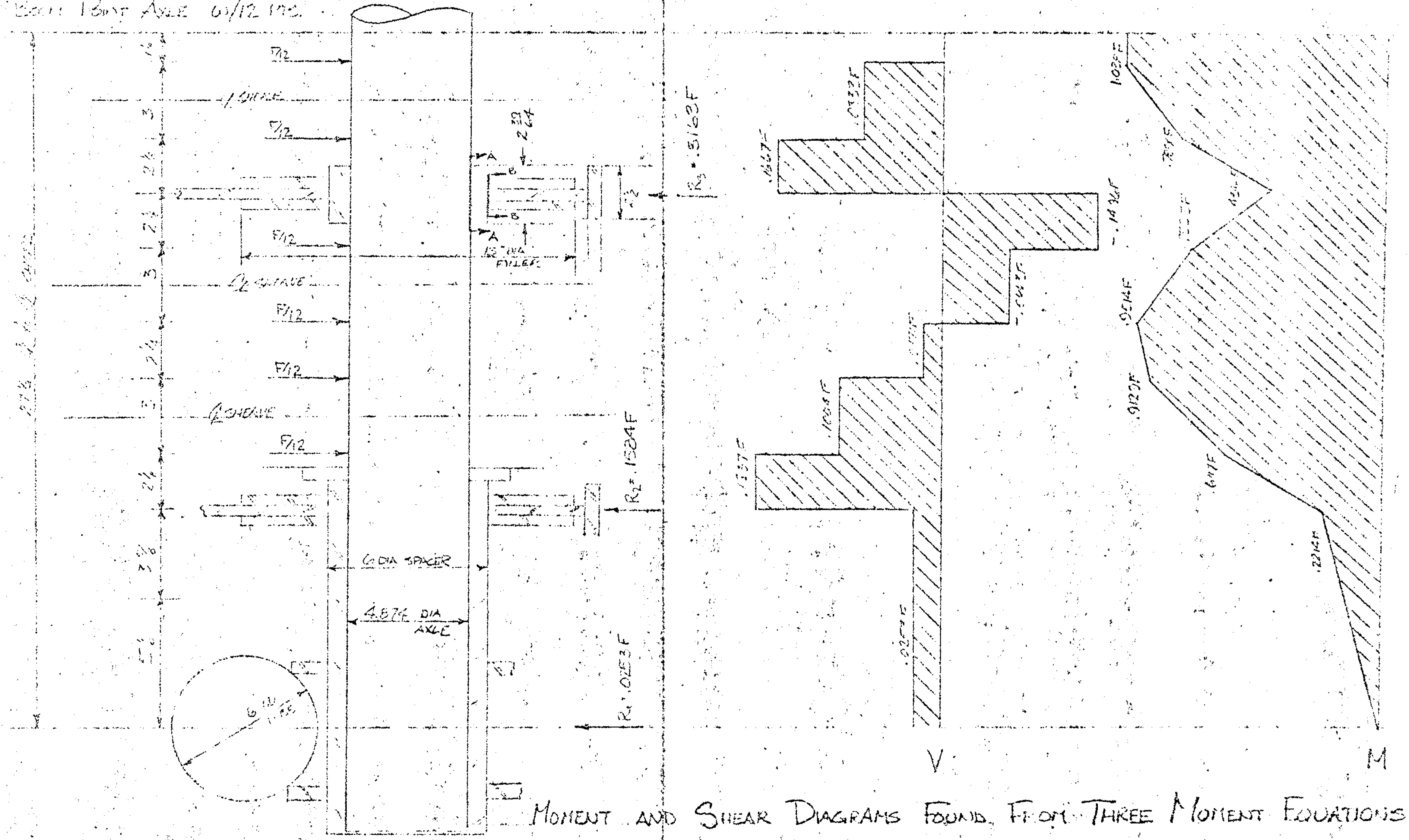
$$(.4352F - .2216F) = (X)2.125 + (X - .0833F)3 + (X - .1667F)2.25$$
$$+ (X - .25F)3 + (X - .333F)2.125$$

$X = .1[illegible]7$ $\qquad R_2 = [illegible]F$

$R_3 = [illegible]F$

MODE OF FAILURE

11750 PEDESTAL CRANE
11/14/75 BR



MOMENT AND SHEAR DIAGRAMS FOUND FROM THREE MOMENT EQUATIONS

MOMENT MAX = 1.038 F   VMAX = .1837 F

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

11750 CRANE (PEDESTAL)

DATE 11/16/75 PR

- MAXIMUM BENDING STRESS $M_{MAX} = 1.038 F$

MAT'L = A-28 BIN 302-341

$F_{UTS} = 140$ $F_y = 120$

DIA = 4.874

$S = 0.098(4.874)^3 = 11.347 \text{ in}^3$

$$140 \text{ KSI} = \frac{1.038F}{11.347 \text{ in}^3}$$

FORCE = 1530 K - MAXIMUM ALLOWABLE FOR 12 PARTS LOAD LINE (127.5K/PART)

- MAXIMUM SHEAR STRESS $V_{MAX} = .1837 F$

$$AREA = \frac{\pi}{4}(4.874)^2 = 18.66 \text{ KSI}$$

$$F_v = .6(120) = \frac{.1827 F}{18.66 \text{ KSI}}$$

FORCE = 7314 K

- CHECK BEARING AT R_3

SECTION A-A

BEARING BETWEEN AXLE & SPACER

$$140 \text{ KSI} = \frac{.3163 F}{4.875 \times 2.61}$$

FORCE = 5630 K

SECTION B-B

BEARING BETWEEN GIRDER & SPACER

$$140 \text{ KSI} = \frac{.3163 F}{1.125 \times 6}$$

FORCE = 2987 K

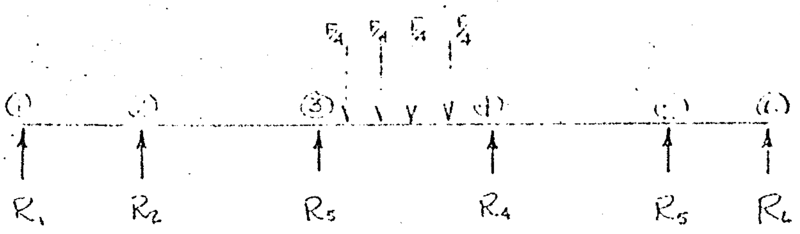
AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

11750 CRANE (HUSKY)

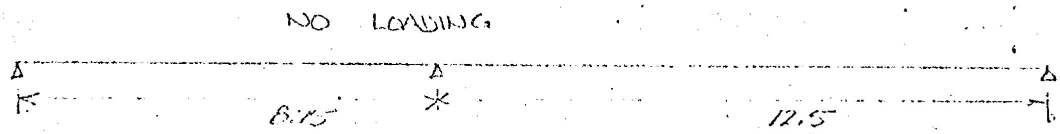
DATE 11/1/1?

B CHECK WITH 4 PARTS
THIS COULD GIVE A LOWER ALLOWABLE FOR PART OF LOAD LINE



USING THREE MOMENTS EQUATION
WITH $M_1 = M_6 = 0$
$M_2 = M_5$
$M_3 = M_4$

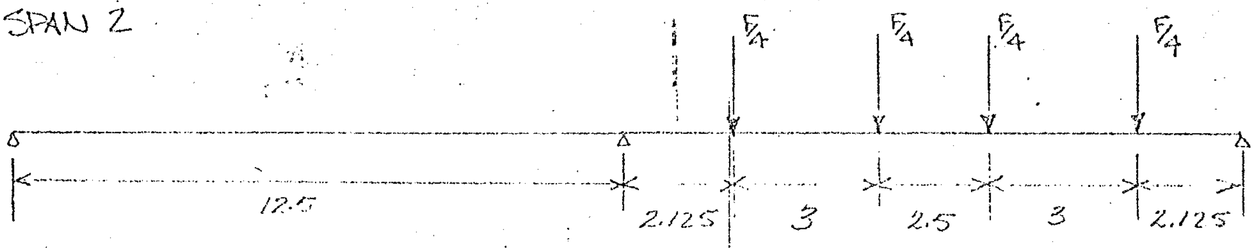
SPAN 1



$$2M_2(8.75 + 12.5) + M_3(12.5) = 0$$
$$M_2\, 42.5 + M_3(12.5) = 0$$

$$M_2 = -M_3(.294)$$

SPAN 2



$$M_2(12.5) + 2(M_3)(2(12.5)) + M_4(12.5) = \frac{-6(4.99)F(6.25)}{12.5}$$

SEE CALCULATIONS 16 12 PARTS

SOLVING FOR M_3

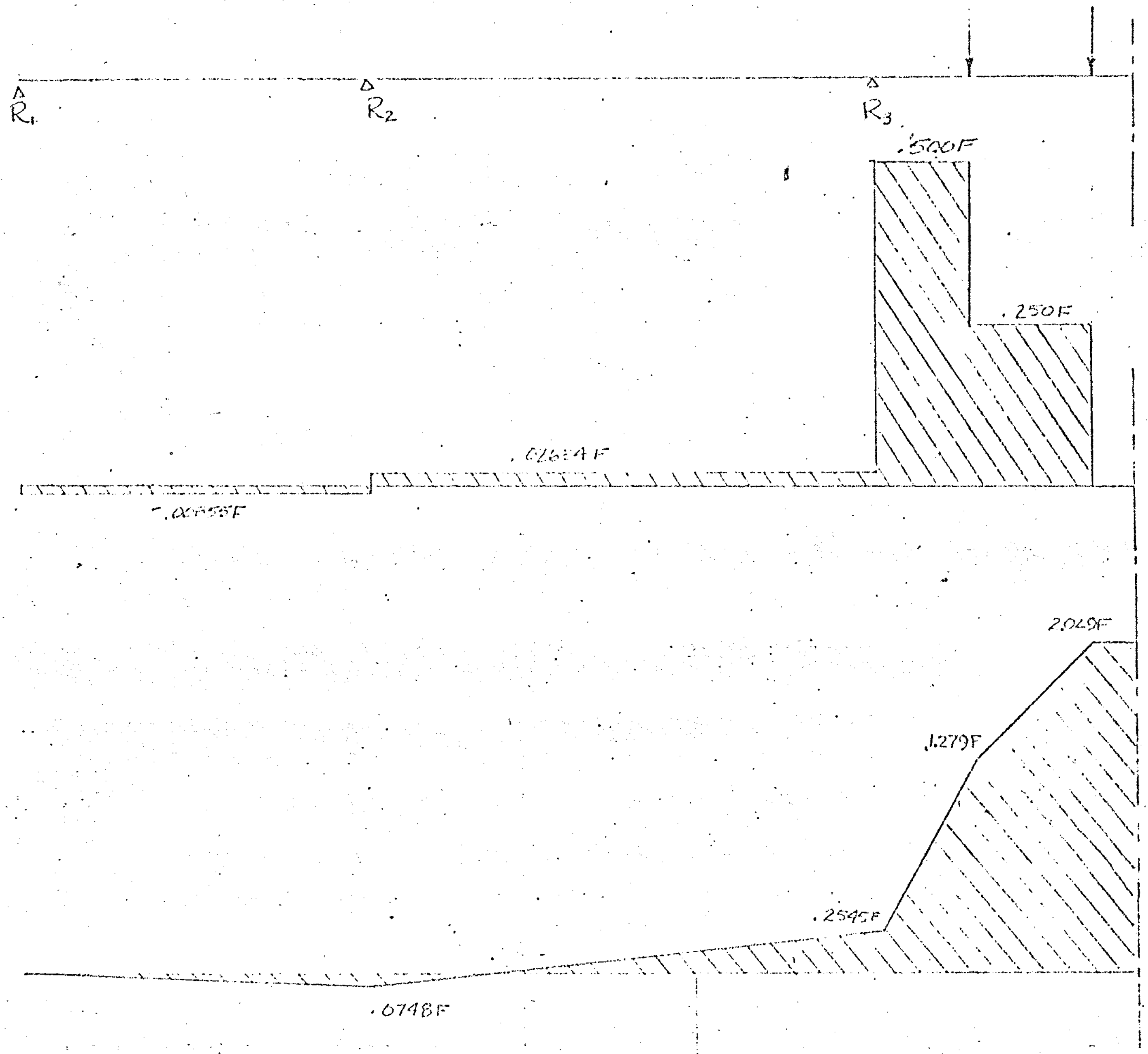
$$-3.676 M_3 + 50 M_3 + 12.5 M_3 = -14.97F$$
$$M_3 = -.2540F$$
$$M_2 = +.0718F$$

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

1175D: CRANE (TRIPTAN)

DATE 11/1/7_



$M_2 = 0.0748F = R_1 \times 8.75$

$R_1 = .00555F$

$M_3 - M_2 = .2545F + .0748F = R_2(12.5)$

$R_2 = .02634F$

$R_3 = .4822F$

AMERICAN HOIST & DERRICK CO.
ST. PAUL, MINN.

MODE OF FAILURE

11750 [illegible] ([illegible])

DATE [illegible]

[illegible] 17458
[illegible] 17446

① MAXIMUM BENDING STRESS

MAT'L A-28 BHN 302-341

$F_{UTS} = 140$ $F_y = 120$

DIA = 4.874

$$140_{ksi} = \frac{2.0249\,F}{11.347\,in^2}$$

F = 784.52 K — MAXIMUM ALLOWABLE FOR 4 PARTS OF LOAD LINE (196.1 K/PART)

② MAXIMUM SHEAR STRESS

AREA = 18.66 ksi

$$.6(120\ ksi) = \frac{.4822\,F}{18.66}$$

F = 2786 K

③ CHECK BEARING AT R_3

SECTION A-A

BEARING BETWEEN SPACER & AXLE

$$140\ ksi = \frac{.4822\,F}{4.875 \times 2.61}$$

F = 3694 K

SECTION B-B

BEARING BETWEEN GIRDER & SPACER

$$140\ ksi = \frac{.4822\,F}{1.125 \times 6}$$

F = 1960 K