McElhanney

WATER
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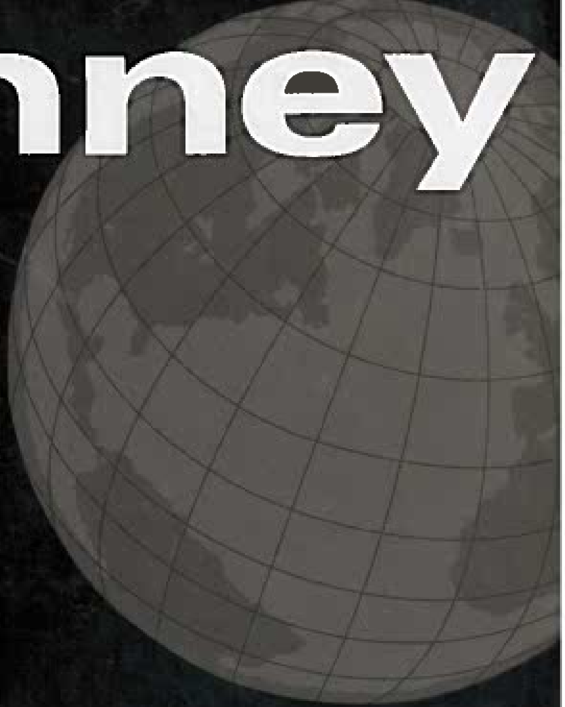

FINAL REPORT

FOR THE

REVIEW AND PROFESSIONAL CERTIFICATION

OF

ENVIRONMENT CANADA'S HEAVY DUTY CABLEWAY DESIGNS

McElhanney

Return to
Curt Naumann.
201 - 401 Burrard St
Vancouver.

20 June 2002
Our File: 2111 01745-1

Environment Canada
Meteorological Service of Canada
Water Survey Division
~~1200 West 73 Avenue - Suite 700~~
Vancouver BC V6P 6H9

Attention: Curt Naumann, M.A.Sc., P.Eng.
Project Engineer

Dear Sir:

Review and Professional Certification of Environment Canada's Heavy-Duty Cableway A-Frame Designs.

McElhanney Consulting Services Ltd. is pleased to submit this report for the Review and Professional Certification of Environment Canada's Heavy-Duty Cableway A-Frame designs.

This report identifies the heavy-duty cableway design criteria, the structural design methodology and a summary of the results of the analysis.

The report includes a copy of the structural design calculations and a complete set of hard copy AutoCAD Drawings Nos. 3136-1 to 3136-10 with Drawing Nos. 3136-1 to 3136-6 inclusive, as well as 3136-9 being professionally certified.

1.0 BACKGROUND

Environment Canada installs water monitoring stations throughout the Pacific and Yukon Region for the purpose of collecting and storing discharge, water level, and sediment data. The structures used for collecting the data vary depending on the physiographic site conditions, and range in complexity from simple in-stream hydraulic structures such as weirs to more complex structures such as metering bridges and hydrometric cableways.

Hydrometric cableways are used on rivers where the water is too deep or the flow is too fast to permit the safe collection of the water data by wading measurements.

Environment Canada, Pacific and Yukon Region, currently uses two different cableway A-Frame designs. Light-Duty Cableway A-Frame Designs are used for short spans up to 150 metres and A-Frame heights up to 5.0 metres. Heavy-Duty Cableway A-frame Designs are used for spans between 150 and 300 metres and A-frame heights from 1.0 to 10.0 metres. They are also used on shorter spans where A-Frame heights exceed 5.0 metres. Spans greater than 300 metres are custom designed.

continued....

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Environment Canada is currently reviewing the cableway A-Frame designs based on the revised design criteria and therefore has requested that the Heavy-Duty Cableway A-Frame Designs be professionally reviewed and certified.

2.0 SCOPE

The scope of this project involves the following tasks:

1. A review of Environment Canada's Heavy-Duty Cableway A-Frame designs, (Drawings Nos. 3136-1 to 3136-10 inclusive). Drawings Nos. 3136-7, 3136-8, and 3136-10 pertain to footing details and other various A-frame components that will not be reviewed at this time.
2. Professional Certification of the existing AutoCAD drawings (Drawing Nos. 3136-1 to 3136-6 inclusive, as well as 3136-9).
3. Submission of a letter report highlighting: the hydrometric cableway design criteria, the structural design methodology, the structural design calculation notes and a full set of drawings.

3.0 HYDROMETRIC CABLEWAY DESIGN CRITERIA

3.1 General

Environment Canada's Hydrometric Cableways are designed based on the maximum design loads being applied to the main cable and A-frames. These result when the meter cable catches a debris snag and is pulled downstream. The distance and angle at which the load is applied is based on the length of meter cable and the type of sounding reel used. The design philosophy is such that the meter cable will break before the main cable, towers or anchorages fail.

The snagging of floating debris on the meter cable may cause a substantial downstream load on the cable, which would be transmitted to the cableway A-frames. This causes a large downward force on the downstream leg of the A-Frame and may cause a negative (lifting) force on the upstream leg. Calculations used to compute loads on A-Frames and their footings are based on the following design criteria.

3.2 Heavy Duty Cableway Design Criteria

- Applicable for spans from 150 to 300 metres and A-Frame heights from 1.0 to 10.0 metres. Also used on shorter spans where A-Frame heights exceed 5.0 metres;
- All nuts and bolts shall be ASTM A325, Type 2, Galvanized;
- For use in areas not subject to heavy ice or ground snow loads over 4.5 kN/m^2;

continued....

- Wind Loads up to 0.5 kN/m^2;
- **Marker line** consists of ½" diameter wire rope, Weight = 0.44 lbs/ft, Breaking Strength = 11.8 tons = 23,600 lbs;
- **The main cable** – Environment Canada states in the "Safety Guide-Construction and Operation of Stream-Gauging Cableways", Fisheries and Environment Canada, 1977, that a factor of safety of 5 must be used for the design of the main cable. Also that the thimble and clip connections develop a maximum of 80% of the ultimate strength of the cable. The USGS, "Streamgauging Cableways", Open File Report 91-84, recommends a factor of safety of 5 for the main cable. However, appropriate design factors for static cable have been suggested as 3 to 4 in "Machinery's Handbook", 21st edition, page 84, and 3 to 5 in "Marks, Handbook for Mechanical Engineering", 8th edition, pages 10 to 35.

  For normal operating loads, i.e., cable car with two men and a sounding reel, we recommend a safety factor of 5. For the extraordinary loading occasioned by the breaking of the snagged meter cable, a safety factor of 3 is adequate.

  The recommended main cable wire rope used for spans from 150 to 300 metres consists of 1" diameter, 6 x 19, IWRC, Improved Plow, right regular lay galvanized wire rope. Weight = 1.76 lbs./ft, Breaking Strength = 40.8 Tons = 81,600 lbs.
- **Design loads** for the main cable comprise the following:
  1. Uniform load based on the mass of main cable, (1.76 lbs/ft)
  2. Concentrated load of 2250 lbs carried by the cable car consists of:
     - Breaking Strength of meter cable (snag load) = 1600 lbs.
       For the purpose of estimating the vertical component of the snag load, it was assumed that the D Reel was used, having a 1/8" diameter cable, cable length = 175 ft. and acting at 20 ft. above the water surface. The vertical component of this snag load = 182 lbs.
     - Weight of the Heavy duty cable car = 200 lbs. Height of car = 2.0 metres
     - Weight of the sounding reel = 50 lbs.
     - Weight of occupant(s) = 400 lbs.

     The total design vertical component when the snag load is considered = 832 lbs.
- The main cable designed such that the unloaded sag is set at 2% of the span.
- The review has been based on the tops of the A-Frames being at the same elevation;
- The Aircraft Marker Spheres that are used on longer spans (greater than 150 metres) have a diameter of 30 inches and are made of fiberglass. The spheres weigh approximately 19 lbs each. The Ministry of Transport requires one sphere every 45 metres.

continued....

- The angle of the main cable as it approaches the anchor is assumed to be 30 degrees below horizontal.

4.0 STRUCTURAL DESIGN METHODOLOGY

The following structural design methodology and various loading conditions were used to review the Heavy Duty Cableway A-Frames.

1. The design load, including the snag load, applied at mid-span acting vertically downward;
2. The design load applied at mid-span with the 1600 lbs breaking strength of the meter cable (snag load) acting downstream.
3. The design load applied at ¼ of the span acting vertically downward;
4. The design load applied at ¼ of the span with the 1600 lbs breaking strength of the meter cable (snag load) acting downstream.
5. The design load applied at mid-span without the snag load.

The above loading conditions were analyzed for a 150 metre and a 300 metre span.

5.0 SUMMARY OF RESULTS

The 150 metre span was initially analyzed using a 1" diameter IWRC, IP, wire rope under the above loading conditions. The results of the analysis are summarized in Table 1.

Table 1. Summary of Analysis for 150 m Span, 1" Wire Rope, BS = 81,600 lbs.

Loading Condition	Load	H	Cable	A-Frames
(See Section 4.0)	(lbs)	(lbs)	S.F.	(With Snow)
1. ½ span, vertically down	2,250	20,020	4.1	O.K.
2. ½ span with snag load	832	20,020	4.1	O.K.
3. ¼ span, vertically down	2,250	18,959	4.3	O.K.
4. ¼ span with snag load	832	18,959	4.3	O.K.

The results show that under the design loading conditions, the A-Frames meet the design criteria with the snow load applied. The main cable has a factor of safety ranging from 4.1 to 4.3, which is acceptable.

The 300 metre span was then analyzed using the 1" IWRC, IP, wire rope, under the above loading conditions. The results are summarized in Table 2.

continued....

Table 2. Summary of Analysis for 300 m Span, 1" Wire Rope, BS = 81,600 lbs.

Loading Condition	Load	H	Cable	A-Frames
(See Section 4.0)	(lbs)	(lbs)	S.F.	(With Snow)
1. ½ span, vertically down	2,250	24,317	3.4	O.K.
2. ½ span with snag load	832	24,317	3.4	O.K.
3. ¼ span, vertically down	2,250	22,608	3.6	O.K.
4. ¼ span with snag load	832	22,608	3.6	O.K.
5. ½ span no snag load	650	15,436	5.3	O.K.

The results show that under the design loading conditions, the A-Frames meet the design criteria with the snow loads applied.

The diameter of the main cable was increased to 1$^{1/4"}$ and the 300 metre span was then analyzed under the above loading conditions. The results are summarized in Table 3.

Table 3. Summary of Analysis for 300 m Span, 1$^{1/4}$" Wire Rope, BS = 141,000 lbs.

Loading Condition	Load	H	Cable	A-Frames
(See Section 4)	(lbs)	(lbs)	S.F.	(With Snow)
1. ½ span, vertically down	2,250	30,592	4.6	Remove Snow from 10 m Towers
2. ½ span with snag load	832	30,592	4.6	Remove Snow from 10 m Towers
3. ¼ span, vertically down	2,250	28,803	4.9	Remove Snow from 9 & 10 m Towers
4. ¼ span with snag load	832	28,803	4.9	Remove Snow from 9 & 10 m Towers
5. ½ span no snag load	650	-	5+	

The results show that under the design loading conditions, the snow load should be removed from the 9.0 and 10.0 m A-Frames prior to use. The main cable has a factor of safety of 4.6 or greater, which is acceptable.

6.0 SUMMARY AND RECOMMENDATIONS

The existing Heavy-Duty Cableway A-Frame designs meet the revised hydrometric design criteria for spans between 150 and 300 metres, with the following conditions:

continued....

1. It is recommended that the wire rope used on the Heavy Duty Cableways for spans between 150 metres and 300 metres should be 1" diameter, 6 x 19, IWRC, Improved Plow, right regular lay, galvanized wire rope.

2. It is also recommended that if using the 1¼" main cable, the snow be removed from the platforms on the 9.0 metre and the 10.0 metre A-Frames prior to use, or to consider redesigning the platforms to allow snow to pass through without accumulation.

As noted, these designs incorporate certain specific conditions such as the tops of the A-Frames being at the same elevations, and the main cable backstays being at 30° to horizontal. Great accuracies of analysis for actual conditions should not be counted on.

We have enjoyed working with you on this project and we trust this report provides the information that you require and that it meets the expectations outlined in the project scope.

Yours very truly,

McELHANNEY CONSULTING LTD.

A.A. Williams, P.Eng.
Senior Bridge Specialist
Vancouver Region Engineering

e-mail: awilliams@mcelhanney.com
AAW:lfd

APPENDIX A

STRUCTURAL DESIGN CALCULATIONS

Design Sketch — McElhanney

SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
MOE HEAVY DUTY A FRAMES	DATE	DATE		

INDEX

Spans 150 m to 300 m

Start with 2% sag of unloaded cable.

Backstay 30° to horiz.

Towers:- 1m to 10m in 1m incr.

Cables 1 ϕ or 1¼ ϕ

Stretch to incl. backstays for 6m tower

Load:- Car	200 #	Meter line 175' long
Reel	50	1600 # B.S.
2 men	400	Car 20' above water
Basic Load	650	
	1600	
	2250	

Structural Steel - G40.21-M GRADE 350W GALV.

Ground Snow Load = 4.5 KN/m² × .6 = 2.7 = 56 psf

1" ϕ IWRC 1.76 plf B.S. = 40.8 tons = 81.6 K

1¼ ϕ 2.75 70.4 = 141 K

1 ϕ EA = 18500 × .7854 = 14530 1¼ EA = 18500 × 1.227 = 22700

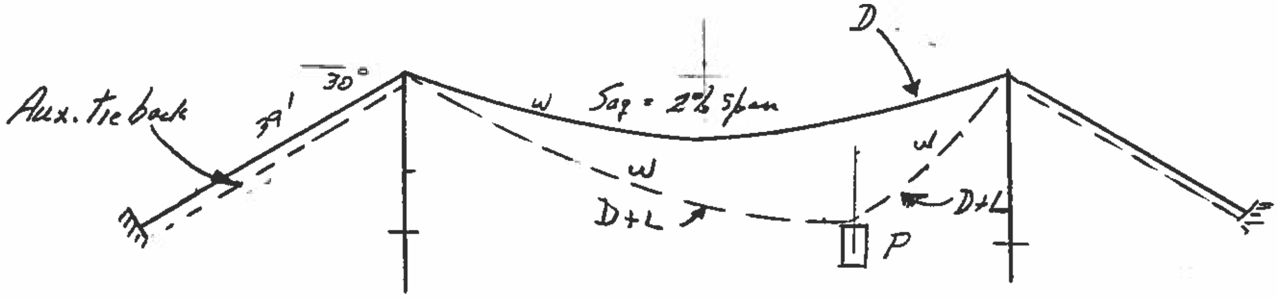
ENVIRONMENT CANADA DWGS 3136-1 to 3136-10

DWG 2812-R2

Handbook of Rigging Rossnagel McGraw Hill 3rd Ed.

Design Sketch **McElhanney**

SUBJECT ENVIRONMENT CANADA CABLEWAY - BASIC THEORY	DESIGN [illegible] DATE Nov 08 01	CHECK DATE	JOB NO. 2111 01745-1	PAGE G-2



Stretch in Cable based on 6m high towers
= 39'x2 + Span = Span + 78'
w = cable wt./foot

Tower top supported by aux. tiebacks ----
∴ Tension in cable constant all the way. T = H

Load to Tower = Vert. reaction from susp. cable V_R
+ H tan 30° from back span

[Note: This should be H sin 30 but to account for vertical into tower from Aux. tie back cables use H tan 30°]

See P. G-3

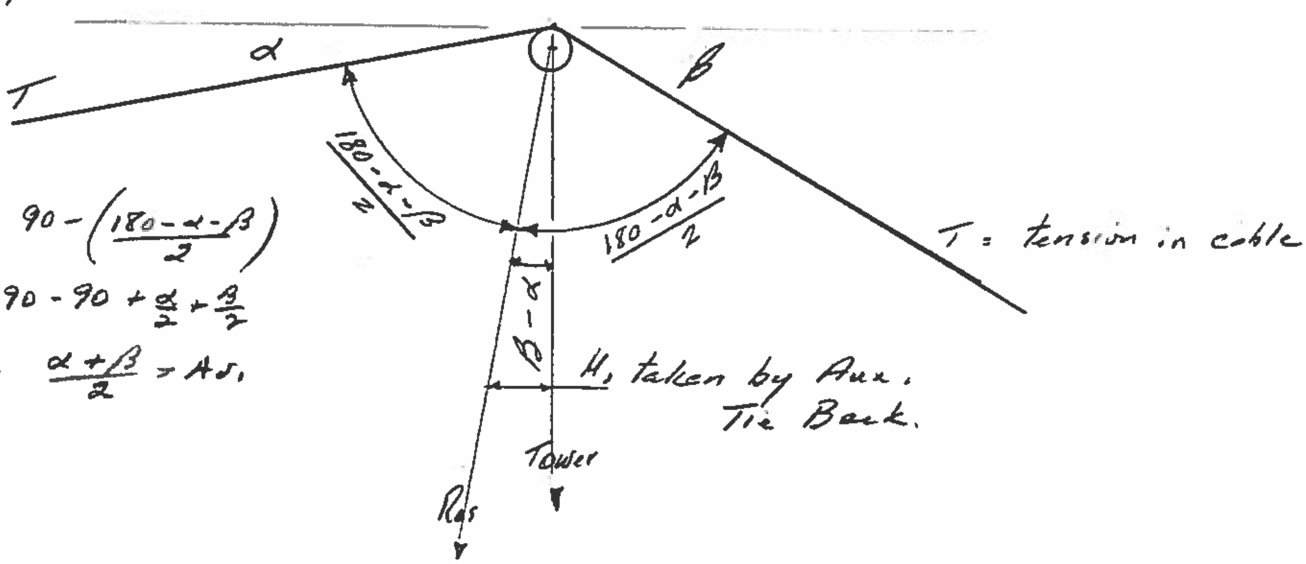
Tension to Anchor Rod (in ground) = H/cos 30°

P.16 Max Cable Tens = 30.59

Assume T = H

$\alpha \doteq 6°$ for some cases.

$\beta = 30°$



$90 - \left(\frac{180-\alpha-\beta}{2}\right)$

$= 90 - 90 + \frac{\alpha}{2} + \frac{\beta}{2}$

$= \frac{\alpha+\beta}{2} = \text{Ans.}$

$Res = 2T \cdot \sin\frac{\alpha+\beta}{2}$ $\qquad H_1 = 2T \sin\frac{\alpha+\beta}{2} \cdot \sin \beta-\alpha$

$Tower = 2T \sin\frac{\alpha+\beta}{2} \cos \beta - a$

If $\alpha = 6°$; $\beta = 30°$

Res = 0.62 T

Tower = 0.56 T

H_1 = 0.25 T – taken by Aux. Tie Back

; adds to Tower Load.

AND adds to T for pull on anchor.

∴ Design anchor for H/cos β.

Design Sketch McElhanney

SUBJECT	DESIGN aam	CHECK	JOB NO. 2111	PAGE
GEOM A FRAME PARTS	DATE May 22 02	DATE	01745-1	G-4

1/5

DWG. 4 – A FRAME TOP

Given L find S

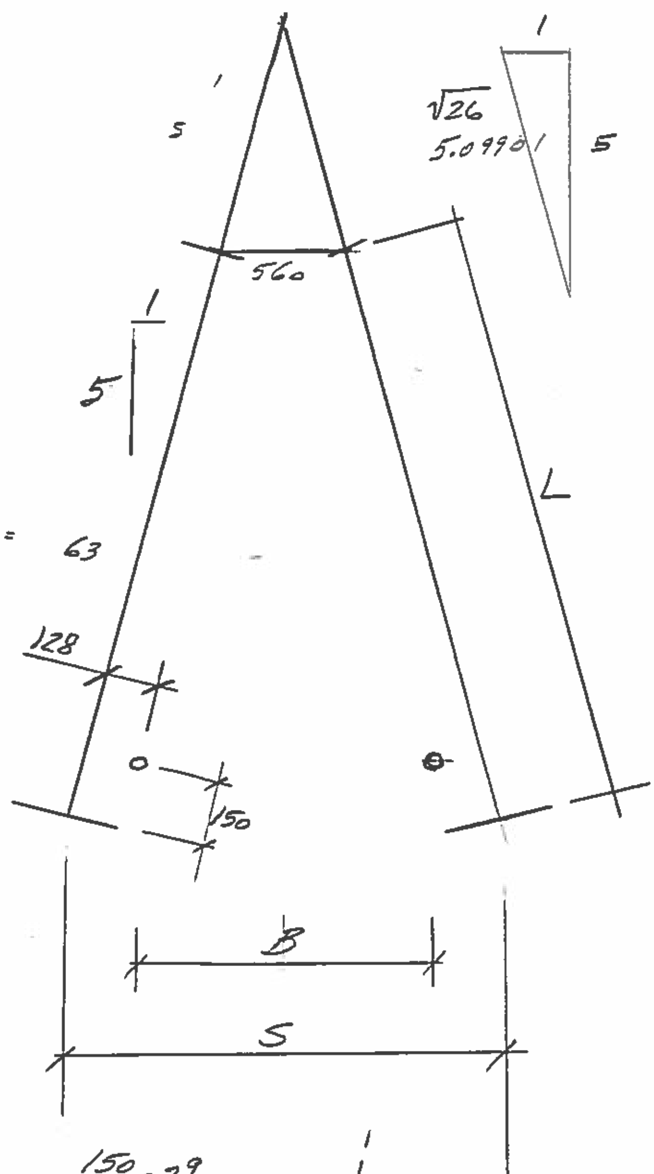
$$S = 560 + \frac{2L}{\sqrt{26}} \quad (01)$$

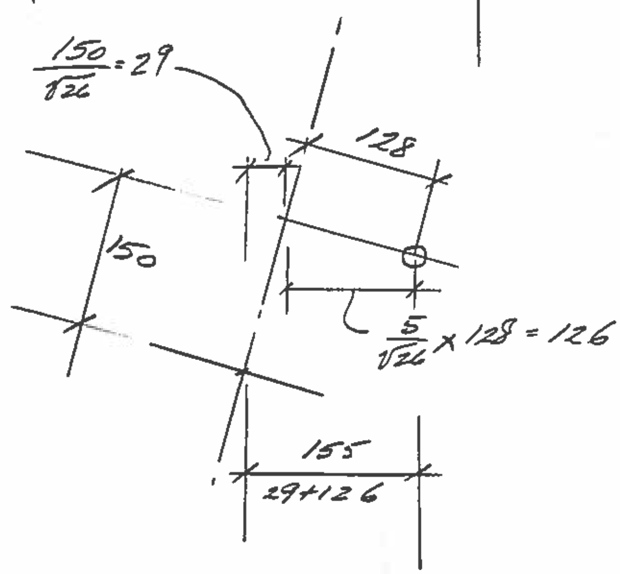
L	S	B	$+2\times35 = +70$
1000	952	642	
2000	1344	1034	1104
3	1737	1427	1497
4	2129	1819	1889
5	2521	2211	
6	2913	2603	2673
7	3306	2996	3066
8	3698	3388	3458
9	4090	3780	3850
10000	4482	4172	4242

$\frac{127}{2} = 63$

BRACE $B = S - 155\times2$

$= S - 310$





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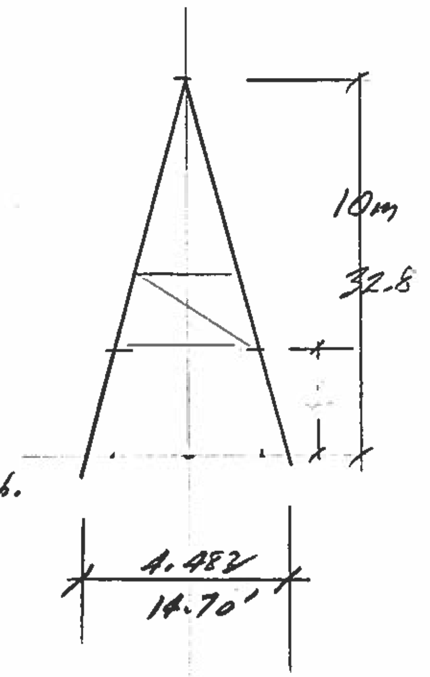
Design Sketch

SUBJECT	DESIGN	CHECK	JOB NO. 2111	PAGE
10m Heavy Duty A-frame	DATE Nov 06 01	DATE	01745-1	T-1

HSS 127 × 127 × 4.78 for all frames 50 Fy
1m to 10m.

HSS 5 × 5 × 0.188 $A = 3.53 in^2$
$I = 13.5$
SM = 5.39
r = 1.95



Cap'y per leg $\frac{Kl}{r}$ K = 1.0 (most probable)

$= \frac{1 \times 32.8 \times 12}{1.95} = 202$

$F_a = 3.73$ Cap'y = 3.73 × 3.53 = 13.17 K/leg. Comp.

COMPACT? $255/\sqrt{50} = 36$

Unsupp. = (5 − 2 × .188) / .188 = 24.6

∴ Compact $F_a = .66 \times 50 = 33$

∴ Cap'y in bending $= 33 \times \frac{5.39}{12} = 14.82^{K}$

Sway 4m = 13' $\frac{Kl}{r} = \frac{1.2 \times 13' \times 12}{1.95} = 97$ $F_a = 16.0$ Cap'y $= 56^{K}$

BOLTED CONN. 8 − 16φ Bolts A = 5/8φ: 8 × .3068 = 2.45 in² < 3.53

$I_{8\ Bolts}$ = 90 ÷ 3.54" $I = (.3068 \times 3.54^2) 6 = 23.11 > 13.5$

∴ OK conn is stronger than HSS

SNOW ON PLATFORM Dwg WSC 3136-9 2m × 1.5m

Area = 6.56' × 4.92' = 32.3 ft² Snow Grd Load: 4.5 × 0.6 = 2.7 KN/m² = 56 psf.

Load = 32.3 × 56 = 1.82^{K} = 0.91^{K}/leg

$M = 0.91 \times \left(\frac{6.56}{2} + \frac{5}{12 \times 2}\right) = 3.17^{IK}$/leg. (3.49)

Design Sketch — McElhanney

SUBJECT	DESIGN	CHECK	JOB NO. 2111	PAGE
Heavy Duty A-frames	DATE Nov 07 01	DATE	01745-1	T-2

CAPACITY per LEG IN COMP. HSS A = 3.53 r = 1.95 50 Fy

			Kl/r	F_a	Cap ^{k}	Spread
10m	=	32.8'	= 202	3.73	13.2	14.7
9	=	29.5	182	4.50	15.9	13.2
8	=	26.3	162	5.68	20.1	11.8
7	=	23.0	141	7.49	26.4	
6	=	19.7	121	10.2	36.0	
5	=	16.4	101	14.6	51.5	
4	=	13.1	81	20.4	72.0	
3	=	9.84	61	23.5	83.0	
2	=	6.56	40	26.8	94.6	
1	=	3.28	20	30.0	105.9	

SWAY FORCES FROM SNAG LOAD

8m Tower is not braced Dwg. 3136-2

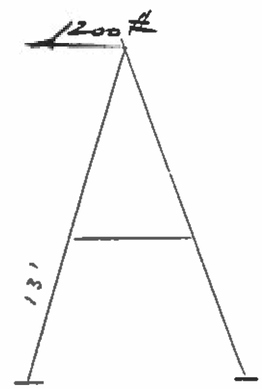
Unbraced = 4m = 13'

P.14 Horiz = 1600 × 3/4 = 1200# @ Tower

M/leg = $\frac{1200}{2} \times \frac{13}{2}$ = 3.9 k/connection

$f_b = \frac{3.9 \times 12}{5.34}$ = 8.8 ksi F_a = 33 0.27

To P.14



Horiz. 10m Tower = 4172 c/c — HSS 63.5 × 63.5 × 3.18 r = 24.4

$\frac{Kl}{r} = \frac{1 \times 4172}{24.4}$ = 171 - OK.

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Design Sketch

SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
Top - Heavy Duty A-Frame	Adal DATE Jan 09 02	DATE	01745-1	T-3

Dwg 3164-4 Rev 0

Load to Main Sheave. P.12 = 19.66^k = 20^k

On HSS 127x127x4.78 = 5x5x0.188 S = 5.39

As a beam - Span .500 = 20" $M = 19.66 \times \frac{20}{4} = 98''^{k}$

$f_b = 98/5.39 = 18$ - OK.

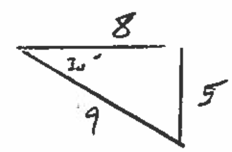
Shear $19.66/4 = 5^k$/web of 5"x0.188 $f_v = \frac{5}{5 \times 0.188} = 5.32$ OK.

Bearing Under Sheave 20/2 = 10^k on 1 web. 5" →

$f_p = \frac{10^k}{.188(5+?)} = 10.6 < .75 \times 50$

Back Stay Eyebolt. P. 6-3 $H_1 = 0.25T$ = 0.25x35 = 8^k (P. AP-1)

5 Weld 3/16 = 2.4^k/in 2 sides OK in 1"



Sheave Diameter Hndbk P.65

200 ⌀ Sheave Wire 1¼" ∴ $\frac{200}{1.25 \times 25} = 6.4$ - OK - not running

Also brg on sheave $p = \frac{T}{rd} = \frac{35}{3'' \times 1\frac{1}{4}} = 9.3$ ksi - OK not running.

Sheave Pin 39⌀ = 1.54" R = .62x30.59 = 20^k

Shear Cap. = $2 \times 10 \times 1.50^2 \times \frac{\pi}{4} = 35^k$ - O.K.

Bearing on saddle $2 \times 60 \times \frac{3}{4} \times 1.50 = 135^k$

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Design Sketch

SUBJECT MOE MIDSPAN 150m — LOADED · VERT. SNAG. 2250 #

DESIGN ARW DATE Oct 23 01 | CHECK | DATE | JOB NO. 2111 01745 1 | PAGE 1

$Sag_{D.L.}$ = 2% of span P: 650 # + 1600 Snag = 2250 # Cable = 1.76 x 492 = 866 ΣWt = 3116 ½ = 1558

Use 6m tower for stretch = 2x12 = 24m + for lgth = + 78' Cable for stretch = 492 + 78 = 57[illegible]

INCLUDES STRETCH on 6m high backstays.

	MIDSPAN #1	#2	#3	#4	#5
SPAN	150 m 492				
$Sag_{D.L.}$	9.84'				
H_{DL}	5412				
Lgth	492.52				
Wcable	866				
P/W	2.60				
$Sag_{L.L.}$	x1.466 1.44				
Sag ± D+L	11.29				
H_{D+L}	29230	17290	21133	19351	20641
H_{LL}	23818	11878	15721	13939	15229
Stretch	0.94	0.47	0.62	0.55	0.60
New lgth	493.46	492.99	493.14	493.07	493.12
½ lgth	246.73	246.49	246.57	246.53	246.56
defln @ 01	19.00	15.60	17.00	16.00	16.50
Sag @ 03	0.77	0.63	0.688	0.645	.665
H	17290	21133	19351	20641	20020
Lgth ½	246.74	246.50	246.59	246.53	246.56
V_L	1552	1557	1554	1559	1559
V_R	1119	1124	1121	1126	1125
2250 Live Load	2238	2248	2242 (966)	2252	2250
3116 Σ Load	3104	3114	3108	3118	3118

$H_{D+L} = L\left(\frac{2LL + 866}{8\,sag}\right)$

Str: $\frac{ft \times kips}{18500 \times .7854}$

= (493 + 78) 571'

CABLE

H = 20020

vs 81.6

S.F. = 4.08

VERT T. TOWER

= 1.6 + 20 tan 30°

= 13.2^K = 6.6^K/leg

< 13.2^K/leg.

ADD SNOW

$\frac{6.6 + 0.91}{13.2} + \frac{3.17}{14.87}$

= 0.57 + 0.21

= 0.78 OK.

150m MIDSPAN SNAG VERT 1"4

Design Sketch

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SUBJECT 150 m Mid Span 150 m Loaded + Snag (Sloped) 1" Φ	DESIGN / DATE	CHECK / DATE	JOB NO. 01745 1	PAGE 2

P = Vert. Load = 650 + 182 = 832# P/W = 832/866 = 0.96
Cable = 866
Σ = 1698 ½ = 849

Including Stretch.

	#1	#2	#3			
Span	150 m 492'					
Sag D.L.	9.84					
H D.L.	5412					
Lgth	492.52					
W cable	866					
P/W	0.96					
Sag L.L.	.1306 1.29					
Sag D+L	11.13					
H D+L / H LL	13980 / 8568	10913 / 5501	11994 / 6582	11477 / 6065		
Stretch / New lgth	0.34 / 492.86	0.22 / 492.74	0.26 / 492.78	0.24 / 492.76		
½ lgth.	246.43	246.37	246.39	246.38		
defln (01)	14.2	13.0	13.6			
Sag (03)	1.22	1.11	1.16			
H	10913	11994	11477			
Lgth ½	246.43	246.36	246.39			
849 V_L	846	850	851			
416 V_R	413	417	418			
832 Live Load	826	834	836			
1698 Σ Load	1692	1700	1702			

$H_{D+L} = L\left(\frac{2LL + 2LL}{8\,Sag}\right)$

Str. = $\frac{571 \times 8.568}{18500 \times .7854}$ = 0.24

150m Mid Span Snag Hor. 1"Φ

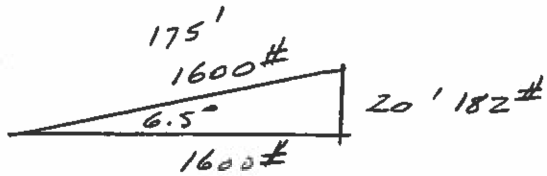
Design Sketch — **McElhanney**

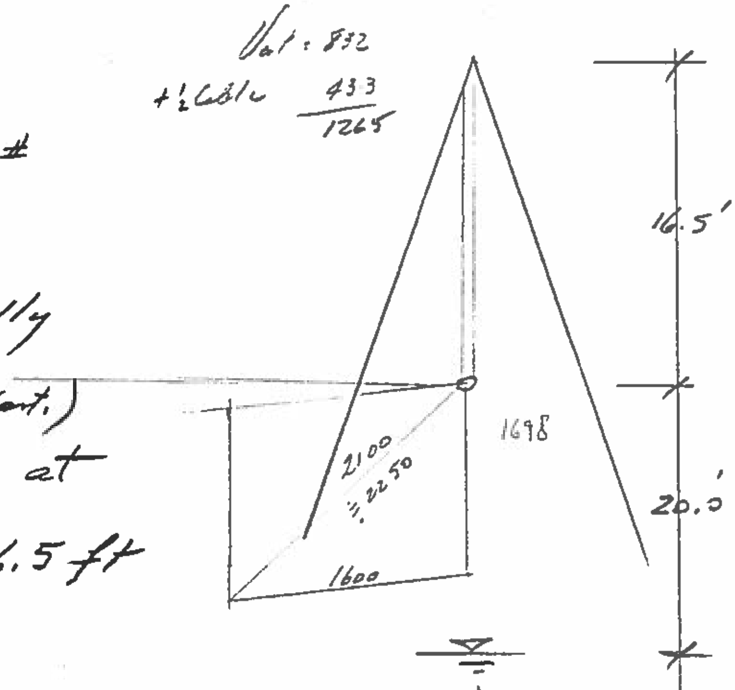
SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
Mid Span 150 m / Snag Load 10m Tower	DATE	DATE	2111 / 01745-1	3

Ref T-7 Former

Meter line 1600# B.S.

175' long Water to cable = 20'





For 1600# pulling laterally at midspan sag (horiz : vert.) will approximate 2250 # at mid span from P. 1 16.5 ft

H = 20,020#

10m Tower = 33'

∴ Vert. load to tower = V_L = 851 #

From H @ 30°: 20020 Tan 30° = 11662

Vert. to Tower = 12513

Spread = 4.482m = 14.70'

M to Tower = 1600# @ mid span = 800#/tower

Hor. Snag Load goes to tower top. × 33' = 26.4 K

Load to leg $= \frac{12.513}{2} \pm \frac{26.4}{14.7} = 6.26 \pm 1.80 = 8.06$ or 4.46

Comb. $= \frac{8.06}{13.17} + \frac{0}{14.82} = 0.61$

P.T-1

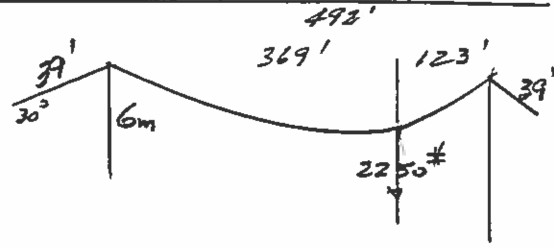
With Snow $\frac{8.06+0.91}{13.17} + \frac{3.17}{14.82} = 0.68 + 0.21 = 0.89$ OK.

10m Tower

CABLE H = 20,020 vs 81.6 = 4.1 S.F.

SUBJECT 150m ¼ SPAN LOADED + VERT SNAG. 1"φ	DESIGN AQW DATE Oct 29 01	CHECK DATE	JOB NO.	PAGE 4

CL 2250
866
3116



Stretch based on 2×39 + 492 = 571'

SPAN	369'	123'					Str. = 11138 × 571' / 18550 × .7854
Sag D.L.	9.84						= 0.44
H DL	5412						492.52
Lgth	492.52						492.96
Wcable	866						
P/W	×						
Sag L.L.							
Sag D+L							
H D+L / H LL	16550 / 11138						
Stretch / New lgth	0.44 / 492.96						
½ lgth.	—						
defln @ 01	-13.0	+13.0					
Sag @ 03	1.58	0.176					
H	18959	18959					
Lgth	369.25	123.69					
VL	993	1896					
VR	-343	-2112					
2250 Live Load	2239						
3116 E Load	3105						
Lgth	492.94 vs						

492.96.

LOAD TO TOWER

SPAN = 2112
Bkstg. 18959 / tan 30° = 10946
13058
= 6529/leg < 13.17

Tension = 18.959
vs 81.6
S.F. = 4.3

ADD SNOW

6.53 + 0.91 / 13.17 + 3.17 / 14.82

0.56 + 0.21
= 0.78

McElhanney

Design Sketch

SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
150 m ¼ SPAN LOADED + SNAG (Sloped) 1"ϕ	[illegible] DATE Oct 29 01	DATE		5

P = VERT. LOAD = 650 + 182 = 832   832/866 =
Cable = 866
1698

1600 # Dnstream.

SPAN	369	123					
$Sag_{D.L.}$	9.84						
H_{DL}	5412						
$Lgth_{D.L}$	492.52						
Wcable	866						
P/W	×						
$Sag_{L.L.}$							
Sag_{D+L}							
H_{D+L} / H_{LL}	10660 / 5248						
Stretch / New lgth	0.21 / 492.73						
½ lgth.	–						
defln @ 01	−11.0	+11.0					
Sag @ 03	2.81	0.312					
H	10660	10660					
Lgth X	369.22	123.49					
V_L	643	−845					
V_R	7	1062					
832 Live Load	838						
1698 E Load	1705						
Lgth	492.73 = 492.73						

Str. = $\frac{5248 \times 571}{18500 \times .7854}$
= 0.21
492.52
492.73

150 m ¼ SPAN SNAG HOR.   1"ϕ

Vert. to tower = 1062 + H tan 30°

=

Sag = 13.6' H = 11477

1600# laterally ÷ 2250 at mid span
= H = 20020 with sag 16.5 See P. 3

Vert to tower = 1062 + 20020 tan 30
= 12.62^K

M to tower 1600# @ 1/4 = 1200# to tower top
10m Tower M = 1.2 × 33' = 39.60

Load to leg = $\frac{12.62}{2} \pm \frac{39.60}{14.70'}$ = 6.31 ± 2.69 = 9.00 or 3.62

Comb = $\frac{9.00}{13.17} + \frac{0}{14.82}$ = 0.68 OK 10m Tower

With Snow $\frac{9.00 + 0.91}{13.17} + \frac{3.17}{14.82}$ = 0.75 + 0.21 = 0.97 O.K.

Cable H = 20,020 vs 81.6 S.F = 4.08

Design Sketch McElhanney

SUBJECT	300m Mid Span Load + Vert Snag. 1"φ	DESIGN	[illegible]	CHECK		JOB NO.		PAGE
		DATE	Oct 30 01	DATE				7

Vert. load = 650#

Snag Vert. = 1600 / 2250# P

Cable: 984 x 1.76 = 1732#

3982

½ = 1991

Lgth for stretch = 984 + 2x39 = 1062' (78)

H_{D+L} : 984 (2x2250 + 1732) / 8x22.39 = 34389

Stretch = (H − 10.824) x (00) + (01) / 2 = ½ lgth.

SPAN	984'						H = H_D = 10824 H_L
$Sag_{D.L.}$	19.68						
H_{DL}	10824						
Lgth	985.05						
W_{cable}	1732						
P/W	1.30						
$Sag_{L.L.}$	.1378 2.71						
Sag_{D+L}	22.39						
H_{D+L} H_{LL}	34389 23565	29556 18762	23154 12330	24317 13493			
Stretch New lgth	1.72 986.77	1.37 986.42	0.90 985.95	0.99 986.04			
½ lgth	493.39	493.21	492.98	493.02			
defln (01)	−26	−32	−31.5	−31.5			
Sag (03)	1.80	2.30	2.19	2.19			
H	29586	23154	24317	24317			
Lgth ½	492.70	493.068	493.033	493.033			
1991 V_L	1996	1939	1990	1990			
1125 V_R	1131	1073	1124	1124			
2250 Live load	2262	2146	2248				
3982 Σ Load	3992	3878	3980				

300 MidSpan Load + Vert Snag 1"φ

McElhanney

Design Sketch

SUBJECT 300 m MID SPAN LOAD + VERT SNAG. 1φ	DESIGN [initials] DATE Dec 14 01	CHECK DATE	JOB NO.	PAGE 7A

Vert. to tower = 1990
+ 24317 tan 30 = 14040
16.030

Load per leg = ÷ 2 = 8.02 < 13.17 OK.

With snow $\frac{8.02 + 0.91}{13.17} + \frac{3.17}{14.82} = 0.68 + 0.21 = 0.89$

OK to 10 m tower

Tension in 1φ Cable = 24.3 K n/s 81.6 SF = 3.36

Design Sketch — **McElhanney**

SUBJECT 300m MID SPAN LOAD ONLY 1"Φ	DESIGN Q.Q.W DATE June 13 02	CHECK DATE	JOB NO. 2111 01745-1	PAGE 7B

Vert Load 650#

Cable = 984 × 1.76 = 1732#

Total Wt = 2382# ½ = 1191

Lgth for stretch = 1062'

Stretch = $(H - 10.824)\frac{1062}{14530}$ (.073) = ½ lgth

SPAN	984'						
Sag D.L.	19.68						
H_{DL}	10824						
Lgth	985.05						
W cable	1732						
P/W							
Sag L.L.							
Sag D+L							
H_{D+L} / H_{LL}							
Stretch / New lgth	.68 / 985.73	.34 / 985.39					
½ lgth	492.87	492.69					
defln (01)	-22.00	-24.00					
Sag (03)	3.25	3.45					
H	16386	15436					
Lgth ½	492.55	492.65					
1191 V_L	1166	1186					
325 V_R	300	320					
650 Live Load	600	640					
Σ Load	2382	2372					

Cable S.F.

$= \frac{81.6}{15.4}$

= 5.3

300m Mid NO SNAG 1"Φ

McElhanney

Design Sketch

SUBJECT 300 m Mid Span Load + Snag (Sloped) 1Ø"	DESIGN Allen DATE Oct 30 01	CHECK DATE	JOB NO.	PAGE 8

Vert Load = 650 + 182 (Snag) = 832 Vert Load. P

Cable weighs 1.76 × 984 = 1732

2564

Stretch = (H − 10.824) × (00) + (01) (Orig) = ½ lgth.

	#1			#4			
SPAN	984						$H_{D+L} \frac{(2LL + 1732)L}{8\,sag}$
$Sag_{D.L.}$	19.68						=
H_{DL}	10824						
Lgth	985.05						
Wcable	1732						
P/W	0.48						
$Sag_{L.L.}$	.11 2.16						
Sag_{D+L}	21.84						
H_{D+L} / H_{LL}	19126 / 8302			16138 / 5314			
Stretch / New lgth	0.61 / 985.66			0.39 / 985.44			
½ lgth.	492.83			492.72			
defln (01)	22			−25.8			
Sag (03)	2.00			3.30			
H	26627			16138			D+L Sag = 25.8
Lgth ½	492.51			492.74			% 984 = .026
1282 V_L	1624			1279			2.6 %
416 V_R	758			413			
832 Live Load				826			
2564 Σ Load				2558			

300 mid Snag hor. 1Ø

McElhanney

Design Sketch

SUBJECT 300 m Mid SPAN LOAD + SNAG SLOPED 1Φ	DESIGN [initials] DATE Dec 14 01	CHECK DATE	JOB NO. 2111 01745-1	PAGE 8A

1600# laterally ÷ 2250 at midspan

∴ H = 24317 See P.7

Vert. to Tower = 1279 + 24317 tan 30°

= 15.32

M to tower $\frac{1600}{2}$ = 800 × 33' = 26.4'K

Load to leg = $\frac{15.32}{2} \pm \frac{26.4}{14.70}$ = 7.66 ± 1.80 = 9.46 or 5.86

Comb = $\frac{9.46}{13.17} + \frac{0}{14.82}$ = 0.72 + 0 = 0.72

With Snow $\frac{9.46+0.91}{13.17} + \frac{3.17}{14.82}$ = 0.79 + 0.21 = 1.00

ok to 10m tower.

Tension in cable 24.317 vs. 81.6 = 3.36

Design Sketch — **McElhanney**

SUBJECT 300m (984) ¼ SPAN LOAD + SNAG (SLOPED) 1φ	DESIGN [initials] DATE May 23 02	CHECK DATE	JOB NO. 2111 01745-1	PAGE 8B

Vert Load = 650 + 182 = 832

Cable = 1.76 × 984 = 1732

2564

AE = .7854 × 18500 = 14530 (31)

Lgth. for stretch = 984 + 2×39 = 1062'

$Str_1 = (H - H_D)\frac{1062}{14530} = (H-H_D).073$

SPAN	738			246			
$Sag_{D.L.}$	984' 19.68						
H_{DL}	10824						
$Lgth_{D.L.}$	985.05						
W_{cable}	1732						
P/W	—						
$Sag_{L.L.}$							
Sag_{D+L}							
H_{D+L} H_{LL}							
Stretch New lgth							
½ lgth.							
defln (01)	− 21			+ 21			
Sag (03)	8.0			.889			
H	14978			14978			
Lgth ℄	738.53			246.90			
V_L	1076			− 1062			
V_R	223			1495			
832 Live Load	839						
2564 Σ Load	2571						
Σ Lgth =	985.43	Str. =	.30 +	985.05 =	985.35		

Tower:

Vert = 1495

22.6 tan 30 = 13.050

14.50 K

= 7.25 / leg.

1600# @ ¾ = 1200# @ Tower

10m Tower

M = 1.2 × 33' = 39.6

Load / leg =

$7.25 \pm \frac{39.6}{14.7}$

= 7.25 ± 2.69

= 9.94 or 4.56

Comb = $\frac{9.94}{13.17} + 0 = 0.75$

Snow $\frac{9.94 + 0.91}{13.17} + \frac{3.17}{14.87}$

= 0.82 + 0.21 = 1.04 OK.

H from 8c approx. of H from snag horizontal

22608 vs 81600

S.F. = 3.6

300m ¼ Snag horiz 1φ

McElhanney

Design Sketch

SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
300 m (98A) ¼ SPAN LOAD + SNAG (VERT) 1"Ø	DESIGN aow DATE May 25 07	CHECK DATE	2111 01745-1	8 C

Vert. = 650
Snag Vert = 1600
2250 #

Cable 1.76x984 = 1732
3982

$Str. = (H - H_0)\frac{1062}{14530} = (H - H_0) .073$

SPAN	738			246			
Sag DL	984 / 19.68						
H DL	10824						
Lgth	985.05						
W cable	1732						
P/W							Snow OK.
Sag LL							
Sag D+L							
H D+L / H LL							
Stretch / New lgth							
½ lgth.							Cable S.F. $= \frac{81.6}{22.6} = 3.61$
defln (01)	- 25.5			+25.5			
Sag (03)	5.3			0.589			
H D+L	22608			22608			
Lgth ℄	738.54			247.32			
VL	1431			2127			
VR	-132			2560			
Live Load	2259						
Σ Load	3991						
Lgth =	985.86	Str. = .86 + 985.05 = 985.91					

300m ¼ Snag Vert 1Ø

McElhanney

Design Sketch

SUBJECT 300m 984' MID SPAN LOAD + SNAG (SLOPED) 1¼ϕ | DESIGN | DATE | CHECK | DATE | JOB NO. | PAGE 9

Vert. Load = 650 + 182 = 832
Cable weight 2.75 × 984 = 2706
3538

	SPAN	492						
	$Sag_{D.L.}$	19.68						
	H_{DL}	16913						
	Lgth	985.05						
	W_{cable}	2706						
	P/W	.3075						
	$Sag_{L.L.}$	.09 1.77						
	Sag_{D+L}	21.5						
	H_{D+L} H_{LL}			22308 5395				
	Stretch New lgth			0.25 985.30				
	½ lgth.			492.65				
	defln (01)	24		24				
	Sag (03)	3.73		3.73				
	H	22308		22308				
	Lgth ½	492.66						
1769	V_L	1765						
416	V_R	412						
832	Live load	824						
3538	Σload	3540						

D+L Sag $= \frac{24}{984} = .024$

300m MID SPAN SNAG HOR. 1¼ϕ

10m Tower

1600 # laterally ÷ 2250 at midspan

∴ H = 30592 See P. 15

Vert. to tower = 1765 + 30592 tan 30
= 19.42^K

M to Tower 1600/2 = 800 to Tower top

∴ M = .800 × 33' = 26.4

Load to leg = $\frac{19.42}{2} \pm \frac{26.4}{14.70}$ = 9.71 ± 1.80 = 11.51 or 7.91 (10m Tower)

Comb $\frac{11.51}{13.17} + \frac{0}{14.82}$ = 0.87

With Snow $\frac{11.51+0.91}{13.17} + \frac{3.17}{14.82}$ = 0.94 + 0.21 = 1.16

∴ Remove snow from 10m Tower.

Tension in CABLE H = 30592 for Snag sloped.

∴ Tension = 30.6^K vs 141^K S.F. = 4.6

Try 8m Tower (26') M = .800 × 26 = 20.8 To leg = 11.51 or 7.91

Comb $\frac{11.51+0.91}{20.1} + \frac{3.17}{14.82}$ = 0.62 + 0.21 = 0.83 OK.

∴ Remove snow for 9 + 10m Tower.

Design Sketch — McElhanney

SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
300m (984') 1/4 SPAN LOAD + VERT. SNAG. 1 1/4"φ	[illegible] DATE Oct 31 01	DATE		11

Vert Load = 650 + 1600 = 2250

$1\frac{1}{4}$φ Cable = 2.75 plf × 984 = 2706 #

70.4 T B.S. = 141 K A = 1.227

AE = 1.227 × 18500 = 22703 (21)

H_{DL}

300m = 984' = 246' + 738'

L for stretch = 984 + 2 × 39 = 1062'

Str = (H − H_{DL}) (02) 1062'/22703 .0468 (00)

Lgth D = 985.05

SPAN	738'			246'		
Sag D.L.	984' 19.68					
H_{DL}	16913					
Lgth	985.05					
W cable	2706					
P/W	—					
Sag L.L.						
Sag D+L						
H_{D+L} / H_{LL}						
Stretch / New lgth						
½ lgth						
defln (01)	23			23		
Sag (03)	6.50		÷9 =	1722		
H	28803			28803		
Lgth #	738.51			247.08		
V_L	1912			−2355		
V_R	117			3031	T = 28971 ∠ 6°.007	
2250 Live load	2238					
4956 Σ load	4943					
Lgth =	985.59	Str. =	985.61	o.K.		

H = 28803

Str = 0.56'

D lgth 985.05

985.61

Tension

28.8

vs 141

S.F. = 4.9 to 1

Load To Tower

3031 + 28803 tan 30

= 19.66 K

= 9.83 K/leg

< 13.17 K

o.K.

Add Snow

$\frac{9.83 + 0.91}{13.17} + \frac{3.17}{14.82}$

= 0.82 + 0.21

= 1.03 o.K.

300m ¼ Snag Vert. 1¼φ

McElhanney

Design Sketch

SUBJECT 300m ¼ SPAN LOAD + VERT SNAK. 1¼ ϕ	DESIGN [illegible] DATE Nov 08 01	CHECK DATE	JOB NO. 2111 01745-1	PAGE 12

Vert to tower 3031

+ 28803 tan 30 = 16629

19660

Load per leg : ÷ 2 = 9.83 < 13.17 OK

With Snow

$$\frac{9.83 + 0.91}{13.17} + \frac{3.17}{14.82}$$

= 0.82 + 0.21

= 1.03 O.K.

Tension in CABLE H = 28803

Tension = 28.8 K vs 141 SF = 4.9 to 1

McElhanney

Design Sketch

SUBJECT 300m (984') 1/4 SPAN LOAD + SNAG (SLOPED) 1/4φ	DESIGN RGW DATE Oct 31 01	CHECK DATE	JOB NO.	PAGE 13

Vert Load = 650 + 182 = 832
Cable 2.75 × 984 2706
3538

SPAN	738			246			H = 21275
Sag D.L.	984/ 19.68						Str. 0.20 985.05 985.25
H DL	16913						
Lgth	985.05						
W cable	2706						
P/W							
Sag L.L.							
Sag D+L							
H D+L H LL							
Stretch New lgth							
1/2 lgth.							
defln @ 01	19			19			
Sag @ 03	8.80			0.978			
H	21275			21275			
Lgth	738.52			246.74			
V_L	1562			-1305			
V_R	467			1981			
832 Live Load	838						
3538 Σ Load	3543						
Σ Lgth = 985.26 → Stretched = 985.25							

300 1/4 Snag hor. 1/4φ

McElhanney

Design Sketch

SUBJECT 300m ¼ SPAN LOAD + SNAG SLOPED 1¼ φ	DESIGN	DATE Nov 07 01	CHECK	DATE	JOB NO. 2111 01745-1	PAGE 14

1600# laterally & 2250 vertically.

∴ H = 28803 See P. 11

FOOTING.

Load to leg = 12.00^k

Do not incl. snow.

Vert to tower = 1981 + 28803 tan 30

= 18.61^k

M to tower = 1600 × ¾ × 33' = 39.6'^k

Load to leg = $\frac{18.61}{2} \pm \frac{39.6}{14.7}$

= 9.31 ± 2.69 = 12.00 or 6.62

Comb. $\frac{12.00}{13.17} + \frac{0}{14.82} = 0.91$

With Snow $\frac{12.00+0.91}{13.17} + \frac{3.17}{14.82} = 0.98 + 0.21 = 1.19$

9m Tower $\frac{}{15.9}$ + 0.81 + 0.21 = 1.02

8m Tower $\frac{}{20.1}$ + = 0.64 + 0.21 = 0.85

∴ Remove snow for 9m & 10m Towers.

Sway to 8m Tower = 0.27 (P. T-2) = 0.85 + 0.27 = 1.12 OK.

< 1.33

Tension in CABLE 28.8^k vs 141 S.F = 4.9

Load to Tower SHEAVE 18.61^k on 1½ φ D.S. = $\frac{18.61}{2 \times 1.77}$ = 5.27 ksi < 10 ksi
∴ Any steel OK.

Bending = 18.61^k → 9.3^k × ½" say = 4.7"^k

S.M. = .331 fb = 14.2 ksi - O.K. Any bolt.

300m ¼ Snag Hor. 1¼ φ

McElhanney

Design Sketch

SUBJECT 300m MID SPAN LOAD + VERT. SNAG 1 1/4 φ	DESIGN [illegible] DATE Nov 1 01	CHECK DATE	JOB NO.	PAGE 15

Vert. load = 650
Snag Vert. 1600
2250 1/2 = 1125

Cable 2.75 × 984 = 2706
Σ Wt = 4956 1/2 = 2478

Lgth for stretch = 984
6m Tower 2×39 = 78
1062'

SPAN	984'							Stretch (03) $\frac{(H-H_D)1062}{18500 \times 1.227}$
$Sag_{D.L.}$ 2%	19.68		= .020 Span					$= (H-H_D) \times .0468$
H_{DL}	16913							= (01)
Lgth	985.05							+ 985.05
Wcable	1732							
P/W								
$Sag_{L.L.}$								
Sag_{D+L}								Cable S.F.
H_{D+L} / H_{LL}		30592 / 13679						$= \frac{141}{30.59} = 4.6$
Stretch / New lgth		.64 / 985.69						
1/2 lgth		492.84						
defln (01)	29.0	29.00	= .030 Span = (1.50 DL Sag)					
Sag (03)	2.72	2.72						
H	30592	30592						D+L Sag
Lgth 1/2	492.89	492.89						$= \frac{29}{984} = .029$
2478 V_L	2480	2480						
1125 V_R	1127	1127						
2250 Live Load	2254	2254						
Σ Load	–	–						

300m Mid Span Vert Snag 1 1/4 φ

McElhanney

Design Sketch

SUBJECT 300 m MID SPAN LOAD + VERT. SNAG 1¼ ϕ	DESIGN DATE	CHECK DATE	JOB NO.	PAGE 15A

D.L. Sag = 3%

Vert. Load = 650 + 1600 = 2250 ½ = 1125

Cable 2.75 × 984 = 2706

EWT = 4956 ½ = 2478

Lgth for Stretch = 984 + 2×39 = 1062'

Stretch = (H − H₀) 1062 / 18500 × 1.227 = (H − H₀) × .0468

+986.36

SPAN	984						
Sag D.L.	29.52		= .030 Span				
H D.L.	11275						
Lgth	986.36						
W cable	2706						
P/W							
Sag L.L.							
Sag D+L							
H D+L H LL		24546 13271					
Stretch New lgth		0.62 986.98					
½ lgth		493.49					
defln @ .01	36.0	36.0	= .037 Span		(1.23 D.L Sag)		
Sag @ .03	3.39	3.89					
H	24546	24546					
Lgth ½	493.38	493.38					
2478 V_L	2473	2473					
1125 V_R	1120	1120					
Live load	2240	2240					
E load							

3% D.L Sag.

300 m Mid Vert Snag 1¼ ϕ

Vert to tower 2478 = 2.5
+ H tan 30 = 30592 = 17.7
Σ = 20.1

Load per leg = 20.1/2 = 10.1 < 13.17 OK.

With SNOW $\frac{10.1 + 0.91}{13.17} + \frac{3.17}{14.82}$

= 0.83 + 0.21

= 1.05

Remove Snow from 10m
OK 9m & less

Tension in CABLE H = 30592 vs 141 = 4.61 S.F.

Design Sketch — **McElhanney**

SUBJECT	DESIGN	CHECK	JOB NO.	PAGE
300 m MARKER	rad DATE Jan 04 02	DATE		17

984' – 30"ϕ 19# ea. at 45 m. = 150' Wt: $\frac{19}{150}$ = 0.13 plf – Markers

$\frac{3}{8}\phi$ = 0.25 + 0.13 = 0.38 plf.

$H = \frac{0.38 \times 984^2}{8 \times .02 \times 984} = 2317^{\#}$ T = 2400 #   B.S. = 23600

S.F = 10

Add 1" ice =

$\overline{2\frac{3}{8}}$ $A_{ice} = \pi \frac{2.625^2}{4} - \pi \frac{.375^2}{4} = 5.30 \text{ in}^2$

@ 60 pcf = 2.21 plf.

On bells

Vol. $= \pi \frac{32^3}{6} - \pi \frac{30^3}{6} = 3000 \text{ in}^3$

1.75 ft³/bell

= 1.75 × 60/150' = 0.70 plf.

∴ Cable + Markers + ice on cable + ice on bells

0.25 + 0.13 + 2.21 + 0.70 = 3.29 plf.

$H = \frac{3.29 \times 984}{8 \times .02} = 20.2^{K}$ T = 21

With ice use ½" Cable.

Table 2. Summary of Analysis for 300 m Span, 1" Wire Rope, BS = 81,600 lbs.

Loading Condition	Load	H	Cable	A-Frames
(See Section 4.0)	(lbs)	(lbs)	S.F.	(With Snow)
1. ½ span, vertically down	2,250	24,317	3.4	O.K.
2. ½ span with snag load	832	24,317	3.4	O.K.
3. ¼ span, vertically down	2,250	22,608	3.6	O.K.
4. ¼ span with snag load	832	22,608	3.6	O.K.
5. ½ span no snag load	650	15,436	5.3	O.K.

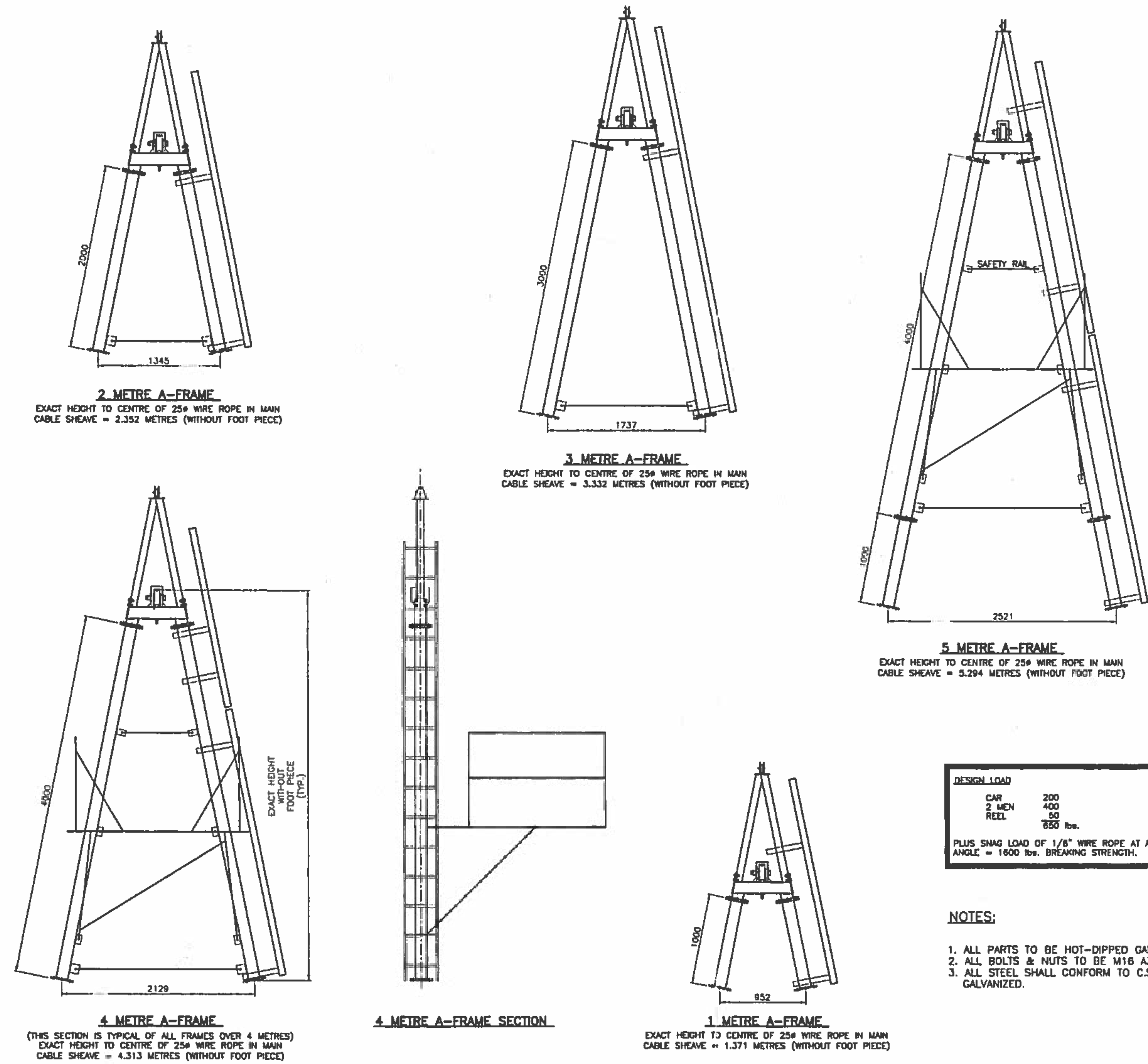
Table 3. Summary of Analysis for 300 m Span, 1[1/4]" Wire Rope, BS = 141,000 lbs.

Loading Condition	Load	H	Cable	A-Frames
(See Section 4)	(lbs)	(lbs)	S.F.	(With Snow)
1. ½ span, vertically down	2,250	30,592	4.6	Remove Snow from 10 m Towers
2. ½ span with snag load	832	30,592	4.6	Remove Snow from 10 m Towers
3. ¼ span, vertically down	2,250	28,803	4.9	Remove Snow from 9 & 10 m Towers
4. ¼ span with snag load	832	28,803	4.9	Remove Snow from 9 & 10 m Towers
5. ½ span no snag load	650	-	5+	

Table 1. Summary of Analysis for 150 m Span, 1" Wire Rope, BS = 81,600 lbs.

Loading Condition	Load	H	Cable	A-Frames
(See Section 4.0)	(lbs)	(lbs)	S.F.	(With Snow)
1. ½ span, vertically down	2,250	20,020	4.1	O.K.
2. ½ span with snag load	832	20,020	4.1	O.K.
3. ¼ span, vertically down	2,250	18,959	4.3	O.K.
4. ¼ span with snag load	832	18,959	4.3	O.K.

LOADING SUMMARY



DESIGN LOAD

CAR	200
2 MEN	400
REEL	50
	650 lbs.

PLUS SNAG LOAD OF 1/8" WIRE ROPE AT ANY ANGLE = 1600 lbs. BREAKING STRENGTH.

NOTES:

1. ALL PARTS TO BE HOT-DIPPED GALVANIZED C.S.A. G-164.
2. ALL BOLTS & NUTS TO BE M16 A325M TYPE 2 GALVANIZED.
3. ALL STEEL SHALL CONFORM TO C.S.A. G40.21M GRADE 350W GALVANIZED.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

BILLS OF MATERIAL

A COMPLETE 2 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	2 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.1 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
2	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
1	3m LADDER	3136-10	OTHER * W.S.C.

EST. W.T. 217.0 kg

A COMPLETE 3 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	3 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.5 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
2	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
1	4m LADDER	3136-10	OTHER * W.S.C.

EST. W.T. 265.3 kg

A COMPLETE 4 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
2	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
1 1	2m LADDER 3m LADDER	3136-10	OTHER * W.S.C.

EST. W.T. 580.3 kg

A COMPLETE 5 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
4	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
2	3m LADDERS		OTHER * W.S.C.

EST. W.T. 668.0 kg

* WATER SURVEY OF CANADA

A COMPLETE 1 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	1 METRE LEG ASSEMBLY	3136-5	CONTRACTOR

EST. W.T. 173.4 kg

No.	Date	Revision	Dr	Ch
1	JUNE/02	APPROVED AND REDRAWN BY MCSI	KDW	AAW

McElhanney
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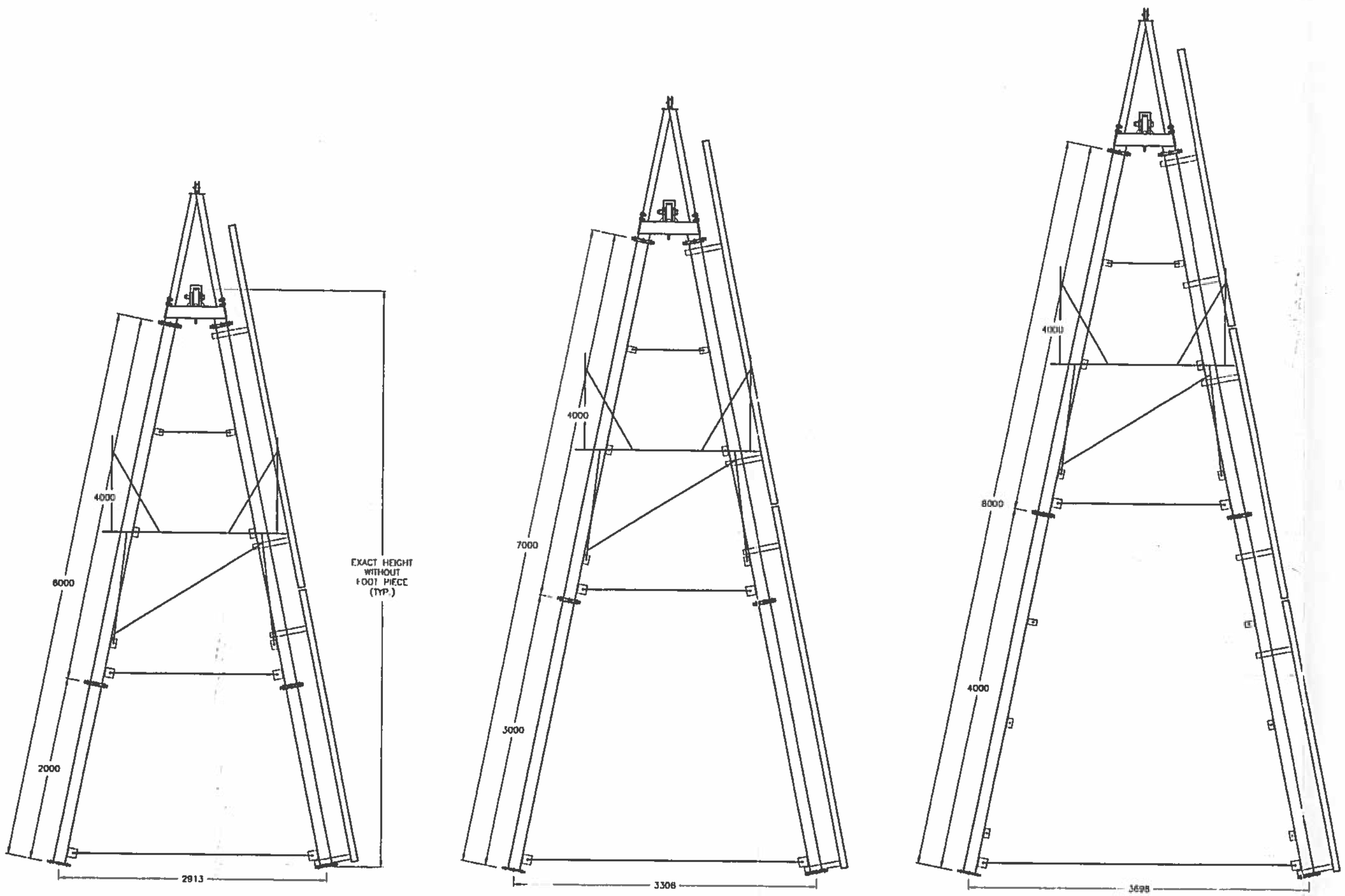
13160-88 Ave., Surrey, B.C., Canada V3W 3K3 Telephone (604)596-0391

DEPT. OF THE ENVIRONMENT
WATER SURVEY OF CANADA, VANCOUVER, B.C.
HEAVY DUTY A-FRAMES
1, 2, 3, 4, & 5 METRE HEIGHTS
VANCOUVER, B.C.

JUN 2 0 2002

Designed D.O.E.	Job No. 2111-01745-1	Drawing No. 3136-1
Drawn K.D.W	Scale 1:25	
Checked A.A.W.	Date APRIL 2002	
Approved	Revision 1	of 10



6 METRE A-FRAME
EXACT HEIGHT TO CENTRE OF 25ø WIRE ROPE IN MAIN CABLE SHEAVE = 6.274 METRES (WITHOUT FOOT PIECE)

7 METRE A-FRAME
EXACT HEIGHT TO CENTRE OF 25ø WIRE ROPE IN MAIN CABLE SHEAVE = 7.255 METRES (WITHOUT FOOT PIECE)

8 METRE A-FRAME
EXACT HEIGHT TO CENTRE OF 25ø WIRE ROPE IN MAIN CABLE SHEAVE = 8.235 METRES (WITHOUT FOOT PIECE)

BILLS OF MATERIAL

A COMPLETE 6 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	2 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	2.7 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
4	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
1 1	4m LADDER 3m LADDER	3136-10	OTHER * W.S.C.

EST. W.T. 718.1 kg

A COMPLETE 7 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	3 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	3.1 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
4	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
2	4m LADDERS	3136-10	OTHER * W.S.C.

EST. W.T. 763.6 kg

A COMPLETE 8 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
2	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	3.5 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
6	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
3	3m LADDERS	3136-10	OTHER * W.S.C.

EST. W.T. 811.3 kg
* WATER SURVEY OF CANADA

DESIGN LOAD

CAR	200
2 MEN	400
REEL	50
	650 lbs.

PLUS SNAG LOAD OF 1/8" WIRE ROPE AT ANY ANGLE = 1610 lbs. BREAKING STRENGTH.

NOTES:

1. ALL PARTS TO BE HOT-DIPPED GALVANIZED C.S.A. G-164.
2. ALL BOLTS & NUTS TO BE M16 A325M TYPE 2 GALVANIZED.
3. ALL STEEL SHALL CONFORM TO C.S.A. G40.21M GRADE 350W GALVANIZED.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

No	Date	Revision	Dr	Ch
1	JUNE/02	APPROVED AND REDRAWN BY MCSL	KDW	AAW

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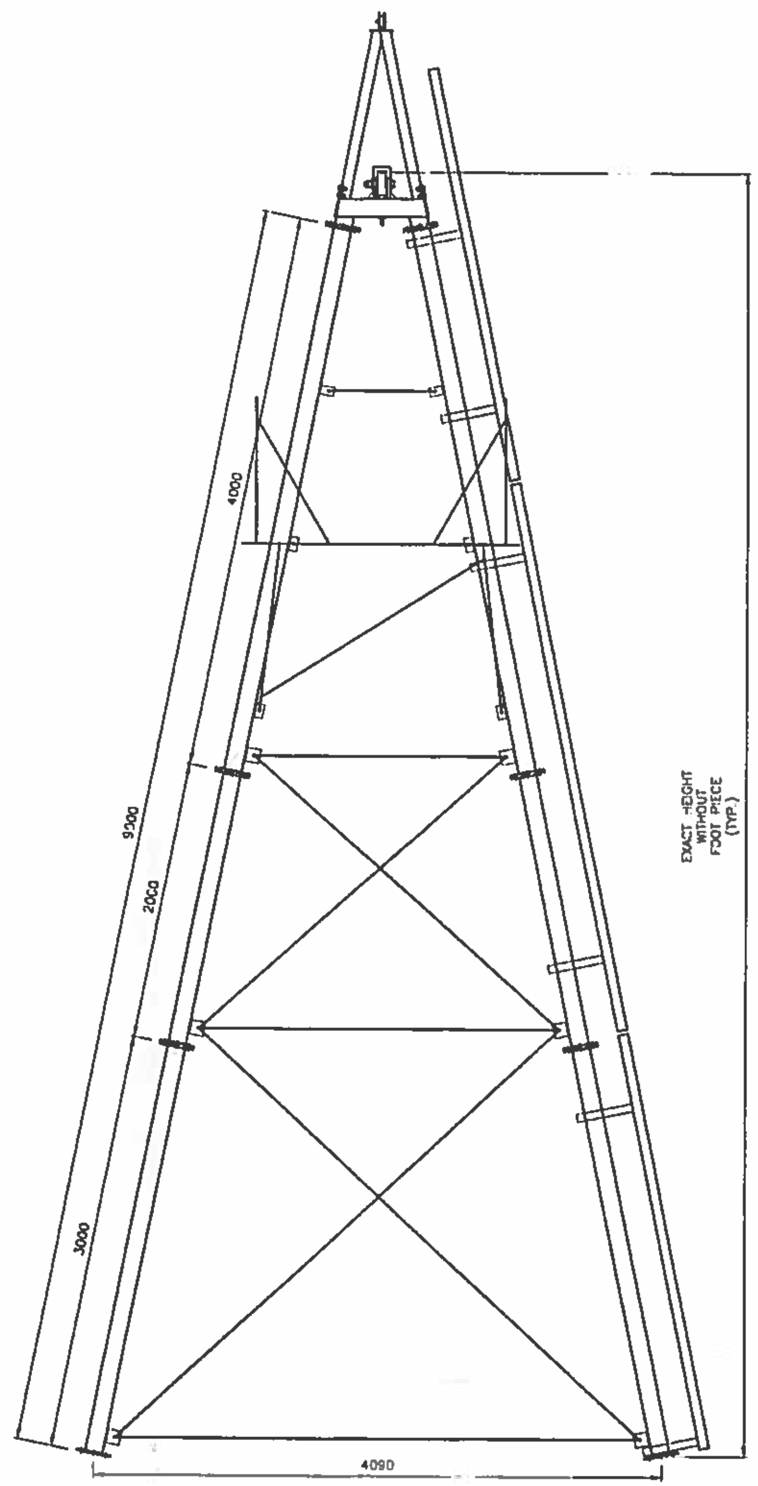
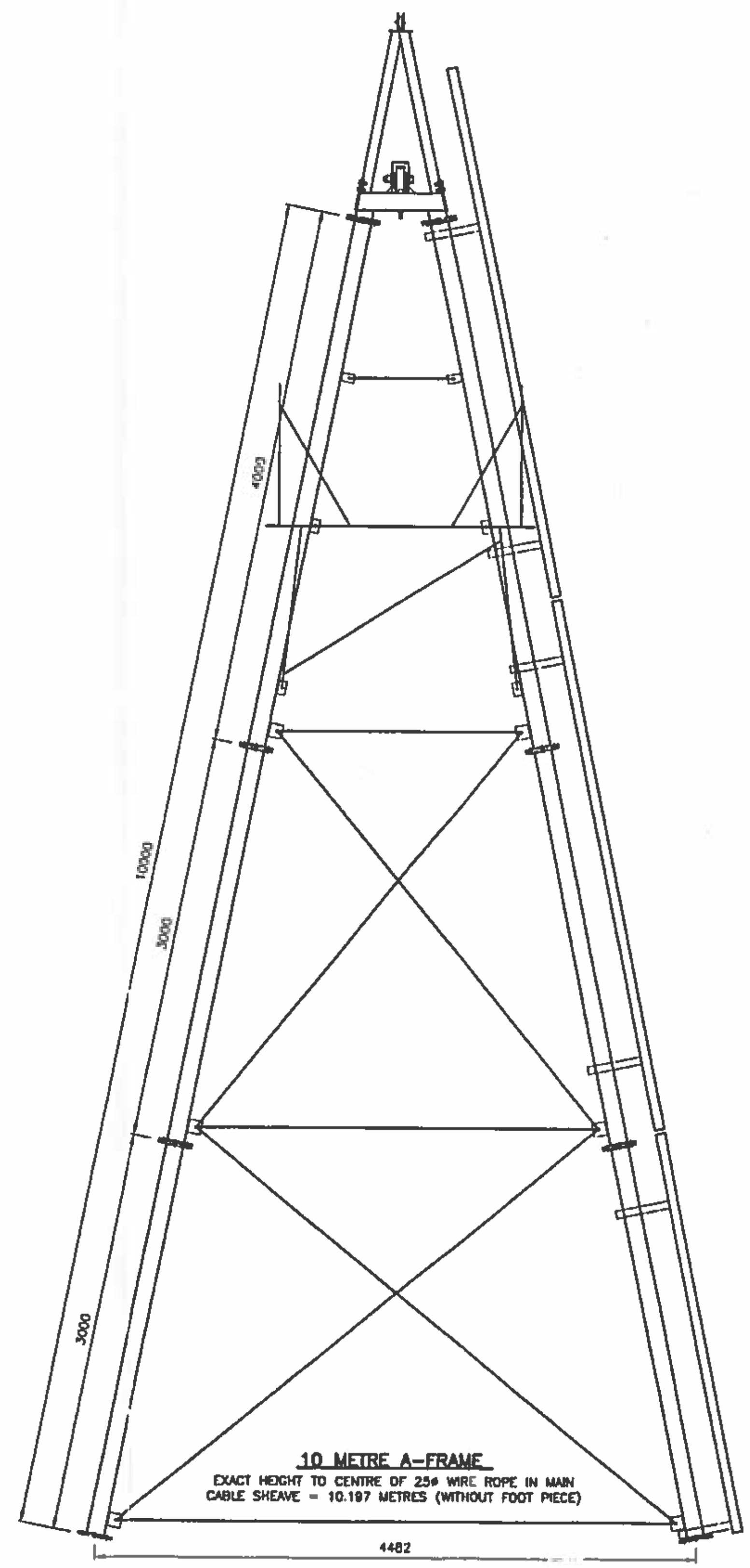
DEPT. OF THE ENVIRONMENT
WATER SURVEY OF CANADA, VANCOUVER, B.C.
HEAVY DUTY A-FRAMES
6, 7, & 8 METRES
VANCOUVER, B.C.

JUN 2 0 2002

Designed D.O.E.	Job No. 2111-01745-1	Drawing No. 3136-2
Drawn K.D.W	Scale 1:25	
Checked A.A.W.	Date APRIL 2002	
Approved	Revision 1	of 10



9 METRE A-FRAME
EXACT HEIGHT TO CENTRE OF 25ø WIRE ROPE IN MAIN CABLE SHEAVE = 9.218 METRES (WITHOUT FOOT PIECE)



10 METRE A-FRAME
EXACT HEIGHT TO CENTRE OF 25ø WIRE ROPE IN MAIN CABLE SHEAVE = 10.197 METRES (WITHOUT FOOT PIECE)

BILLS OF MATERIAL

A COMPLETE 9 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	2 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	3 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	2.7 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	3.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	LATERAL BRACING ASSEMBLY FOR 9 METRE A-FRAME	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
6	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
1 2	4m LADDER 3m LADDERS	3136-10	OTHER * W.S.C.

EST. W.T. 980.7 kg
* WATER SURVEY OF CANADA

A COMPLETE 10 METRE A-FRAME ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP ASSEMBLY	3136-4	CONTRACTOR
1	4 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
2	3 METRE LEG ASSEMBLY	3136-5	CONTRACTOR
1	1.9 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	3.1 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	4.2 METRE HORIZONTAL BRACE ASSEMBLY	3136-6	CONTRACTOR
1	LATERAL BRACING ASSEMBLY FOR 10 METRE A-FRAME	3136-6	CONTRACTOR
1	PLATFORM ASSEMBLY	3136-9	CONTRACTOR
1	CAR HOOK ASSEMBLY LEG	3136-10	CONTRACTOR
6	LADDER BRACKET ASSEMBLY	3136-10	CONTRACTOR
1 2	3m LADDER 4m LADDERS	3136-10	OTHER * W.S.C.

EST. W.T. 1056.9 kg

NOTES:

1. ALL PARTS TO BE HOT-DIPPED GALVANIZED C.S.A. G-164.
2. ALL BOLTS & NUTS TO BE M16 A325M TYPE 2 GALVANIZED.
3. ALL STEEL SHALL CONFORM TO C.S.A. G40.21M GRADE 350W GALVANIZED.

DESIGN LOAD

CAR	200
2 MEN	400
REEL	50
	650 lbs.

PLUS SNAG LOAD OF 1/8" WIRE ROPE AT ANY ANGLE = 1600 lbs. BREAKING STRENGTH.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

No.	Date	Revision	Dr	Ch
1	JUNE/02	APPROVED AND REDRAWN BY MCSL	KDW	AAW

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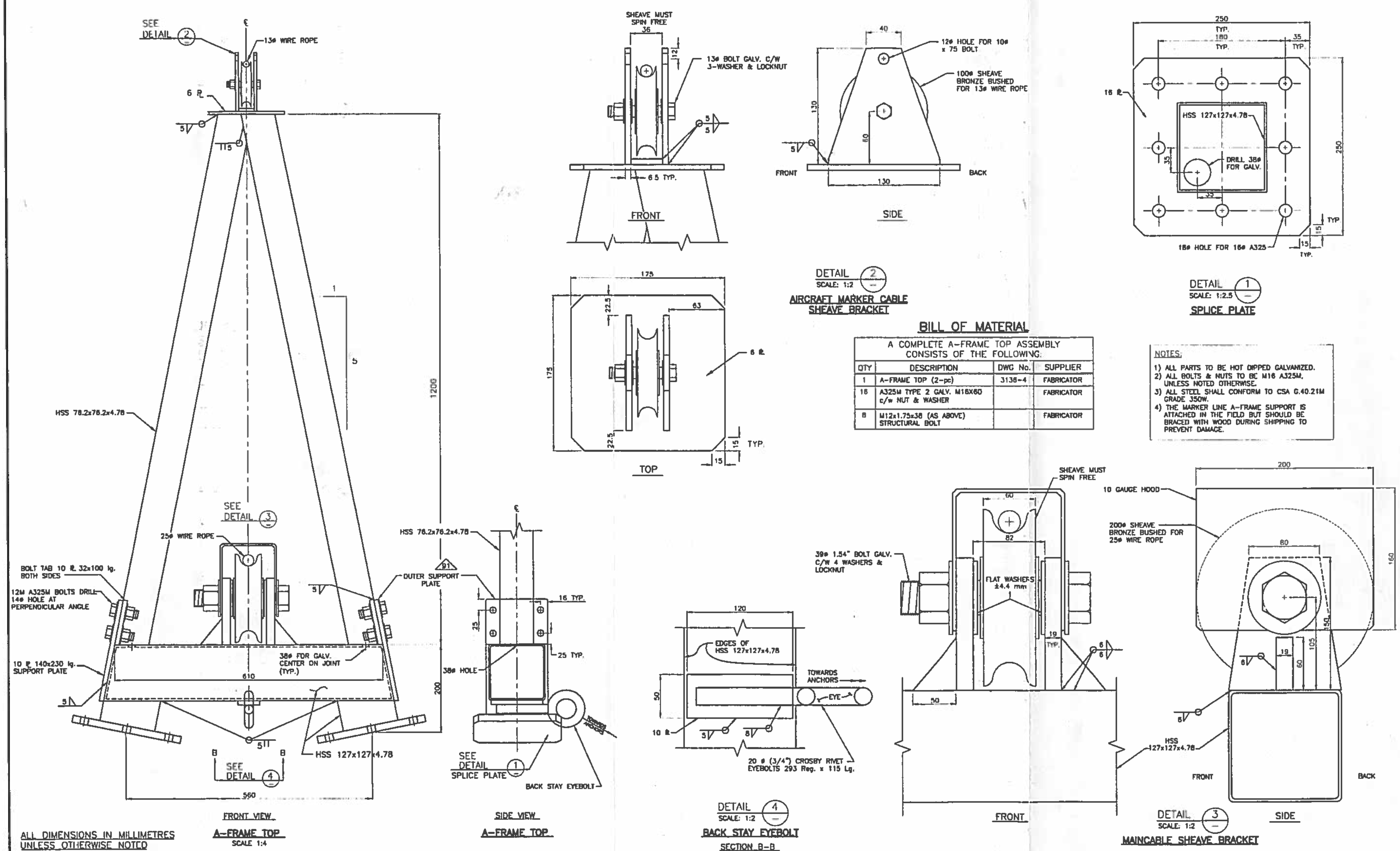
DEPT. OF THE ENVIRONMENT
WATER SURVEY OF CANADA, VANCOUVER, B.C.
HEAVY DUTY A-FRAMES
9 & 10 METRES
VANCOUVER, B.C.

JUN 20 2002

Designed D.O.E.	Job No. 2111-01745-1	Drawing No. 3136-3
Drawn K.D.W	Scale 1:25	
Checked A.A.W.	Date APRIL 2002	
Approved	Revision 1	of 10



ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

BILL OF MATERIAL

A COMPLETE A-FRAME TOP ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	A-FRAME TOP (2-pc)	3136-4	FABRICATOR
16	A325M TYPE 2 GALV. M16X60 c/w NUT & WASHER		FABRICATOR
8	M12x1.75x38 (AS ABOVE) STRUCTURAL BOLT		FABRICATOR

NOTES:

1) ALL PARTS TO BE HOT DIPPED GALVANIZED.
2) ALL BOLTS & NUTS TO BE M16 A325M, UNLESS NOTED OTHERWISE.
3) ALL STEEL SHALL CONFORM TO CSA G.40.21M GRADE 350W.
4) THE MARKER LINE A-FRAME SUPPORT IS ATTACHED IN THE FIELD BUT SHOULD BE BRACED WITH WOOD DURING SHIPPING TO PREVENT DAMAGE.

No.	Date	Revision	Dr	Ch
1	JUNE/07	APPROVED AND REDRAWN BY MCSI	KDW	AAW

McElhanney

McElhanney Consulting Services Ltd.

13160-88 Ave., Surrey, B.C., Canada V3W 3K3 Telephone (604)596-0391

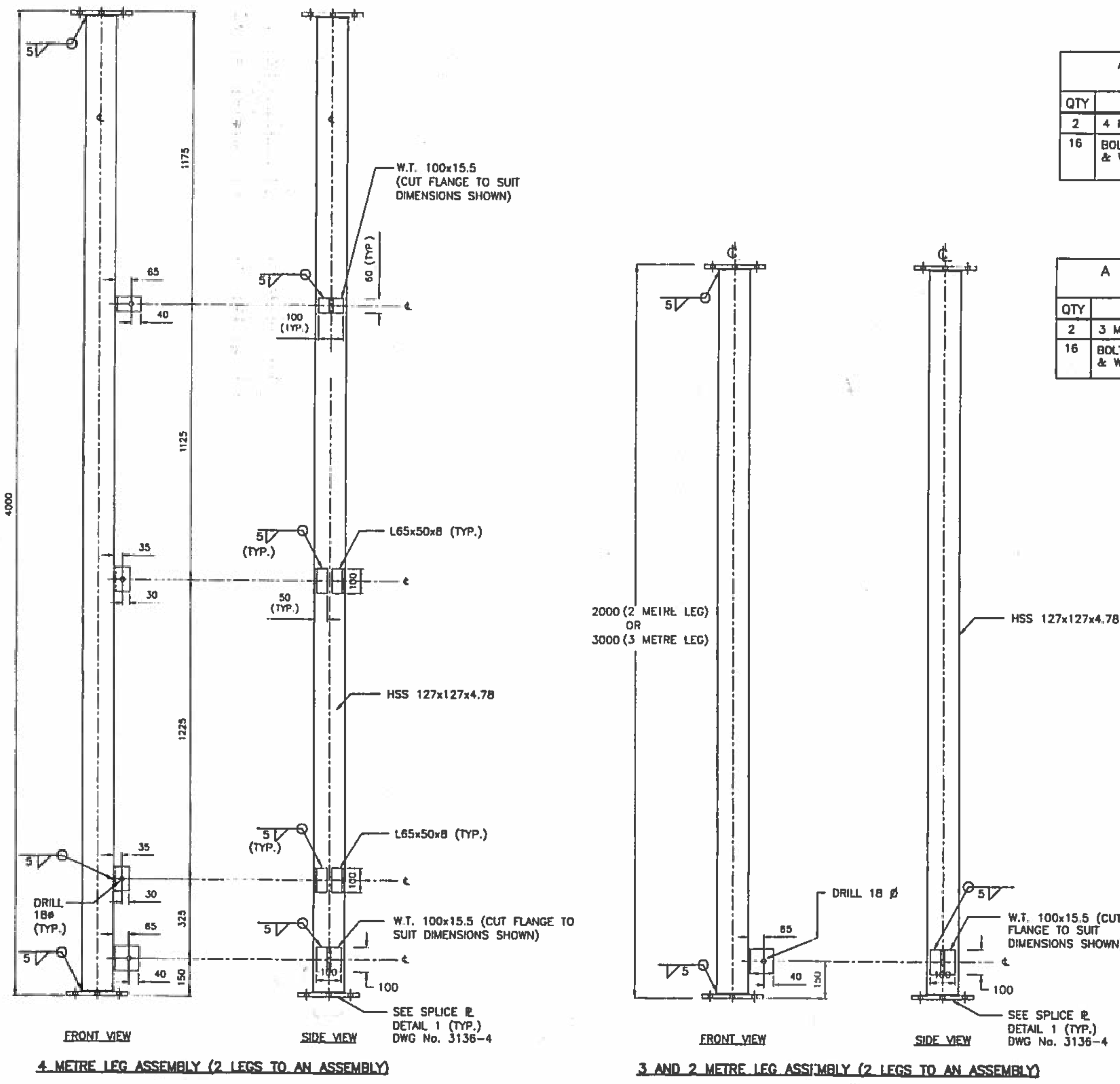
DEPT. OF THE ENVIRONMENT
WATER SURVEY OF CANADA, VANCOUVER, B.C.

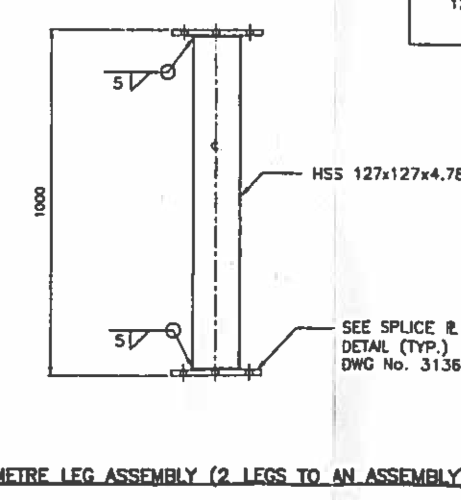
HEAVY DUTY A-FRAMES
VARIOUS DETAILS, TOP ASSEMBLY

VANCOUVER, B.C.

JUN 2 0 2007

Designed D.O.C.	Job No. 2111-01745-1	Drawing No.	3136-4
Drawn K.D.W	Scale AS SHOWN		
Checked A.A.W.	Date APRIL 2002		
Approved	Revision 1	of 10	





BILLS OF MATERIAL

A COMPLETE 4 METRE LEG ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
2	4 METRE LEG	3136-5	FABRICATOR
16	BOLTS M16x60 A325 c/w NUT & WASHER		FABRICATOR

EST. W.T. 187.4 KG

A COMPLETE 2 METRE LEG ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
2	2 METRE LEG	3136-5	FABRICATOR
16	BOLTS M16x60 A325 c/w NUT & WASHER		FABRICATOR

EST. W.T. 101.5 KG

A COMPLETE 3 METRE LEG ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
2	3 METRE LEG	3136-5	FABRICATOR
16	BOLTS M16x60 A325 c/w NUT & WASHER		FABRICATOR

EST. W.T. 144.7 KG

A COMPLETE 1 METRE LEG ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
2	1 METRE LEG	3136-5	FABRICATOR
16	BOLTS M16x60 A325 c/w NUT & WASHER		FABRICATOR

EST. W.T. 70.6 KG

NOTES:

1. ALL PARTS TO BE HOT-DIPPED GALVANIZED
2. ALL BOLTS & NUTS TO BE A325M TYPE 2 GALVANIZED, UNLESS NOTED OTHERWISE
3. ALL STEEL SHALL CONFORM TO C.S.A. G.40.21M GRADE 350W.

* ALL LEG ASSEMBLIES ARE TO BE MADE UP OF A SINGLE PIECE OF HSS 127x127x4.78, NO WELDED JOINT.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

No.	Date	Revision	Dr	Ch
1	JUNE/02	APPROVED AND REDRAWN BY MCSL	KDW	AAW

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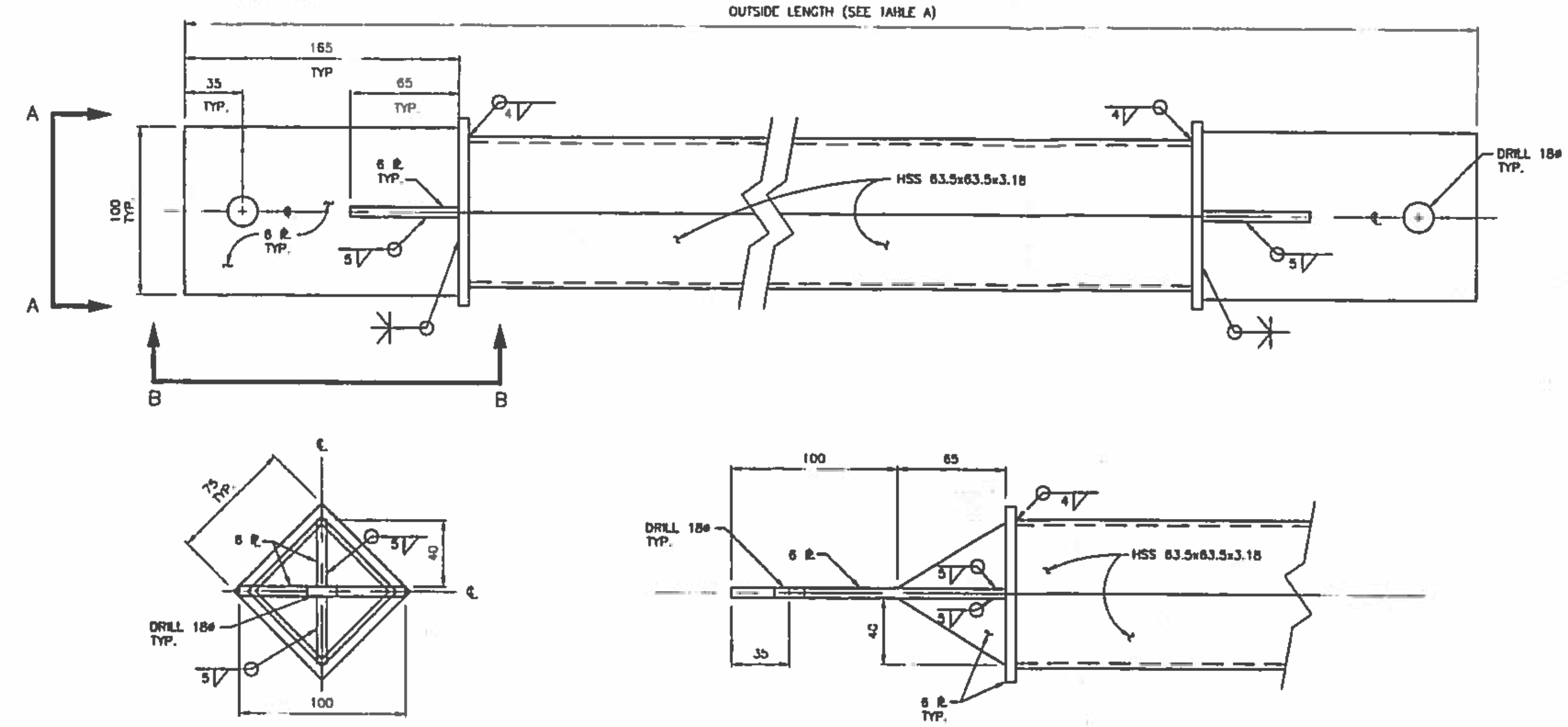
DEPT. OF THE ENVIRONMENT
WATER SURVEY OF CANADA, VANCOUVER B.C.

HEAVY DUTY A-FRAMES
VARIOUS DETAILS, LEG ASSEMBLY

VANCOUVER, B.C.

JUN 20 2002

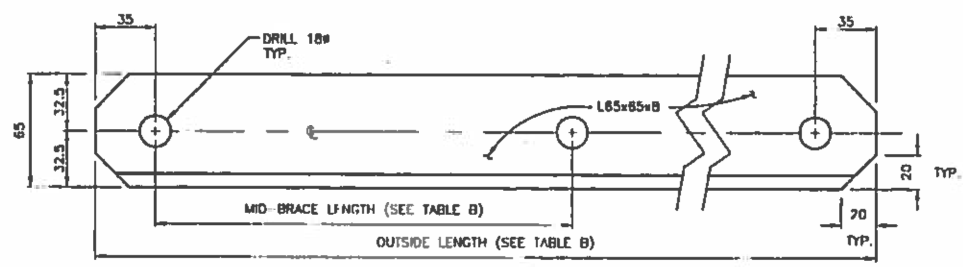
Designed D.O.E.	Job No. 2111-01745-1	Drawing No.	
Drawn K.D.W	Scale AS SHOWN	3136-5	
Checked A.A.W.	Date APRIL 2002		
Approved	Revision 1	of 10	



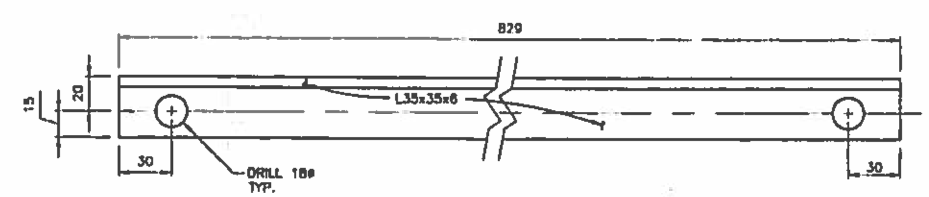
SECTION A-A

SECTION B-B

HORIZONTAL BRACE



LATERAL BRACE



SAFETY RAIL (SEE ALSO DWG 3136-9)
EST. WT. 4.9 kg

TABLE A

NOMINAL LENGTH OF HORIZONTAL BRACE	OUTSIDE LENGTH IN MILLIMETRES	EST. WT. & BOLTS
1.1 METRE	1104	7.3 kg
1.5 METRE	1496	9.6 kg
1.9 METRE	1888	11.9 kg
2.7 METRE	2673	'6.5 kg
3.1 METRE	3065	18.7 kg
3.5 METRE	3457	21.0 kg
3.9 METRE	3849	23.3 kg
4.2 METRE	4241	25.6 kg

TABLE B

NOMINAL LENGTH OF LATERAL BRACE	MID-BRACE LENGTH IN MILLIMETRES	OUTSIDE LENGTH IN MILLIMETRES	EST. WT. (kg)
3.0 METRE	1740	3025	17.5
4.4 METRE	2570	4410	25.7
3.9 METRE	2365	3871	22.5
4.7 METRE	2699	4706	27.5

BILLS OF MATERIAL

A COMPLETE HORIZONTAL BRACE ASSEMBLY CONSISTS OF THE FOLLOWING:

QTY	DESCRIPTION	DWG No.	SUPPLIER
1	HORIZONTAL BRACE OF VARIOUS NOMINAL LENGTHS (SEE TABLE A)	3136-6	FABRICATOR
2	BOLT M16x45, C/W NUT & WASHER		FABRICATOR

A COMPLETE LATERAL BRACING ASSEMBLY FOR A 9 METRE A-FRAME CONSISTS OF:

QTY	DESCRIPTION	DWG No.	SUPPLIER
2	3 METRE LATERAL BRACE (SEE TABLE B)	3136-6	FABRICATOR
2	4.4 METRE LATERAL BRACE (SEE TABLE B)	3136-6	FABRICATOR
2	BOLTS M16x50, C/W NUT & WASHER		FABRICATOR

EST. W.T. 86.9 kg

A COMPLETE LATERAL BRACING ASSEMBLY FOR A 10 METRE A-FRAME CONSISTS OF:

QTY	DESCRIPTION	DWG No.	SUPPLIER
2	3.9 METRE LATERAL BRACE (SEE TABLE B)	3136-6	FABRICATOR
2	4.7 METRE LATERAL BRACE (SEE TABLE B)	3136-6	FABRICATOR
2	BOLTS M16x50, C/W NUT & WASHER		FABRICATOR

EST. W.T. 100.5 kg

NOTES:

1. ALL PARTS TO BE HOT-DIPPED GALVANIZED C.S.A. G-164
2. ALL BOLTS & NUTS TO BE A325M TYPE2 GALVANIZED, UNLESS NOTED OTHERWISE
3. ALL STEEL SHALL CONFORM TO C.S.A. G. 40.21M GRADE 350W.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED

No.	Date	Revision	Dr	Ch
1	JUNE/02	APPROVED AND REDRAWN BY MCSL	KDW	AAW

McElhanney
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DEPT. OF THE ENVIRONMENT
WATER SURVEY OF CANADA, VANCOUVER, B.C.

HEAVY DUTY A-FRAMES
VARIOUS DETAILS, HORIZONTAL BRACE ASSEMBLY LATERAL BRACING ASSEMBLY
SAFETY RAIL
VANCOUVER, B.C.

JUN 2 0 2002

Designed D.O.C.	Job No 2111-01745-1	Drawing No. 3136-6
Drawn K.D.W	Scale AS SHOWN	
Checked A.A.W.	Date APRIL 2002	
Approved	Revision 1	of 10