AVRO AIRCRAFT

TECHNICAL REPORT

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

ANALYZED

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105

REPORT NO: 7/0583/12

FILE NO: ~~CONFIDENTIAL~~

NO. OF SHEETS:

TITLE: FIN - DETAIL STRESSING OF HINGE FITTINGS & ADJACENT STRUCTURE

Classification cancelled / Changed to UNCLASS
By authority of AVRS
Date 30 Sept 86
Signature
Unit / Rank / Appointment AVRES

PREPARED BY DATE

CHECKED BY DATE

SUPERVISED BY DATE

APPROVED BY DATE

ISSUE NO.	REVISION NO.	REVISED BY	APPROVED BY	DATE	REMARKS

FORM 1316A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 0 - 1

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	G Gordon	SEPT 58
		CHECKED BY	DATE

CONFIDENTIAL

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AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/2552/12
SHEET No. 1-1

AIRCRAFT		PREPARED BY	DATE
707	FIN	L Gardiner	APR 58
		CHECKED BY	DATE

INTRODUCTION

GENERAL STRUCTURE

THIS REPORT DEALS WITH THE HINGE FITTINGS AND THE ADJACENT STRUCTURE SUCH AS SPAR #1 AND THE SKINS NEAR THE FITTINGS. THE SKIN JOINT NEAR THE LOWER HINGE IS ALSO ANALYSED HERE.

THE TRAILING EDGE OF THE FIN IS A BOX LIKE STRUCTURE BETWEEN SPAR #1 AND SPAR #2. THE FITTINGS ARE MOUNTED TO SPAR #1 AND THE SKIN. THE BOX CONTAINS AN INTERCOSTAL CHORDWISE RIB ABOVE & BELOW EACH FITTING.

GENERAL METHOD OF ANALYSIS

THE FITTINGS ARE ANALYSED FOR THE MOST CRITICAL RUDDER LOADS WHICH COMES FROM THE 0.25 C OF RUDDER CASE.

SPAR #1 IS ANALYSED FOR THE CRITICAL HINGE LOADS PLUS SHEAR FLOW. UNFORTUNATELY, A RIGOROUS ANALYSIS WHICH WOULD BALANCE ALL LOADS DOES NOT SEEM PRACTICAL. INSTEAD THE CRITICAL REGION OF SPAR #1 NEAR THE CONTROL CUTOUT WILL BE ANALYSED LOCALLY NEAR EACH FITTING. SHEAR FLOWS WILL BE TAKEN EITHER FROM 7/0583/10 OR BY ESTIMATION OF SHEAR FLOW WHERE THEY DO NOT SEEM REASONABLE.

SPAR #1 SHEAR FLOWS GIVEN IN 7/0583/10 ARE NOT REASONABLE IN SOME CASES. FOR EXAMPLE SOME OF THESE SHEAR FLOWS ARE LESS THAN 100 #/IN. HOWEVER, THE SHEAR ON SPAR #1 SHOULD BE APPROX 30% OF THE TOTAL SHEAR ON THE FIN FOR ANY PARTICULAR STATION AS SHOWN IN 7/0583/14 SHT 4-18.

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/2583/12
SHEET No. 2 - 1

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	J Jurdjevic	AUG 55
		CHECKED BY	DATE

REPORT REFERENCES

7/0593/17 SHT 7-18 ESTIMATION SHEAR FLOW IN SPAR #1

7/0582/10 SHT 132 SHEAR FLOWS IN SPAR #1

7/0594/2 SEC 5 HINGE REACTIONS

TEXTS

ANC - 5

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/2583/12
SHEET No. 2 - 2

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gardner	AUG 55
		CHECKED BY	DATE

DRAWING LIST

7-1083-29 HINGE #1

7-1083-301 HINGE #2

7-1083-305 HINGE #3

7-1083-311 HINGE #4

7-1083-315 HINGE #5

7-1083-317 BRACKET HINGE #5

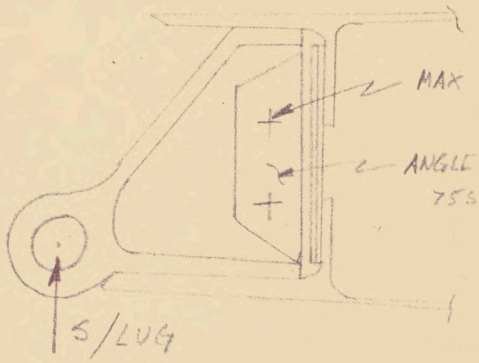
ORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/OSED/12
SHEET No. 3-1

AIRCRAFT:		PREPARED BY	DATE
		S. YOUNG	SEPT. 26/55
		CHECKED BY	DATE

HINGE SHEAR ATTACHMENT SUMMARY



±.005 TOLERANCE

HINGE	S/LUG	P	BOLT DIA.	ANGLE THICKNESS	ALLOW LOAD	M.S.	
LOCATING	11,800	3380	1/4		4650	.38	CONS.
1	7600	3640	1/4	.140	4380	.20	
2	4800	3520	1/4	.140	4380	.24	
3	2820	2010	1/4	.125	3910	.91	
4	5100	4190	1/4	.188	4650	.11	
5	4150	1380	3/16		2650	.92	
TOP	3230	3230	1/4	.11	3760	.17	

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

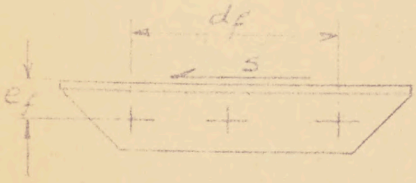
REPORT No. 7/1083/12
SHEET No 3-2

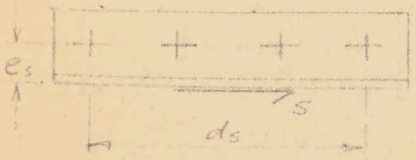
AIRCRAFT:		PREPARED BY	DATE
C105	FIN	[illegible]	March [illegible]
		CHECKED BY	DATE

HINGE ATTACHMENT ANGLES.

(CHANGES DUE TO RE-DESIGN OF TRAILING EDGE BOX)

HINGE N°	DRG. N° 7-1083 - ⑥	SIZE ①	ATTACHMENTS TO :- FITTING	SPAR N° 1
1	1831	·17 × 1·10 × ·15 × 1·15	3 - 1/4 BOLTS	4 - 1/4 BOLTS
	1843	·12 × 1·10 × ·15 × 1·15	3 - 1/4 BOLTS	2 - 5/16 BOLTS 2 - 1/4 "
2	1841	·12 × 1·70 × ·15 × 1·20	2 - 1/4 BOLTS	2 - 5/16 " 1 - 1/4 "
3	③ 1833	·12 × 1·25 × ·12 × 1·25	2 - 1/4 BOLTS	2 - 5/16 BOLTS 1 - 1/4 "
	③ 1835	·14 × 1·75 × ·12 × 1·25	2 - 1/4 BOLTS	3 - 1/4 "
4	④ 1837	·125 × × ·188 ×	2 - 1/4 BOLTS	2 - 5/16 "





ASSUMING THE OUTER ATTACH^NS ONLY TO CHECK THE OFFSET MI

LET d = DIST. BETWEEN OUTER ATTACH^NS

t = LEG THICKNESS

e = SHEAR (S) OFFSET

n = N° OF ATTACHMENTS.

SUBSCRIPT

f = FITTING LEG.

s = SPAR LEG.

THEN, $R_{MAX.} = \sqrt{(S/n)^2 + (Se/d)^2}$

④ MAKE FROM AND 10133-1204

③ MAKE FROM AND 10133-1203

② MATERIAL (ALL PARTS) SPEC. QQ-A-277 T6, EXTRUDED

① FIRST THICKNESS IS FOR LEG ATTACHING TO SPAR WEB, THIS LEG BEING THINEST, HAVING THE LARGER N° OF ATTACH^NS & WIDER SPACING.

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

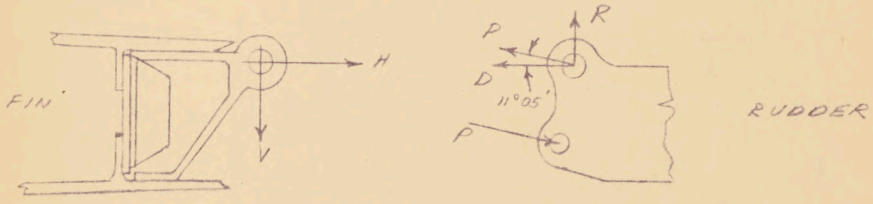
REPORT No 7/0583/12

SHEET No 4 - 1

AIRCRAFT		PREPARED BY	DATE
C105	FIN	L Gustafson	AUG 58
		CHECKED BY	DATE

FIN HINGE LOADS

RUDDER ANGLE - 10° → 11°05' (STB'D)
FIN & RUDDER LOADS IN SAME DIRECTION



$V = R + P \sin 11°05'$ (.1925)

$H = D + P \cos 11°05'$ (.9813)

CP @ 0.5C

1	2	3	4	5	6	7	8	9	10
	LIMIT							ULTIMATE	
HINGE	R 7/0584/2 5-25	P 7/0584/2 5-29	D	P SIN 11°05' (3) .1925	P COS 11°05' (3) .9813	V (2)+(5)	H (4)+(6)	V (7) 1.364	H (8) 1.364
LOCATION	-3913		178			-3913	178	-5340	243
1	2160	10,320	110	3140	16,020	10,300	16,130	14,080	23,000
2	2127	15,300	245	2945	15,030	5072	15,275	6930	20,850
3	-389	19,820	89	3825	19,520	3426	19,609	4680	26,700
4	2440	14,090	294	2710	13,830	5150	14,124	7030	19,300
5	1918	14,440	199	2780	14,170	4498	14,369	6150	19,600
UPPER	1090		162			1087	162	1490	221

CP @ .25 C

	7/0584/2 5-24	7/0584/2 5-29	7/0584/2 5-29						
LOC	-2486		357			-2486	357	-3400	487
1	3042	16,320	220	3140	16,020	11,182	16,240	15,200	22,200
2	4085	15,300	490	2945	15,030	7030	15,520	9600	21,200
3	339	19,820	178	3825	19,520	4134	19,698	5640	26,900
4	4789	14,090	587	2710	13,830	7499	14,417	10,200	19,700
5	3311	14,440	398	2780	14,170	6091	14,568	8310	19,900
UPPER	2370		323			2370	323	3230	441

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

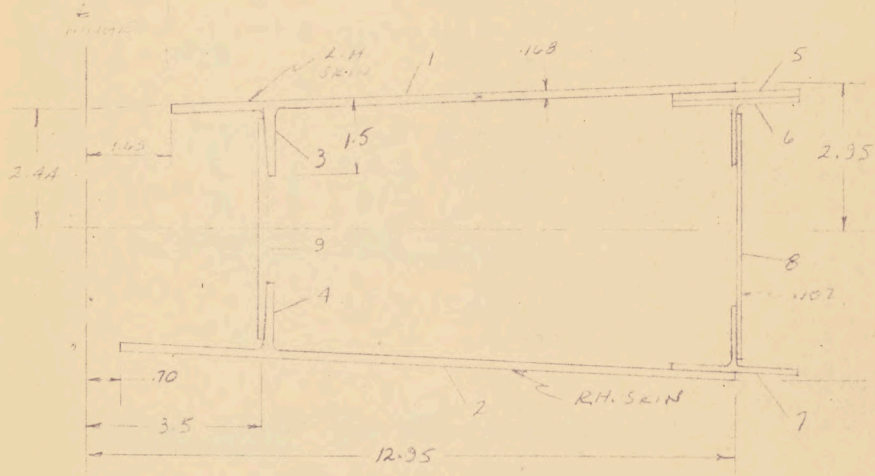
REPORT No. 7/0583/12

SHEET No. 5-1

AIRCRAFT		PREPARED BY	DATE
C-105		McCABE	4-28-55
		CHECKED BY	DATE

I/E BOTTOM JOINT - STA. 42.05 (7-0183-132)

SECTION PROPERTIES STA. 42.05



SEC A-A

	AREA	$\bar{y}$	$A\bar{y}$	$A\bar{y}^2$	I_o
1	1.300	3.864	5.02	13.27	
2	2.060	-2.706	-5.57	15.07	
3	.200	1.918	.38	.73	.030
4	.200	-1.318	-.38	.73	.030
5	1/2 × .412	2.700	.56	1.51	
6	1/2 × .383	2.334	.45	1.05	
7	1/2 × .383	-2.681	-.51	1.37	
Σ	4.943		-.05	33.73	.060

$I_x = 33.73 + .06 = 33.79$

FORM 1193A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/0583/12
SHEET No 5-2

AIRCRAFT		PREPARED BY	DATE
C-105	FIN	MC CABE	4-28-55
		CHECKED BY	DATE

T/E BOTTOM JOINT - STA 42.05 (7-0183-132)

LOADS ON STA. 42.05 JOINT

(REF SEC. A A, PG.1)

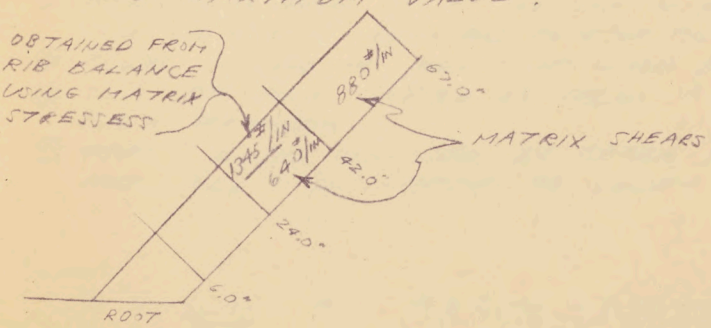
BENDING MOMENT AT STA. 42.05 = 460,000 IN-LBS

I_x = 33.73 (PG.1) REF. 7/0583/10, VOL 1, SHT 34

	M/I_x	$\bar{y}$	$f_b = -My/I$	AREA	LOAD = $f_b \times$ AREA
1	13600	2.64	-35900	1.900	-68200
2		-2.706	36800	2.060	75800
3		1.918	-26000	.200	-5200
4	13600	-1.918	26000	.200	5200

SHEAR LOAD ON SKIN PANELS

THE TRUE VALUE OF THE SHEAR FLOWS IS UNKNOWN AT THE PRESENT TIME, SINCE DIFFERENT METHODS OF ANALYSIS HAVE YIELDED WIDELY DIFFERING RESULTS. WE HAVE USED A SHEAR FLOW WHICH IS CLOSE TO THE MAXIMUM VALUE.



SKIN SHEAR FLOW IN T.E.
(REF 7/0583/38 VOL 1)

SHEAR FLOW USED FOR ANALYSIS (UPPER PANEL) = 1500 #/IN

∴ SHEAR LOAD = 1500 x 9.45" = 14,200 #

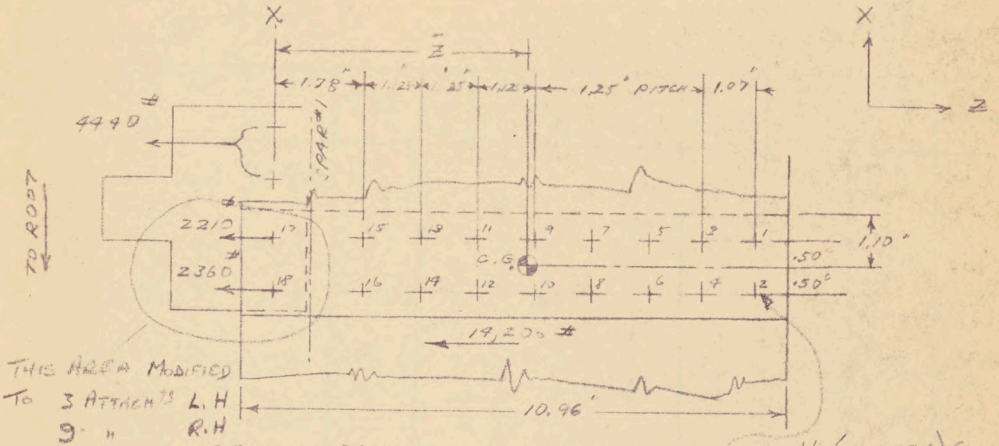
FORM 1310A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 2/ar 85/12
SHEET NO. 5-3

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	LSC	AUG 57
		CHECKED BY	DATE

F.E. BOTTOM JOINT STA 92



SPLICE JOINT L.H. SKIN

18 - 1/4 (NAS 334) SCREWS

AV STRESS AT SPLICE = 35,900 PSI

SKIN LOAD / INCH = .168 x 35,900 = 6040 #/in

TOTAL LOAD = 6040 x 10.96
= 66,200 #

ASSUMATIONS :

① AXIAL LOAD IN MACHINED STRINGER (SPAR #1) IS REACTED BY FITTING
② REDISTRIBUTION OF ft AT ULT LOAD OCCURS SUCH NO MOM IS APPLIED TO BOLT PATTERN DUE TO ft.
③ BOLTS 17, AND 18 REACT NO LOAD // SPLICE.
④ 50% OF MOM CAUSED BY SHEAR IS REACTED BY EACH PATTERN.
⑤ 4440 # LOAD APPLIED BY UPPER PART OF FITTING ADDS ADDITION SHEAR TO LOWER SPLICE BOLTS.

$$\bar{z} = \frac{\Sigma A z}{\Sigma A} = \frac{1.28 + 2.905 + 4.030 + 5.155 + 6.280 + 7.405 + 8.53 + 9.60}{9}$$

$$= \frac{45.68}{9} = 5.08"$$

SHEAR LOAD = 17,200 + 2210 + 2360 + 4440 = 23,210 #

MOMENT = 23,210 x 1.10
= 25,500 " #

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0533/12
SHEET No. 5-7

AIRCRAFT:	
C105	FIN

PREPARED BY	DATE
[illegible]	AUG 55
CHECKED BY	DATE

T.E. BOTTOM JOINT

REFERRED TO C.G.

BOLT	Z	Y	Z^2	M/I	LOADS FROM MAN $\downarrow P_x$	LOADS FROM MAN $\rightarrow P_z$	$\downarrow P_x$ 66,000/18	$P_z \rightarrow$ 25500/16	$\downarrow \Sigma P_x$	$\vec{\Sigma} P_z$	P RESULT
1	4.52	0.50	20.4	152		76	3670↑	1600←			
2	4,52	-.50	20.4								
3	3.45	.50	11.9								
4	3.45	-.50	11.9								
5	2.325	.50	5.4								
6	2.325	-.50	5.4								
7	1.20	.50	1.44								
8	1.20	-.50	1.44								
9	.025	.50	0								
10	.025	-.50	0								
11	-1.05	.50	1.10								
12	-1.05	-.50	1.1								
13	-2.175	.50	4.74		330	76→			4000↑	1524←	4230
14	-2.175	-.50	4.74		330	76←			4000↑	1676←	4340
15	-3.30	.50	10.9		500	76→			4170↑	1524	4440
16	-3.30	-.50	10.9		500	76←		1600←	4170↑	1676	4500
17	-5.08	.50	25.8		770	76→		0	4440↑	2210	4950
18	-5.08	-.50	25.8		770	76←	3670	0	4440↑	2360	5070

163.4

$I = 163.4 + \Sigma x^2 = 167.9$

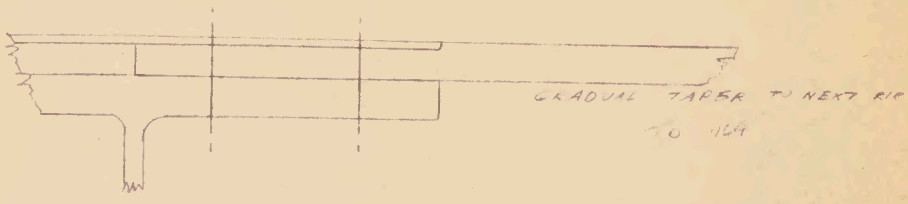
FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No 2/CS32/12
SHEET No 5-5

AIRCRAFT		PREPARED BY	DATE
C105	F1H	L Gradassi	JUNE 58
		CHECKED BY	DATE

T.E. BOTTOM JOINT



BEARING IN STEEL SPLICE PLATE

ASSUMING THAT THE OUTER SPLICE PLATE CARRIES A LOAD OF 2380 # AND THAT THE INNER CAP REACTS THE REMAINDER.

SINCE THIS IS A DOUBLE SHEAR JOINT THE ALLOWABLE MAY GO UP TO THE FULL F_{Btu}

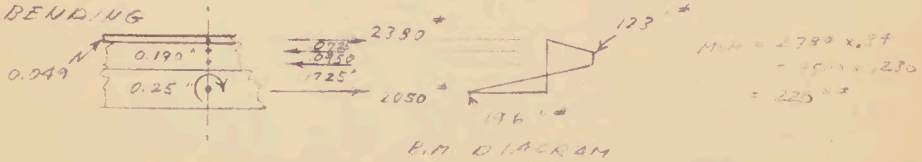
ie ALLOWABLE = .25 × 190,000 × 0.050
= 2380 #

M.S. OK

BOLTS # DIA, F_{tu} = 180 KSI (BOLT #16)

SHEAR RATIO = $\frac{2450}{4650}$ = 0.527

BENDING



B.M DIAGRAM

M.M = 2390 × .94
− 450 × .230
= 225 in-#

$f_B = \frac{178 \times .125}{.000192}$ = 112,000 P.S.I. MODULUS RUPTURE = 306 KSI

BENDING RATIO = $\frac{112}{306}$ = 0.366

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/2582/12

SHEET No 5 - 6

AIRCRAFT		PREPARED BY	DATE
C 105	FIN	[illegible]	JUNE 55
		CHECKED BY	DATE

T.E. BOTTOM JOINT

BOLTS

$$M.S. = \frac{1}{\sqrt{R_s^2 + R_b^2}} - 1$$

$$= \frac{1}{\sqrt{1.527^2 + .966^2}} - 1$$

ULT. M.S. = 0.56

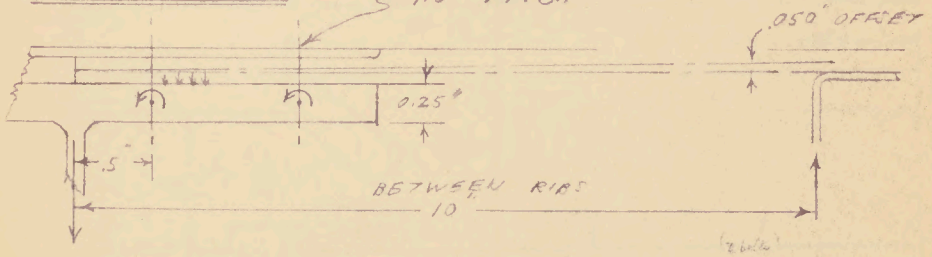
SKIN IN BEARING

LOAD = 4500 #

ALLOWABLE FOR ¼ SCREW BEARING IN .15" 75S-T6 = 5820 # (Fbru 137 ksi)

ULT M.S. = 0.29

INNER SPLICE



LOAD APPLIED TO RIB, LIMIT = $\frac{4500}{1.364} \times 2 \times \frac{.05}{10} = 33$ #

BM. APPLIED TO INNER SPLICE BY RIB = 33 x .5 = 16.5 "#

BM APPLIED BY BOLTS (SHT 5) = $\frac{220}{1.364} \times 2 = 322$ "#

TOTAL BM = 338 "# (LIMIT)

NOTE: ANALYSIS IS PESSIMISTIC SINCE THERE WILL BE RESTRAINT FROM SPARS.

$$f_b = \frac{338 \times 6}{.25^2 \times 0.75} \times \frac{66}{76} = 37,503 \text{ PSI}$$

REDISTRIBUTION FACTOR AT YIELD (AVRO MANUAL) = $\frac{66}{76}$

$$f_c = \frac{4500 \times 2}{1.364 \times .82 \times .25} = 30,000 \text{ PSI}$$ (4760) (14820)

NEGLECTS AMOUNT GOING THRU STEEL STRIP

CROSS GRAIN

f_t ult = 67,500 PSI F_{tu} = 62,000 PSI (LIMIT) M.S. @ .18

ULT WILL NOT BE CRITICAL SINCE YIELDING WILL RELIEVE BENDING

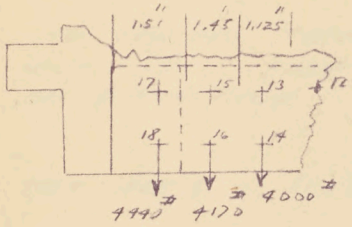
A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/0583/12
SHEET No. 5-2

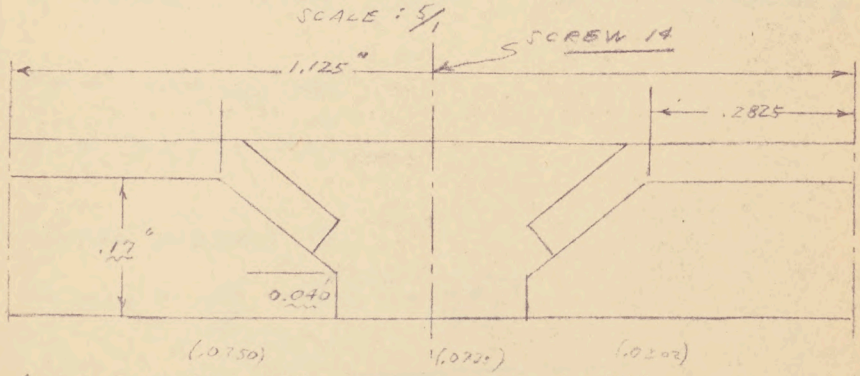
AIRCRAFT:		PREPARED BY	DATE
C 105	FIN		
		CHECKED BY	DATE

T.E. BOTTOM JOINT

SKIN NET SEC



CONSIDERING NET SEC FROM P7 MID WAY BETWEEN 15 & 13 AND MIDWAY BETWEEN 12 & 13



AREA = 0.040 x .825 + .565 x .13 + .155 x .13

= 0.1287 in²

$f_t = \frac{4000 \times 2}{.1287} = 62,100$ PSI

$f_s = \frac{1626}{.1287} = 13,000$ PSI

BY MOHR'S ⊙ $f_{s\,MAX} = \frac{62,100}{2} + \sqrt{13,000^2 + 31,050^2}$

$= 64,200$ PSI

MAT'L 755-T6 ALCLAD $F_{tu} = 72$ KSI * M.S. = .11

* (NOTE BENDING OR STRESS CONC. MAY BE PRESENT)

ORM 1319A

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/0583/12
SHEET No. 5-8

AIRCRAFT:		PREPARED BY	DATE
101	FIN		
		CHECKED BY	DATE

T.E. BOTTOM JOINT STA 42

STEEL SPLICE - IN TENSION

CONSIDERING TENSION AREA ADJACENT TO BOLT 13 HALF WAY BETWEEN BOLTS ON EACH SIDE

NET AREA = $(1.125 - 0.25)\ 0.050 = .0437^{\square"}$

P TENSION = $2380 \times 2 = 4760^{\#}$

P SHEAR = $\frac{1524 + 1676}{2} = 1600^{\#}$ (ASSUMING $\frac{1}{2}$ IN ST)

$f_t = 109{,}000$ PSI

$f_s = 36{,}600$ PSI

WING MOHR'S ⊙

$$f_{H\,MAX} = \frac{f_t}{2} + \sqrt{f_s^2 + \left(\frac{f_t}{2}\right)^2}$$

$$= \frac{109{,}000}{2} + \sqrt{36600^2 + 50{,}750^2}$$

$$= 112{,}200 \text{ PSI}$$

STEEL HT TO F_{tu} = 150 KSI

M.S. = .33

ORM 1319A

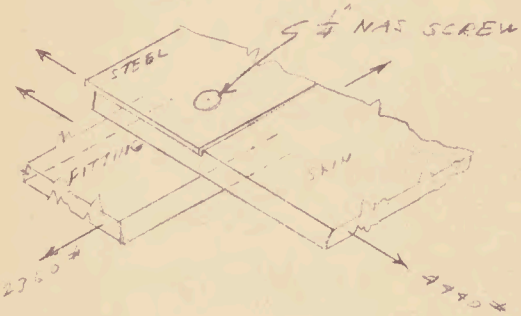
A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/0583/12
SHEET No. 5-9

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

T.E. BOTTOM JOINT

BOLT #13 ON L.H. SKIN



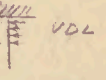
ASSUMING ABOUT ½ OF 4440 # COMES OFF ON SHEAR SURFACE BETWEEN FITTING & SKIN.

∴ LOAD ON SHEAR SURFACE BETWEEN FIT. & SKIN
$= \sqrt{2360^2 + 2220^2}$

$= 3240$ #

SINGLE SHEAR ALLOWABLE = 4650 #

SHEAR RATIO $= \frac{3240}{4650} = 0.70$

ASSUMING SCREW BENDING LOAD OF :  VDL
∴ B.M. $= 3240 \times \frac{.15}{2}$
≈ 243 in #

$f_b = \frac{Mc}{I} \approx \frac{243 \times .125}{.000192} = 158{,}000$ PSI Approx

F_{tu} = 180 KSI MODULUS RUPTURE = 306 KSI

BENDING RATIO $= \frac{158}{306} = .516$

$M.S. = \frac{1}{\sqrt{R_s^2 + R_b^2}} - 1 = \frac{1}{\sqrt{.70^2 + .516^2}}$

M.S. ≈ 0.15

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

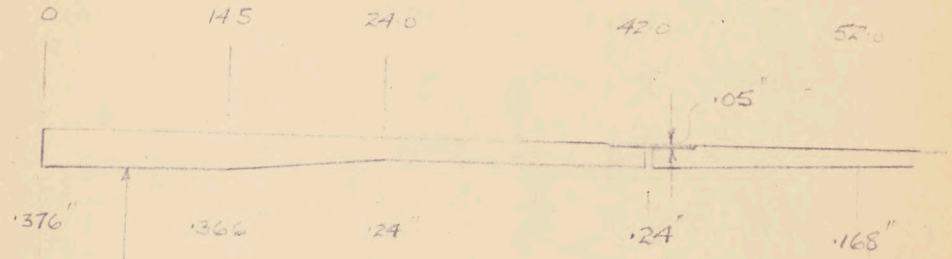
REPORT No. 7/0589/12

SHEET No. 5-10

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	[signature]	JUNE '55
		CHECKED BY	DATE

T.E. BOTTOM JOINT

M/C. SKIN THICKNESSES.



·00072 INS/INS TAPER RATE

145 × ·00072 = ·0104 INS.

·376 − ·010 = ·366 INS.

NO! IN THE PROCESS OF BEING CHANGED - Oct '55

FORM 1316A

AVRO AIRCRAFT LIMITED

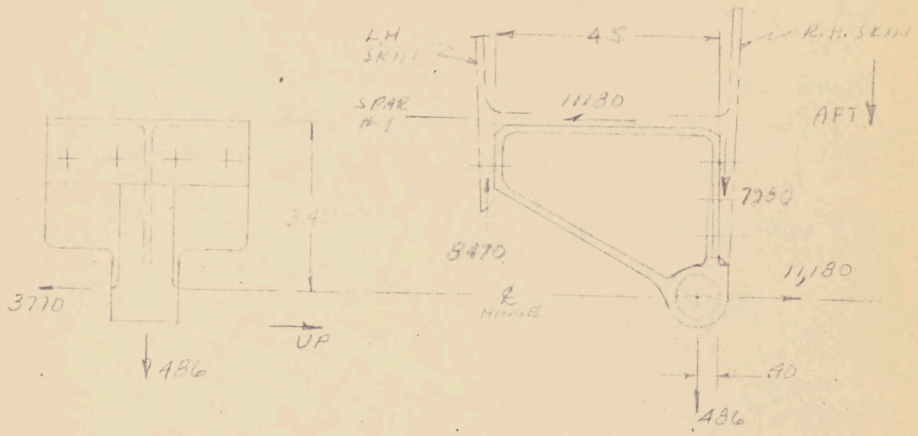
TECHNICAL DEPARTMENT (Aircraft)

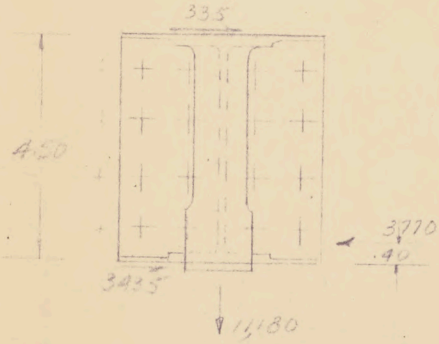
AIRCRAFT		REPORT No 7/0582/12
C-105		SHEET No 5-11

PREPARED BY	DATE
Mc CABE	4-28-55
CHECKED BY	DATE

T/E BOTTOM JOINT – STA 42.05

BOTTOM HINGE LOADS





HINGE LOADS (LOADS OPP. CASE)

DRAG = 486 LBS. – SHT. 5/29 } ‡

SIDE = 11,180 LBS. – SHT. 5/24 } ‡

INERTIA = 3770 LBS. – SHT. 7/3 *

‡ 7/0584/2

* 7/0584/3

FITTING REACTIONS FROM HINGE LOADS

INERTIA LOAD

THE INERTIA LOAD IS REACTED IN L.H. & R.H. SKINS.

L.H. SKIN REACT. = $\frac{.40 \times 3770}{4.50}$ = 335 LBS.

R.H. SKIN REACT. = 3770 – 335 = 3435 LBS.

FORM 1719A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/0582/12

SHEET No 5-12

AIRCRAFT		PREPARED BY	DATE
C-105		MCCABE	4-28-55
		CHECKED BY	DATE

T.E. BOTTOM JOINT - STA. 42.05" (7-0183-132)

FITTING REACTIONS FROM HINGE LOADS

DEAD & SIDE LOADS

THE SIDE LOAD IS REACTED AT SPAR #1

REACTION AT SPAR #1 = 11130 LBS.

THE MOMENT FROM THE SIDE LOAD AND THE DEAD LOAD IS REACTED IN L.H. & R.H. SKINS

L.H. SKIN REACTION = $\frac{3.4 \times 11130 + .96 \times 436}{45}$

$= \frac{37820 + 1134}{45} = 8470$ LBS.

R.H. SKIN REACTION = 8470 - 486 = 7984 LBS.

FORM 1119A

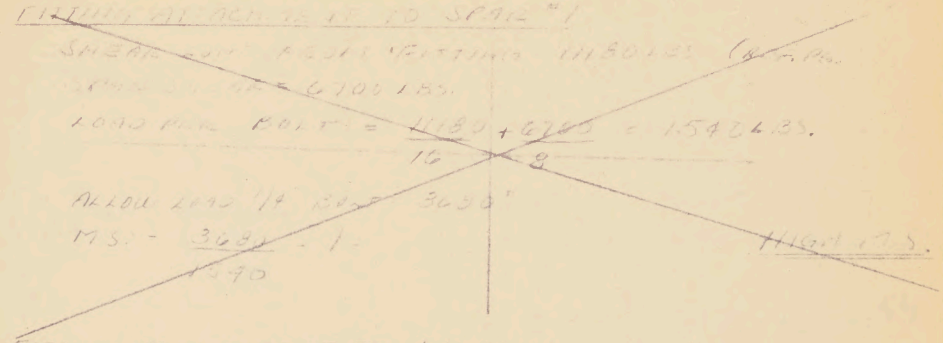
AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0582/12
SHEET NO 5-13

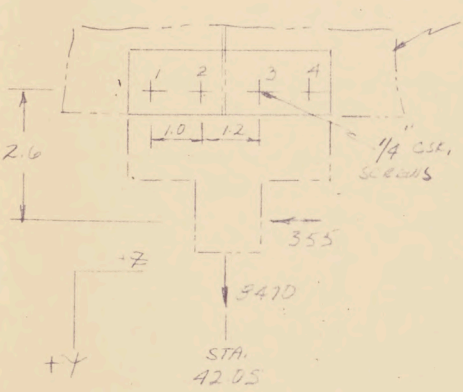
AIRCRAFT		PREPARED BY	DATE
C-105		MCCABE	5-2-55
		CHECKED BY	DATE

T.E. BOTTOM JOINT - STA. 42.05 (7-0183-132)

FITTING ATTACHMENT TO SKIN



FITTING ATTACHMENT TO L.H. SKIN



LOADS ON L.H. SKIN ATTACHMENTS

DRAG LOAD = 8470# (REF. PG. 8)

INERTIA LOAD = 355# (REF. PG. 8)

MOMENT ON ATTACHMENTS = 2.6 x 355 = 871 IN.-LBS.

IP = 5.84

	Z	M/I	LOAD FROM MOMENT Σ M/I	P_1 = 8470/4	P_2 = 355/4	P_1 + P_2 TOTAL	RESULT.
1	-1.6	150	-240	2120	-89	1880	
2	-.60	↓	-90	↓	↓	2030	
3	.60	↓	90	↓	↓	2210	
4	1.6	150	240	2120	-89	2360	2360

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

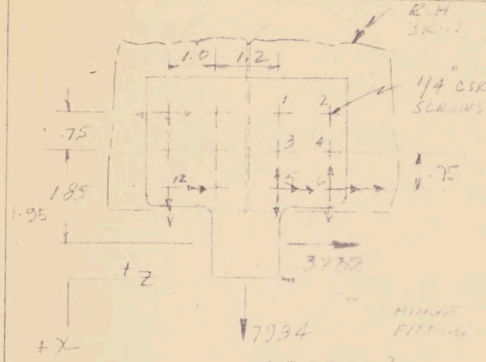
REPORT NO 2/0882/12

SHEET NO 5 - A

AIRCRAFT		PREPARED BY	DATE
C-105		McCABE	5-2-55
		CHECKED BY	DATE

F/E BOTTOM JOINT - STA 92.05 (7-0183-132)

FITTING ATTACHMENT TO R.H. SKIN



BB 13 - ?

LOADS ON R.H. SKIN ATTACHMENTS

DRAG LOAD 7934 #

INERTIA LOAD = 3770 #

MOMENT = $\frac{1.85}{1.95} \times 3770 = 6,770$ IN.#

IP = 22 (7350)

I.E $I = 4(.75^2+1.6^2) + 4(.6^2+.75^2) + (2\times.6^2) + (2\times1.6^2)$

$= 12.48 + 3.69 + .72 + 5.12$

$= 22.01$.

	Z	Y	M/I	LOADS DUE TO MOMENT ↓P_Y	→P_Z	↓P_Y 7934/12	→P_Z 3770/12	P_Y (TOTAL)	P_Z (TOTAL)
1	.60	-.75	317	-190	-238	665	314	475	76
2	.60	-.75	↑	507	-238	↑	↑	158	76
3	.60	0		190				475	314
4	.60	0		507				158	314
5	.60	.75	↑	190	238	↑	↑	475	552
6	.60	.75	317	507	238	665	314	158	552

RESULTANT LOAD $[(1524)^2+(1172)^2]^{1/2} = 1260$ #

ALLOW LOAD 4600#

7350 / 22

12	1.6	.75	334	535	251	740	314	1275	565

FORM 1704

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No	7/0582/12
SHEET No	5 - 15
AIRCRAFT	C-105
PREPARED BY	McCABE
DATE	5-3-55
CHECKED BY	
DATE	

T/E BOTTOM JOINT STA 42.05

BOTTOM [illegible] LOADS

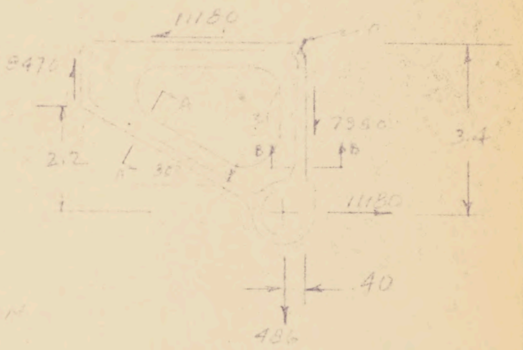
SEC A A.

TAKING [illegible] ABOUT "B"

END LOAD [illegible]

$= \dfrac{1180 \times 3.4 + .40 \times 486}{3.1}$

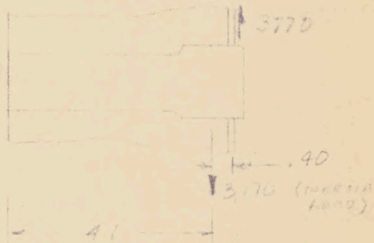
= 12300 LBS



ASSUME END LOAD TO BE [illegible] BY [illegible] FROM

MOMENT (A-A) .35 × 12300

= 4310 IN-LBS



f_b = 4310 / .033 = 130,000

f_c = 12300 / .23 = 53500 PSI

F_t 150,000

FOR K = 1.5

ALLOW. MOM = 1.5 × .033 × 150,000

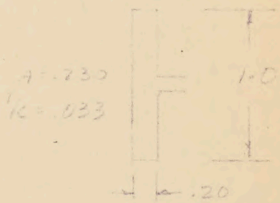
= 7430 IN LBS

$R_B = \dfrac{4310}{7430} = .58$

SEE PG. 14

$R_c = \dfrac{53500}{150,000} = .36$

M.S. $\dfrac{1}{(.58+.36)} - 1 =$ .06 M.S.



SEC A-A

SEC B-B

END LOAD 7980 LBS.

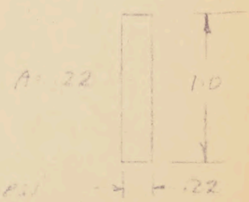
ASSUME ALL OF INERTIA LOAD CARRIED IN TORSION

TORSION = 3770 × .28 = 1060 IN LBS.

f_c = 7980 / .22 = 36200 PSI

$f_s = \dfrac{T}{ab^2}\left(3 + 1.8\dfrac{b}{a}\right)$

$= \dfrac{1060}{1.0(.22)^2}\left(3 + 1.8\dfrac{.22}{1.0}\right) = 21900(3.37) = 74400$ PSI



SEC B-B

FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105		REPORT No. 7/0582/12	SHEET No. 5 - 16
		PREPARED BY: McCABE	DATE: 5-5-55
		CHECKED BY:	DATE:

T/E BOTTOM JOINT - STA. 42.25
BOTTOM FLANGE
[illegible] (COND. 2)

$F_C = 150,000$
$F_S = 90,000$
$R_C = \frac{36200}{150,000} = .24$
$R_S = \frac{74,400}{90,000} = .83$
$R_S^2 + R_C = 1$
M.S. = .04 M.S.

WEB STRESS
WEB SHEAR 11,800 LBS
[illegible] .25 [illegible] PSI
4 x 10
F_S = 20 [illegible]
M.S. = 30,000 [illegible] HIGH M.S.

FORM 1719A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 2/0583/12

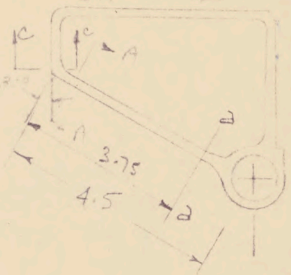
SHEET No 5-17

AIRCRAFT:	
C-105	

PREPARED BY	DATE
M-CABLE	5-20-55
CHECKED BY	DATE

TYP. BOTTOM JOINT - SIM 42.05 (THIS ANALYSIS SUPERSEDES ANALYSIS ON PG 12.)

STRESS AT SEC. A-A



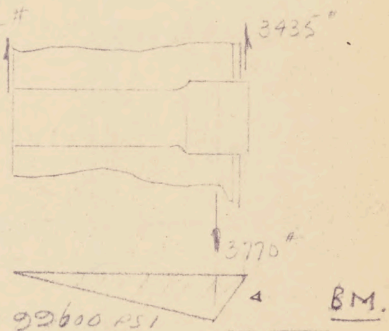
ASSUME HINGE INERTIA LOAD IS CANTILEVERED FROM HINGE & TO L & R 'SKINS'

MOMENT ON SEC a-a FROM INERTIA LOAD = 335 x 3.75 = 1255 IN.LBS

END LOAD ON SEC A-A = 12300# P.12

f_b = 1255 / .033 = 38100 PSI.

f_t = 12300 / .20 = 61500 PSI



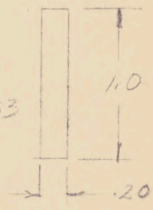
TOTAL f_b = 61500 + 38100 = 99600 PSI

Ft 150,000

M.S. = 150,000 / 99,600 - 1 = .51 M.S.

A = .20

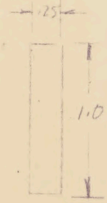
I/c = .033



SEC. A-A

STRESS AT SEC C-C ✗ ZERO MOMENT AT A-A IS REASONABLE.

AT SEC C-C, THE MOMENT CALCULATED AT SEC. A-A ABOVE, CAN BE RESOLVED INTO COMPONENTS AS FOLLOWS:



TORSIONAL MOMENT = 1570 COS 30° = 1360 IN.LBS.

BENDING MOMENT = 1570 SIN 30° = 785 IN.LBS.

f_s = T / ρ^2 (3+1.8 a/b) = 1360 / (1.01.25)² (3+1.8 .25/1.0) = 75,000 PSI

f_b 785 / .041 = 19000 PSI

SEC C-C

A = .25

I/c = .041

END LOAD = 8470 LBS

f_t = 8470 / .25 = 34000

f_c (TOTAL) = 34000 + 19000 = 53000 PSI

Fc = 150,000 ; Fs = 90,000 PSI

Rt = 53000 / 150,000 = .35 ; Rs = 75000 / 90,000 = .83

M.S. = $\frac{1}{(.35^2 + .83^2)^{1/2}}$ - 1 =

.11 M.S.

FORM 1716 A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

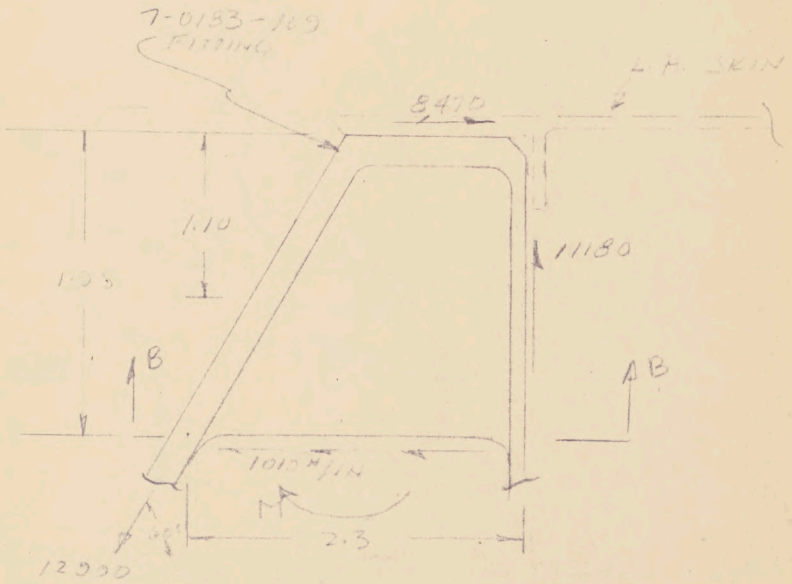
REPORT No 7/0583/12

SHEET No 5-18

AIRCRAFT	
C-105	

PREPARED BY	DATE
MCCABE	5-20-55
CHECKED BY	DATE

T/E BOTTOM JOINT - STA 47.05



END LOAD IN DIAGONAL 11180 / COS 30° = 12900 LBS.

FIN SKIN LOAD = 8470 #

WEB SHEAR = 8470 - 12900 COS 60°

= 8470 - 6450 = 2020 LBS

$q = \frac{2020}{2} = 1010$ #/IN

MOMENT AT SEC B-B = 2.3 × 11180 - 1.05 × 8470

= 25100 - 16500 = 9200 IN LBS

ASSUME .10 WEB CARRIES ALL OF BENDING LOAD

THEN, $I/c = .10 \times 2.3^2/6 = .088$

$S_b = \frac{9200}{.088} = 104{,}000$ PSI

$S_s = 1010 / .10 = 10100$ PSI

$F_t = 120{,}000$; $F_s = 58{,}000$

$R_t = 104000 / 120{,}000 = .69$; $R_s = 10100 / 58{,}000 = .11$

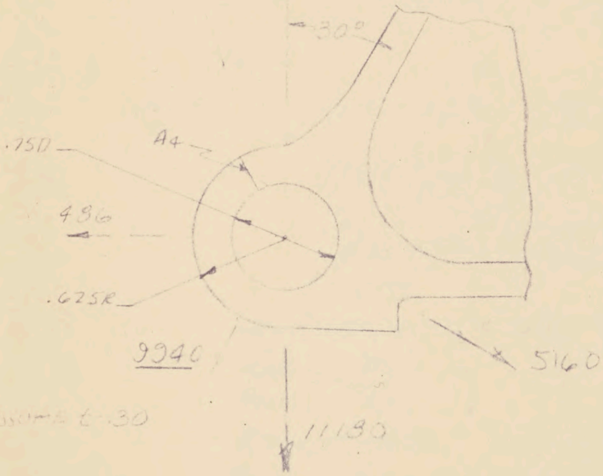
$M.S. = \frac{1}{(.69^2 + .11^2)^{1/2}} - 1$ .43 M.S

FORM 1719A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105	REPORT NO. 7/0583/12	SHEET NO. 5-19
	PREPARED BY: McCABE	DATE: 5-18-5[illegible]
	CHECKED BY:	DATE:

T/E BOTTOM JOINT - STA 42.0 :
HINGE LUG



ASSUME t = .30

TRANSVERSE LOAD = 11180 SIN 30° − 486 COS 30°
= 5580 + 420 = 5160 LBS.
AXIAL LOAD = 11180 COS 30° + 486 SIN 30°
= 9700 + 240 = 9940 LBS

ALLOW. AXIAL LOAD

a/D = ~~.625~~ .60 / .75 = ~~.83~~ .80
W/D = ~~1.25~~ 1.20 / .75 = ~~1.67~~ 1.60
D/t = .75 / .30 = 2.5
Abr = .75 × .30 = .225
At = (1.25 − .75) .30 = ~~.150~~ .135
Kbr = .59
Kt = .88 ✓
Pbru = .59 × .225 × 150 000 = 19900 LBS.
Ptu = .88 × .135 × [illegible] = 22,100 LBS.

FORM 1310A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/0383/12
SHEET No. 5-20

AIRCRAFT:		PREPARED BY	DATE
C-105		McCABE	5-2-55
		CHECKED BY	DATE

T/E BOTTOM JOINT - STA. 42.05
HINGE LUG

ALLOWABLE TRANSVERSE LOAD

ASSUME $A_1 = A_2 = A_3 = A_4 = .075$

$$n_{AV.} = \frac{6}{3/A_1 + 1/A_2 + 1/A_3 + 1/A_4}$$

$$= \frac{6}{3/.075 + 1/.075 + 1/.075 + 1/.075}$$

$$= \frac{6}{40 + 13.3 + 13.3 + 13.3}$$

$$= .075$$

$A_{BR} = .75 \times .30 = .225$

$\frac{A_{BV}}{A_{BR}} = \frac{.075}{.225} = .333$

$K_{TR} = .48$

$P_{TR} = .48 \times .225 \times 150{,}000 = 16{,}200$ LBS.

$R_a = 9940 / 19500 = .50$

$R_{TR} = 5160 / 16200 = .32$

$R_a^{1.6} + R_{TR}^{1.6} = 1$

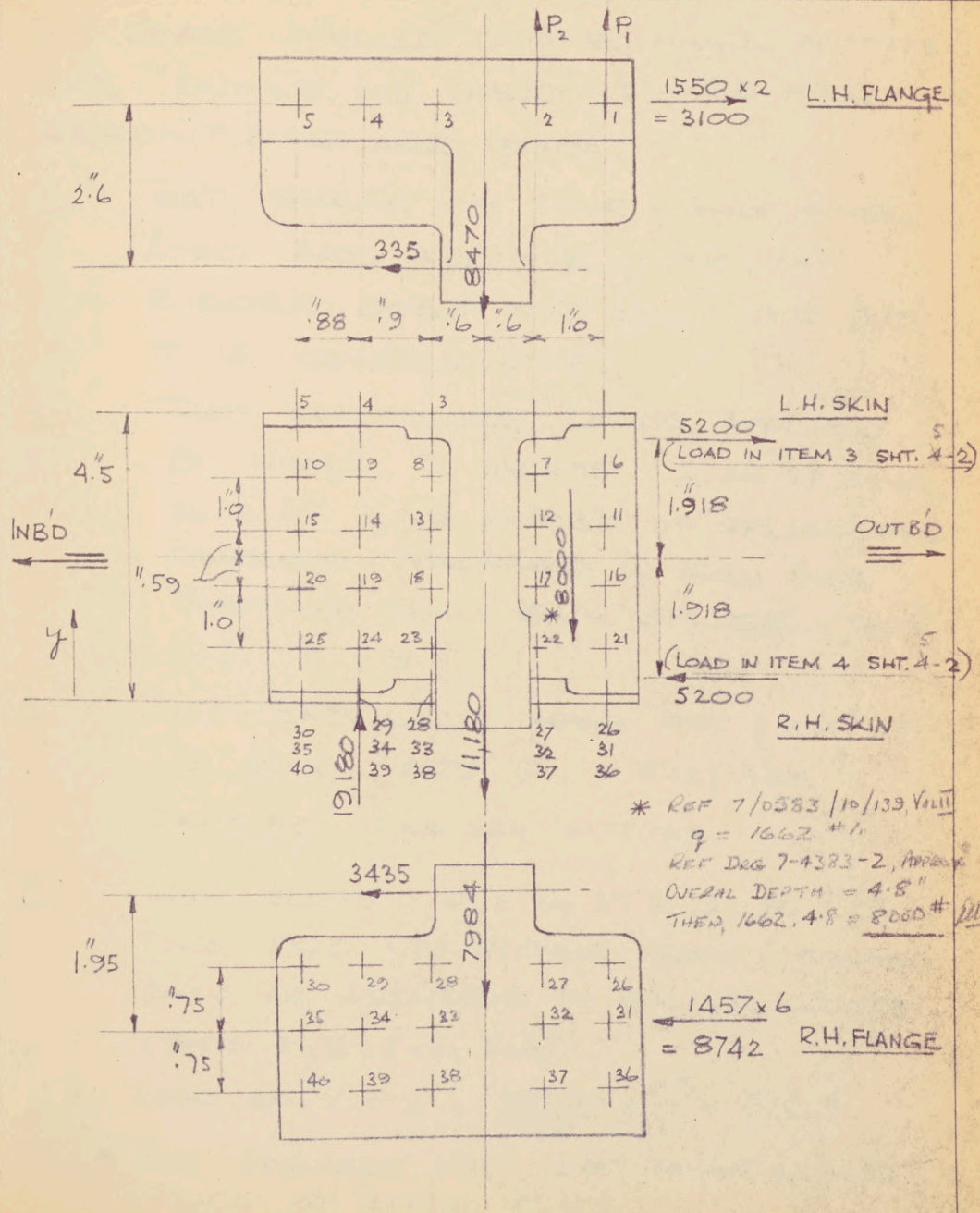
M.S. = .56 M.S.

FORM 1719A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:		REPORT No. 7/0588/12	
		SHEET No. 5-21	
C.105.	FIN T.E. BOTTOM JOINT	PREPARED BY	DATE
		J.D. O'BOHERTY	30-6-55
		CHECKED BY	DATE



* REF 7/0583/10/139, Vol II
q = 1662 #/"
REF DRG 7-4383-2, Appx 3
OVERAL DEPTH = 4·8"
THEN, 1662 . 4·8 = 8000 #

LOAD SUMMARY FOR ATTACHMENT CALCS. ON FOLLOWING SHEETS.

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12

SHEET No. 5-22

AIRCRAFT	
C. 105.	FIN T.E. BOTTOM JOINT.

PREPARED BY	DATE
CHECKED BY	DATE

THE LOADS APPLIED TO THE HINGE FITTING ARE SHOWN ON SHEET 2. THE FOLLOWING ASSUMTIONS ARE MADE :-

1. THAT SHEAR ON SPAR I AND HINGE LOAD ARE ADDITIVE. WORK ON RUDDER DOES NOT SHOW THIS BUT IT IS CONSERVATIVE.

2. THAT CHORDWISE LOADS APPLIED BY HINGE TO BOLTS 1, 2, 26, 27, 31, 32, 36 & 37 (I.E OUTB'D OF SPLICE) ARE CARRIED FORWARD IN SKIN AND THROUGH MAIN SKIN SPLICE (SHTS. 5.3 & 5.8).

3. THAT END LOAD FROM PTS. 3 & 4 OF T/E BOX (SHTS. 5-1 & 5-2) ARE CARRIED THROUGH FITTING.

4. THAT BOLTS 1, 2 & 26, 27, 31, 32, 36 & 37 TAKE LOAD INTO FITTING FROM OUTBOARD SKIN AS ASSUMED IN SPLICE CALCS. (SHTS 5-2; 5-3; 5-8),

LOAD ON 1 & 2 = $\frac{68200}{22} \times \frac{1}{2}^{*} = \underline{1550\ \#}$.

* THIS ASSUMES HALF LOAD TAKEN ACROSS SPLICE BY STEEL PLATE.

LOAD ON 26, 27, 31, 32, 36 & 37 = $\frac{75800}{26 \times 2^{*}} = \underline{1457\ \#}$.

FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/582/12
SHEET No 5-23

AIRCRAFT		PREPARED BY	DATE
C.105	FIN T.E. BOTTOM JOINT.	J.D.O'DOHERTY	5-7-55
		CHECKED BY	DATE

Σny OF BOLTS ON INBOARD SIDE OF SPLICE

$= (3 \times 4.50)^{3,4,5} + (3 \times 3.84)^{8,9,10} + (3 \times 2.84)^{13,14,15} + (3 \times 1.66)^{18,19,20} + (3 \times .66)^{23,24,25}$

$= 13.5 + 11.51 + 8.52 + 4.98 + 1.98 = 40.49$

$\therefore$ $\bar{y}$ OF BOLTS $= \frac{40.49}{24} = 1.686$. I.E. .564 BELOW $\frac{1}{4}$ OF WEB.

Σr^2 OF BOLTS $= (3 \times 2.814^2)^{3,4,5} + (9 \times 1.686^2)^{28,29,30,33,34,35\ etc} + (2.154^2 + .88^2)^{4,10} + (2.154^2 + .9^2)^{8,} + (1.026^2 + .88^2)^{25,} + (1.026^2 + .9^2)^{23,} + (1.154^2 + .88^2)^{15} + (1.154^2 + .90^2)^{13} + (.026^2 + .88^2)^{20} + (.026^2 + .90^2)^{18} + 1.154^{2\,14} + .026^{2\,19}$

$= 23.75 + 25.6 + 8.84 + 3.10 + 3.24 + 2.11 + 4.01$

$= 70.65$

MOMENT ABOUT C.G OF BOLTS IN THIS GROUP

$= (8000 \times 2.6) + (11,180 \times 1.5) + (5200 \times 3.836) + (3100 \times \overline{2.25 + .564}) + (8742 \times \overline{2.25 - .564})$

$= 20,800 + 16,770 + 19,950 + 8,720 + 14,730$

$= 80,970$.

$\therefore$ $\frac{\text{MOMENT}}{\Sigma r^2} = \frac{80,970}{70.65} = \underline{1,146.}$

$\therefore$ MOMENT LOAD PER BOLT 3,4 & 5 $= 1,146 \times 2.814$
$= 3,225$ # →

" " " " 28,29,30 etc $= 1,146 \times 1.686$
$= 1,932$ # ←

" " " " 8 & 10 = $\begin{cases} 1,146 \times 2.154 = 2,355 \text{ \#} \rightarrow \\ 1,146 \times 0.90 = 1,032 \text{ \#} \end{cases}$ ↑10 ↓8

FORM 1119A

AVRO AIRCRAFT LIMITED 4

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12

SHEET NO 5-24

AIRCRAFT		PREPARED BY	DATE
C.105	FIN T.E BOTTOM JOINT	J.D. O'DOHERTY	5-7-55
		CHECKED BY	DATE

DIRECT SHEAR LOAD ↓ PER BOLTS 8 & 10 = $\frac{19180}{12}$

= 1600 # ↓

" " " ← PER BOLTS 3,4,5; 8 & 10; 28, 29, 30 etc = $\frac{8742-3100}{24}$

= 235 # ←

CENTROID OF BOLTS 1,2,3,4 & 5 FROM BOLT 5

= $\frac{3.98 + 2.98 + 1.78 + .88}{5} = \frac{9.62}{5} = 1.924$ IN

$\Sigma r^2 = 2.056^2 + 1.056^2 + .144^2 + 1.044^2 + 1.924^2$

= 4.23 + 1.12 + .02 + 1.09 + 3.70 = 10.16 IN.²

MOMENT ABOUT BOLT C.G = $(335 \times 2.6) + 8470(2.38 - 1.924)$

= 871 + 3860 = 4731 #"

∴ LOAD ON BOLT 1 = $\delta P_1 = \frac{4731}{10.16} \times 2.056 = 957$ # ↓

∴ " " " 2 = $\delta P_2 = \frac{4731}{10.16} \times 1.056 = 492$ # ↓

∴ " " " 5 = $\frac{4731}{10.16} \times 1.924 = 898$ # ↑

DIRECT SHEAR LOAD ↓ PER BOLT $\frac{1}{5}$ ↓ = $\frac{8470}{5} = 1694$ # ↓

" " " ← " " $\begin{Bmatrix}3\\4\\5\end{Bmatrix}$ = $\frac{335}{3} = 112$ # ←

NOTE :- LOADS $P_1 = \delta P_1 + 1694 = 2651$ # & $P_2 = \delta P_2 + 1694$

= 2186 # ARE TAKEN CHORDWISE ACROSS L.H. SKIN SPLICE.

FORM 1114A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 5-25

AIRCRAFT:		PREPARED BY	DATE
C.105.	FIN T.E. BOTTOM JOINT	J.D. O'DOHERTY	5-7-55
		CHECKED BY	DATE

CENTROID OF BOLTS 26 – 40 FROM LINE 30, 35, 40
= 1.924 (AS PREVIOUS SHEET)

ASSUME BOLTS 26, 27, 31, 32, 36, 37 TAKE MOMENT LOAD IN CHORDWISE DIRECTION ONLY (I.E. LOADING R.H. SKIN SPLICE).

$\Sigma y^2 = (3 \times 2.056^2) + (3 \times 1.056^2) + (3 \times .144^2) + (3 \times 1.044^2) + (3 \times 1.924^2) + (3 \times .75^2 \times 2)$

$= 12.69 + 3.36 + .06 + 3.27 + 11.10 + 3.38 = 33.86$

MOMENT ABOUT BOLT C.G = $7984(2.38 - 1.924) - (3435 \times 1.95)$

$= 3640 - 6700 = 3060$ #

∴ MOMENT LOAD PER BOLT $\left\{\begin{matrix}26\\31\\36\end{matrix}\right\} = \frac{3060}{33.86} \times 2.056 = 186$ # ↑

" " " " $\left\{\begin{matrix}27\\32\\37\end{matrix}\right\} = \frac{3060}{33.86} \times 1.056 = 95$ # ↑

" " " " $\left\{\begin{matrix}30\\35\\40\end{matrix}\right\} = \frac{3060}{33.86} \times 1.924 = 174$ # ↓

& $\frac{3060}{33.86} \times 0.75 = 68$ # ← 30, → 40

DIRECT SHEAR LOAD ↓ PER BOLT = $\frac{7984}{15} = 531$ # ↓

" " ← " " $\left\{\begin{matrix}28-30\\33-35\\38-40\end{matrix}\right\} = \frac{3435}{9} = 382$ # ←

NOTE :- LOADS $3(531 - 186) = 1035$ # ↓ & $3(531 - 75) = 1308$ # ↓ ARE TAKEN CHORDWISE ACROSS R.H. SKIN SPLICE.

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

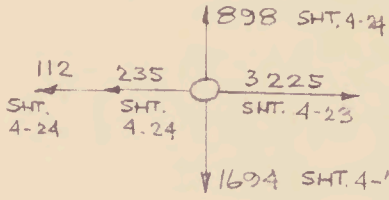
REPORT No 7/0582/12

SHEET No 5-26

AIRCRAFT		PREPARED BY	DATE
C. 105	FIN T.E BOTTOM JOINT.	J.S. O'DOHERTY	5-7-55.
		CHECKED BY	DATE

SUMMATION OF LOADS ON BOLTS

BOLT 5



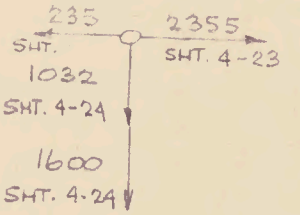
RESULT. LOAD $= \sqrt{2878^2 + 796^2}$

$= 2990$ #

SINGLE SHEAR STRENGTH ¼" NAS SCREW = 4650 #

M.S = $\frac{4650}{2990} - 1 = .55$.

BOLT 8



RESULT. LOAD $= \sqrt{2120^2 + 2632^2}$

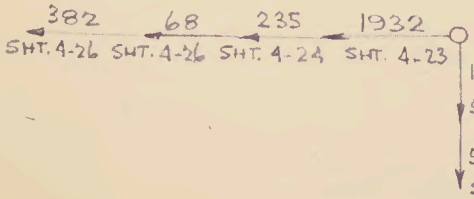
$= 3380$ #

BOLT BEARS IN .1 WEB & .15 CAP OF SPAR 1 (I.E .25 TOTAL) AND IN .1 STEEL FITTING.

∴ STRENGTH OF ¼" NAS BOLT = 4650 #

M.S = $\frac{4650}{3380} - 1 = .38$

BOLT 30



RESULT. LOAD $= \sqrt{705^2 + 2617^2}$

$= 2710$ #

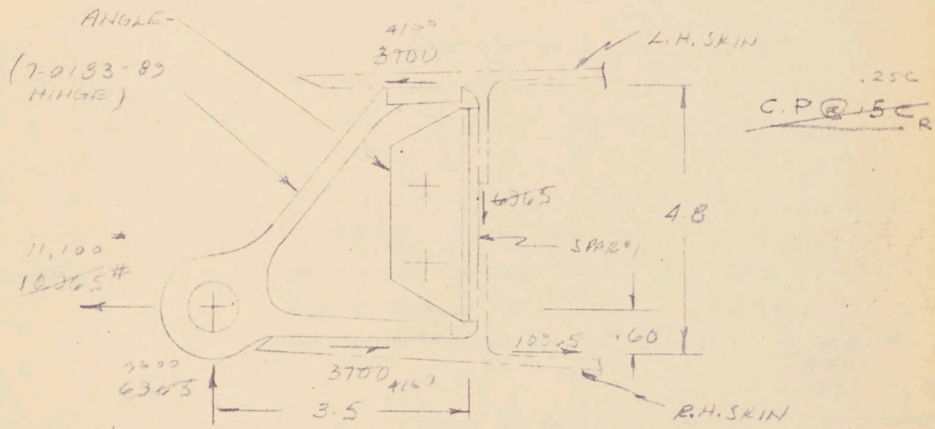
COVERED ABOVE

FORM 1119A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105	FIN	REPORT NO 7/0583/12	SHEET NO 6-1
		PREPARED BY: McCABE	DATE: 5-24-55
		CHECKED BY:	DATE:

RUDDER CONTROL HINGE #1 (7-0183-89) (7-1083-291)



FROM 7/0583/10, VOL. I, SHEET 19, SHT 4-1 THIS REPORT

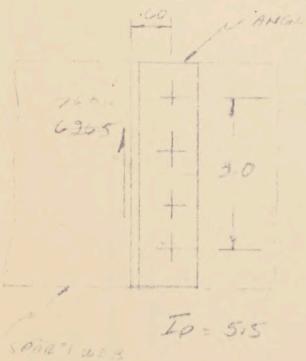
HINGE SIDE LOAD PER LUG = 13,930/2 = 6965 LBS. 7600#

HINGE DRAG LOAD PER LUG = 21,930/2 = 10965 LBS. 11,100#

L.H SKIN REACTION = $\frac{6965 \times 3.5 - 10965 \times .60}{4.8}$

= $\frac{24300 - 6570}{4.8}$ = 3700 LBS. (26,600 − 6660; 4160)

ANGLE ATTACHMENT TO SPAR #1 WEB



$I_p = 5.5$

SHEAR LOAD ON ANGLE = 6965 LBS. (7600)

MOMENT = .60 × 6950 = 4170 IN.LBS. (7600; 4560)

LOAD ON CRIT. ATTACH. FROM MOMENT =

$\frac{4170 \times 1.5}{5.5}$ = 1140 LBS. → (1240)

LOAD PER ATTACHMENT FROM SHEAR LOAD

= 6965/4 = 1740 ↑

7630/4 = 1908

NOT SO CRITICAL AS BOLTS ON OTHER LEG.

FORM 1316A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0587/12

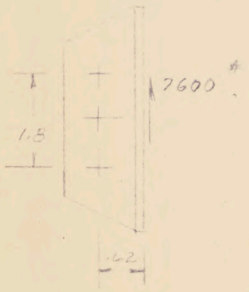
SHEET No. 6-2

AIRCRAFT	
C-103	

PREPARED BY	DATE
McCABE	5-24-55
CHECKED BY	DATE

RUDDER CONTROL RIBS #1 (70183-89)

ANGLE ATTACHMENT TO HINGE



SHEAR LOAD ON ANGLE = 7600 #

LOAD ON ATTACHMENTS FROM MOMENT =

$\frac{7600 \times .62}{1.8} = 2620$ LBS.

LOAD PER ATTACHMENT FROM SHEAR LOAD =

7600 / 3 = 2530 LBS.

RESULTANT = $\sqrt{2620^2 + 2530^2}/2 = 3640$ LBS.

ALLOW SHEAR 1/4 NAS BOLT 4650 LBS. #

ALLOW BEARING, t = .115" F_{brg} = 125 KSI = 3650 / 4380 #

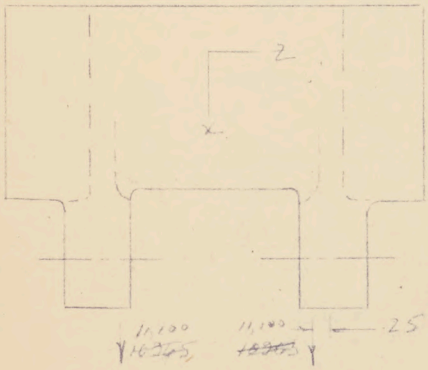
M.S. = $\frac{.14}{}$ .20

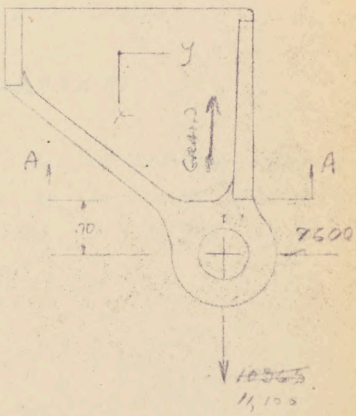
STRESSES ON SEC. A-A

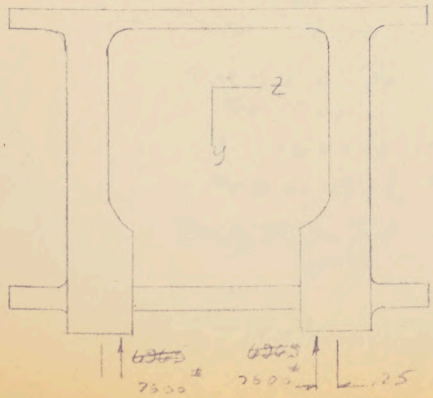
REF D QF 7/664 :

F_{tu} = 75000 PSI F_{su} = 65000 PSI

F_{bru} = 5%







MOMENTS ON SEC. A-A

$M_{ZA} = .70 \times 7600 + .52 \times 11{,}100$

$= 5320 + 5770 = 11{,}090$ IN. LBS.

ASSUMING LUGS EQUALLY LOADED THEN,

$M_{yA} = .25 \times 11{,}100 = 2780$ IN. LBS.

$M_{xA} = .25 \times 7600 = 1900$ IN. LBS.

FORM 1316A

AVRO AIRCRAFT LIMITED

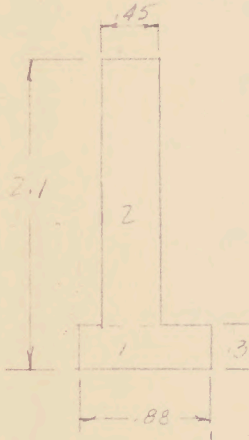
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT	REPORT No. 7/0587/12
C-105	SHEET No. 6-3

PREPARED BY	DATE
MCCABE	5-24-55
CHECKED BY	DATE

RUDDER CONTROL HINGE #1 (7-0193-93)

STRESSES ON S.C. A-A



	AREA	Z-AXIS				Y-AXIS			
		y	Ay	Ay^2	I_o	z	Az	Az^2	I_o
1	.264	.150	.0396	.0044	-	.44	.116	.051	.017
2	.810	1.200	.9720	1.1680	.218	.515	.417	.215	.0136
Σ	1.074	$\bar{y}$ = .94	1.0116	1.1724	.218	$\bar{z}$ = .50	.533	.266	.0306

I_z = 1.1724 + .218 − 1.0116 × .94 = .45

I_y = .2664 + .031 − .533 × .50 = .031

I_z/c = .45 / .94 = .48

I_y/c = .031 / .50 = .062

$$f_{bz} = \frac{M_z a}{I_z/c} = \frac{11070}{.48} = 23{,}100 \text{ PSI}$$

$$f_{by} = \frac{M_y a}{I_y/c} = \frac{2780}{.062} = 44{,}800 \text{ PSI}$$

IN CALCULATING TORSIONAL SHEAR STRESS, ASSUME SEC A-A TO BE RECTANGULAR IN SHAPE (2.1 × .35)

$$f_s = \frac{T}{q b^2}\left(3 + 1.8\frac{b}{d}\right) \quad \text{(REF. AVRO STRESS MANUAL)}$$

$$= \frac{1900}{2.1 \times (.45)^2}\left(3 + 1.8\frac{.45}{2.1}\right)$$

$$= 15{,}100 \text{ PSI}$$

f_t = 11,100 / 1.078 = 10,300 PSI.

ALLOWABLE M_{ZA}

F_c = 70,000 PSI

$K = 2\bar{y}_m / I_z/c = 2(.73 \times .264 + .286 \times .32)/.48 = 1.24$ (at web)

$M_{z(allow)} = K F_c\, I_z/c = 1.24 \times 70{,}000 \times .48 = 41{,}600$ IN-LBS.

ALLOWABLE T_{1A}

F_t = 10,000

K = 1.5 (at web)

$M_{YA(allow)} = K F_t\, I_y/c = 1.5 \times 70{,}000 \times .062 = 6{,}500$ IN-LBS

FORM 1315A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12

SHEET No. 6-4

AIRCRAFT		PREPARED BY	DATE
C-105		MCCABE	5-24-55
		CHECKED BY	DATE

RUDDER CONTROL HINGE #1

STRESSES ON SEC A-A (CONT'D)

MARGIN OF SAFETY

$R_{BZ} = \frac{11,090}{41600} = .27$ (.249)

$R_{BY} = \frac{4780}{6500} = .43$ (.393)

$R_t = \frac{10300}{70,000} = .15$ (.137)

$R_S = \frac{15102}{70000} = .23$

$M.S. = \frac{1}{[(R_{BZ}+R_{BY}+R_t)^2+R_S^2]^{1/2}} - 1$ (.17)

$= \frac{1}{[(.27+.43+.15)^2+.23^2]^{1/2}} - 1 =$ .09 M.S.

ATTACHMENT TO R.H. SKIN

ATTACHMENT PER LUG IS BY 4-1/4 DIA. SCREWS.

LOAD PER LUG = 11,100 + 4160 = 15260 LBS.

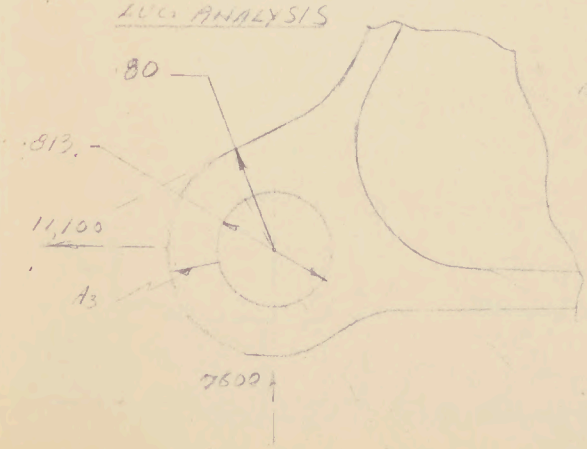
LOAD PER SCREW = 15260 / 4 = 3820 LBS.

ALLOWABLE SHEAR # SCREW = 4650 #

BEARING IN .22 SKIN CLK > 4650 #

.22 M.S.

LUG ANALYSIS



TRANSVERSE LOAD 7638#

AXIAL = 0 = 11,100#

FORM 1116A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT:		REPORT NO. 7/0588/12	
C-105		SHEET NO. 6-5	
		PREPARED BY	DATE
		McCABE	5·24·55
		CHECKED BY	DATE

RUDDER CONTROL HINGE #1

LUG ANALYSIS (CONT'D)

ALLOWABLE AXIAL LOAD

ASSUME $t = .50$

$a = .80$ $\quad a/D = .80/.81 = .99$

$D = .81$ $\quad W/D = 1.6/.81 = 1.98$

$W = 1.6$ $\quad D/t = .81/.50 = 1.62$

$t = .50$ $\quad A_{br} = .81 \times .50 = .405$

$A_t = (1.6 - .81).50 = .395$

$K_{br} = .83$

$K_t = .70$

$P_{bru} = .83 \times .405 \times 70{,}000 = 23500$ LBS. (75000) (25,200)

$P_{tu} = .70 \times .395 \times 70{,}000 = 19{,}300$ LBS. (75000) (20,700)

ALLOWABLE TRANSVERSE LOAD

$A_{AV} = .50 \times (.80 - .81/2) = .197$

$\frac{A_{AV}}{A_{br}} = \frac{.197}{.405} = .487$

$K_{tru} = .45$ (55000 Grain)

$P_{tru} = .45 \times .405 \times 70{,}000 = 12{,}750$ LBS.

MARGIN OF SAFETY

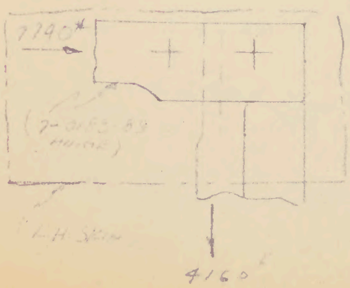
$R_A = 11{,}100/19300 = .575$ (.536)

$R_{TR} = 7600/12750 = .595$

$R_a^{1.6} + R_{tr}^{1.6} = 1$

$M.S. = \frac{1}{(.575^{1.6} + .595^{1.6})^{.625}} - 1 =$ .12 M.S. (.02)

ATTACHMENT TO L.H. SKIN



LOAD FROM HINGE = 4160# (PG.)

END LOAD = 7740# (PG. 5)

RESULTANT $= \left[\left(\frac{7740}{2}\right)^2 + \left(\frac{4160}{2}\right)^2\right]^{1/2}$

$= 4400$ LBS.

ALLOW LOAD 1/4" SCREW = 4650#

$\frac{4650}{4400} - 1 =$ .06 M.S.

(BEARING NOT CRITICAL)

FORM 1319

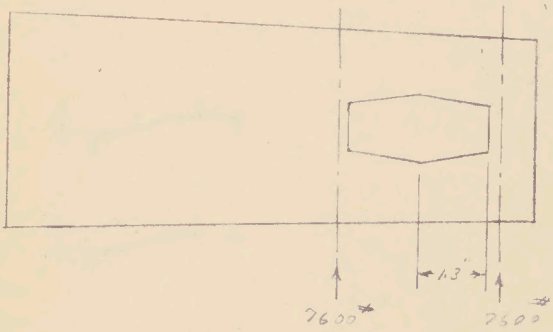
AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

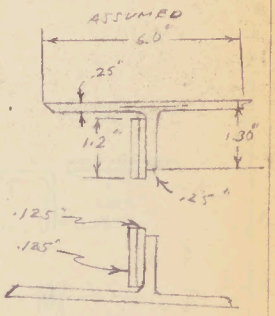
REPORT NO. 7/1583/12
SHEET NO 6-6

AIRCRAFT		PREPARED BY	DATE
105	FIN	L Gardner	JULY 55
		CHECKED BY	DATE

CONTROL # 1

* SEE NEXT SHT.





SHEAR ON SPAR # 1 ≈ 30% TOTAL FIN SHEAR

= 0.30 × 31,000 ← (7/1583/20 SHT 3-17)

= 9300 #/in

ASSUMING 60% OF UPPER LUG LOAD GOES ACROSS CUTOUT

* ∴ SHEAR LOAD = 9300 + 7600 × .60 = 13,850 #

ASSUMING SHEAR IS DISTRIBUTED ∝ I

STRINGER $y = \frac{1.18 \times .25 \times 0.57}{1.18 \times .25 + 6 \times .25} = 0.10"$ STRINGER $I = \frac{1.18^3 \times .25}{3} = 0.105"^4$

DOUBLER + WEB $I = \frac{1.2^3 \times .25}{12} = 0.036"^4$

$\Sigma I = 0.282"^4$

∴ SHEAR LOAD ON STRINGER = $13,850 \times \frac{.105}{.282} = 5160$ #

B.M. = 5160 × 1.3 = 6700 "#

$f_B = \frac{6700}{.105} \times 1.08 = 69,000$ PSI

f_B DUE TO FIN BENDING $I_{STRINGER} = 180"^4$ (STA 51) (7/1583/38 SHT 1-20)

B.M. = 2000000 "#

(STRINGER) $f_B = \frac{My}{I} = \frac{2 \times 10^6 \times 1.0}{180} = 11,100$ PSI

f_B TOTAL ≈ 80,000 PSI $F_c = F_{cy} = 76$ KSI (PLASTIC CENANG)

* M.S. ≈ +.05

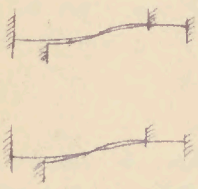
FORM 1318A

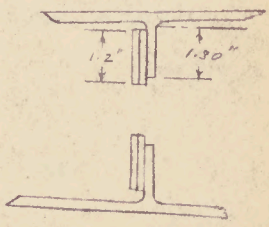
A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 2/05-93/
SHEET NO. 6-7

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gustison	AUG 55
		CHECKED BY	DATE

CONTROL # 1





ASSUMPTIONS:

① WEB ACTS LIKE A BEAM FIXED AT THE EDGE OF THE HOLE
② THE STRINGER ACTS LIKE A BEAM FIXED AT THE ATTACHMENT
③ δ'S OF ALL BEAMS ARE EQUAL AND NO RESTRAINT BETWEEN BEAMS.

I OF STRINGER $= \frac{1.30^3 \times 0.12}{3} = 0.0880''^4$

I OF WEB + D. $= \frac{1.2^3 \times 0.25}{12} = 0.0361''^4$

$\therefore$ δ OF A CANTALEVER BEAM $= \frac{PL^3}{3EI}$

$\therefore$ δ'S ARE EQUAL

$\therefore$ $P \propto \frac{I}{L^3}$

I/L^3 STRINGER $= \frac{0.0880}{2.27^3} = 0.0075$

I/L^3 WEB + D $= \frac{0.0361}{1.3^3} = 0.0164$

$\Sigma I/L^3 = 0.0239 \times 2 = .0478$

$\therefore$ % LOAD CARRIED BY STRINGER, ONE SIDE $= \frac{.0075 \times 100}{.0478}$
$= 15.7\ \%$

$\therefore$ % LOAD CARRIED BY WEB + D, ONE SIDE $= \frac{.0164 \times 100}{.0478}$
$= 34.3\ \%$

FORM 1219A

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/0583/12
SHEET No. 6-7 6-9

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

CONTROL #1

SHEAR LOAD ACROSS CUTOUT USED FOR ANALYSIS IS 13,850 #

LATER WORK 2/0583/10 INDICATES A SHEAR LOAD OF 22500 #

∴ M.S. QUOTED IS PESSIMISTIC

ATTACH. TO R.H. SKIN S. YOUNG SEPT 27/55

CAP END LOAD = 7740# PG 6-5 (?)

FITTING DRAG LOAD = 11160 + 4160 = 15260# Pg 6-1

LOAD/SCREW = $\frac{7740}{4}$ +∿ $\frac{15260}{4}$ = 1931 +∿ 3810 = 4270#

ALLOW 1/4 COK STEEL SCREW = 4450# SHEAR

BRG .125 - NOT CRITICAL

MS .08

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

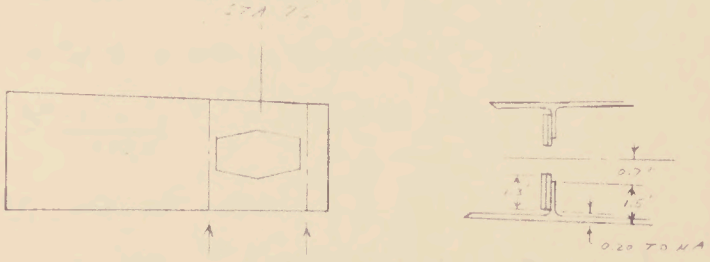
REPORT NO 9/2227/12

SHEET NO 7-1

AIRCRAFT		PREPARED BY	DATE
C105	FIN	[illegible]	JULY 58
		CHECKED BY	DATE

CONTROL # 2

SHEAR IN SPAR #1



4800# 9880#

SHEAR FLOW BASED ON NOMINAL @ OF 33%
OF TOTAL FIN SHEAR IN SPAR #1

TOTAL FIN SHEAR = 22,000#

∴ SHEAR ON SPAR #1 = 22,000 × .3 = 6600#

ASSUMPTIONS:

① 60% OF LOAD ON UPPER LUG GOES THROUGH SPAR #1 ACROSS HOLE.
② NONE OF LOAD ON LOWER LUG CROSSES HOLE.

* SHEAR ACROSS CUTOUT = 6600 + 4800 × .6
= 9480#

ASSUMING SHEAR @ I AND ASSUMING EACH ELEMENT BENDS ABOUT ITS OWN N.A.

I STRINGER = $\frac{1.3^3 \times .1}{2}$ = 0.0939 33.8% TOT I
EACH

I WEB & OTHER = $\frac{1.3^3 \times .25}{12}$ = 0.0458

ΣI = 0.1192 × 2 = .238 in⁴

LOAD CARRIED BY ONE STRINGER = .338 × 9480 = 2920#

* SEE NEXT SHT

A. V. ROE CANADA LIMITED
MALTON ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0587/12
SHEET No. 7-2

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	[illegible]	JULY 55
		CHECKED BY	DATE

CONTROL # 2

BENDING OF STRINGER

B.M. = 2920 × 1.3 = 3800 "#

$f_B = \frac{3800 \times 1.3}{0.3934} = 6270$ PSI

DIRECT f_B OF FIN

FIN $\frac{L}{STA\ 76} = \frac{130}{}$ "# (7/0587/38 SHT 1-20)

FIN B.M. AT STA 76 = 1,300,000 "#
(REF 7/0587/38 SHT 3-14)

$f_B = \frac{My}{I} = \frac{1300,000 \times .7}{130} = 7000$ PSI

TOTAL f_B = 62,000 + 7000 = 74,000 PSI

$F_c \cong F_{cy}$ APPROX

F_{cy} = 64 KSI

INCLUDING REDISTRIBUTION FOR RECTANGULAR SECTION F_{cy} = 76 KSI (AVRO MANUAL)

* M.S ≈ 0.0

* THE WEB WAS STRESSED FOR A SHEAR OF 9480 "#
BUT LATER WORK INDICATES A SHEAR
OF ABOUT 8800 "# REF. 7/0584

NOTE MORE EXACT METHOD NEXT SHT

FORM 1319A

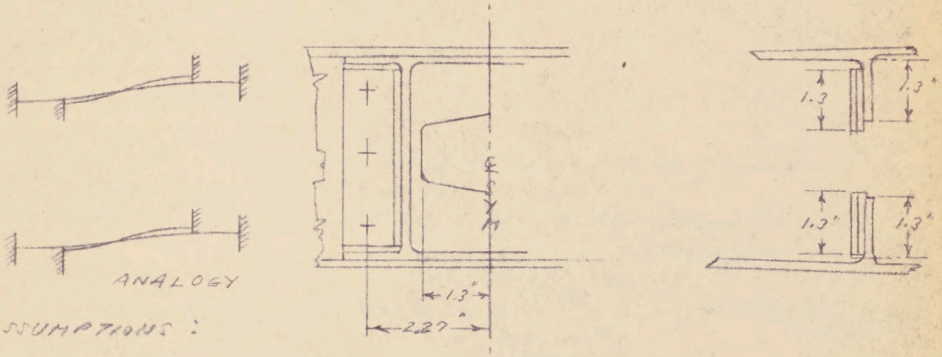
A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0882/1
SHEET No. 7-24

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	G Gradias	AUG 55
		CHECKED BY	DATE

CONTROL # 2

REGION NEAR CONTROL CUTOUT



ASSUMPTIONS :

① SPAR WEB ACTS LIKE A BEAM FIXED AT THE HOLE EDGE
② MACHINED SKIN ACTS LIKE A BEAM FIXED AT ATTACH'T.
③ BEAMS BEND SEPARATELY & δ'S ARE EQUAL.

I STRINGER $= \frac{1.3^3 \times 0.12}{3} = 0.0880$ "⁴

I WEB + D. $= \frac{1.3^3 \times 0.25}{12} = 0.0458$ "⁴

FOR A CANTALEVER BEAM $\delta = \frac{PL^3}{3EI}$

$\therefore$ δ'S ARE EQUAL
$\therefore$ LOAD $\propto \frac{1}{L^3}$

STRINGER $\frac{1}{L^3} = \frac{0.0880}{2.27^3} = 0.00752$

(WEB + D) $\frac{1}{L^3} = \frac{0.0458}{1.3^3} = 0.0208$

$\Sigma \frac{1}{L^3} = .0283 \times 2 = .0566$

% OF TOTAL LOAD

LOAD ON STRINGER (ONE SIDE) $= 100 \times \frac{.00752}{.0566} = 13.3\%$

LOAD ON WEB + D. (ONE SIDE) $= 100 \times \frac{.0207}{.0566} = 36.7\%$

FORM 1318A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/12
SHEET NO. 7-28

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

CONTROL #2

LOAD

ASSUMPTIONS:

① 60% OF LOAD ON UPPER LUG GOES THROUGH SPAR #1 ACROSS HOLE.
② 80% OF FIN SHEAR GOES DOWN SPAR #1 (7/0583/14 SH 4-18)
(7/0583/13 P 3-14)

SHEAR ACROSS CUTOUT = 22200 × .70 + 9200 × 0.60
= 9480 #

LOAD ON WEB + DOUBLER AT NOSE = 36.7 %
(FROM PREVIOUS SH)

LOAD ON D. & WEB = .37 × 9480 = 3480 #

$f_B = \frac{3480 \times 1.3 \times 1.3}{.0458} = 128{,}000$ PSI

ALLOWABLE F_c = F_{cy} × FORM FACTOR
= 76 KSI

M.S. = +.41

NOTE: A. Young SEPT 28/55

$f_{B_{TOTAL}} = 128\,000$ PSI

F_{BU} = F_{TU} × FORM FACTOR
= 72000 CLAD 75ST × 1.5 = 108,000 PSI

M.S. = −.16

FORM 1319A

AVRO AIRCRAFT LIMITED

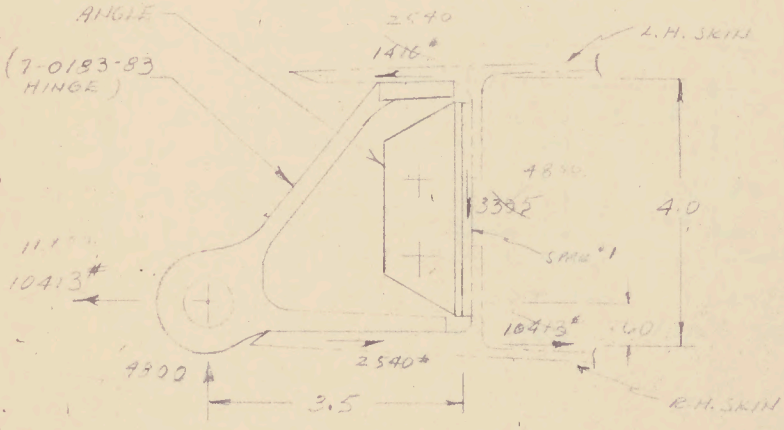
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0582/12

SHEET NO 7-3

AIRCRAFT		PREPARED BY	DATE
C-105		McCABE	5-16-55
		CHECKED BY	DATE

RUDDER CONTROL HINGE #2 (7-0183-83)



FROM 7/0582/10, VOL I SH# 19

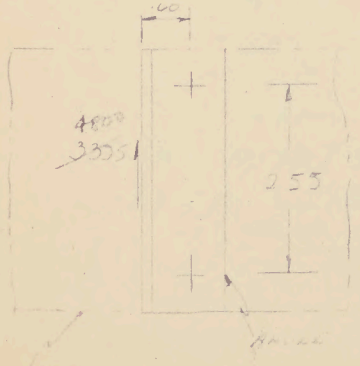
HINGE SIDE LOAD = 9600/2 = 4800 = 3395# PER LUG

HINGE DRAG LOAD = 20826/2 = 22200 = 10413# PER LUG

L.H SKIN REACTION = $\frac{4800 \times 3.5 - 11,100 \times 60}{4.0}$

$= (16800 - 6650)/4 = 2540$ #

ANGLE ATTACHMENT TO SPAR #1 WEB



SHEAR LOAD ON ANGLE = 4800#

LOAD ON ATTACHMENTS FROM MOMENT =

4800 x .60/2.55 = 1130 LBS.

LOAD PER ATTACHMENT FROM SHEAR =

4800/2 = 2400 LBS

RESULTANT = $(1130^2 + 2400^2)^{1/2}$ = 2650 #

ALLOW LOAD 1/4" NAS = 4650#

M.S. = $\frac{4650}{2650} - 1$ = M.S. .75

FORM 1118A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/0583/12

SHEET No 7-5

AIRCRAFT: C-105

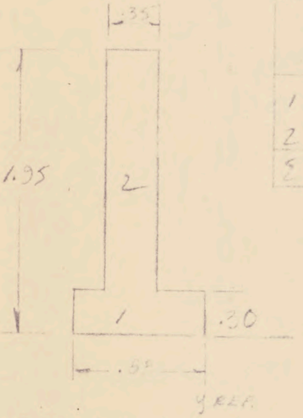
PREPARED BY McCABE DATE 5-17-55

CHECKED BY DATE

RUDDER CONTROL HINGE #2 (7-0183-83)

[illegible] (CONT'D)

SECTION PROPERTIES



	AREA	Z-AXIS				Y-AXIS			
		y	Ay	Ay²	I_o	z	Az	Az²	I_o
1	.264	.150	.0396	.0044		.44	.116	.051	.017
2	.576	1.125	.6470	.7280	.131	.505	.291	.147	.006
Σ	.840	$\bar{y}$ = .82	.6866	.7324	.131	z = .48	.407	.198	.023

$I_z = .7324 + .131 - .82 \cdot .6866$
$= .8634 - .5630 = .300$
$I_z/c = .300/.82 = .366$

$I_y = .198 + .023 - .48 \cdot .407$
$= .221 - .196 = .025$
$I_y/c = .025/.48 = .052$

SEC A-A (PG. 7)

$f_{bz} = \frac{M_{ZA}}{I_z/c} = \frac{7790}{.366} = 21{,}300$ PSI.

$f_{by} = \frac{M_{YA}}{I_y/c} = \frac{1660}{.052} = 32{,}000$ PSI.

IN CALCULATING TORSIONAL SHEAR STRESS, ASSUME SEC A-A TO BE RECTANGULAR [illegible] (1.95 × .35), THEN,

$f_s = \frac{T}{\alpha b^2}(3 + 1.8\, b/a)$ (REF. [illegible] STRESS MANUAL)

$= \frac{720}{1.95(.35)^2}(3 + 1.8 \frac{.35}{1.95})$

10,100 PSI

$f_t = 11{,}100/.840 = 13{,}200$ PSI

ALLOWABLE M_{ZA}

$F_t = 66{,}000$ (75S-T6 EXTR ACROSS GRAIN)

$K = 2Q_m/I_z/c = 2(.670 \times .264 + .182 \times .26)/.366 = 1.22$

M_{ZA} (ALLOW) $= K F_t I_z/c = 1.22 \cdot 66{,}000 \times .366 = 29{,}400$ IN. LBS.

ALLOWABLE M_{YA}

F_t 66,000

K = 1.5

M_{YA} (ALLOW) $= K F_t I_y/c = 1.5 \times 66{,}000 \times .052 = 5140$ IN. LBS.

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0593/12

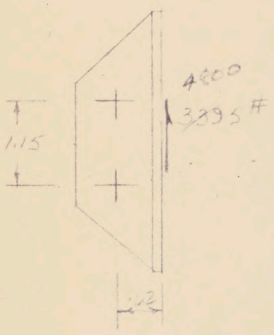
SHEET No. 7-4

AIRCRAFT:	
C-105	

PREPARED BY	DATE
McCABE	5-16-55
CHECKED BY	DATE

RUDDER CONICAL HINGE #2 (7-0153-93)

ANGLE ATTACHMENT TO HINGE



SHEAR LOAD ON ANGLE = 4650 #

LOAD ON ATTACHMENTS FROM MOMENT = 4800 × .62 / 1.15 = 2580 #

LOAD PER ATTACHMENT FROM SHEAR = 4800 / 2 = 2400 #

RESULTANT = $(2580^2 + 2400^2)^{1/2}$ = 3520 #

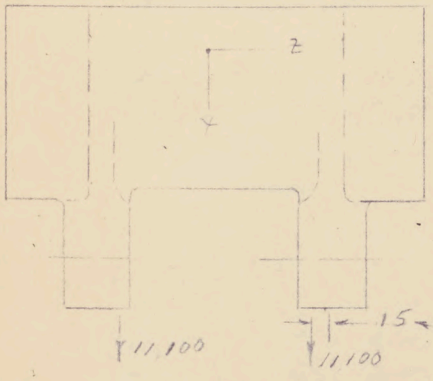
ALLOW LOAD 1/4" NAS BOLT = 4650 #

M.S. = $\frac{4650}{3520} - 1$ = .14

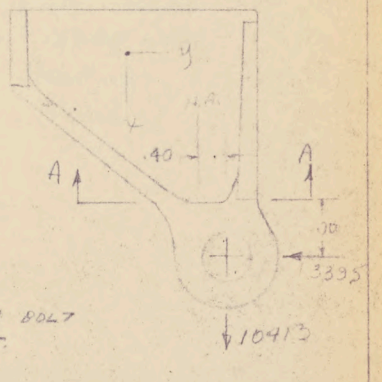
ALLOW BEARING .115" 75-ST = ~~2600~~ 4380 # (125 KSI)

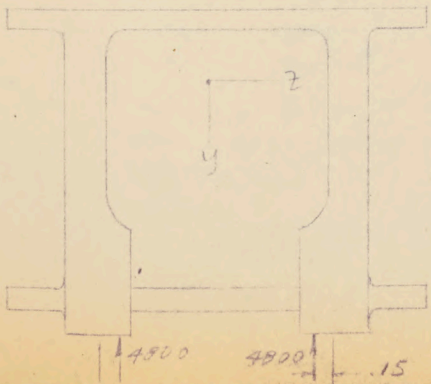
M.S. .02 / .24

STRESSES ON SEC. A-A



ASSUMING A BOLT LOAD OUT





MOMENTS ON SEC. A-A

M_{ZA} = .70 × 4800 + .40 × 11,100

= 3360 + 4430 = 7790 IN. LBS.

ASSUMING LOADS ARE APPLIED EQUALLY TO EACH,

M_{ZA} = .15 × 11,100 = 1660 IN. LBS.

M_{YA} = .15 × 4800 = 720 IN. LBS.

FORM 1316A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 4/05823/12

SHEET No 7-6

AIRCRAFT: C-105		PREPARED BY: McCABE	DATE: 5-17-55
		CHECKED BY	DATE

RUDDER CONTROL HORN #2 (7-0183-93)

STRESSES ON SEC A-A (CON'D)

MARGIN OF SAFETY

$R_{BZ} = \frac{6620}{29,400} = .22$

$R_{BY} = \frac{1660}{5140} = .32$

$R_E = \frac{13,200}{66,000} = .20$

$R_S = \frac{10100}{43,000} = .23$

$M.S. = \frac{1}{[(R_{BZ}+R_{BY}+R_E)^2 + R_S^2]^{1/2}} - 1$

$= \frac{1}{[(.22+.32+.20)^2 + .23^2]^{1/2}} - 1$ M.S. .29

ATTACHMENT TO R.H. SKIN

ATTACHMENT PER LUG IS BY 4-1/4 CSK. SCREWS.

LOAD PER LUG = 2540 + 11,100 = 13640 LBS.

LOAD PER SCREW = 13640/4 = 3400 LBS.

ALLOW. LOAD 1/4" HOS SCREW = 4050 LBS.

M.S. = $\frac{4050}{3400} - 1 =$ M.S. .37

LUG ANALYSIS

TRANSVERSE LOAD = 4900

AXIAL LOAD = 11100

ALLOWABLE LOADS (REF. HINGE #5 MATERIAL PDS 10620)

P_{BU} = 14500 #

P_{TU} = 14,200 #

R_B = 11,100/14,600 = .76

R_T = 4900/14,200 = .34

$R_B^{1.6} + R_T^{1.6} = 1$

M.S. = $\frac{1}{(.76^{1.6} + .34^{1.6})} - 1 =$ M.S. .13

$.76^{1.6} = .644$

$.34^{1.6} = .178$

FORM 1318A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

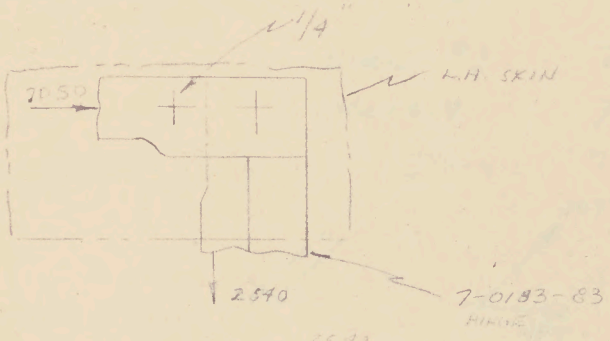
REPORT No 2/105 B3/13

SHEET No 7-7

AIRCRAFT		PREPARED BY	DATE
C-105		McCABE	5-19-55
		CHECKED BY	DATE

RUDDER CONTROL HINGE #2 (7-0183-83)

HINGE ATTACHMENT TO L.H. SKIN.



LOAD FROM HINGE 7-0183-83 (Pg. 6) 2540#

END LOAD = 7050# (Pg. 3.)

$$\text{RESULTANT} = \sqrt{\left(\frac{2540}{2}\right)^2 + \left(\frac{7050}{2}\right)^2}^{1/2}$$

$$= 3740 \text{ LBS}$$

ALLOW. LOAD 1/4" SCREW = 4050#

$$M.S. = \frac{4050}{3740} - 1 = .24$$

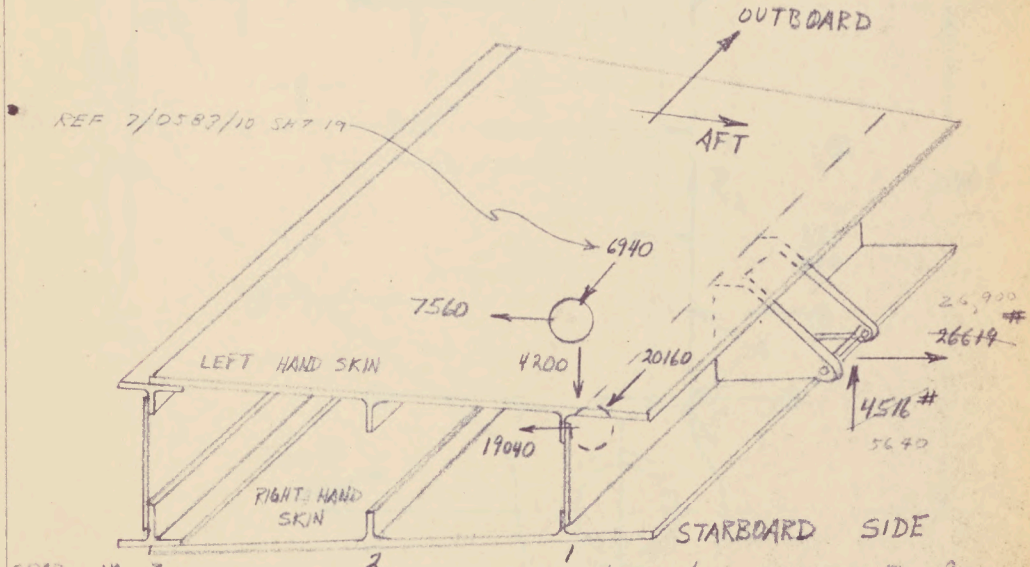
AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12
SHEET NO 9-1

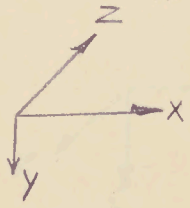
AIRCRAFT		PREPARED BY	DATE
C 105	FIN HINGE FITTINGS	S. YOUNG	MAY 16/55
		CHECKED BY	DATE

RUDDER CONTROL HINGE #3

HINGE #3 7-0183-91
ASSEMBLY 7-0183-84
PRODUCTION - HINGE 3 (DETAIL) 7-1083-305



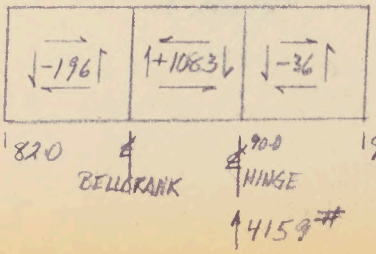
LOADS: 7/0583/10 VOL. I Pg 19
HINGE MOMENT = 245,000 "#



Obsolete

LOADS: 7/0583/10 VOL II Pg 139
HINGE MOMENT = 205,000 "#

REAR SPAR SHEAR FLOWS



FORM 1192A

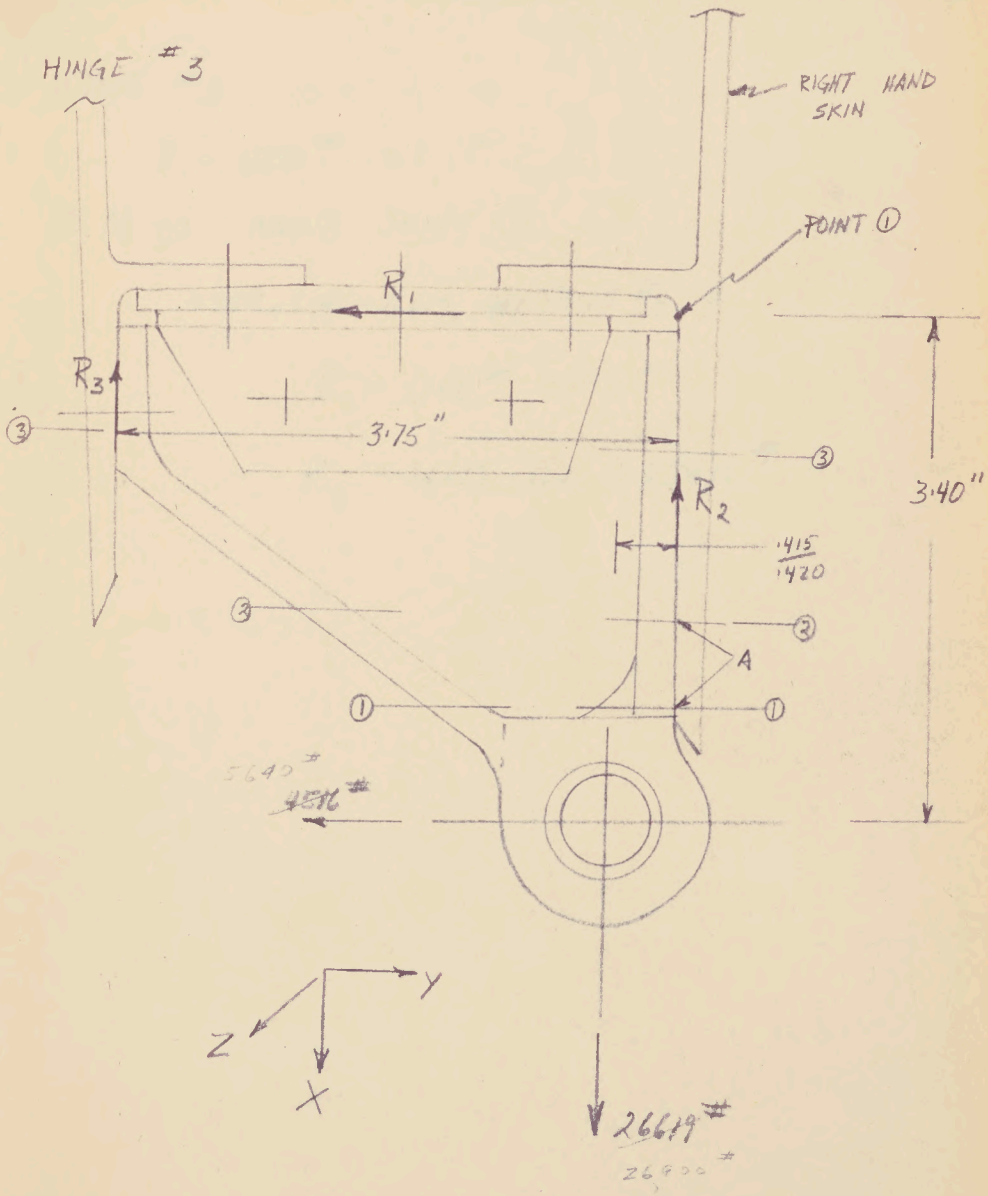
AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/1583/12

SHEET No. B-2

AIRCRAFT		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 16/55
		CHECKED BY	DATE



AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/12
SHEET NO 8-3

AIRCRAFT		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 16/55
		CHECKED BY	DATE

HINGE #3

$R_1 = 4516^{\#}$ 5640#.

$\Sigma M = 0$ ABOUT POINT ①

$$+4516 \times 3.40 - 26619 \times .417 + 3.75 R_3 = 0$$

$$R_3 = 1140^{\#}$$

$$R_2 = 26619 - 1140 = 25479^{\#}$$

FORM 1310A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/13
SHEET NO 8-4

AIRCRAFT		PREPARED BY	DATE
C 105	FIN HINGE FITTINGS	S. YOUNG	MAY 25/55
		CHECKED BY	DATE

HINGE #3

FITTING ATTACHMENTS

ATTACH LOAD TO PORT SKIN = ~~1440~~ 2100 #

ALLOW 4 - 3/16" SCREW (NAS 333) CSK .15 SKIN BASIC
.20 AT FITTING

= 4, 3680 # PRODUCT ENG. MAY 1946

M.S. = HIGH

ATTACH. LOAD TO STARBOARD SKIN = ~~25479~~ 24,500 #

ALLOW 8 - 1/4" NAS 334 SCREWS (REF PROD ENGR MAY 46) CSK .15 SKIN BASIC .20 AT FITTING

= 8 x 4650 # = 37,200 #

$$M.S. = \frac{37200}{24800} - 1 \qquad .50$$

ATTACH. SHEAR LOAD = 5640 #

$$\text{MAX BOLT LOAD} = \frac{5640}{6} + \frac{\frac{5640}{2} \times .6}{2.25} = 940 + 755 = 1695\ \#$$

ALLOW NAS464 P4A BOLT BRG WEB & DOUBLER

BRG = NOT CRITICAL

SHEAR = 4650 #

$$M.S. = \frac{4650}{1695} - 1 \qquad 1.7$$

$$\text{BOLT LOAD ON FTG} = \left[\frac{5640^2}{4} + \left(\frac{5640}{2} \times \frac{.21}{1.50}\right)^2\right]^{\frac{1}{2}} = 1940\ \#$$

1/4 S.L.T. IN .119 ANGLE (125 KSI) = FITTING = 3720 # M.S. = .91

FORM 1139A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12
SHEET NO 8-5

AIRCRAFT		PREPARED BY	DATE
C 105	FIN HINGE FITTINGS	S. YOUNG	MAY 16/55
		CHECKED BY	DATE

HINGE #3

CHECK LUG END BY ANALYSIS OF MELCON & HOBLIT IN PRODUCT ENGINEERING, JUNE 1953

MATERIAL

75ST AL. BAR
QQ-A-277 T6

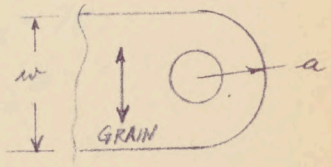
$F_{TU_L} = 78000$ $F_{TY_L} = 70000$

$F_{TU_T} = 66000$ $F_{TY_T} = 58000$

$F_{CY_{L,T}} = 70000$ $F_{SU} = 43000$

AXIAL LOAD $P_a = 26,900\#/2 = 13,450\#$

TRANSVERSE LOAD $P_{tr} = 5640\#/2 = 2820\#$

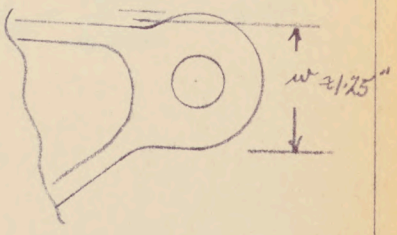


AXIAL LOADING:

$w/D = \frac{1.25}{.813} = 1.538$

$t/D = \frac{.70}{.813} = .86$

$D/t = \frac{.813}{.88} = .924$



$K_t = .87$

$A_t = (w - D)t = .437 \times .88$

$P'_{tu} = K_t A_t F_{TU} = .87(.437 \times .88)66000 = 22100\#$

FORM 1110A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/1583/12
SHEET No. 8-6

AIRCRAFT		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55
		CHECKED BY	DATE

HINGE #3

$K_{BR} = .61$ $\quad A_{br} = .813 \times .188 = .716 \square''$

$P'_{br} = K_{br} A_{br} F_{tu_x} = .61 \times .716 \times 66000 = 28{,}850^{\#}$

. TO BE COMPATIBLE WITH THE OTHER HINGE STRESSING & TO REDUCE OFFSETS, USE AN EFFECTIVE LUG THICKNESS OF 0.55"

WIDTH $w = 1.140$

$w/D = \frac{1.140}{.813} = 1.72$ $\quad K_t = .75$

$A_t = (w - D)t = (1.140 - .813).55 = .322 \square''$

$P'_{tu} = .75 \times .322 \times 66000 = 15950^{\#}$

$P_a = 13310^{\#}$ $\quad K_a = \frac{13450}{15950} = .843$

TRANSVERSE LOADING:

$A_{At} = \left(.70 - \frac{.813}{2}\right) .55'' = .162 \square''$

$A_{br} = Dt = .813 \times .55 = .447 \square''$

$A_{At}/A_{br} = .368$ $\quad K_{tru} = .28$ (CURVE ④ FIG 18)

$P'_{tru} = K_{tru} A_{br} F_{tu_x} = .28 \times .447 \times 66000 = 7960^{\#}$

$P_{tr} = 2258$ $\quad R_{tr} = \frac{2820}{7960} = .354$

6

FORM 1084

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/0583/12

SHEET No 8-7

AIRCRAFT		PREPARED BY	DATE
C.105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55
		CHECKED BY	DATE

HINGE #3

$$M.S. = \frac{1}{(R_a^{1.6} + R_{tr}^{1.6})^{.625}} - 1$$

$$= \frac{1}{(.843^{1.6} + .354^{1.6})^{.625}} - 1 = \frac{1}{\quad} - 1 =$$

105

$.354^{1.6} =$

$.843^{1.6} =$

7

FORM 1119A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12
SHEET NO 8-8

AIRCRAFT		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55
		CHECKED BY	DATE

HINGE # 3

SECTION 1-1 WITH LOADS REFERENCED TO POINT 'A'

$T_x = 13450^{\#}$ TENSION

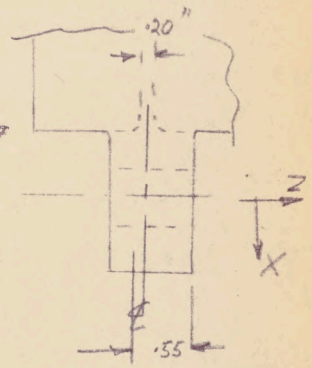
$S_y = 2820^{\#}$ SHEAR

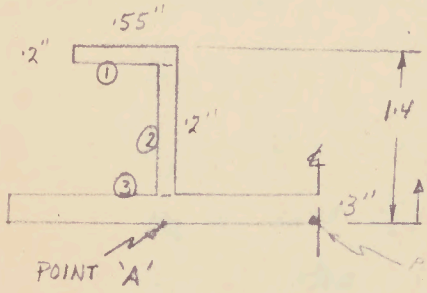
$M_z = 13450 \times .417 - 2820 \times .170 = 3630$ "#

WEB OFFSET = $\frac{.55}{2} - \frac{.85}{2} = .165$"

MOMENT, $M_y = .165 \times 13450 = 2220$ "#

TORSION, $M_x = .165 \times 2258 = 372$ "#





ASSUME 1" EFFECTIVE OF ITEM (3)

ITEM	A	Y'	AY'	AY'²	I_o	Y	AY
1	.11	1.3	.143	.186		.767	.084
2	.18	.7	.126	.088	.012	.267	.048
3	.30	.15	.045	.007		−.383	.132
Σ	.59	.533	.314	.281	.012		

$I = .281 + .012 - .533^2 \times .59 = .125$ IN⁴

FORM 1110A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 8-9

AIRCRAFT		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55
		CHECKED BY	DATE

HINGE #3 SECTION ①-①

M_z ABOUT CENTROID OF SECTION

$= 3970 - 13310 \times .533 = 3970 - 7100 = -3130$ "# COMP ON ITEM ①

$f_{b_①} = \frac{3130}{.125} \times .767 = -19{,}200$ PSI

$f_{b_③} = \frac{3130}{.125} \times .383 = +9590$ PSI

$f_t = \frac{13310}{.59} = +22600$ PSI

$\gamma = \frac{2258 \times .132}{.125 \times .120} = 11{,}900$ PSI

CHECK MOMENT $M_y = 2195$ "#

$I_① = \frac{.20}{12} \times .55^3 = .00278$

$I_③ = \frac{.130}{12} \times 1^3 = .025$

$M_③ \approx 2195 \frac{.025}{.028} = 1960$ "#

$f_{b_③} = \frac{1960}{.025} \times .5 \times 1.3 = 30{,}400$ PSI

FORM FACTOR FOR KEY 253-T6

CHECK TORSION $M_x = 372$ "#

$K = \frac{bt^2}{3}$ $f_s = \frac{T}{K}$

$K = \frac{1}{3}(.55 \times .20^2 + .9 \times .20^2 + 1 \times .3^2) = .049$

$f_s = \frac{372}{.049} = 7600$ PSI

FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 5 of 12

AIRCRAFT:		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55.
		CHECKED BY	DATE

HINGE #3 SECTION ① - ①

POINT 'B'

ADDITION OF TENSION & BENDING STRESSES.
SHEAR IS 0 AT CORNER.

ITEM 3

$f_1 = +9590 + 22600 = +32190$ PSI

$f_2 = 33,400$ PSI

$f_{cal} = 66,360$ PSI

$F_{tu} = 66$ KSI M.S. = .00

POINT 'A'

SHEAR AND BENDING.

$f_t = 22,800$ PSI

$f_{b3} = 13,560$ PSI

$f_{cal} = 36,360$ PSI

f_s (DIRECT SHEAR) $= \frac{2283}{.18} = 12,700$ PSI

f_s (DUE TO TORSION) $= 9500$ PSI

$f_{s\,TOT} = 22,200$ PSI

BY MOHR'S ⊙

$f_{s\,MAX} = \sqrt{\left(\frac{36,360}{2}\right)^2 + 22,200^2} = 28,600$ PSI

$F_{su} = 43$ KSI M.S. = 0.51

FORM 1158A

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/12
SHEET NO. B - 11

AIRCRAFT		PREPARED BY	DATE
C105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55
		CHECKED BY	DATE

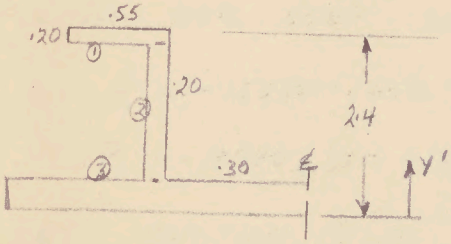
HINGE #3 SECTION ② - ②

$T_x = 13310$ #

$S_y = 2258$ #

ABOUT HEEL LINE 'A'

$M_z = 13310 \times .417 - 2258 \times 1.35 = +2500$ PSI



ASSUME 1.5" OF ITEM ③ EFFECTIVE

ITEM	A	Y'	AY'	AY'²	Y	AY
1	.11	2.3	.253	.582	-1.475	-.162
2	.38	1.2	.456	.547	-.375	-.142
3	.145	.15	.067	.010	.675	.304
Σ	.94	.825	.776	1.139		

$I = 1.139 - .94 \times .825^2 = .499$ IN⁴

ABOUT CENTROID,

$M_z = +2500 - .825 \times 13310 = +2500 - 10980 = -8480$ " #

$f_{b_{t①}} = \frac{8480}{.499} \times 1.475 = -25050$ PSI

$f_{b_{t③}} = \frac{8480}{.499} \times .675 = +11,450$ PSI

$f_t = \frac{13310}{.94} = +14150$ PSI

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 8-12

AIRCRAFT:		PREPARED BY	DATE
C 105		S. YOUNG	MAY 24/55
		CHECKED BY	DATE

HINGE #3 SECTION ③-②

$f_{③} = 14150 + 11450 = 25\,600$ PSI

$$M.S. = \frac{66100}{25600} - 1 = 1.58$$

CHECK WEB COMP DUE TO SLOPE IN MEMBER ①

$f_1 = -25050 + 14150 = -10900$ PSI

$P_1 = -10900 \times .11 = -1199^{\#}$ AT SECTION ③-②

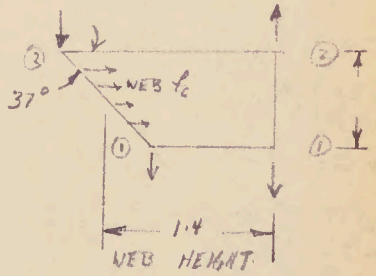
AT SECTION ①-①

$f_1 = -19200 + 22600 = +3400$ PSI

$P_1 = +3400 \times .11 = +374^{\#}$

CAP LOAD CHANGE OVER .45" BETWEEN SECTIONS

$\Delta P = +374 - (-1199) = 1573^{\#}$



$\text{TAN } 37° = \frac{\Delta P}{\text{WEB } P_c}$

$\text{WEB } P_c = \frac{1573}{.1754} = 2085^{\#}$

PER INCH

$\text{WEB } P_c = \frac{2085^{\#}}{.45''} = 4660^{\#}/_{in}$

FORM 1318A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/12
SHEET NO. 8-13

AIRCRAFT		PREPARED BY	DATE
C 105	FIN HINGE FITTINGS	S. YOUNG	MAY 24/55
		CHECKED BY	DATE

HINGE #3 SECTION ②-②

WEB $P_{CR} = \frac{C\pi^2 EI}{L^2}$ TAKE $C = 2$

$L = 1.4''$

$E = 10 \times 10^6$

PER INCH, $I = \frac{1}{12} \times .20^3 = \frac{.008}{12}$

$$P_{CR} = \frac{2\pi^2 \times 10^7}{1.4^2} \frac{.008}{12} = 66200 \text{ LB/IN}$$

$$f_{CR} = \frac{66200}{1'' \times 12''} = 331000 - \text{HIGH}$$

USE $F_{CY} = 70000$ PSI

$P_{CR} = 70000 \times 1 \times .2 = 14000$ #/" WEB STRENGTH AMPLE

$$\rho = \sqrt{\frac{I}{A}} = \sqrt{\frac{.008}{\frac{1}{2} \times .2}} = \sqrt{.0333} = .0575 \text{ in.}$$

$$\frac{L}{\rho} = \frac{1.4}{.0575} = 24.4 \quad \text{Satisfactory.}$$

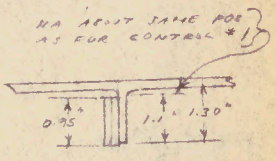
FORM 1119A

A. V ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 8-14

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gardiner	JULY 55
		CHECKED BY	DATE

CONTROL # 3



*NOTE: SHEAR ACROSS HOLE WAS ESTIMATED TO BE 8290# AND M.S. I QUOTED ON THIS VALUE. LATER WORK 7/0583/10 INP-32 SHOWS THE SHEAR TO BE 3125# APPROX

* NOTE MORE EXACT METHOD FOLLOWING SHT

SHEAR ON SPAR #1 ≈ 30% TOTAL FIN SHEAR
(REF 7/0583/14 4-18)

TOTAL FIN SHEAR STA 90 = 22,000# ← (7/0583/20 3-14)

SHEAR ON SPAR #1 ≈ 22,000 x .30 = 6600# APPROX

SHEAR DUE TO UPPER HINGE LUG
ASSUMING 60% GOES THROUGH CUTOUT

SHEAR = 2820 x 0.60 = 1690#

TOTAL SHEAR = 8290#

SHEAR IS CARRIED ACROSS HOLE BY BENDING OF SPAR LEG, WEB & DOUBLER.
ASSUMING SHEAR ∝ I FOR EACH ELEMENT

$I_{SPAR\ LEG} = \frac{1.1^3 \times 0.12}{3} = .0535\ ^{"4}$

$I_{WEB + DOUBLER} = \frac{0.95^3 \times .25}{12} = .0179\ ^{"4}$

$\Sigma I = .0714 \times 2 = .1428\ ^{"4}$

∴ SHEAR REACTED BY SPAR LEG = $8290 \times \frac{.0535}{.1428}$
= 3100# ~~.1428~~

∴ B.M. " " " " = 3100 x 1.3 = 4030 "#

$f_B = \frac{4030 \times 1.1}{.0535} = 83{,}000$ PSI $F_c = F_B = 76$ KSI PLASTIC

* M.S. = -.08

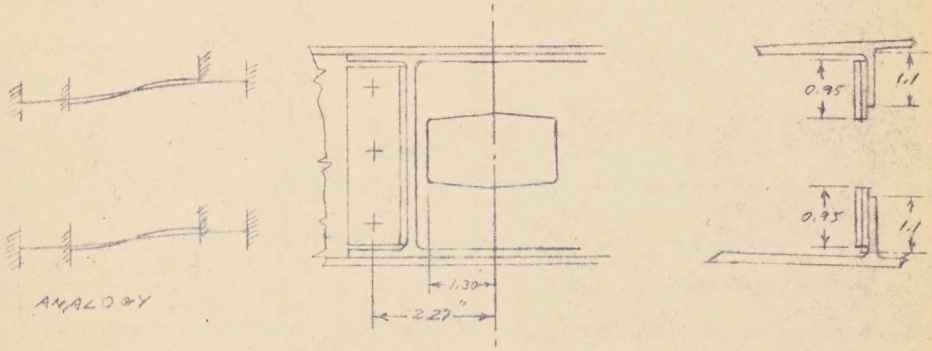
A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/25827/17
SHEET No. 8-15

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	G Sanders	AUG 55
		CHECKED BY	DATE

CONTROL # 3

REGION AROUND CONTROL CUTOUT



ASSUMPTIONS :

① SPAR WEB ACTS LIKE A FIXED BEAM AT THE HOLE EDGE
② MACHINED SKIN ACTS LIKE A FIXED BEAM AT ATTACH
③ BEAM END SEPARATELY & δ'S ARE EQUAL.

$I_{STRINGER} = \frac{1.1^3 \times 0.12}{3} = 0.0531^{-4}$

$I_{WEB} = \frac{0.95^3 \times .25}{12} = 0.0179^{-4}$

LOAD IS PROPORTIONED ACCORDING TO $\delta = \frac{PL^3}{3EI}$

$\therefore$ δ'S ARE EQUAL

$\therefore$ LOAD $\propto \frac{I}{L^3}$

STRINGER $\frac{I}{L^3} = \frac{0.0531}{2.27^3} = 0.00454$

WEB + D. $\frac{I}{L^3} = \frac{0.0179}{1.3^3} = \frac{0.00813}{0.01267 \times 2 = .02534}$

% OF TOTAL LOAD

$\therefore$ LOAD ON STRINGER (ONE SIDE) $= 100 \times \frac{.00454}{.02534} = 18\%$

$\therefore$ LOAD ON WEB + D. (ONE SIDE) $= 100 \times \frac{.00813}{.02534} = 32\%$

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 8-16

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

CONTROL # 7

SHEAR ON SPAR # 1 =

ASSUMPTIONS :

① 33% OF FIN SHEAR IS APPLIED TO SPAR # 1 (REF 7/0583/14 SHT 9-18)

② 60% OF UPPER LUG LOAD CROSSES CUTOUT, (REF 7/0583/PB 9-14)

∴ LOAD ACROSS HOLE = 22,600 × 0.30 + 2820 × .60

= 8290 #

LOAD APPLIED TO WEB #D. = 32% (PREVIOUS SHT) OF 8290

= 2650 #

$f_D = \frac{2650 \times 1.5 \times .095}{.0139} = 21{,}000$ PSI

F_c = F_{cy} × FORM FACTOR
= .25 KSI (AVRO MANUAL

* M.S = -.64

* LATER WORK (7/0583/10 SHT 178-38) SHOWS SHEAR TO BE 3125

NOTE: S. Young SEPT 28/65

f_B = 211 000 PSI

F_{BU} = F_{TU} × FORM FACTOR

= 72000 CLAD 75ST × 1.5 = 108 000 PSI

M.S. = -.48

FORM 1319A

AVRO AIRCRAFT LIMITED

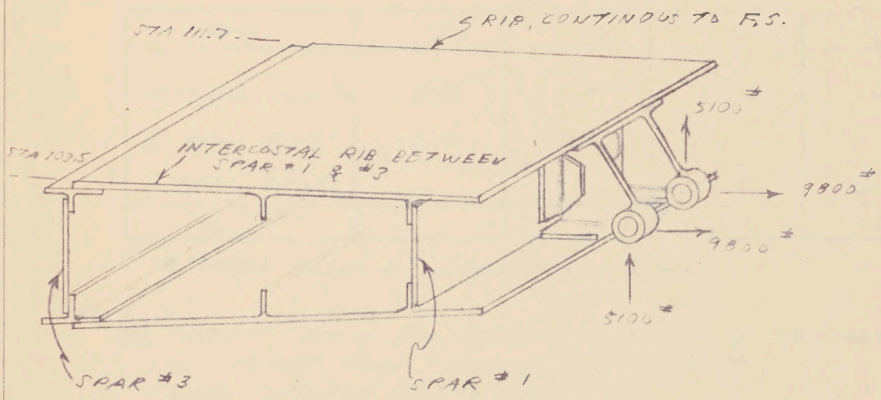
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12

SHEET NO 9-1

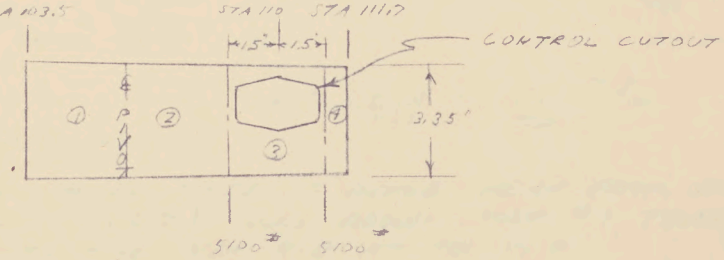
AIRCRAFT		PREPARED BY	DATE
C105	FIN	L Gardiner	JULY 55
		CHECKED BY	DATE

CONTROL # 4



SHEAR FLOW

THE CRITICAL SHEAR FROM SEVERAL SOURCES WILL BE USED.



(A) SHEAR FLOW FROM 7/0583/10 SAT 137 FOR PIVOT & NOMINAL SHEAR + HINGE SHEAR.

SHEAR DUE TO HINGE PROPORTIONED TO RIBS AS THOUGH SPAR #1 WAS CUT AT RIBS TO BE CONSISTENT WITH REPORT 7/0583/10

$$q_{(2)} = \frac{5100}{3.35} + \frac{6.0}{8.2} \times \frac{5100}{3.35} = 2630 \text{ \#/IN}$$

$$q_{(3)} = \frac{6.0 \times 5100}{8.2 \times 3.35} = 1110 \text{ \#/IN}$$

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12
SHEET NO 9-2

AIRCRAFT		PREPARED BY	DATE
C105	FIN	L Saunders	JULY 55
		CHECKED BY	DATE

CONTROL #4

(1) SHEAR FLOW FROM 7/0583/10 SHT 107 + HINGE LOAD

BAY	①	②	③	④
NOMINAL SHEAR F.	280	240	280	280
q FROM PIVOT	-678	551	551	551
q FROM HINGE			-1110	-2673
Σ			*-279	-1779

* SHEAR FLOW IS UNREASONABLY LOW.

(2) SHEAR FLOW BASED ON NOMINAL q OF 30% OF TOTAL FIN SHEAR ON SPAR #1
(REF. 7/0583/19 9-18)

TOTAL FIN SHEAR AT STA 110 = 18,200#
(REF 7/0583/38 SHT 3-14)

∴ SHEAR SPAR #1 = 18,200 × 0.30 = 5460#

SPAR h = 3.35"

∴ q = 5460/3.35 = 1630 #/IN

ASSUMPTIONS:

(1) ASSUMING MORE OF HINGE SHEAR, FROM UPPER LUG, (60%) GOES DOWN SPAR #1 THAN FOR'D INTO FIN VIA RIB AT STA 111.7

(2) NONE OF HINGE SHEAR FROM LOWER LUG GOES INTO UPPER RIB.

(3) NONE OF PIVOT LOADS GOES INTO UPPER RIB.

∴ SHEAR LOAD ACROSS HOLE = 5460* × 0.6 + 5100#
= 8380*

∴ q = 8380/3.35 = 2501 #/IN

* SEE NEXT PAGE

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/2583/12
SHEET No. 9-3

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	LBS	
		CHECKED BY	DATE

CONTROL # 4

SHEAR ACROSS HOLE AT STA 110 = -650 #

REFERENCE 7/0583/10 137-37

SHEAR USED FOR ANALYSIS 8380 #

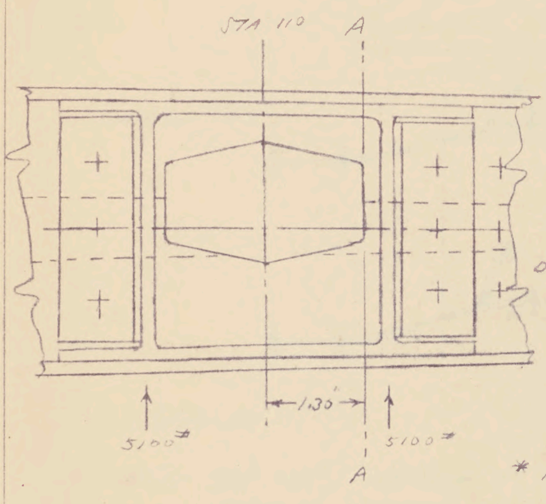
∴ M.S. QUOTED IS VERY PESSIMISTIC

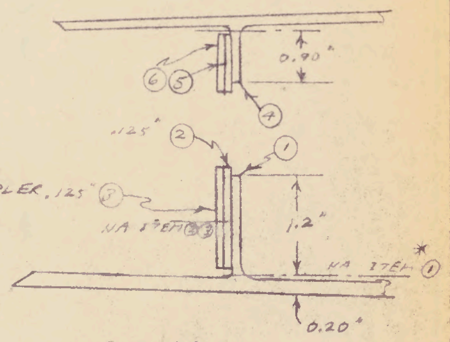
FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO	7/0553/12	
SHEET NO	9 - 4	
AIRCRAFT: C105	FIN	
PREPARED BY		DATE
CHECKED BY		DATE

CONTROL # 4





SEC AA

* NA IS ABOUT CORRECT FOR 6" OF SKIN WITH t = .15"

SHEAR LOAD TO BE TRANSMITTED ACROSS HOLE = 8380#

ASSUMING SHEAR CARRIED BY ELEMENTS ∝ I.
ASSUMING ELEMENTS BEND ABOUT THEIR OWN NEUT AXIS.

I ITEM (1) $= \frac{1.2^3 \times 0.12}{3} = 0.0695''^4$ ← 46.4 % OF TOTAL I

I ITEM (2)(3) $= \frac{1.2^3 \times 0.25}{12} = 0.0362''^4$

I ITEM (4) $= \frac{0.9^3 \times .12}{3} = 0.0293''$

I ITEM (5)(6) $= \frac{.9^3 \times .25}{12} = 0.0152''^4$

$\Sigma I = 0.150''^4$

∴ ITEM (1) REACTS 46.4 % OF LOAD = .464 × 8380
= 3890#

ASSUMING FIXED END AT SEC AA
AND FLEXURE POINT AT STA 110,

∴ BM = 1.3 × 3890 = 5050"#

$f_B = \frac{5050 \times 1.2}{0.0695}$ = 87,400 PSI (NOTE FIN f_B IS SMALL HERE)

* SEE PREVIOUS SHT

$F_c \approx F_{cy}$ = 76,000 PSI (INCLUDING PLASTIC BENDING AVRO MANUAL)

* M.S. ≈ -.13

NEXT SHT MORE EXACT METHOD

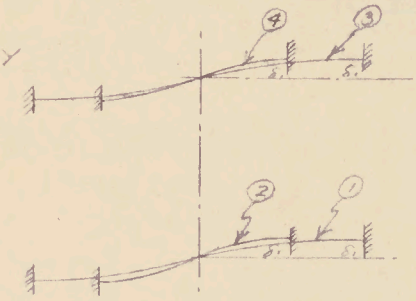
A. V ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0563/n
SHEET No. 9-4A

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

CONTROL # 4

ANALOGY



ASSUMPTIONS :

① ALL BEAMS DEFLECT THE SAME AMOUNT
② ALL BEAMS BEND SEPARATELY,
③ WEB IS FIXED AT THE EDGE OF THE HOLE
④ STRINGER IS FIXED AT FITTING ATTACHMENTS

∴ GEOMETRY IS SAME
∴ LOAD CAN BE PROPORTIONED BETWEEN ① & ③, AND ② & ④

∴ LOAD ON ① & ② = $\frac{I_{①}}{I_{①} + I_{③}} = \frac{.0695}{.0695 + .0293} \times 100 = 70.3\%$ (OF TOT P)

EQUATING $\delta = \frac{Pl^3}{3ET}$ TO DET'M LOAD ON EACH ITEM

$$\frac{P_1 \times 2.27^3}{3E \times 0.0695} = \frac{P_2 \times 1.3^3}{3E \times 0.0362}$$

$$P_1 = \frac{6.3.7}{16.8} P_2$$

$P_1 + P_2 = 8380 \times .703 = 5900$ #

$P_1 = 5900 \times \frac{60.7}{229} = 1560$ #

ITEM ① $f_B = (1560 \times 2.27) \frac{1.2}{.0695} = 61{,}200$ PSI

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/GSS3/12
SHEET No. 9-48

AIRCRAFT:		PREPARED BY	DATE
		CHECKED BY	DATE

ITEM ② $f_b = (49{,}40 \times 1.3)\frac{0.60}{.0362} = 93{,}500$ PSI

F_{cy} = FORM FACTOR = 76 KSI

* M.S. = -.19

* LATER WORK (7/GSPD/12 108-33)
INDICATES A LOAD OF -650 # INSTEAD OF -820#

NOTE: L. Young SEPT 28/55

$f_B = 93500$ PSI

$F_{BU} = F_{TU} \times$ FORM FACTOR
$= 72000$ CLAD 75ST $\times 1.5 = 108{,}000$ PSI

M.S. = .15

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0582/12

SHEET NO 9-5

AIRCRAFT		PREPARED BY	DATE
C105	FIN	[illegible]	JULY 55
		CHECKED BY	DATE

CONTROL # 4

ATTACHMENTS TO DOUBLER.

LOADS DUE TO HINGE LOAD = 10,200 #

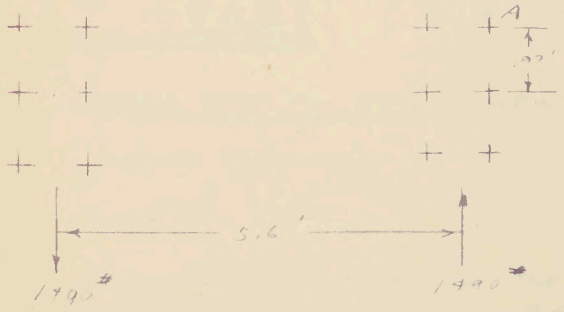
LOAD / BOLT = $\frac{10,200}{6}$ - 1700 # ↑

LOADS DUE TO SHEAR IN DOUBLER

SHEAR REACTED BY DOUBLER = $\frac{I \text{ DOUBLER}}{I \text{ TOTAL}} \times \text{SHEAR}^{\#/\text{IN}}$

= $\frac{.0181 + .0076}{.150} \times 8,350$

= 1490 #



ASSUMING ½ MOM COMES OFF ON EACH SIDE.

MOM / SIDE = $\frac{1490 \times 5.6}{2}$

= 4170 "#

$\Sigma R^2 = .15^2 \times 6 + .97^2 \times 4 = 5.26$ "²

P ← = $\frac{4170}{5.26} \times .97$ = 770 #

P ↑ DUE TO MOM = $.15 \times \frac{4170}{5.26}$ = 396 #

P ↑ " " SHEAR = $\frac{1490}{6}$ = 248

P ↑ " " HINGE LOAD = $\frac{10,200}{12}$ = 850 #

P RESULT = $\sqrt{770^2 + 1494^2}$ = 1680 #

FORM 1108A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/25837/12
SHEET No. 9-6

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	[illegible]	
		CHECKED BY	DATE

CONTROL #4

BOLT SHEAR $\frac{1}{4}$ NAS = 4650 #

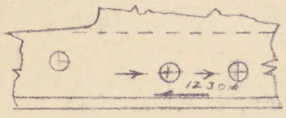
BEARING IN .12 75S-T6 = 137,500 x .25 x .12 = 4100 #
(BEARING) M.S. = 1.4

SHEAR OF MACHINED STRINGER STRINGER

SHEAR DUE TO DOUBLER MOM.

MOM = 4170 "# (PREVIOUS SHT)

LOAD AT INNER SKIN SURFACE = $\frac{4170}{3.4}$ = 1230 #



ASSUMING THIS IS REACTED BY 2" OF SPAR LEG

$\therefore f_s = \frac{1230}{2 \times .12}$ = 5100 PSI

SHEAR DUE TO DIRECT SHEAR

SHEAR REACTED BY SPAR #1 LEG & I

∴ SHEAR " " " = 3890 # (PREVIOUS SHT)

ASSUMING PARABOLIC SHEAR DISTRIBUTION WITH CONCENTRATION FACTOR OF 1.5 SINCE LEG IS RECTANGULAR.

DEPTH FROM NA = 1.2" t = .18 AT BASE

$\therefore f_s = \frac{3890 \times 1.5}{.18" \times 1.2}$ = 27,000 PSI

∴ TOTAL f_s = 27,000 + 5100 = 32,100 PSI
OCCURRING AT JUNCTION OF SKIN & LEG.

THIS f_s WILL BE CONSIDERED IN CONJUNCTION WITH R_B

CRM 1139A

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/12
SHEET NO. 9-2

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gradeen	JULY 55
		CHECKED BY	DATE

CONTROL # 4

CALC. OF BENDING STRESS AT STA 112

I TOTAL OF FIN = 72.6 "⁴ (REF 7/0583/38 SHT 1-13)

B.M. TOTAL = 620,000 "# (REF. 7/0583/38 SHT 3-14)

DIST. OF SKIN FROM NA = 2.0"

$\therefore f_B = \frac{620{,}000 \times 2}{72.6} = 17{,}100$ PSI

NEGLECTING CONCENTRATION DUE TO FIN TWIST

COMBINING f_S & f_B BY MOHR'S ⊙

$$f_{S\,MAX} = \sqrt{\left(\frac{f_B}{2}\right)^2 + f^2}$$

$$= \sqrt{8550^2 + 32{,}100^2}$$

$$= 33{,}200 \text{ PSI}$$

FSU 755-76 = 43,000 PSI * M.S = 0.09

* SHEAR LOAD USED WAS LARGER THAN MORE RECENT INFORMATION - SEE 4 PAGES PREVIOUS.

FORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0532/12

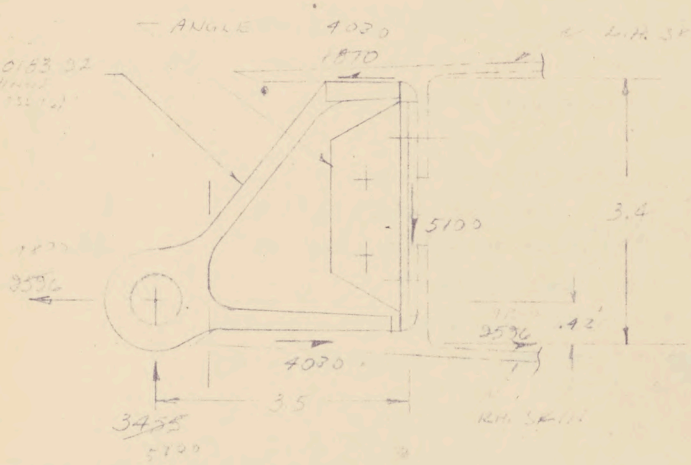
SHEET No. 9-8

AIRCRAFT:	
C-105	

PREPARED BY	DATE
McCABE	5-11-55
CHECKED BY	DATE

RUDDER CONTROL HINGE #4 (7-0183-32)

7-1083-311 — Proa. Drg.



HINGE SIDE LOAD = 6910/2 = 3455 LBS. PER LUG.

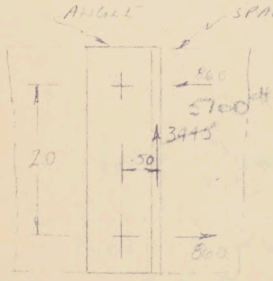
HINGE DRAG LOAD = 7072/2 = 3536 LBS. PER LUG.

L.H. SKIN REACTION FROM HINGE LOADS $\frac{5100 \times 3.5 - 42 \times 9800}{3.4}$

$= (17,800 - 4,110)/3.4$

$= 4030$ LBS.

ANGLE ATTACHMENT TO SPAR "I" WEB



SHEAR LOAD ON ANGLE = 5100 LBS.

LOAD ON ATTACHMENTS FROM MOMENT =

$5100 \times .50 / 2.0 = 1270$ LBS.

LOAD PER ATTACHMENT FROM SHEAR LOAD =

$5100/2 = 2550$ LBS.

RESULTANT = $(1270^2 + 2550)^{1/2} = 2850$ LBS.

ALLOW. LOAD 1/4" N = 4650 LBS.

M.S. = .63

FORM 1104

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

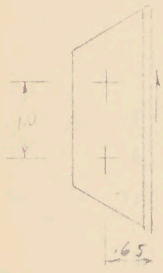
REPORT NO. 7/65B2/12

SHEET NO. 9-9

AIRCRAFT		PREPARED BY	DATE
C-105		McCABE	5-11-55
		CHECKED BY	DATE

RUDDER CONTROL HORN #4 (7-0103-32)

ANGLE ATTACHMENT TO HORN



SHEAR LOAD ON ANGLE = 5100 LBS

LOAD ON ATTACHMENTS FROM TORQUE =

$\frac{.65 \times 5100}{1.0} = 3310$ LBS.

LOAD ON ATTACHMENT FROM SHEAR LOAD =

5100 / 2 = 2550 LBS.

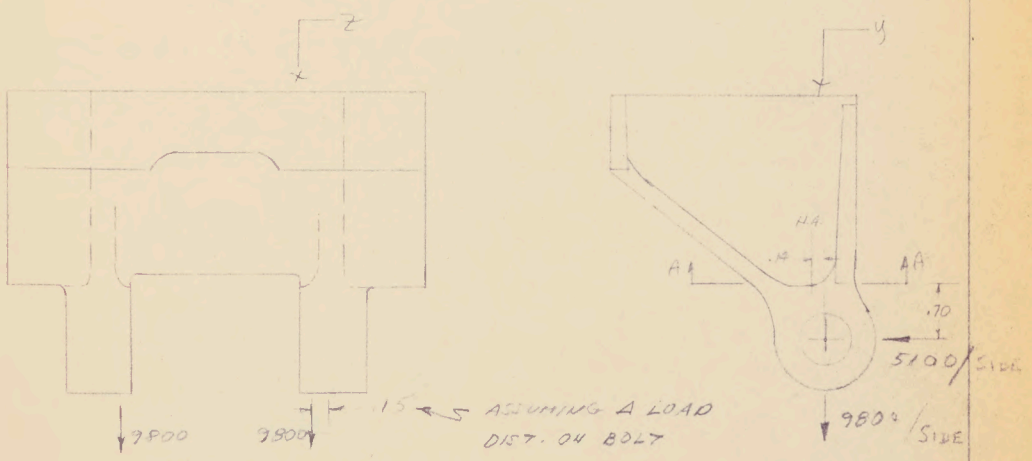
RESULTANT = $(3310^2 + 2550^2)^{1/2}$

= 4170 LBS.

ALLOW LOAD 1/4" BOLT (180 KSI) = 4650 LB

ALLOW BEARING IN 1/8" 75S-T6 (125 KSI) = 5810 # M.S. = .11

STRESSES ON SEC A-A



MOMENTS ON SEC A-A

$M_{ZA} = .70 \times 5100 + .14 \times 3800$

$= 3570 + 1970 = 4940$ IN LBS.

ASSUMING LUG IS ECCENTRICALLY LOADED, THEN,

$M_{YA} = .15 \times 9800$ 1470 IN LBS

$M_{XA} = .15 \times 5100$ 765 IN LBS

FORM 1194

AVRO AIRCRAFT LIMITED

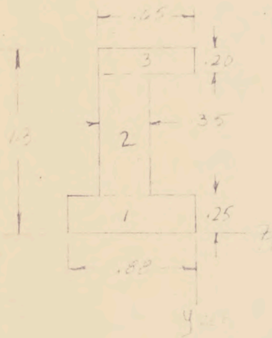
TECHNICAL DEPARTMENT (Aircraft)

REPORT No	7/0583/12
SHEET No	9-10
PREPARED BY	McCABE
DATE	5-12-[illegible]
CHECKED BY	
DATE	

AIRCRAFT: C-105

RUDDER CONTROL HINGE #4 (7-0183-32)

STRESS [illegible]



	AREA	Z-AXIS				Y-AXIS			
		y	Ay	Ay²	I_o	z	Az	Az²	I_o
1	.220	.125	.0275	.0034		.44	.0968	.0426	.014
2	.298	.670	.2000	.1340	.018	.475	.1420	.067	.0032
3	.130	1.20	.1560	.1870		.325	.0422	.0137	.0046
Σ	.648	$\bar{y}$ .59	.3835	.3244	.018	$\bar{z}$ .434	.2810	.1233	.0218

$I_z = .3244 + .018 - .59 \times .3835$
$= .342 - .226 = .116$
$I_z/c = .116/.59 = \underline{.197}$

$I_y = .1233 + .0218 - .434 \times .2810$
$= .1451 - .1230 = .022$
$I_y/c = .022/.44 = \underline{.05}$

$f_{bz} = \frac{M_{z}}{I_z/c} = \frac{4940}{.197} = 25{,}000$ PSI

$f_{by} = \frac{M_{y}}{I_y/c} = \frac{1470}{.05} = 29{,}400$ PSI

IN CALCULATING TORSIONAL SHEAR STRESS, ASSUME SEC A-A TO BE RECTANGULAR IN SHAPE (1.3 × .35), THEN

$f = \frac{T}{ab^2}(3 + 1.8\,b/a)$ (REF [illegible])

$= \frac{T}{1.3(.35)^2}(3 + 1.8\,\frac{.35}{1.3})$

$= 16{,}700$ [illegible]

$f_t = 9800/.648 = 15{,}100$ PSI

ALLOWABLE MZA

Ft = 70,000

K = 2Qm / Iz/c = $\frac{2(.465 \times .220 + .113 \times .17)}{.197} = 1.24$

MzA (allow) = K·Ft·Iz/c = 1.24 × 66,000 × .197 = 16,100 IN LBS

ALLOWABLE MYA

Ft 66,000

K 1.5

MyA (allow) = K·Ft·Iy/c = 1.5 × 66,000 × .05 = 4940 IN LBS.

FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT		REPORT No 7/0583/12	
C-105		SHEET No 9-11	
		PREPARED BY	DATE
		McCrew	5-12-55
		CHECKED BY	DATE

RUDDER CONTROL HINGE #A (7-0183-32)

STRESSES ON SEC. A-A (CONT'D)

MARGINS OF SAFETY

$R_{bz} = \frac{4940}{16,100} = .31$

$R_{by} = \frac{1470}{4940} = .30$

$R_t = \frac{15,100}{66,000} = .23$

$R_s = \frac{16,700}{43,000} = .39$

$$M.S. = \frac{1}{[(R_{bz}+R_{by}+R_t)^2+R_s^2]^{1/2}} - 1$$

$$= \frac{1}{[(.31+.30+.23)^2+.39^2]^{1/2}} - 1 =$$ M.S. = .08

ATTACHMENT TO R.H. SKIN

ATTACHMENT PER LUG IS BY 4-1/4 CSK. SCREWS

LOAD PER LUG = 4030 + 9800 = 13,830 LBS.

LOAD PER SCREW = $\frac{13,830}{4}$ = 3460 LBS.

ALLOW LOAD 1/4" NAS SCREW = 4,650 LBS.

$M.S. = \frac{4650}{3460} - 1 =$ M.S. = .34

LUG ANALYSIS

TRANSVERSE LOAD = 5100 #

AXIAL LOAD = 9800 LBS

ALLOWABLE LOADS (REF. HINGE #5 ANALYSIS, R.S. 13820)

P_{tu} = 12,400 LBS

P_{bru} = 12,600 LBS

R_a = 9800 / 14,600 = .67

R_{tr} = 5100 / 14,200 = .36

$R_a^{1.6} + R_{tr}^{1.6} = 1$

$$M.S. = \frac{1}{(.67^{1.6} + .36^{1.6})^{.625}} - 1 =$$ M.S. = .23

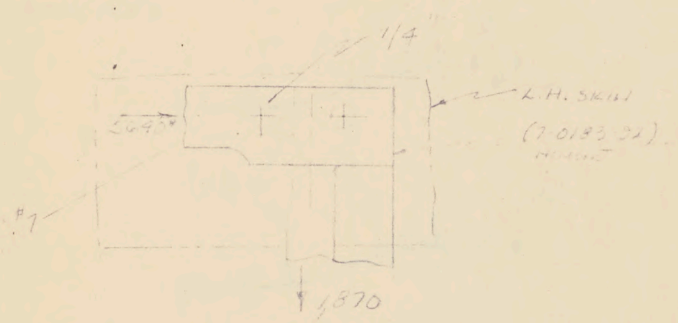
FORM 1319A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0582/12
SHEET No. 9-12

AIRCRAFT:		PREPARED BY	DATE
C-105		MC CABE	5-12-55
		CHECKED BY	DATE

RUDDER SERVO HINGE #4 (7-0183-32)
ATTACHMENT TO L.H. SKIN



LOAD FROM HINGE = 4030# (Pg. 6)
S.H.O. 2040 = 5640# (Pg 3)

RESULTANT = $\left(\frac{5640^2}{2} + \frac{4030^2}{2}\right)^{1/2}$

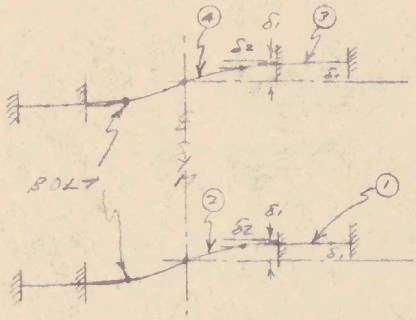
= 3460 LBS.

Allow 1040 44 screws = 4650 lbs (NAS)

M.S. = $\frac{4650}{3460} - 1$ = .34

CONTROL # 4

ANALOGY



THE PROBLEM CAN BE SIMPLIFIED DUE TO THE FACT THAT THE GEOMETRY AND THE STIFFNESS OF THE WEB COMPARED TO THE STRINGER IS THE SAME ON EACH SIDE OF THE HOLE.

∴ LOAD ON ONE SIDE THE HOLE ∝ STIFFNESS

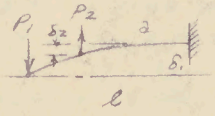
% LOAD REACTED BY ITEM ① & ② $= \frac{I_①}{I_① + I_②} \times 100$

$= \frac{0.0695}{.0695 + .0273} \times 100$

$= 70.3\ \%$

APPORTIONING LOAD BETWEEN ITEM ① & ②

ITEM ①



$$\delta_1 = \frac{P_1 \times \ell^3}{3EI_1} - \frac{P_2 a^2 (3\ell - a)}{6EI_1} \quad \text{---- (1)}$$

$$\delta_2 = -\frac{P_2 \times a^3}{3EI_1} + \frac{P_1 a^2 (3\ell - a)}{6EI_1} \quad \text{---- (2)}$$

ITEM ②

$$\delta_1 = \frac{P_3 \times c^3}{3EI_2} + \frac{P_2 b^2 (3c - b)}{6EI_2} \quad \text{---- (3)}$$

$$\delta_2 = \frac{P_2 \times b^3}{3EI_2} + \frac{P_3 b^2 (3c - b)}{6EI_2} \quad \text{---- (4)}$$

CONTROL # 4

DATA :

$a = 0.97"$
$\ell = 2.27"$
$b = 0.55"$
$c = 1.30"$
$I_1 = 0.0695"^4$
$I_2 = 0.0362"^4$

$$\delta_1 = \frac{P_1 \times 2.27^3}{3 \times E \times .0695} - \frac{P_2 \times 0.97^2 (3 \times 2.27 - .97)}{6 \times E \times .0695}$$

$$\delta_1 = \frac{24.8\ P_1}{E} - \frac{5.49\ P_2}{E} \quad \text{------ (1)}$$

$$\delta_2 = \frac{P_1 \times 0.97^2 (3 \times 2.27 - 0.97)}{6\ E \times .0695} - \frac{P_2 \times 0.97^3}{3E \times .0695} \quad \text{--- (2)}$$

$$\delta_2 = \frac{13.1\ P_1}{E} - \frac{4.37\ P_2}{E}$$

$$\delta_1 = \frac{P_3 \times 1.3^3}{3E \times .0362} + \frac{P_2 .55^2}{6E \times .0362} \quad \text{-------- (3)}$$

$$\delta_1 = \frac{20.3\ P_3}{E} + \frac{1.38\ P_2}{E}$$

$$\delta_2 = \frac{P_2 \times .55^3}{3E \times .0362} + \frac{P_3 \times .55^2 (3 \times 1.3 - .55)}{6E \times .0362} \quad \text{-- (4)}$$

$$= \frac{1.53\ P_2}{E} + \frac{1.67\ P_3}{E}$$

EQUATING EQU (1) & (3)

$$24.8 P_1 - 5.49 P_2 - 20.3 P_3 - 1.38 P_2 = 0$$
$$24.8 P_1 - 6.87 P_2 - 20.3 P_3 = 0 \quad \text{-------- (5)}$$

EQUATING EQU (2) & (4)

$$13.1 P_1 - 4.37 P_2 - 1.53 P_2 - 1.67 P_3$$
$$13.1 P_1 - 5.90 P_2 - 1.67 P_3 = 0 \quad \text{--------- (6)}$$

HALF (5) by $\frac{5.90}{6.87}$ SUBT. (6)

$$21.3 P_1 - 5.90 P_2 - 17.4 P_3 = 0 \quad \text{--- (7)}$$
$$-13.1 P_1 + 5.90 P_2 + 1.7 P_3 = 0$$
$$8.2 P_1 \qquad 0 \qquad - 15.7 P_3 = 0$$

$$\therefore \quad P_1 = 1.92\ P_3$$

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No.
SHEET No. 9-15

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

CONTROL # 4

SUBST IN (6)

$$12.1 \times 1.92 P_3 - 5.90 P_2 - 1.67 P_3 = 0$$

$$24.9 P_3 = 5.90 P_2$$

$$P_2 = P_3 \times 4.26$$

SOLVING FOR THE APPLIED LOAD OF 83 P.D #

LOAD ON ITEM ① & ② = 8380 × .703
= 5900 #

$\therefore P_1 + P_3 = 5900$ #

$\because P_1 = 1.92 P_3$

$\therefore 1.92 P_3 + P_3 = 5900$

$P_3 = 2020$ #

$\therefore P_1 = 3880$ #

$P_2 = P_3 \times 4.26 = 4.26 \times 2020 = 8600$ #

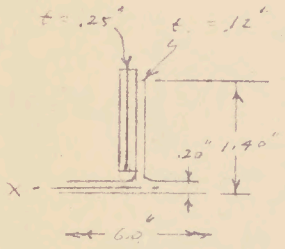
FORM 1319A

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. _____
SHEET No. 9-16

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

INVESTIGATION OF BENDING DOUBLERS TO SPAR # 1



CONTROL # 4

$$\bar{y} = \frac{1.4 \times .32 \times 0.7}{1.4 \times .32 + 6.0 \times .2} = 0.21$$

$$I_{LEG} = \frac{.32 \times 1.09^3}{3} = 0.157 \text{ in}^4$$

$$I_{SKIN} = 6 \times .20 \times .21^2 = 0.053$$

$$I_{TOT} = 0.210 \text{ in}^4$$

WHEN SHEAR ACROSS HOLE = 8300 #

THEN LOAD CARRIED ON THIS SIDE = $8300 \times \frac{1.1^3}{1.1^3 + .8^3}$

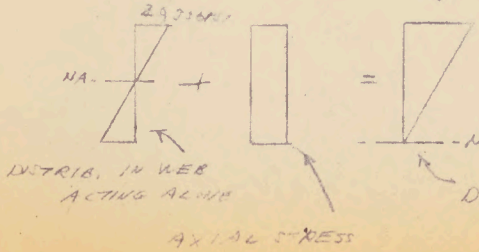
= 6040 #

∴ B.M. = 1.3 × 5350 = 7850 in #

THEN: ASSUMING IT ALL ACTS TOGETHER.

$$f_B = \frac{7850 \times 1.09}{0.210} = 40,700 \text{ PSI}$$

IF ITEMS ACT SEPARATELY AND CURVATURE IS THE SAME THEN f_B IN WEB = $40,700 \times \frac{0.55}{1.1}$ = 29350 PSI



∴ f_{AXIAL} = 20,350 PSI

ORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. _____
SHEET No. 9-17

AIRCRAFT:		PREPARED BY	DATE
C105	FIN		
		CHECKED BY	DATE

SHEAR CAUSED BY AXIAL STRESS

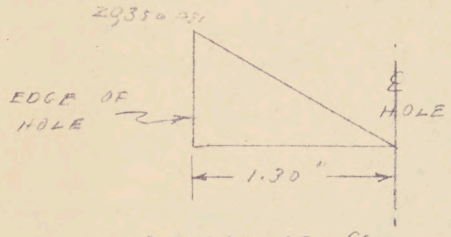


DIAGRAM OF fc

∴ TENSION LOAD = 2935 × 1.2 × .25 = 6100#

AREA IN SHEAR ≈ 1.30 × 1.2
≈ 1.56 in²

fs DUE TO EXTENSION = 3900 PSI

ORM 1319A

AVRO AIRCRAFT LIMITED

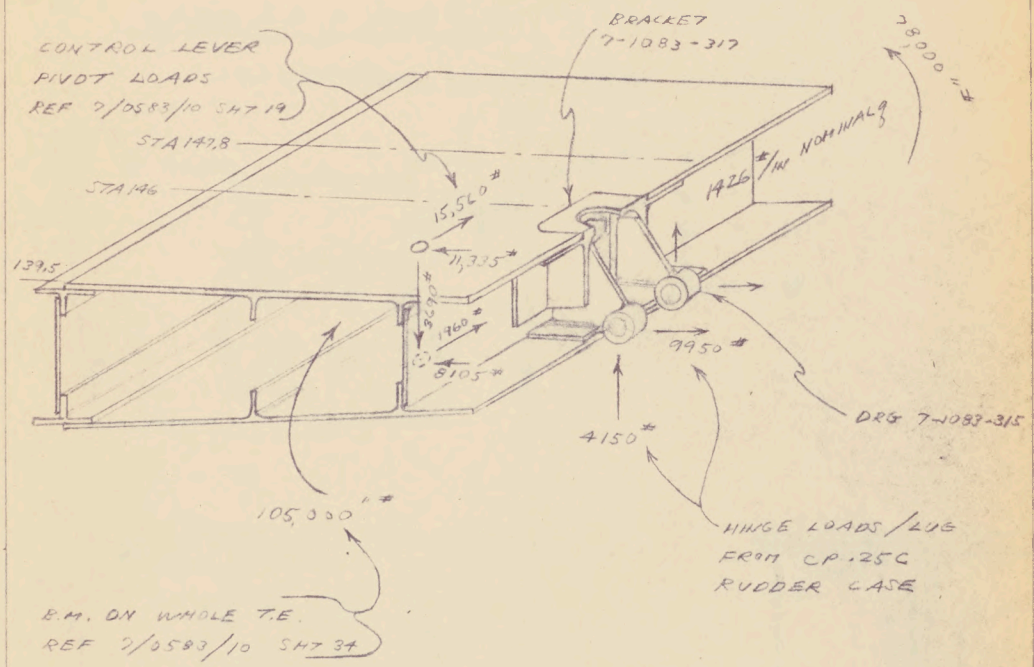
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12

SHEET No. 10-1

AIRCRAFT		PREPARED BY	DATE
C105	FIN	L Saunders	JULY 55
		CHECKED BY	DATE

CONTROL HINGE #5



DISCUSSION

A RIGOROUS ANALYSIS WHICH WOULD BALANCE ALL LOADS DOES NOT SEEM PRACTICAL FOR SEVERAL REASONS. FIRSTLY, THE CRITICAL HINGE LOADS ARE FROM THE CP.25C RUDDER CASE, WHILE THE SHEARS ON THE FIN ARE FOR THE CP.5C CASE. SECONDLY, THE CONCEPT OF ISOLATING THE T.E. BOX MAY NOT YIELD EXACT RESULTS.

FORM 1110A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/3393/12

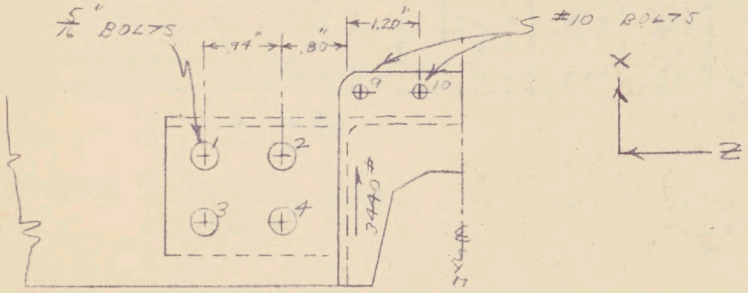
SHEET No 10-2

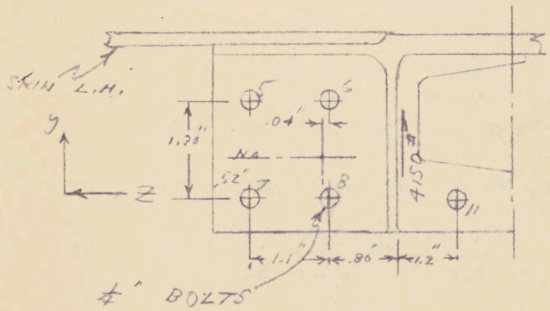
AIRCRAFT		PREPARED BY	DATE
C105	FIN	C Gardiner	JULY 58
		CHECKED BY	DATE

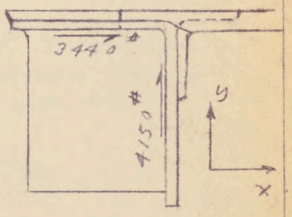
CONTROL #5

BRACKET 7-1093-317

CONSIDERING LOADS FROM FITTING







ASSUMPTIONS FOR 4150# LOAD

① 4150# LOAD IS REACTED BY BOLTS 5, 6, 7, 8, AND 11 ASSUMING FITTING IS FLEXIBLE ACROSS ℄

$$\bar{Z} = \frac{\text{C.G. BOLTS } 5,6,7,8,11}{1\times 2.0 - 2\times 1.1} = .04"$$

$$\bar{Y} = \frac{2\times 1.8}{5} = 0.52"$$

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/3523/

SHEET No 10-3

AIRCRAFT		PREPARED BY	DATE
C105	FIN	E Gundersen	JULY 55
		CHECKED BY	DATE

CONTROL #5

BOLT LOADS FROM 4150# BRACKET LOAD

NUT	y	z	y^2	z^2	$-M/R^2$	LOADS FROM MOM P_z	LOADS FROM MOM P_y	DIRECT LOAD P_y	ΣP_y	ΣP_z	P_{RES}
5	.78	1.06	.61	1.12	-414	-322	-444	830	386	322	503
6	.78	-.04	.61	.0	↓	-322		830	830	322	891
7	-.52	1.06	.27	1.12		+214	-444	830	386	-214	442
8	-.52	-.04	.27	0	↓	+214		830	830	-214	860
11	-.52	-2.04	.27	4.16	-414	+214	843	830	1673	-214	1685

2.03 6.40

MOM = 4150 x 0.84
= 3486 "#

Σr^2 = 2.03 + 6.40
= 8.43

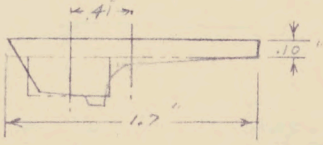
BOLT LOADS FROM 3440# BRACKET LOAD

THE LOAD WILL TEND TO COME OFF UNIFORMLY ON BOLTS 1, 2, 3, 4, 9, & 10 IN ∴ BEARING AREA PROVIDED FITTING IS SUFFICIENTLY STIFF.

CHECK OF STRENGTH & STIFFNESS SEC AT E

NEGLECTING BOLT 10

MOMENT < 3440 x (0.80 + .94/2) ≈ 4200 "#



$\bar{y} = \frac{.55 \times .25 \times 0.41}{.55 \times .25 + .11 \times 1.7}$
= 0.17"

$I = \frac{.11 \times 1.32^3}{3} + \frac{.11 \times 0.68^3}{3} + .137 \times .24^2$
= 0.0582 "⁴

$f_B \approx \frac{4200}{.0582} \times 1.02$ = 73,000 PSI (CHECK OF STIFFNESS ONLY)

∴ f_B IS HIGH
∴ NOT ALL OF THE BOLTS MAY BE EFFECTIVE.

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 2/95/82/12

SHEET No 10-4

AIRCRAFT		PREPARED BY	DATE
C105	FIN	RAG	JULY 58
		CHECKED BY	DATE

CONTROL # 5

BOLT LOADS FROM 3440# BRKT LOAD

ASSUMPTIONS: THE LOAD IS REACTED BY BOLTS 2, 4, 9, AND 10. FITTING BENDING RELIEVES LOAD IN BOLTS 1, AND 3.

LOAD IS ASSUMED ∝ $AREA_{BR}$

BOLT	$AREA_{BR}$	% AREA	LOAD
2	0.312 × .1	31	1066
4	0.312 × .1	31	1066
9	0.19 × .1	19	654
10	0.19 × .1	19	654

ALL LOADS IN CHORDWISE DIRECTION POITIVE "x"

BOLT LOADS DUE TO END LOADS

f_c IN FITTING THROUGH ITEM 11 S47

$$= \frac{MOM_{TOT} \times y}{I} \times \frac{E_{S7}}{E_{FIT}}$$

$$= \frac{24,000 \times 1.73 \times 3}{13.54}$$

$$= 22,030 \text{ PSI}$$

∴ LOAD = 22,000 × AREA ITEM 11

= 27,000 × .204

= 5500 #

ASSUMPTIONS:

LOAD IS REACTED BY BOLTS 1, 2, 9, 10, 5, AND 6 IN ∝ THEIR DIAMETERS.

FORM 1103A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: C-105	FIN DETACHABLE T/E SHEET	REPORT No. 7/0533/12	SHEET No. 10-6
		PREPARED BY: McCABE	DATE
		CHECKED BY	DATE

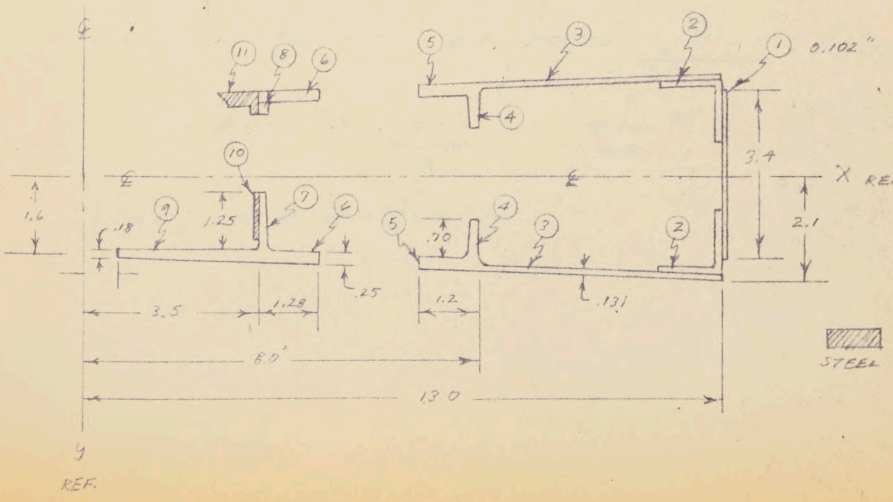
SECTION AT [illegible] (CONT'D)

SEC A A (SHEET PG. 2)

ITEM	AREA	y	Ay	Ay²	I_o
1	.346				.33
2	.502	1.608		1.30	
3	1.310	1.938		4.92	
4	.210	1.304		.34	
5	.600	1.753		1.86	
6	.640	1.634		1.71	
7	.185	−.862	−.162	.14	
8	.027	.413	.038	.05	
9	.662	−1.514	−.948	1.49	
10	3 × .100	−.710	.213	.15	
11	3 × .204	.451	.858	1.29	
Σ	5.466	$\bar{y}$ = −.083	−.397	13.25	.33

$I_{xx} = 13.25 + .33 - .083 \times .397$

$= 13.54$



FORM 1318A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/0592/12

SHEET No 10-7

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gardiner	JULY 55
		CHECKED BY	DATE

CONTROL #5

LOADS DUE TO END LOAD ON ITEM 11

BOLT	DIAM.	% / BOLT	LOAD	BOLT	
1	.31	20.6	-1130	1'	1130
2	.31	20.6	-1130	2'	1130
5	.25	16.7	-920	5'	920
6	.25	16.7	-920	6'	920
9	.19	12.7	-700	9'	700
10	.19	12.7	-700	10'	700
Σ	1.50		5500 #		

BOLTS ON UPPER SIDE

SIGN CONVENTION
POS. LOAD APPLIED TO SKIN OR SPAR IS TOWARDS ROOT

LOADS DUE TO END LOAD ON ITEM 10

f_t ITEM 10 = $84{,}000 \times \frac{1.71}{13.54} \times 3 = 13{,}203$ PSI

LOAD = $13{,}203 \times 0.10$
= 1320 #

ASSUMPTIONS:

LOAD IS REACTED BY BOLTS 7, 8, 11 EQUALLY

∴ LOAD EACH = $\frac{1320}{3} = 440$ #

LOADS IN Z DIRECTION

FORM 1104

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/12
SHEET NO. 12-8

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gambetta	JULY 55
		CHECKED BY	DATE

CONTROL #5

SPAR #1 (SHEAR FLOW)

WE HAVE REASON TO DOUBT THE SHEAR FLOWS GIVEN IN 7/7590/10 SINCE THEY ARE UNREASONABLY LOW IN SOME CASES.

ESTIMATED SHEAR FLOW IN SPAR #1 BASED ON 30% OF TOTAL FIN SHEAR (REF 7/0593/14 4-18)

TOTAL FIN SHEAR AT STA 146 = 15,200 #

∴ SHEAR ON SPAR #1 = 15,200 × .30 = 4550 #

ASSUMING 60% OF UPPER LUG LOAD GOES ACROSS FITTING.

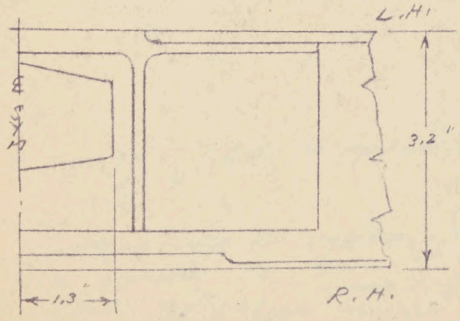
UPPER LUG LOAD = 4150 #

∴ SHEAR DUE TO HINGE LOAD = 4150 × .6 = 2490 #

* ∴ TOTAL SHEAR = 4550 # + 2490 #
= 7040 #

* SEE NEXT PAGE

BENDING NEAR HOLE



SKIN DWG 7-0193-129

SHEAR IS TRANSFERRED ACROSS HOLE BY BENDING OF FITTING & MACHINED SKIN STRINGER.

ASSUMPTIONS:

① ALL SHEAR IS REACTED ON R.H. SIDE OF HOLE

② ELEMENTS ARE FIXED ADJACENT TO EDGE OF HOLE.

③ LOAD & STIFFNESS OF ELEMENTS

④ EACH ELEMENT BENDS ABOUT ITS OWN NA.

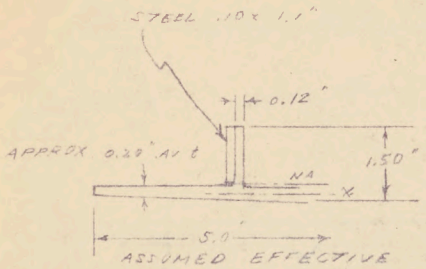
FORM 1319A

A. V. ROE CANADA LIMITED
MALTON ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0533/12
SHEET No. 10-9

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	L Gunderson	JULY 55
		CHECKED BY	DATE

CONTROL #5



C. G.

$$y = \frac{1.4 \times .12 \times 0.7}{1.4 \times .12 + 5 \times .2} = 0.10"$$

$$I \text{ MACHINED SKIN} = \frac{1.3^3 \times 0.12}{3} + 0.10^2 \times 1.1 = 0.099"^4$$

$$I \text{ STEEL BRACKET} = \frac{1.1^3 \times .10}{12} \times 3 = 0.033"^4$$

$$I \text{ TOT} = 0.131"^4$$

$$B.M. = 7070 \times 1.3 = 9190 \#$$

$$f_B \text{ MACHINED SKIN} = \frac{9190 \times 1.3}{.131} = 91{,}000 \text{ PSI}$$

$F_c = F_{cy}$ (PLASTIC BENDING FOR RECT) = 76 KSI
AVRO MANUAL

* M.S. ≈ −.16

* SHEAR USED IN ANALYSIS AND FOR M.S. WAS 7045 #

SHEAR FROM LATER INFORMATION INDICATES A SHEAR OF 4600 #
REF 7/0533/10 130-77

NOTE; L. Young SEPT. 28/55.
f_B = 91000 PSI
$F_{BU} = F_{TU} \times$ FORM FACTOR = 77000 × 1.5 = 115,500 PSI

MS= .26

ORM 1319A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 2/25893/12

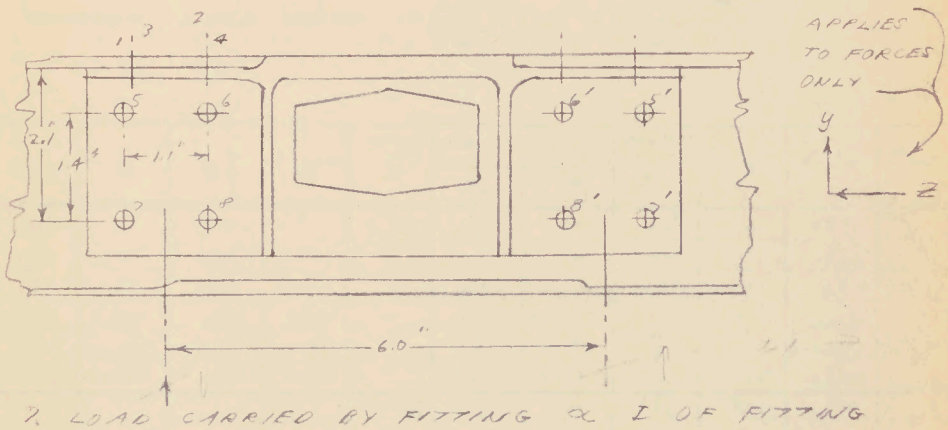
SHEET No 10-11

AIRCRAFT		PREPARED BY	DATE
C105	FIN	L Sanders	
		CHECKED BY	DATE

CONTROL #5

BOLT LOADS DUE TO SHEAR

SHEAR = 3950 #



% LOAD CARRIED BY FITTING & I OF FITTING AND MACHINED SKIN

I SKIN = 0.088 "⁴

I FITTING = 0.033 "⁴

% LOAD IN FITTING = $\frac{0.033}{.088 + .033} \times 100 = 29.8\%$

LOAD = 0.298 × 3450 = 1030 #

ASSUMING ½ MOM REACTED ON EACH SIDE

∴ MOM = $\frac{6.0}{2} \times 1030 = 3090$ "#

ASSUMING SHEAR REACTED BY BOLTS 5, 6, 7, 8 AND MOM BY BOLTS 5, 6, 9, 8, 1, AND 2

A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0697/12
SHEET No. 10 - 12

AIRCRAFT: C105	FIN	PREPARED BY	DATE
		[illegible] Gordon	AUG 55
		CHECKED BY	DATE

CONTROL #5

C. G.

$y = \frac{0.90 \times 2 \times 2.1 \times 2}{6} = 0.93"$ FROM L.H. SKIN

DIRECT LOAD EACH $= \frac{-2100}{4} = -525$ #

	y	z	y^2	z^2	M/I	LOADS FROM M.M. P_z	LOADS FROM M.M. P_y	DIRECT LOAD P_y	ΣP_y	ΣP_z	P_{RES}
1	.93	—	.87	—	1090	1010	—	—	—	1010	
2	.93	—	.87	—	↓	1010	—	—	—	1010	
5	.23	-.55	.05	.302	↓	250	-600	-525	-75	250	
6	.23	+.55	.05	.302		250	+600	↓	1125	250	
7	-1.17	-.55	1.37	.302		-1230	-600	↓	-75	-1230	
8	-1.17	+.55	1.37	.302		-1230	+600	-525	1125	-1230	
1'					1090	1010	—	-525	-525	1010	
2'					↓	1010	—	↓	-525	1010	
5'					↓	250	600	↓	75	250	
6'					↓	250	-600	↓	-1125	250	
7'						-1230	600	↓	75	-1230	
8						-1230	-600	-525	-1125	-1230	

4.58 1.21

$I = 5.79$ .4

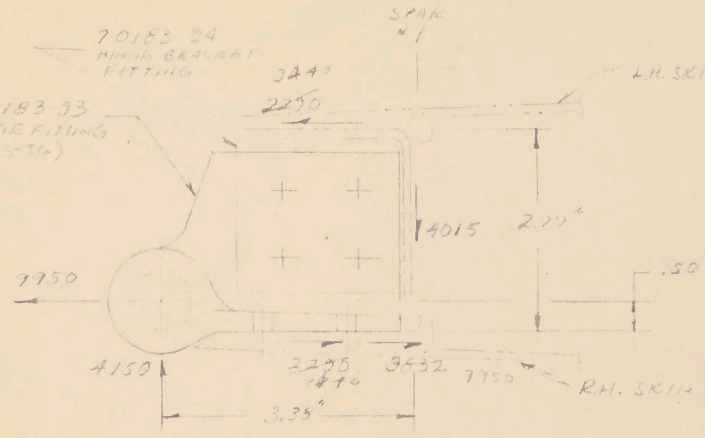
AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT		REPORT No. 7/0583/12
C-105		SHEET No. 10-15
		PREPARED BY: McCABE — DATE:
		CHECKED BY: — DATE:

RUDDER CONTROL HINGE "S" (70183-33)

PROD. DRG. 7-1083-315.



REF. DWG. 70183-86

HINGE LOADS PER LUG

SIDE LOAD = 8300 / 2 = 4150 LBS.

DRAG LOAD = 19900 / 2 = 9950 LBS.

HINGE SIDE LOAD IS REACTED AT SPAR "I" AND HINGE DRAG LOAD IS REACTED BY SKINS.

ASSUME MOMENT ON HINGE FITTING IS REACTED BY COUPLE LOADS IN L.H. & R.H. SKINS.

$$\text{SKIN COUPLE LOADS} = \frac{3.38 \times 4150 - .50 \times 9950}{2.77}$$

$$= \frac{14000 - 4975}{2.77}$$

$$= 3440 \text{ LBS.}$$

BETWEEN SHEAR FACES

FORM 1394A

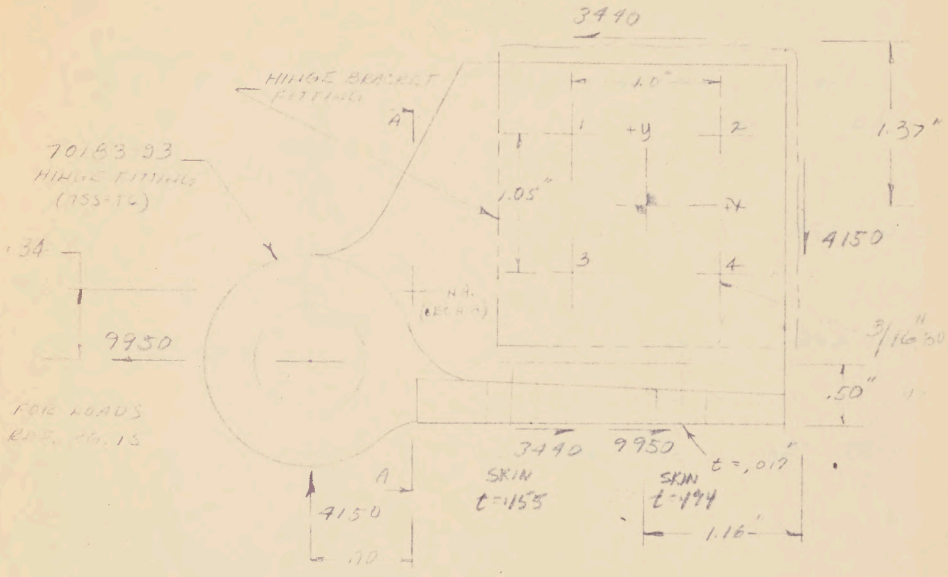
AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7/0583/12
SHEET NO 10-16

AIRCRAFT		PREPARED BY	DATE
C-105		McCABE	
		CHECKED BY	DATE

RUDDER CONTROL HINGE #5 (70183-93)

ATTACHMENT TO HINGE BRACKET FITTING



MOMENT ON ATTACHMENTS 1.16 × 4150 − 1.37 × 3440

= 4820 − 4720 = 100 IN.LBS.

$I_P = 4(.52^2 + .50^2) = 2.08$

BOLT	y	x	M / I_P	LOADS FROM MOMENT P_y	LOADS FROM MOMENT P_x	P_y = 4150/4	P_x = 3440/4	P_y (TOTAL)	P_x (TOTAL)	RESULT
1	.52	-.50	49	24	25	-1040	-860	-1016	-835	
2	.52	.50	↓	24	25	↑	↓	-1064	-835	
3	-.52	-.50	↓	24	-25	↓	↓	-1016	885	
4	-.52	.50	49	24	-25	-1040	-860	-1064	885	1380

ALLOW LOAD 3/16 BOLT = 2650 #

M.S. = 2650 / 1380 − 1 = .92

BOLTS TO SKIN − ¼ DIA

LOAD = 9950 ÷ 2440 = 3350 # EACH

¼ BRG .155 = 3850
¼ BRG .194 = 4550
ALLOW SHEAR = 4550
ALLOW (AVGE) = 4200

M.S. = .25

FORM 1194

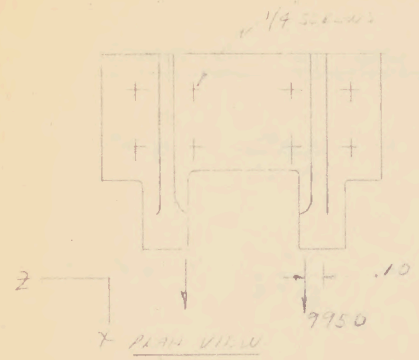
AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 2/05-83/12
SHEET NO. 12 - 17

AIRCRAFT		PREPARED BY	DATE
C-105		MCCABE	
		CHECKED BY	DATE

CUSHION CONTROL HINGE #5 (70183-33)

STRESSES ON SEC. A-A (REF. PG. 16)



MOMENTS ON SEC. A-A

FROM VIEW ON PG. 16,

$M_{ZA} = .34 \times 9950 + .70 \times 4015$

$= 3380 + 2900 = 6280$ IN.LBS.

LOOKING AT PLAN VIEW, ASSUME LUG TO BE ECCENTRICALLY LOADED, THEN

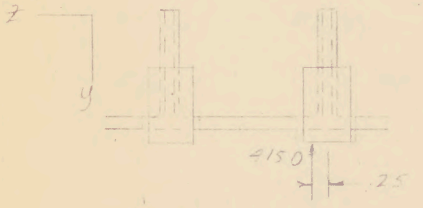
$M_{YA} = .10 \times 9950 = 995$ IN.LBS.

LOOKING AT END VIEW,

$M_{XA} = .25 \times 4150 = 1040$ IN.LBS.

END LOAD = 9950 LBS. (TENSION)

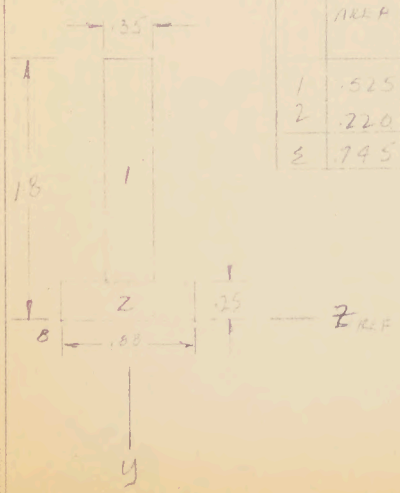
$f_t = 9950 / .745 = 13300$ PSI.



END VIEW

SECTION PROPERTIES (SEC. A-A, PG 16)

	AREA	Z-AXIS				Y-AXIS	
		$\bar{y}$	$A\bar{y}$	$A\bar{y}^2$	I_o		I_o
1	.525	1.03	.538	.551	.108	0	.0056
2	.220	.125	.027	.003	.001	0	.0142
Σ	.745	$\bar{y}$ .76	.565	.554	.109		.0198



$I_Z = 109 + .554 - .76 \times .565$

$= .663 - .429 = .234$

$I_y = .0198$

$I_Z / c = .234 / .76 = .308$

$I_y / c = .0198 / .44 = .045$

FORM 1194A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/25R3/12

SHEET NO. 10-18

AIRCRAFT		PREPARED BY	DATE
C105	FIN	L Gardner	7 MAY
		CHECKED BY	DATE

RUDDER CONTROL HINGE #5

STRESSES ON SEC AA AT POINT B

$$f_{B\,Z} = \frac{M_{Z\,A}}{I_Z/c} = \frac{6280}{.308} = 20,400 \text{ PSI}$$

$$f_{B\,y} = \frac{995}{0.045} = 22,100 \text{ PSI}$$

$f_t = 13,300$ PSI

$f_{t\,Calc} = 55,800$ PSI

$F_{tu} = 66,000$ PSI 75S-T6 ACROSS GRAIN M.S. = .18

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/0583/12
SHEET No. 17-19

AIRCRAFT		PREPARED BY	DATE
C-105		MCCABE	
		CHECKED BY	DATE

RUDDER CONTROL HINGE #5 (70183-93)

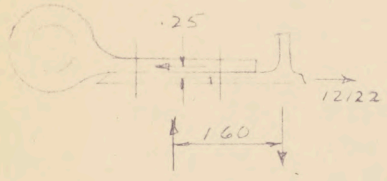
ATTACHMENT TO R.H. SKIN

ATTACHMENT PER LUG IS BY 4 - 1/4 CSK. SCREWS

LOAD PER LUG = 9950 + 2230 = 12122 LBS. (PG. 15)

SHEAR LOAD PER SCREW = $\frac{12122}{4}$ = 3030 LBS.

LOAD ECCENTRICITY IMPOSES A TENSION LOAD ON SCREWS.



TENSION LOAD PER SCREW = $\frac{.25 \times 12122}{1.6 \times 4}$ = 480 LBS.

ALLOW. SHEAR = 4650 #

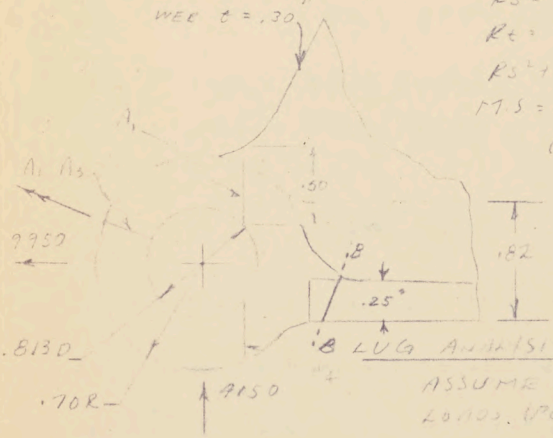
ALLOW. TENSION = 5000 #

R_S = 3030/4650 = .65

R_t = 480/5000 = .10

$R_S^2 + R_t^2$ = .43 + .01 = .44

M.S. = $\frac{1}{(.65^2 + .10^2)^{1/2}} - 1$ = .52 M.S.



ACTUAL LUG t = .88"

ASSUME LUG TENSION (BS) = .44 (TO ALLOW FOR CUT AWAY AT BACK)

RESULTANT LOAD = $\sqrt{9950^2 + 4150^2}$ = 10,800 #

θ = TAN $\frac{4150}{9950}$ = .418 = 22.7°

ALLOW. AXIAL LOAD

a = .70, w = 1.4, D = .813, t = .44

a/D = .70/.813 = .86

w/D = 1.4/.813 = 1.72

D/t = .813/.44 = 1.85

A_{br} = .813 x .44 = .358

A_t = .44 (1.4 - .813) = .259

K_{br} = .62

K_t = .98

P_{Brg} = .62 x .358 x 66,000 = 14,600 LBS.

P_{Ten} = .98 x .259 x 66,000 = 16,700 LBS.

FORM 1784

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 2/0583/12
SHEET NO 19-20

AIRCRAFT		PREPARED BY	DATE
C-105		MC CABE	
		CHECKED BY	DATE

AUXILIARY CONTROL HINGE #5 (7-01-83-93)

LUG ANALYSIS (CONT'D)

ALLOWABLE TRANSVERSE LOAD

$$R_{AV.} = \frac{6}{\frac{3}{.50 \times 44} + \frac{1}{.234 \times 44} + \frac{1}{.294 \times 44} + \frac{1}{.331 \times 44}}$$

$$= \frac{6}{17.1 + 9.7 + 9.7 + 17.5} = .171$$

R_{BR} D.E. $= .813 \times .44 = .358$

R_{AV}/R_{BR} $\frac{.171}{.358}$ $= .48$

$K_{STA} = .60$

$P_{STA} = .60 \times .358 \times 66{,}000 = 14{,}200$ LBS.

$R_A = 9950 / 14{,}600 = .68$

$R_{TR} = 4015 / 14200. = .29$

$R_A^{1.6} + R_{TR}^{1.6}$

$M.S. = \frac{1}{(.68^{1.6} + .29^{1.6})^{.625}} - 1 =$ M.S. $\simeq .32$

$.68^{1.6} = (\text{LOG } 9.852 - \text{LOG } 10) 1.6 = 1.6 \times -.148 = -.238 \text{ LOG} = .582 \text{ LOG} = .540$

$.29^{1.6} = (\text{LOG } 9.462 - \text{LOG } 10) 1.6 = 1.6 \times -.538 = -.878 = .122 \text{ LOG} = .195$

$.645^{.625} = (\text{LOG } 9.81 - \text{LOG } 10) .625 = -.119 \text{ LOG} + 10. = .881 \text{ LOG} = .26$

FORM 1194

AVRO AIRCRAFT LIMITED

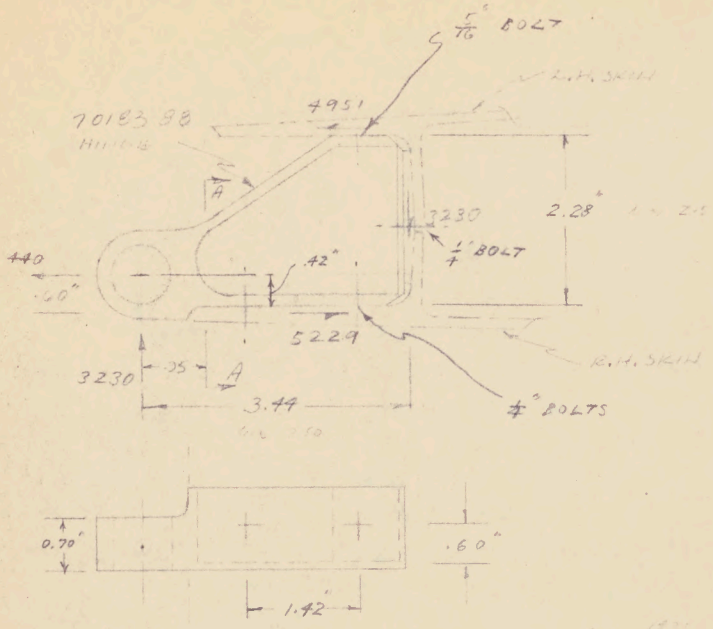
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7/3592/12

SHEET No. 11-1

AIRCRAFT		PREPARED BY	DATE
C-105		MCCABE	5-25-55
		CHECKED BY	DATE

RUDDER HINGE — UPPER (7-1083-323)



HINGE SIDE LOAD = 3230 LBS.

HINGE DRAG LOAD = 440 LBS.

R.H. SKIN REACTION = $\frac{3230 \times 3.44}{2.28} + \frac{1.86 \times 440}{2.28}$

= 5229 LBS

L.H. SKIN REACTION = 4870 + 440 × $\frac{.42}{2.28}$ = 4951 LBS

ATTACHMENT TO R.H. SKIN

END LOAD LOAD ON ATTACHMENTS FROM MOMENT = $\frac{.25 \times 440}{1.42}$ = 77 #

VERT " " " " = $\frac{.25 \times 3230}{2.28}$ = 354 #

LOAD ON ATTACHMENTS FROM SHEAR = 5229/2 = 2615 #

RESULTANT = $\left(2615^2 + (77+354)^2\right)^{\frac{1}{2}}$ = 2670 #

ALLOWABLE SHEAR # BOLT (FSU = 180 KSI) = 4650 #

ALLOWABLE BEARING IN .11" 75S-T6 FITTING = 3750 # M.S. = 0.40

ALLOWABLE BEARING IN SKIN .16 CSK = 4600 # (P. ENG MAY 46)

ATTACHMENT TO L.H. SKIN

LOAD PER BOLT = 4951 #

5/16" NAS SCREWS @ .14 = 6000 # (BEARING) BEARING IN .19 CSK = 6000 #

(CONTINUED NEXT PAGE)

MS .21

FORM 1310A

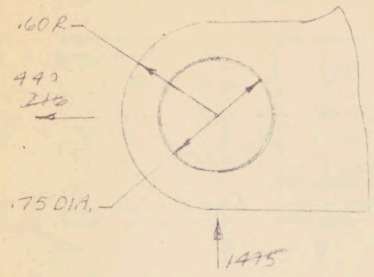
AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/3523/12
SHEET NO. 11-2

AIRCRAFT	
C-105	

PREPARED BY	DATE
MCCABE	3-25-55
CHECKED BY	DATE

RUDDER HINGE - UPPER LUG



t = .70

TRANSVERSE LOAD 1475#
AXIAL LOAD = 216#

ALLOW AXIAL LOAD

a = .60
D = .75
W = 1.20
t = .70
a/D = .60/.75 = .80
W/D = 1.2/.75 = 1.6
D/t = .75/.70 = 1.07
Abr = .75 x .70 = .525 in²
At = (1.2-.75).70 = .315
Kt = .94
Kbr = .54
Pbru = .54 x .525 x 70000 = 19,800 LBS.
Ptu = .94 x .315 x 70,000 = 19,200 LBS.

ALLOWABLE TRANSVERSE LOAD

Aav. = .70 x .225 = .157
Aav. = .157 = .30
Abr. .525
Kbru = .12
Pbru = .12 x .525 x 70,000 = 4410 LBS.

MARGIN OF SAFETY

AXIAL LOAD NEGLEGIBLE
M.S = 4410 - 1 = (METHOD IS PESSIMISTIC) M.S > .36
3230

ATTACHMENT TO SPAR WEB (CONT FROM PREVIOUS SHT)

LOAD = 3230 #

ALLOWABLE SHEAR ¾" BOLT = 4650#

ALLOWABLE BEARING IN 0.11 ¼" FITTING 755-76 = 3760# M.S.= 0.17
Form = 137 KSI

FORM 1318A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 2/2583/12

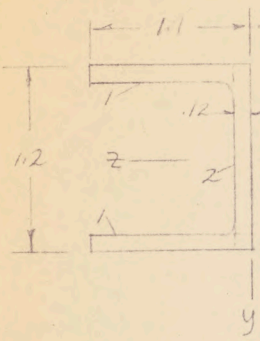
SHEET No. 11-3

AIRCRAFT:		PREPARED BY	DATE
C-105		MCCABE	5-20-55
		CHECKED BY	DATE

RUDDER HINGE - UPPER

STRUCTURE - SECTION A-A

SECTION PROPERTIES



	AREA	Z-AXIS				Y-AXIS			
		y	Ay	Ay²	I_o	z	Az	Az²	I_o
1	.235	.54	.127	.070		.61	.143	.087	.023
2	.144	—			.017	.06	.008	-	
Σ	.379			.070	.017	.40	.151	.087	.023

$I_z = .070 + .017 = .087$

$Z_o/c = .087/.60 = .145$

$I_y = .087 + .023 - .151 \times .40$

$= .110 - .060 = .050$

$I_y/c = .050/.55 = .091$

MOMENTS - SEC. A-A

$M_{ZA} = .35 \times 3230 + .18 \times 440$

$= 3060 + 80 = 3140$ IN-LBS

$M_{YA} = 440 \times .05 = 22$ IN-LBS (NEGLIGIBLE)

$M_{XA} = .72 \times 3230 = 2320$ IN-LBS

BENDING STRESS

$f_{bz} = \frac{3140}{.145 \cos 35^\circ} = 26{,}300$ PSI

SHEAR STRESS (REF. ROARK PG 172)

$a = .60$

$d = b = .12$

$\theta = .28$

$r = .25$

$c = .38$

$A = .379$

$K_1 = ab^3\left[\frac{1}{3} - .21\frac{b}{a}\left(1 - \frac{b^4}{12a^4}\right)\right]$

$= .60(.12)^3\left[.333 - .21\frac{.12}{.60}\left(1 - \frac{.12^4}{12 \times .60^4}\right)\right]$

$= .0103\left[.333 - .025\right]$

$= .0032$

$K_2 = cd^3\left[\frac{1}{3} - .105\frac{d}{c}\left(1 - \frac{d^4}{192c^4}\right)\right]$

$= .38(.12)^3\left[.333 - .105\frac{.12}{.38}\left(1 - \frac{.12^4}{192(.38)^4}\right)\right]$

$= .0168\left[.333 - .013\right]$

$= .0054$

$\alpha = \frac{b}{d}\left(.07 + .076\frac{r}{b}\right)$

$= \frac{.12}{.12}\left(.071 + .076\frac{.25}{.12}\right)$

$= .228$

FORM 1318A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7/0583/02
SHEET NO. 11-4

AIRCRAFT:		PREPARED BY	DATE
C-105		MCAB	3-25-57
		CHECKED BY	DATE

RUDDER MINOR - UPPER

STRESSES ON SEC A-A

SHEAR STRESS

$$K = 2(K_1 + K_3 + \alpha D^4)$$
$$= 2(.0032 + .0054 + .1218 \times .23^4)$$
$$= 2(.0032 + .0054 + .0012)$$
$$= .102$$

$$C = \frac{D}{1 + \frac{\pi^2 D^4}{16A^2}} \left[1 + .15\left(\frac{\pi^2 D^4}{16A^2} - \frac{D}{2r}\right)\right]$$

$$= \frac{.28}{1 + \frac{\pi^2 (.28)^4}{16(.379)^2}} \left[1 + .15\left(\frac{\pi^2 (.28)^4}{16(.379)^2} - \frac{.28}{2r.25}\right)\right]$$

$$= .270 \left[1 + .15(.0026 - .56)\right]$$
$$.256$$

$$f_s = \frac{T_2}{K} = \frac{2820 \times .256}{.102} = 29,706 \text{ PSI}$$

MARGIN OF SAFETY

F_t = 70,000 PSI

F_s = 46,000 PSI.

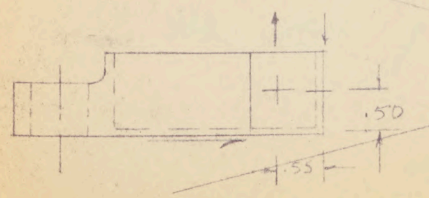
R_B = 24,200/70,000 = .377

R_S = 29,700/46000 = .646

$$M.S. = \frac{1}{(.377^2 + .646^2)^{1/2}} - 1 =$$

M.S. .35

ATTACHMENT TO L.H. SKIN



LOAD ON FLANGE = 2014 (PG 1)

MOMENT = 2014 × 50 = 1007 IN. LBS.

ASSUME MOMENT IS REACTED BY COUPLE FORCES ACTING ON FLANGE ATTACHMENT & WEB ATTACHMENT

COUPLE FORCES = M/.55 = 1007/.55 = 1950#

RESULT. LOAD ON ATTACHMENT TO SKIN = $(1950^2 + 2014^2)^{1/2}$ = 2790 LBS.

$$M.S. = \frac{4650}{2790} - 1 =$$

.66 M.S.

FORM 1316A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 2/5382/12

SHEET NO 12-1

AIRCRAFT		PREPARED BY	DATE
C105	SPAR 1 WEB STA 42 OUTB'D	S. YAUNG	JULY 3/58
		CHECKED BY	DATE.

LOADING

FROM 7/5582/10 VOL II PG 139

CONTROL HINGE	WEB q
1	2542
2	1430
3	1082
4	1022
5	2023

MAX WEB q = 2542 #/ft AT CONTROL #1

FROM 7/5582/3B VOL I PG 3-60

CONTROL HINGE	WEB q
1	1350
2	1070
3	1000
4	1000
5	1150

MAX WEB q = 1550 #/ft AT STA 24 (PET)

1450 #/ft AT CONTROL #5

FORM 1119A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT No 2/05823/12

SHEET No 12-2

AIRCRAFT		PREPARED BY	DATE
C105	SPAR 1 WEB STA 42 OUTB'D	S. YOUNG	JULY 31/58
		CHECKED BY	DATE

STRENGTH

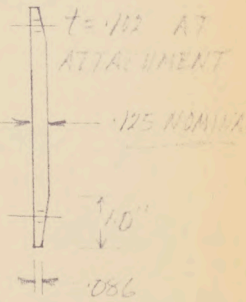
THE GENERAL ATTACHMENT IS 3/16 JO BOLT AT 1" PITCH OR LESS. THIS DOES NOT HOLD AT THE HINGE POSITIONS; HOWEVER, THE WEB & WEB ATTACHMENT ARE CHECKED IN THE HINGE REPORT, AND ARE OMITTED HERE.

3/16 P200 STEEL JO BOLT

SHEAR = 2620#

BRG .102 - 75ST WEB = 2620#

ALLOW $f = \frac{2620\#}{1"}$



AT POSITION OF 2542 #/", PITCH 1.0"

$$M.S. = \frac{2620/1.8\#/"}{2542} - 1 \qquad 0.28$$

AT POSITION OF 1.0" PITCH, $f_{MAX} = 2025$ #/"

$$M.S. = \frac{2620}{2025} - 1 \qquad 0.29$$

FORM 1118A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 24580/12

SHEET NO 14-2

AIRCRAFT		PREPARED BY	DATE
C105	STA 1 WEB STA 42 OUTBD	S. YOUNG	JULY 5/55
		CHECKED BY	DATE

STRENGTH

CHECK WEB BY NACA TN2661

AT STA 42, $q_{MAX} = 2542\ ^{\#}/_{in}$

$$\therefore \tau = \frac{2542}{.125} = 20,300\ PSI$$

DEPTH BETWEEN ATTACHMENTS = 2.9"

CONSIDER INFINITE PANEL LENGTH

$$\tau_{cr/y} = KE\left(\frac{t}{b}\right)^2 = 5.35 \times 10^7 \left(\frac{.125}{2.9}\right)^2 = 99,500\ PSI$$

$\tau_{CR} = 36,000\ PSI$ $\quad F_{cy} = 34,700\ PSI$

WEB SHEAR RESISTANT

$$MS = \frac{34,700}{20,300} - 1 \qquad 0.70$$

CHECK WEB BUCKLING UNDER BENDING STRESSES

$$F_{bcr/y} = KE\left(\frac{t}{b}\right)^2 \qquad t = .125 \quad b = 30" \text{ MAX STA } 42$$

$$= 22.6 \times 10^7 \left(\frac{.125}{30}\right)^2 = 39,500\ PSI$$

$$\therefore F_{bcr} = F_{cy} = 76,000\ PSI$$

NO BUCKLING

FORM 1118A

AVRO AIRCRAFT LIMITED
TECHNICAL DEPARTMENT (Aircraft)

REPORT No 7/0583/12
SHEET No C-8

AIRCRAFT:		PREPARED BY	DATE
C105	FIN	LL	
		CHECKED BY	DATE

CONTROL #1

SHEAR LOAD ACROSS HOLE (REF 7/5203/H 4-15)

ASSUMING SHEAR = 30% TOTAL FIN SHEAR + 60% OF UPPER LUG LOAD

$= 0.30 \times 31{,}000 + 0.60 \times 7{,}500$
$= 9390 + 4560$
$= 13{,}950$ #

* THE M.S WILL BE QUOTED ON THE ABOVE LOAD HOWEVER, LATER WORK (7/0583/10 SHT 138-33) INDICATES A SHEAR OF -2250 (?)

DOUBLER AND WEB ON ONE SIDE CARRY 34.3% OF TOTAL LOAD.

$LOAD = .343 \times 13{,}950 = 4780$ #

$f_b = \frac{4780 \times 1.3 \times 0.6}{0.036} = 104{,}000$ PSI (DUE TO SHEAR)

f_b DUE TO FIN BENDING $= \frac{2 \times 10^5 \times 2.1}{TBD \leftarrow 1 \text{ FIN}}$
$= 23{,}400$ PSI

$f_{TOT} = 127{,}400$ PSI

$F_c = F_{cy} \times$ YIELD FORM FACTOR $= 76$ KSI

M.S. ≈ -.40

NOTE A. Young SEPT. 28/55

$f_{B\,TOTAL} = 127{,}000$ PSI

$F_{BU} = F_{TU} \times$ FORM FACTOR $= 72000$ CLAD 75ST $\times 1.5 = 108000$ PSI

M.S. = -.15

FORM 719A

AVRO AIRCRAFT LIMITED

TECHNICAL DEPARTMENT (Aircraft)

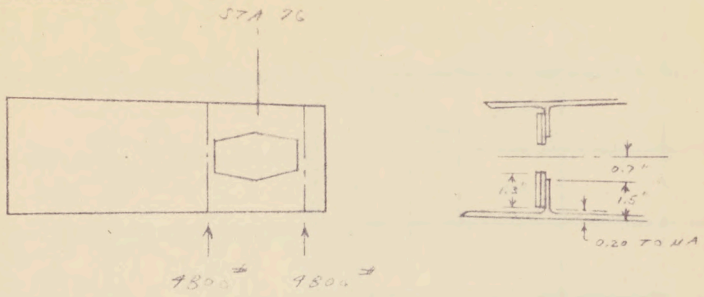
REPORT No. D/2587/12

SHEET No. 7-1

AIRCRAFT		PREPARED BY	DATE
C 105	FIN	L Sanders	JULY 55
		CHECKED BY	DATE

CONTROL # 2

SHEAR FLOW



SHEAR FLOW BASED ON NOMINAL % OF 30% OF TOTAL FIN SHEAR ON SPAR # 1

TOTAL FIN SHEAR = 22,000 #

∴ SHEAR ON SPAR #1 = 22,000 x .3 = 6600#

ASSUMPTIONS:

① 60% OF LOAD ON UPPER LUG GOES THROUGH SPAR #1 ACROSS HOLE.

② NONE OF LOAD ON LOWER LUG CROSSES HOLE.

* SHEAR ACROSS CUTOUT = 6600 + 4800 x .6
= 9480 #

ASSUMING SHEAR ∝ I AND ASSUMING EACH ELEMENT BENDS ABOUT ITS OWN N.A.

I STRINGER EACH = $\frac{1.3^3 \times .1}{9}$ = 0.0734 — 30.8% TOT :

I WEB & DOUBLER = $\frac{1.3^3 \times .25}{12}$ = 0.0458

$\Sigma I = 0.1192 \times 2 = .238$ in⁴

LOAD CARRIED BY ONE STRINGER = .308 x 9480 = 2920#

* SEE NEXT SHT

A. V. RO

TE

AIRCRAFT

WEIGHT

C. G. POSIT

SUMMARY OF BOLT LOADS & M.S.

* SEE 3 PAGES PREVIOUS

BOLT	1	2	3	4	5	6	7	8	9	10	11
	DUE TO FITTINGS			DUE TO END LOAD			DUE TO SHEAR FL				
	P_x	P_y	P_z	P_x	P_y	P_z	P_x	P_y	P_z	ΣP_x	Σ
1						1130			1010		
2	1060					1130			1010		
3											
4	1060									1060	
5		386	322			920		-75	250		31
6		830	322			920		1125	250		195
7		386	-214					-75	-1230		31
8		860	-214					1125	-1230		195
9	654					700				654	
10	654					700				654	
11		1673	-214								

FORM 1543

A. V. ROE CANADA LIMITED

MALTON, ONTARIO

TECHNICAL DEPT. (AIRFRAME)

REPORT NO. - 2/0283/12

SHEET - - 10 - 13

DATE - - AUG 55

AIRCRAFT - -

WEIGHT - -

C. G. POSITION -

PREPARED BY - [illegible]

8	9	10	11	12	13	14	15	16	17	18	19
To SHEAR FL P_y	P_z	ΣP_x	ΣP_y	ΣP_z	P_R RESULT LOAD	ALLOW.	TYPE OF FAILURE	* M.S.			
	1010			2140	2140	6200	⅝ BOLT 100 KSI IN 100° SUN	1.9			
	1010			2140	2400	6200		1.6			
						6200					
		1066			1066	6200		OK			
-95	250		311	1492	1530	3120	⅞ BOLT NO. 091 IN BRG.	1.0			
1125	250		1955	1492	2460	3120		0.27			
-95	-1230		311	-1444	1470	3120		1.1			
1125	-1230		1783	-1444	2460	3120		0.27			
		654		700	960	1900					
		654		700							

ANGLE ATTACHS FOR CONTROL HINGE FITTINGS

NEW DRAWINGS TO COVER CHANGES FROM RE-DESIG

† WHERE 5/16 ATTACHS ARE CALLED, THEY ONLY OCCUR AT THE

* BEARING IN MINIMUM THICKNESS (ie. $t_{NOMINAL} - .01$) ✱ L

	1	2	3	4	5	6	7	8	9	10	
								FITTING LEG			
DRG N° 7-1083-	HINGE N°	S-LS LOAD/ANGLE 7-0585-12	n_f	d_f	e_f	$(e/d)_f$ (5)÷(4)	$\frac{S}{n_f}$ (7)÷(3)	$\frac{e}{d}_f \cdot S$ (2)×(6)	$(7)^2$ ×10⁻⁶	$(8)^2$ ×10⁻⁶	(9)+ ×10
-1831 (U) ✱	1	7,600	3	1·80	·60	·333	2,533	2,533			
-1843 (L)			3	1·80	·60						
-1841 (L)	2	4,800	2	1·16	·66	·569	2,400	2,730	5·76	7·45	13·
			—	ORIGINAL UNCHANGED							
-1833 (L)	3	2,820	2	1·50	·71	·473	1420	1,333	2·02	1·78	3·8
-1835 (U)			2	1·50	·71						
-1837 (L)	4	5,100	2	1·00	·655	·655	2,550	3,340	6·50	11·16	17·6
			—	ORIGINAL UNCHANGED							

FORM 1544

…TTINGS

… RE-DESIGN OF REMOVABLE T.E. (PIVOT FITTING ATTACH^T)

… AT THE EXTREME ENDS OF ANGLES – ALL OTHERS ARE 1/4 S.
… ·01) * (U) & (L) INDICATE UPPER & LOWER ANGLES RESPECTIVELY

A. V. ROE CANADA …
MALTON, ONTARIO
ENGINEERING DIVISION – AI…

AIRCRAFT - - C…
WEIGHT - -
C. G. POSITION -

10	11	12	13	14	15	16	17	18	19	20	21	22	23
…G							→	←				SPAR …	
$(8)^2$ $\times 10^{-6}$	$(9)+(10)$ $\times 10^{-6}$	R_{MAX} (11)	t_f NOMINAL	N.A.S. BOLT DIA	ALLOW. SHEAR LB	* ALLOW BEARING (F_{bru}=125 KSI) LB	M.S. (MIN)	n_s	d_s	e_s	$(e/d)_s$ (20) ÷ (19)	$\frac{S}{n_s}$ (21) ÷ (18)	$(\frac{e}{d})_s$ (…) × (…
	→	3,580	·15	1/4	4,650	4500	·26	4	2·78	·57	·205	1,900	1,56…
		3,580	·15	1/4		4,500	·26	4	2·81	·57	·203	1,900	1,54…
7·45	13·21	3,640	·15	1/4		4,500	·24	3	2·34	·56	·239	1,600	1,15…
	>>												
1·78	3·80	1,950	·12	1/4		3,530	·81	3	2·12	·60	·283	940	80…
		1,950	·12	1/4		3,530	·81	3	2·26	·65	·288	940	81…
11·16	17·66	4,210	·188	1/4		5,720	·10	2	1·74	·60	·345	2,550	176…
	→				4650								

...ING ATTACH^T)

1/4 S.

...SPECTIVELY

A. V. ROE CANADA LIMITED

MALTON, ONTARIO

ENGINEERING DIVISION — AIRCRAFT

AIRCRAFT - - C105

WEIGHT - -

C. G. POSITION -

REPORT NO. - 7-0583-12

SHEET - - 3-3

DATE - - MARCH '56

PREPARED BY - ...

17	18	19	20	21	22	23	24	25	26	27	28	29
					SPAR LEG							
M.S. (MIN)	n_s	d_s	e_s	$(e/d)_s$ (20) ÷ (19)	$\frac{S}{n_s}$ (2) ÷ (18)	$(\frac{e}{d})_s \cdot S$ (21) × (2)	$R_{MAX.}$ $\sqrt{(22)^2+(23)^2}$	t_s NOMINAL	#N.A.S. BOLT DIA.	ALLOW. SHEAR LB	*ALLOW. BEARING LB	M.S.
.26	4	2.78	.57	.205	1,900	1,560	2,460	.12	1/4	4,650	3,530	.43
.26	4	2.81	.57	.203	1,900	1,540	2,450	.12	5/16	7,300	4,430	.81
.24	3	2.36	.56	.239	1,600	1,150	1,970	.12	5/16	7,300	4,430	>1.0
.81	3	2.12	.60	.283	940	800	1,230	.12	5/16	7,300	4,430	>1.0
.81	3	2.26	.65	.288	940	810	1,240	.12	1/4	4,650	3,530	>1.0
.10	2	1.74	.60	.345	2,550	1,760	3,100	.125	5/16	7,300	4,630	.49