173:PY:hab
74-173-M171
9 September 1974

From: P. Yarnall, Code 173.3
To: W.H. Buckley, Hydrofoil Task Principal, Code 173.3

Subj: Fatigue Consideration in the Boeing Design of the PHM Foils

Ref: (a) Watson, F.B., et al, "PHM Structural Design Loads (Rev. C)," Eoeing Document D312-80100-1, Dec 21, 1973
(b) Cecil, A.W., et at, "PHM Foil System Structural Analysis," Boeing Document D312-80143-1, Oct 31, 1972
(c) Yarnall, P., "PHM Strut/Foil System Design Loads Discussion with Mr. Fred Watson, Boeing Company," NSRDC Memorandum 173:PY:ams, 73-173-M281, 13 Sept 1973

Encl: (1) PHM One Factor Load Stress Calculation

1. Among the documentation furnished by the Navy to Grumman Aerospace Corp. for the PHM HY-130 strut/foil contract were References (a), (b), and (c). Grumman has asked for clarification of Reference (c) which states that due to fatigue considerations in their PHM design Boeing "did limit the maximum calculated foil mean Load (stress) to 35,000 psi."

2. It was Boeing's intention to keep the calculated bending stresses for one factor load below 35,000 psi to assure adequate fatigue life. This is alluded to on pages 123 and 130 of Reference (b). To determine the influence of this fatigue criteria upon the foil design, Boeing's calculations (Reference (bj) were reviewed and stress checks were made of the most highly stressed locations in the forward and aft foils. Stress check'calculations are shown in enclosure (1).

3. The review of Boeing's work and the additional calculations show:

a) The mean stress limitation was applied at the root of the semispans of the forward foil,

b) The mean stress limitation was applied to the aft foil, between buttock lines ± 457 (see Figure 1), and in the areas immediately inboard of the port and starboard struts at buttock lines ± 3849,

c) The fatigue stress limitation was not adhered to in the aft foils outboard of the struts,

d) The fatigue limitation'was not adhered to at port and starboard buttock lines 3726, one foot inboard of the respective aft struts.

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4. This information has been transitted by telephone to Mr. Danny Postupack of Grumman Aerospace Corp.

Philip Yarnall, Jr.

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PHM ONE FACTOR FOIL BENDING STRESS CALCULATIONS

Ref: (a) Watson, F.B., et al, "PHM Structural 'Design Loads (Rev. C)," Boeing Document D312-80100-1, December 21, 1973
(b) Cecil, A.W., et al, "PHM Foil System Structural Analysis," Boeing Document D312-80143-1, October 31, 1972

Nomenclature

P_N	=	one factor load
P_{DOWN}	=	maximum foil down load
PULT	=	load resulting from the yield/ultimate loading condition
σ_N	=	stress resulting from the one factor load
σ_{ULT}	=	stress resulting from the ultimate loads
BM_N	=	applied bending moment resulting from the one factor loading condition
BM_{DOWN}	=	applied bending moment resulting from the maximum foil down loading condition
BM_{ULT}	=	applied bending moment resulting from the ultimate loading condition
$\mathbb{Q}$	=	buttock line

ENCLOSURE (1)

Calculation Continued

1. Forward Foil

a) Check at ℄ 185; point of maximum calculated stress under the yield/ultimate loading condition

σ_{ULT} = 699.6 MN/m^2 Ref. (b), Figure 3-2

BM_{ULT} = 2.100 MNm Ref. (b), Figure 3-2

BM_N = 0.683 MNm Ref (a), Figure 3-2 .

$$\sigma_N = \sigma_{ULT} \times \frac{BM_N}{BM_{ULT}}$$

$$\sigma_N = 699.6 \ \frac{MN}{m^2} \times \left(\frac{0.683}{2.100} \right)$$

σ_N = 228 MN/m^2

σ_N = 32,993 psi < 35,000 psi

σ_N is less than the fatigue limit stress of 35,000 psi

2. Aft Foil

a) From Reference (b), page 130 we know that the aft foil was designed at buttock lines 80, 457, and 3849 by the limiting stress of 35,000 psi

b) Check on factor stresses at buttock line (℄) 3726 and 4231, locations of maximum stress under the yield/ultimate loading conditions. See Figure 1 for buttock line locations.

℄ 3726

σ_{ULT} = 922 MN/m^2 Ref. (b), Table 6-l

BM_{ULT} = 1.66 MN, Ref. (b), Figure 3-7 .

BM_{DOWN} = -0.78 MN_m Ref. (b), Figure 3-7

$'DOWN$ = -17d KN/m Ref. (b), Figure 3-5

P_N = 112 KN/m Ref. (a), Figure 3-3

Calculation Continued

$$BM_{LIMIT} = BM_{DOWN}\left(\frac{P_N}{P_{DOWN}}\right)$$

$$BM_N = -0.78\ MN_m \times \left(\frac{112}{-170}\right)$$

$$BM_N = 0.52\ MN,$$

$$\sigma_N = \sigma_{ULT} \times \left(\frac{BM_N}{BM_{ULT}}\right)$$

$$\sigma_N = 922\ MN/m^2 \times \left(\frac{0.52}{1.66}\right)$$

$$\sigma_N = 289\ MN/m^2$$

$$\sigma_N = 41{,}879\ psi > 35{,}000\ psi$$

σ_N is greater than the limiting mean stress

4231

σ_{ULT}	= 95c MN/m^2	Ref. (b), Table 6-1
BM_{ULT}	= 1.44 MNm	Ref. (b), Figure 3-7
BM_{DOWN}	=-0.70 MNm	Ref. (b), Figure 3-7
P_{DOWN}	= -170 KN/m	Ref. (b), Figure 3-5
P_N	= 112 KN/m	Ref, (a), Figure 3-3

$$BM_N = BM_{DOWN} \times \left(\frac{P_N}{P_{DOWN}}\right)$$

$$BM_N = -0.70\ Mm \left(\frac{112}{-170}\right)$$

$$BM_N = 0.46\ MNm$$

Calculation Continued

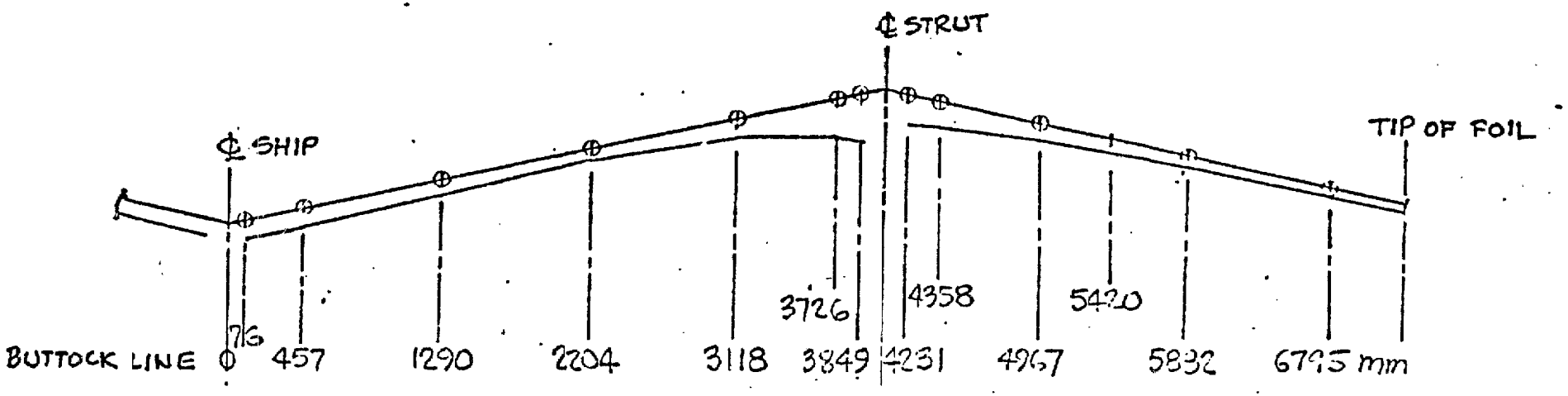
$$\sigma_N = \sigma_{ULT} * \left(\frac{BM_N}{BM_{ULT}} \right)$$

$$\sigma_N = 950 \ MN/m^2 \times \left(\frac{0.46}{1.44} \right)$$

$$\sigma_N = 303 \ MN/m^2$$

$$\sigma_N = 44{,}003 \text{ psi} > 35{,}000 \text{ psi}$$

σ_N is greater than the limiting mean stress



(Buttock lines are measured in millimeters from the ship's ℄)

Figure 1 - PHM Aft Foil (Typical Port and Starboard)