EAS4200C Aerospace Structures Project #2 (Due: Dec. 14th)

Project must be performed individually and submitted online in MS/Word or PDF format. The file name should be Project2_##.doc (or pdf) where ## is your sorting number. Your report must explain step-by-step procedure in detail. Use equations, figures, and tables as necessary.

The objective of this project is to estimate the safety of a fuselage under repeated pressurizations.

Part 1: At every flight, a fuselage is pressurized in order to compensate for pressure drop at high altitude, which can cause crack growth in the panel and eventually facture. One fatigue cycle is composed of increasing pressure from zero to *p* and decreasing it to zero, which represents one flight. The crack growth in the panel is fundamentally Mode I and the rate is governed by the following Paris model:

$$\frac{\mathrm{d}a}{\mathrm{d}N} = C(\Delta K)^m$$

where a is the half crack size (m), N is the number of flights, C and m are crack growth parameters, and ΔK is the stress intensity factor (MPa√m). In the above equation, the geometric correction factor is not considered. During the inspection, a technician found a crack with size of 10mm. The flight record indicates that the current number of flights is 5,000. By approximating the fuselage as a pressurized cylinder with radius r and thickness t, it is possible to estimate the remaining useful life (RUL) of the airplane. The RUL is the number of remaining flights before the crack reaches the critical crack size, which is given as

$$a_C = \left(\frac{K_{IC}}{\Delta\sigma\sqrt{\pi}} \right)^2$$

where K_{IC} is the fracture toughness and $\Delta\sigma$ is the range of applied nominal stress due to pressurization. In addition to explaining calculations, the report should include (1) plot of da/dN vs. ΔK in log-log scale in the domain of ΔK = [1,1000], (2) plot of a vs. N until $a = a_C$.

p (MPa)	K_{IC}(MPa√m)	r (meters)	t (meters)	m	C
0.06	30	3.25	0.00248	3.8	1.5E-10

Part 2: In practice, the crack propagation parameters (m and C) are unknown for a specific panel in the airplane, as well as initial crack size a_0. However, it is possible that a series of measurements of crack size can be used to estimate these parameters. However, since the measured data often include noise (V) and bias (B), the least-square method can be used to identify these parameters. The noise is random due to measurement environment, while the bias is deterministic due to systematic departure. Using a least-square method, identify the crack propagation parameter (m), initial crack size (a_0), and the bias (B). Use C in the above table. The crack size measurement data are available in the class website. The general form of least-square formulation is

$$\underset{X}{\text{minimize}} \sum_{I=1}^{K} \left(a_I^{\text{data}} - a_I^{\text{model}}(N_I, X) \right)^2$$

where N_I is the number of flights at I-th measurement, and a_I^{model} is the estimated half crack size using $X = \{m, a_0, B\}$. You can use Matlab, Excel, or other numerical programs to solve the minimization problem. Also, submit a plot of a_I^{model} vs. N and a_I^{data} vs. N in the same graph.