Composite Structure Engineering
Safety Awareness Course

Definition of A- and B-basis Values and An In-depth Look at CMH-17 Statistical Analysis Techniques

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A-Basis and B-Basis Definitions

Design values must be chosen to minimize the probability of structural failure due to material variability. Compliance is typically shown by selecting design values that ensure material strength with the following probability:

- Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component; **99 percent probability with 95 percent confidence interval (that is, A-basis value).**

- For redundant structure, in which the failure of individual elements would result in applied loads being safely distributed to other load carrying members; **90 percent probability with 95 percent confidence interval (that is, B-basis values).**
A - Basis value = \( \bar{x} - (K_A) \cdot s \)

B - Basis value = \( \bar{x} - (K_B) \cdot s \)
The internet browser-based simulation program is available at NCAMP website
http://www.niar.wichita.edu/coe/ncamp_media.asp
Effect of Sample Size on $K$_factors

Sample Size, $n$

$K$ _factor

A75

B18

B30

B18 Pooling

A55
Effects of CV and Sample Size on Basis Values
Mean=100

When sample size is 15 or more, CV has a greater impact on basis values than the sample size. When CV is unrealistically low, use Modified CV to avoid overly optimistic basis values.
Methods to Calculate Basis Values

- **MIL-HDBK-17F**
  - Normal, Weibull, Lognormal distributions
  - Based on Observed Significance Level (OSL)
  - Non-Parametric
  - Batches pooled within environment
  - Data NOT pooled across environments
    - Large sample size required at each environment
  - ANOVA (assumes normal distribution)
  - STAT-17 (a.k.a. Single Point) Excel Spreadsheet Macro (J. Adelmann, Sikorsky Aircraft)

- **AGATE** (Ref. P. Shyprykevich, ASTM STP 1003, 1989)
  - Normal Distribution only
  - Batches pooled within environment
  - Data pooled across environments
    - Allowables based on mean of small sample and variability of large pooled sample
  - Published in DOT/FAA/AR-03/19
  - ASAP Excel Spreadsheet Macro (K. Suresh Raju, Wichita State University)

  - Normal Distribution only
  - Regression model
  - FORTRAN program

**STATISTICAL FACT:** Much larger sample size needed to estimate std deviation than to estimate mean.

CMH-17 combines the two, giving preference to the AGATE method unless certain assumption are not met.
Material Allowable Generation with STAT-17

- STAT-17 computes basis values one environment at a time (thus a.k.a Single Point)
- STAT-17 method might result in “distributional changes” which produces allowables that do not make engineering sense
- Extremely difficult to obtain “realistic” load enhancement factors and environmental compensation factor

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September 14-16, 2010
Material Allowable Generation with ASAP

- For the ASAP procedure, only normal distribution is utilized thus eliminating the possibility of “distributional changes”**
- Common (pooled) standard deviation results in equal amount of knock-down for every environment**
- Basis values and mean values follow the same trend

** Must meet requirements of normality and pooling across environment. Otherwise, use STAT-17

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Unequal Population Standard Deviations

STAT-17 should be used when population standard deviations are unequal across environment

September 14-16, 2010
Unequal Population Standard Deviations

- For samples that have significantly different variances, STAT-17 should be used.
- Equality of variance test (Levene’s test) is a diagnostic test within ASAP.

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Equal Population Standard Deviations

ASAP produces slightly higher and more stable basis values

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Equal Population Standard Deviations

For samples with equal variances, ASAP will provide basis values that are higher than STAT-17 and those basis values will have less fluctuation due to random differences between samples.

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Conclusions

- Standard deviations can be very unstable when sample size is small (<30); resulting in very erratic basis values, unless pooling method is used.
- Basis values are not material properties
  - they are not fixed values because they depend on the number of specimens you test (i.e. how big your budget is)
  - If you test more specimens, chances are, you will get a higher basis value.
- Basis values will vary each time you repeat the program
  - Don’t be surprised if you get a different number each time (because you should get a different number each time).
- Pooling across environment (ASAP) will typically produce higher and more stable basis values; but it has more stipulations.
- Single point (STAT-17) is more flexible because it can handle datasets with batch-to-batch variability, unequal variances across environment, and various distributions; but it sometimes may produce basis values that seem illogical to engineers.
- Therefore, CMH-17 gives preference to ASAP. STAT-17 is used when ASAP cannot be used.