Composite Structure Engineering Safety Awareness Course

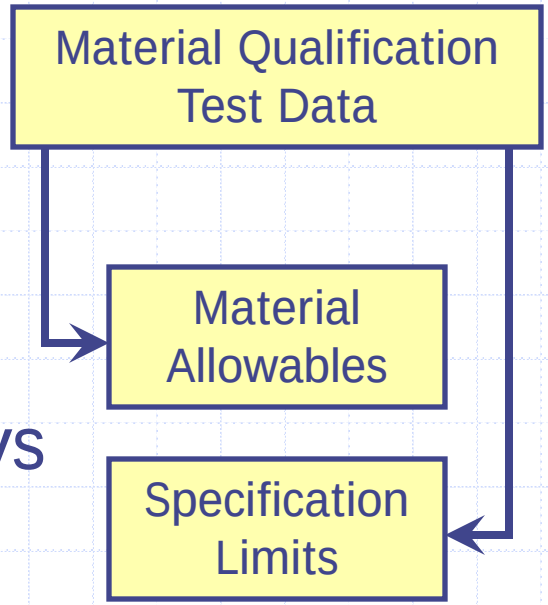
Links Between Material Allowables and Specification Limits

John Adelmann & Yeow Ng

Data Source May be Common

Data for Material Allowables and Specification Limits may initially come from the **same** testing

BUT…



These same data used:

- in two distinctly **different** ways
- to achieve **different** goals

Characteristics of Material Allowables vs. Specification Limits

Material Allowables

- Used for **Design**
- Estimates of Population **Probability of Failure**
  - B-basis estimates 10th percentile of strength population with 95% confidence, for example
- **Many** Properties and Environments
- General **Fixed** (do not change over time) unless "property drift" is detected

Specification Limits

- Used as a **Quality** Assurance Tool
- Established to determine if a **New** material batch is likely to be a **Sample** from the **Same Population** as the **Original** qualification / allowables batches
- **Fewer** Properties and Environments
- May **Change** over Time (as more batch release and receiving inspection data are generated)

Design vs. Quality

Design

- Assumes Materials are Consistent within Limits
- Assumes Material and Process Variability have been accounted for in Material Allowables
- Not Concerned with Specific Material Batches
- Relies on Material and Design Allowables for Safe Structure

Quality

- Assesses Material Consistency Over Time
- Specification Limits Set to Signal Abnormal Material Variability
- Evaluates Each New Production Batch
- Verifies Continued Validity of Original Material Allowables

Probabilities

Design

- Concerned with Probability of Structural Failure
- Material and Design Allowables Calculated to Assure a Specific Level of Structural Reliability

Quality

- Concerned with Probability that Material from a Given Batch is from the Same Population as Material Tested to Generate Material Allowables

Calculations

Design

- Failure Probability Fixed (0.10 for B-basis, 0.01 for A-basis, with 95% confidence)
- Basis Values (B or A) for Strengths
  - Distribution Models (Normal, Weibull, etc.)
  - Non-parametric
  - ANOVA
- Mean Values for Moduli
- Basis Values Depend on Number of Batches and Specimens in Original Database

Quality

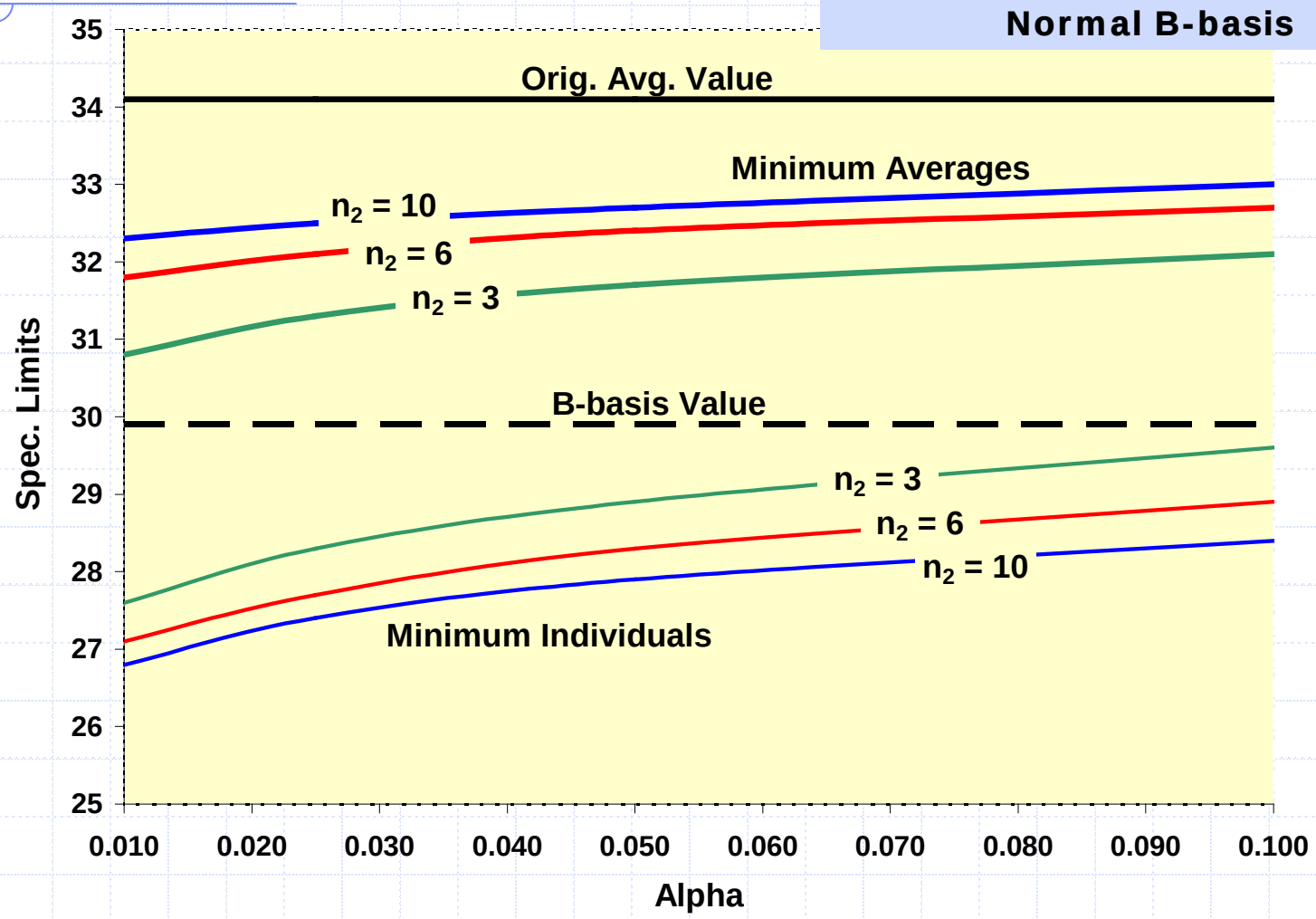
- Probability of Rejecting an Acceptable Batch (α) Set to Desired Level (Not Fixed)
- Minimum Average and Minimum Individual Spec. Limits for Strength
- Average Range for Modulus
- Spec. Limits Depend on Number of Specimens in Production Batch Samples

Calculation Numerical Results

BASIS VALUE
≠
SPECIFICATION LIMIT

Example

No. Orig. Batches	=	4
No. Orig. Spec. (n_1)	=	23
No. New Spec. (n_2)	=	Varied
Orig. Avg.	=	34.1
Orig. %CV	=	6.57
Normal B-basis	=	29.9



Summary

- Same Database May be used for Both Material Allowable and Specification Limit Calculations
- Allowables Relate to Design; Spec. Limits Relate to Quality
- Allowables Assure Safe Design; Spec. Limits Assure Material Consistency Over Time
- Allowables Generally Fixed (however, allowables should be revisited if drift in material properties is detected as more batches are produced); Spec. Limits May Change Over Time
- Allowables and Spec. Limits are NOT Numerically Equal