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Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC Material Allowables Statistical Analysis Report

NCAMP Project Number: NPN 012401

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1. Introduction

This report contains statistical analysis of the Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC material property data published in NCAMP Test Report CAM-RP-2025-023 Rev -. The lamina and laminate material property data have been generated with NCAMP oversight through NCAMP Project Number NPN 012401 and also meet the requirements outlined in NCAMP Standard Operating Procedure NSP 100. The test panels and test specimens have been inspected by NCAMP Authorized Inspection Representatives (AIR) and the testing has been witnessed by NCAMP Authorized Engineering Representatives (AER).

B-Basis values, A-estimates, and B-estimates were calculated using a variety of techniques that are detailed in section 2. The qualification material was procured to NCAMP Material Specification NMS 380/2 Rev – dated May 2, 2024. The qualification test panels were cured in accordance with NCAMP Process Specification NPS 83800 Rev B dated October 22, 2024, using baseline cure cycle "C". The panels were fabricated at National Center for Aviation Training (NCAT)
Wichita State University Tech ,4004 North Webb Rd, Wichita, KS 67226. The NCAMP Test Plan NTP 3801Q1 Rev C was used for this qualification program. The testing was performed at the National Institute for Aviation Research (NIAR) in Wichita, Kansas.

Basis numbers are labeled as 'values' when the data meets all the requirements of CMH-17 Volume 1. When those requirements are not met, they will be labeled as 'estimates.' When the data does not meet all requirements, the failure to meet these requirements is reported and the specific requirement(s) the data fails to meet is identified. The method used to compute the basis value is noted for each basis value provided. When appropriate, in addition to the traditional computational methods, values computed using the modified coefficient of variation method is also provided.

The material property data acquisition process is designed to generate basic material property data with sufficient pedigree for submission to Complete Documentation sections of the Composite Materials Handbook Volume 1 (CMH-17 Vol 1).

The NCAMP shared material property database contains material property data of common usefulness to a wide range of aerospace projects. However, the data may not fulfill all the needs of a project. Specific properties, environments, laminate architecture, and loading situations that individual projects need may require additional testing.

The use of NCAMP material and process specifications do not guarantee material or structural performance. Material users should be actively involved in evaluating material performance and quality including, but not limited to, performing regular purchaser quality control tests, performing periodic equivalency/additional testing, participating in material change management activities, conducting statistical process control, and conducting regular supplier audits.

The applicability and accuracy of NCAMP material property data, material allowables, and specifications must be evaluated on case-by-case basis by aircraft companies and certifying agencies. NCAMP assumes no liability whatsoever, expressed or implied, related to the use of the material property data, material allowables, and specifications.

Part fabricators that wish to utilize the material property data, allowables, and specifications may be able to do so by demonstrating the capability to reproduce the original material properties; a process known as equivalency. More information about this equivalency process including the test statistics and its limitations can be found in Section 6 of DOT/FAA/AR-03/19 and the Chapter 8 of CMH-17 Vol 1. The applicability of equivalency process must be evaluated on program-by-program basis by the applicant and certifying agency. The applicant and certifying agency must agree that the equivalency test plan along with the equivalency process described in Section 6 of DOT/FAA/AR-03/19 and the Chapter 8 of CMH-17 Vol 1 are adequate for the given program.

Aircraft companies should not use the data published in this report without specifying NCAMP Material Specification NMS 380/2. NMS 380/2 has additional requirements that are listed in its prepreg process control document (PCD), fiber specification, fiber PCD, and other raw material specifications and PCDs which impose essential quality controls on the raw materials and raw material manufacturing equipment and processes. *Aircraft companies and certifying agencies should assume that the material property data published in this report is not applicable when the material is not procured to NCAMP Material Specification NMS 380/2.* NMS 380/2 is a free, publicly available, non-proprietary aerospace industry material specification.

This report is intended for general distribution to the public, either freely or at a price that does not exceed the cost of reproduction (e.g. printing) and distribution (e.g. postage).

1.1 Symbols and Abbreviations

Test Property	Abbreviation
Warp Compression	WC
Warp Tension	WT
Fill Compression	FC
Fill Tension	FT
In-Plane Shear	IPS
Short Beam Strength	SBS
Unnotched Tension	UNT
Unnotched Compression	UNC
Filled Hole Tension	FHT
Filled Hole Compression	FHC
Open Hole Tension	OHT
Open Hole Compression	OHC
Single Shear Bearing	SSB
Interlaminar Tension	ILT
Compression After Impact	CAI

Table 1-1: Test Property Abbreviations

Test Property	Symbol
Warp Compression Strength	F_1^{cu}
Warp Compression Modulus	E_1^c
Warp Compression Poisson's Ratio	ν_{12}^c
Warp Tension Strength	F_1^{tu}
Warp Tension Modulus	E_1^t
Warp Tension Poisson's Ratio	ν_{12}^t
Fill Compression Strength	F_2^{cu}
Fill Compression Modulus	E_2^c
Fill Compression Poisson's Ratio	ν_{21}^c
Fill Tension Strength	F_2^{tu}
Fill Tension Modulus	E_2^t
In Plane Shear Strength at 5% strain	$F_{12}^{s5\%}$
In Plane Shear Strength at 0.2% offset	$F_{12}^{s0.2\%}$
In Plane Shear Modulus	G_{12}^s

Table 1-2: Test Property Symbols

Environmental Condition	Abbreviation	Temperature
Cold Temperature Dry	CTD	−65 ± 5˚F
Room Temperature Dry	RTD	70 ± 10˚F
Elevated Temperature Dry	ETD1	180 ± 5˚F
Elevated Temperature Wet	ETW1	180 ± 5˚F
Elevated Temperature Wet	ETW2	250 ± 5˚F

Table 1-3: Environmental Conditions Abbreviations

Tests with a number immediately after the abbreviation indicate the lay-up:

1 refers to a 25/50/25 layup. This is also referred to as "Quasi-Isotropic"
2 refers to a 10/80/10 layup. This is also referred to as "Soft"
3 refers to a 40/20/40 layup. This is also referred to as "Hard"

EX: OHT1 is an open hole tension test with a 25/50/25 layup

Detailed information about the test methods and conditions used is given in NCAMP Test Report CAM-RP-2025-023 Rev -.

1.2 Pooling Across Environments

When pooling across environments was allowable, the pooled co-efficient of variation was used. CMH17 STATS (CMH17 Approved Statistical Analysis Program) was used to determine if pooling was allowable and to compute the pooled coefficient of variation for those tests. In these cases, the modified coefficient of variation based on the pooled data was used to compute the basis values.

When pooling across environments was not advisable because the data was not eligible for pooling and engineering judgment indicated there was no justification for overriding the result, then B-Basis values were computed for each environmental condition separately, which are also provided by CMH17 STATS.

1.3 Basis Value Computational Process

The general form to compute engineering basis values is: $\text{basis value} = \bar{X} - kS$ where k is a factor based on the sample size and the distribution of the sample data. There are many different methods to determine the value of *k* in this equation, depending on the sample size and the distribution of the data. In addition, the computational formula used for the standard deviation, S, may vary depending on the distribution of the data. The details of those different computations and when each should be used are in section 2.

1.4 Modified Coefficient of Variation (CV) Method

A common problem with new material qualifications is that the initial specimens produced and tested do not contain all of the variability that will be encountered when the material is being produced in larger amounts over a lengthy period of time. This can result in setting basis values that are unrealistically high. The variability as measured in the qualification program is often lower than the actual material variability because of several reasons. The materials used in the qualification programs are usually manufactured within a short period of time, typically 2-3 weeks only, which is not representative of the production material. Some raw ingredients that are used to manufacture the multi-batch qualification materials may actually be from the same production batches or manufactured within a short period of time so the qualification materials, although regarded as multiple batches, may not truly be multiple batches so they are not representative of the actual production material variability.

The modified Coefficient of Variation (CV) used in this report is in accordance with section 8.4.4 of CMH-17 Vol 1. It is a method of adjusting the original basis values downward in anticipation of the expected additional variation. Composite materials are expected to have a CV of at least 6%. The modified coefficient of variation (CV) method increases the measured coefficient of variation when it is below 8% prior to computing basis values. A higher CV will result in lower or more conservative basis values and lower specification limits. The use of the modified CV method is intended for a temporary period of time when there is minimal data available. When a sufficient number of production batches (approximately 8 to 15) have been produced and tested, the as-measured CV may be used so that the basis values and specification limits may be adjusted higher.

The material allowables in this report are calculated using both the as-measured CV and modified CV, so users have the choice of using either one. When the measured CV is greater than 8%, the modified CV method does not change the basis value. NCAMP recommended values make use of the modified CV method when it is appropriate for the data.

When the data fails the Anderson-Darling K-sample test for batch to batch variability or when the data fails the normality test, the modified CV method is not appropriate and no modified CV basis value will be provided. When the ANOVA method is used, it may produce excessively conservative basis values. When appropriate, a single batch or two batch estimate may be provided in addition to the ANOVA estimate.

In some cases a transformation of the data to fit the assumption of the modified CV resulted in the transformed data passing the ADK test and thus the data can be pooled only for the modified CV method.

NCAMP recommends that if a user decides to use the basis values that are calculated from as-measured CV, the specification limits and control limits be calculated with as-measured CV also. Similarly, if a user decides to use the basis values that are calculated from modified CV, the specification limits and control limits be calculated with modified CV also. This will ensure that the link between material allowables, specification limits, and control limits is maintained.

2. Background

Statistical computations are performed with CMH17 STATS. Pooling across environments will be used whenever it is permissible according to CMH-17 Vol 1 guidelines. If pooling is not permissible, the results of a single point analysis provided by CMH17 STATS is included instead. If the data does not meet CMH-17 Vol 1 requirements for a single point analysis, estimates are created by a variety of methods depending on which is most appropriate for the dataset available. Specific procedures used are presented in the individual sections where the data is presented.

2.1 CMH17 STATS Statistical Formulas and Computations

This section contains the details of the specific formulas CMH17 STATS uses in its computations.

2.1.1 Basic Descriptive Statistics

The basic descriptive statistics shown are computed according to the usual formulas, which are shown below:

Mean: $$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$ **Equation 1**

Std. Dev.: $$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} \left(X_i - \bar{X} \right)^2}$$ **Equation 2**

% Co. Variation: $$\frac{S}{\bar{X}} \times 100$$ **Equation 3**

Where n refers to the number of specimens in the sample and X_i refers to the individual specimen measurements.

2.1.2 Statistics for Pooled Data

Prior to computing statistics for the pooled dataset, the data is normalized to a mean of one by dividing each value by the mean of all the data for that condition. This transformation does not affect the coefficients of variation for the individual conditions.

2.1.2.1 Pooled Standard Deviation

The formula to compute a pooled standard deviation is given below:

Pooled Std. Dev.: $$S_p = \sqrt{\frac{\sum_{i=1}^{k} \left(n_i - 1 \right) S_i^2}{\sum_{i=1}^{k} \left(n_i - 1 \right)}}$$ **Equation 4**

Where k refers to the number of batches, S_i indicates the standard deviation of i^{th} sample, and n_i refers to the number of specimens in the i^{th} sample.

2.1.2.2 Pooled Coefficient of Variation

Since the mean for the normalized data is 1.0 for each condition, the pooled normalized data also has a mean of one. The coefficient of variation for the pooled normalized data is the pooled standard deviation divided by the pooled mean, as in equation 3. Since the mean for the pooled normalized data is one, the pooled coefficient of variation is equal to the pooled standard deviation of the normalized data.

$$\textbf{Pooled Coefficient of Variation} = \frac{S_p}{1} = S_p \qquad \textbf{Equation 5}$$

2.1.3 Basis Value Computations

Basis values are computed using the mean and standard deviation for that environment, as follows: The mean is always the mean for the environment, but if the data meets all requirements for pooling, S_p can be used in place of the standard deviation for the environment, S.

$$\textbf{Basis Values:} \quad \begin{aligned} A-basis &= \bar{X} - K_a S \\ B-basis &= \bar{X} - K_b S \end{aligned} \qquad \textbf{Equation 6}$$

2.1.3.1 K-factor computations

K_a and K_b are computed according to the methodology documented in the Chapter 8 of the CMH-17 Vol 1 Handbook. The approximation formulas are given below:

$$K_a = \frac{2.3263}{\sqrt{q(f)}} + \sqrt{\frac{1}{c_A(f)\cdot n_j} + \left(\frac{b_A(f)}{2c_A(f)}\right)^2} - \frac{b_A(f)}{2c_A(f)} \qquad \textbf{Equation 7}$$

$$K_b = \frac{1.2816}{\sqrt{q(f)}} + \sqrt{\frac{1}{c_B(f)\cdot n_j} + \left(\frac{b_B(f)}{2c_B(f)}\right)^2} - \frac{b_B(f)}{2c_B(f)} \qquad \textbf{Equation 8}$$

Where

r = the number of environments being pooled together
n_j = number of data values for environment j

$$N = \sum_{j=1}^{r} n_j$$

$$f = N - r$$

$$q(f) = 1 - \frac{2.323}{\sqrt{f}} + \frac{1.064}{f} + \frac{0.9157}{f\sqrt{f}} - \frac{0.6530}{f^2} \qquad \textbf{Equation 9}$$

$$b_B(f) = \frac{1.1372}{\sqrt{f}} - \frac{0.49162}{f} + \frac{0.18612}{f\sqrt{f}} \qquad \textbf{Equation 10}$$

$$c_B(f) = 0.36961 + \frac{0.0040342}{\sqrt{f}} - \frac{0.71750}{f} + \frac{0.19693}{f\sqrt{f}} \quad \textbf{Equation 11}$$

$$b_A(f) = \frac{2.0643}{\sqrt{f}} - \frac{0.95145}{f} + \frac{0.51251}{f\sqrt{f}} \quad \textbf{Equation 12}$$

$$c_A(f) = 0.36961 + \frac{0.0026958}{\sqrt{f}} - \frac{0.65201}{f} + \frac{0.011320}{f\sqrt{f}} \quad \textbf{Equation 13}$$

2.1.4 Modified Coefficient of Variation

The coefficient of variation is modified according to the following rules:

$$\textbf{Modified CV} = CV^* = \begin{cases} .06 & if\ CV < .04 \\ \frac{CV}{2} + .04 & if\ .04 \le CV < .08 \\ CV & if\ CV \ge .08 \end{cases} \quad \textbf{Equation 14}$$

This is converted to percent by multiplying by 100%.

CV^* is used to compute a modified standard deviation S^*.

$$S^* = CV^* \cdot \bar{X} \quad \textbf{Equation 15}$$

To compute the pooled standard deviation based on the modified CV:

$$S_p^* = \sqrt{\frac{\sum_{i=1}^{k}\left((n_i - 1)\left(CV_i^* \cdot \bar{X}_i\right)^2\right)}{\sum_{i=1}^{k}(n_i - 1)}} \quad \textbf{Equation 16}$$

The A-basis and B-basis values under the assumption of the modified CV method are computed by replacing S with S^*

2.1.4.1 Transformation of data based on Modified CV

In order to determine if the data would pass the diagnostic tests under the assumption of the modified CV, the data must be transformed such that the batch means remain the same while the standard deviation of transformed data (all batches) matches the modified standard deviation.

To accomplish this requires a transformation in two steps:

Step 1: Apply the modified CV rules to each batch and compute the modified standard deviation $S_i^* = CV^* \cdot \bar{X}_i$ for each batch. Transform the individual data values (X_{ij}) in each batch as follows:

$$X'_{ij} = C_i\left(X_{ij} - \bar{X}_i\right) + \bar{X}_i \quad \textbf{Equation 17}$$

$$C_i = \frac{S_i^*}{S_i} \quad \textbf{Equation 18}$$

Run the Anderson-Darling k-sample test for batch equivalence (see section 2.1.6) on the transformed data. If it passes, proceed to step 2. If not, stop. The data cannot be pooled.

Step 2: Another transformation is needed as applying the modified CV to each batch leads to a larger CV for the combined data than when applying the modified CV rules to the combined data (due to the addition of between batch variation when combining data from multiple batches). In order to alter the data to match S^*, the transformed data is transformed again, this time setting using the same value of C' for all batches.

$$X''_{ij} = C'\left(X'_{ij} - \bar{X}_i\right) + \bar{X}_i \quad \textbf{Equation 19}$$

$$C' = \sqrt{\frac{SSE^*}{SSE'}} \quad \textbf{Equation 20}$$

$$SSE^* = (n-1)\left(CV^* \cdot \bar{X}\right)^2 - \sum_{i=1}^{k} n_i\left(\bar{X}_i - \bar{X}\right)^2 \quad \textbf{Equation 21}$$

$$SSE' = \sum_{i=1}^{k}\sum_{j=1}^{n_i}\left(X'_{ij} - \bar{X}_i\right)^2 \quad \textbf{Equation 22}$$

Once this second transformation has been completed, the k-sample Anderson Darling test for batch equivalence can be run on the transformed data to determine if the modified co-efficient of variation will permit pooling of the data.

2.1.5 Determination of Outliers

All outliers are identified in text and graphics. If an outlier is removed from the dataset, it will be specified and the reason why will be documented in the text. Outliers are identified as described in section 8.3.3.1 of the CMH-17 Vol 1 Handbook.

$$MNR = \frac{\max_{all\ i}\left|X_i - \bar{X}\right|}{S}, i = 1\ldots n \quad \textbf{Equation 23}$$

$$C = \frac{n-1}{\sqrt{n}}\sqrt{\frac{t^2}{n-2+t^2}} \quad \textbf{Equation 24}$$

where t is the $1-\frac{.05}{2n}$ quartile of a t distribution with n−2 degrees of freedom, n being the total number of data values.

If MNR > C, then the X_i associated with the MNR is considered to be an outlier. If an outlier exists, then the X_i associated with the MNR is dropped from the dataset and the MNR procedure is applied

again. This process is repeated until no outliers are detected. Additional information on this procedure can be found in references 1 and 2.

2.1.6 The k-Sample Anderson Darling Test for Batch Equivalency

The k-sample Anderson-Darling test is a nonparametric statistical procedure that tests the hypothesis that the populations from which two or more groups of data were drawn are identical. The distinct values in the combined data set are ordered from smallest to largest, denoted $z_{(1)}, z_{(2)}, \ldots z_{(L)}$, where L will be less than n if there are tied observations. These rankings are used to compute the test statistic.

The k-sample Anderson-Darling test statistic is:

$$ADK = \frac{n-1}{n^2(k-1)} \sum_{i=1}^{k} \left[\frac{1}{n_i} \sum_{j=1}^{L} h_j \frac{\left(nF_{ij} - n_i H_j\right)^2}{H_j\left(n - H_j\right) - \frac{nh_j}{4}} \right] \quad \textbf{Equation 25}$$

Where

n_i = the number of test specimens in each batch

$n = n_1 + n_2 + \ldots + n_k$

h_j = the number of values in the combined samples equal to $z_{(j)}$

H_j = the number of values in the combined samples less than $z_{(j)}$ plus ½ the number of values in the combined samples equal to $z_{(j)}$

F_{ij} = the number of values in the i^{th} group which are less than $z_{(j)}$ plus ½ the number of values in this group which are equal to $z_{(j)}$.

The critical value for the test statistic at 1−α level is computed:

$$ADC = 1 + \sigma_n \left[z_\alpha + \frac{0.678}{\sqrt{k-1}} - \frac{0.362}{k-1} \right] \quad \textbf{Equation 26}$$

This formula is based on the formula in reference 3 at the end of section 5, using a Taylor's expansion to estimate the critical value via the normal distribution rather than using the t distribution with k-1 degrees of freedom.

$$\sigma_n^2 = VAR(ADK) = \frac{an^3 + bn^2 + cn + d}{(n-1)(n-2)(n-3)(k-1)^2} \quad \textbf{Equation 27}$$

With

$$a = (4g-6)(k-1)+(10-6g)S$$
$$b = (2g-4)k^2+8Tk+(2g-14T-4)S-8T+4g-6$$
$$c = (6T+2g-2)k^2+(4T-4g+6)k+(2T-6)S+4T$$
$$d = (2T+6)k^2-4Tk$$
$$S = \sum_{i=1}^{k}\frac{1}{n_i}$$
$$T = \sum_{i=1}^{n-1}\frac{1}{i}$$
$$g = \sum_{i=1}^{n-2}\sum_{j=i+1}^{n-1}\frac{1}{(n-i)j}$$

The data is considered to have failed this test (i.e. the batches are not from the same population) when the test statistic is greater than the critical value. For more information on this procedure, see reference 3.

2.1.7 The Anderson Darling Test for Normality

Normal Distribution: A two parameter (μ, σ) family of probability distributions for which the probability that an observation will fall between *a* and *b* is given by the area under the curve between a and b:

$$F(x) = \int_a^b \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx \qquad \textbf{Equation 28}$$

A normal distribution with parameters (μ, σ) has population mean μ and variance σ^2.

The normal distribution is considered by comparing the cumulative normal distribution function that best fits the data with the cumulative distribution function of the data. Let

$$z_{(i)} = \frac{x_{(i)}-\bar{x}}{s}, \quad \text{for i = 1,…,n} \qquad \textbf{Equation 29}$$

where $x_{(i)}$ is the smallest sample observation, $\bar{x}$ is the sample average, and s is the sample standard deviation.

The Anderson Darling test statistic (AD) is:

$$AD = \sum_{i=1}^{n}\frac{1-2i}{n}\left\{\ln\left[F_0(z_{(i)})\right]+\ln\left[1-F_0\left(z_{(n+1-i)}\right)\right]\right\}-n \qquad \textbf{Equation 30}$$

Where F_0 is the standard normal distribution function. The observed significance level (OSL) is

$$OSL = \frac{1}{1+e^{-0.48+0.78\ln(AD^*)+4.58AD^*}}, \quad AD^* = \left(1+\frac{4}{n}-\frac{25}{n^2}\right)AD \qquad \textbf{Equation 31}$$

This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if, in fact, the data are a sample from a normal population. If OSL > 0.05, the data is considered sufficiently close to a normal distribution.

2.1.8 Levene's Test for Equality of Coefficient of Variation

Levene's test performs an Analysis of Variance on the absolute deviations from their sample medians. The absolute value of the deviation from the median is computed for each data value. $w_{ij} = \left| y_{ij} - \tilde{y}_i \right|$ An F-test is then performed on the transformed data values as follows:

$$F = \frac{\sum_{i=1}^{k} n_i \left(\bar{w}_i - \bar{w} \right)^2 / (k-1)}{\sum_{i=1}^{k} \sum_{j=1}^{n_i} {}_i \left(w_{ij} - \bar{w}_i \right)^2 / (n-k)} \qquad \textbf{Equation 32}$$

If this computed F statistic is less than the critical value for the F-distribution having k-1 numerator and n-k denominator degrees of freedom at the 1-α level of confidence, then the data is not rejected as being too different in terms of the co-efficient of variation. CMH-17 STATS provides the appropriate critical values for F at α levels of 0.10, 0.05, 0.025, and 0.01. For more information on this procedure, see references 4, and 5.

2.1.9 Distribution Tests

In addition to testing for normality using the Anderson-Darling test (see 2.1.7), CMH17 STATS also tests to see if the Weibull or Lognormal distribution is a good fit for the data.

Each distribution is considered using the Anderson-Darling test statistic which is sensitive to discrepancies in the tail regions. The Anderson-Darling test compares the cumulative distribution function for the distribution of interest with the cumulative distribution function of the data.

An observed significance level (OSL) based on the Anderson-Darling test statistic is computed for each test. The OSL measures the probability of observing an Anderson-Darling test statistic at least as extreme as the value calculated if the distribution under consideration is in fact the underlying distribution of the data. In other words, the OSL is the probability of obtaining a value of the test statistic at least as large as that obtained if the hypothesis that the data are actually from the distribution being tested is true. If the OSL is less than or equal to 0.05, then the assumption that the data are from the distribution being tested is rejected with at most a five percent risk of being in error.

If the normal distribution has an OSL greater than 0.05, then the data is assumed to be from a population with a normal distribution. If not, then if either the Weibull or lognormal distributions has an OSL greater than 0.05, then one of those can be used. If neither of these distributions has an OSL greater than 0.05, a non-parametric approach is used.

In what follows, unless otherwise noted, the sample size is denoted by n, the sample observations by x_1, ..., x_n , and the sample observations ordered from least to greatest by $x_{(1)}$, ..., $x_{(n)}$.

2.1.9.1 One-sided B-basis tolerance factors, k_B, for the normal distribution when sample size is greater than 15.

The exact computation of k_B values is $1/\sqrt{n}$ times the 0.95th quantile of the noncentral t-distribution with non-centrality parameter $1.282\sqrt{n}$ and n − 1 degrees of freedom. Since this is not a calculation that Excel can handle, the following approximation to the k_B values is used:

$$k_B \approx 1.282 + \exp\{0.958 - 0.520\ln(n) + 3.19/n\} \qquad \textbf{Equation 33}$$

This approximation is accurate to within 0.2% of the tabulated values for sample sizes greater than or equal to 16.

2.1.9.2 One-sided A-basis tolerance factors, k_A, for the normal distribution

The exact computation of k_A values is $1/\sqrt{n}$ times the 0.95th quantile of the noncentral t-distribution with non-centrality parameter $2.326\sqrt{n}$ and n − 1 degrees of freedom (Reference 11). Since this is not a calculation that Excel can handle easily, the following approximation to the k_A values is used:

$$k_A \approx 2.326 + \exp\{1.34 - 0.522\ln(n) + 3.87/n\} \qquad \textbf{Equation 34}$$

This approximation is accurate to within 0.2% of the tabulated values for sample sizes greater than or equal to 16.

2.1.9.3 Two-parameter Weibull Distribution

A probability distribution for which the probability that a randomly selected observation from this population lies between a and b $(0 < a < b < \infty)$ is given by

$$e^{-(a/\alpha)^{\beta}} - e^{-(b/\alpha)^{\beta}} \qquad \textbf{Equation 35}$$

where α is called the scale parameter and β is called the shape parameter.

In order to compute a check of the fit of a data set to the Weibull distribution and compute basis values assuming Weibull, it is first necessary to obtain estimates of the population shape and scale parameters (Section 2.1.9.3.1). Calculations specific to the goodness-of-fit test for the Weibull distribution are provided in section 2.1.9.3.2.

2.1.9.3.1 Estimating Weibull Parameters

This section describes the *maximum likelihood* method for estimating the parameters of the two-parameter Weibull distribution. The maximum-likelihood estimates of the shape and scale parameters are denoted $\hat{\beta}$ and $\hat{\alpha}$. The estimates are the solution to the pair of equations:

$$\hat{\alpha}\hat{\beta}\mathrm{n} - \frac{\hat{\beta}}{\hat{\alpha}^{\hat{\beta}-1}}\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{x}_{\mathrm{i}}^{\hat{\beta}} = 0 \qquad \textbf{Equation 36}$$

$$\frac{n}{\hat{\beta}} - n\ln\hat{\alpha} + \sum_{i=1}^{n}\ln x_i - \sum_{i=1}^{n}\left[\frac{x_i}{\hat{\alpha}}\right]^{\hat{\beta}}\left(\ln x_i - \ln\hat{\alpha}\right) = 0 \qquad \textbf{Equation 37}$$

CMH17 STATS solves these equations numerically for $\hat{\beta}$ and $\hat{\alpha}$ in order to compute basis values.

2.1.9.3.2 Goodness-of-fit test for the Weibull distribution

The two-parameter Weibull distribution is considered by comparing the cumulative Weibull distribution function that best fits the data with the cumulative distribution function of the data. Using the shape and scale parameter estimates from section 2.1.9.3.1, let

$$z_{(i)} = \left[x_{(i)}/\hat{\alpha}\right]^{\hat{\beta}}, \quad \text{for } i = 1,\ldots,n \qquad \textbf{Equation 38}$$

The Anderson-Darling test statistic is

$$\mathrm{AD} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \frac{1-2\mathrm{i}}{\mathrm{n}}\left[\ln\left[1-\exp(-\mathrm{z}_{(\mathrm{i})})\right] - \mathrm{z}_{(\mathrm{n}+1-\mathrm{i})}\right] - \mathrm{n} \qquad \textbf{Equation 39}$$

and the observed significance level is

$$\mathrm{OSL} = 1/\left\{1+\exp[-0.10+1.24\ln(\mathrm{AD}^{*})+4.48\mathrm{AD}^{*}]\right\} \qquad \textbf{Equation 40}$$

where

$$AD^{*} = \left(1+\frac{0.2}{\sqrt{n}}\right)AD \qquad \textbf{Equation 41}$$

This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if in fact the data is a sample from a two-parameter Weibull distribution. If OSL ≤ 0.05, one may conclude (at a five percent risk of being in error) that the population does not have a two-parameter Weibull distribution. Otherwise, the hypothesis that the population has a two-parameter Weibull distribution is not rejected. For further information on these procedures, see reference 6.

2.1.9.3.3 Basis value calculations for the Weibull distribution

For the two-parameter Weibull distribution, the B-basis value is

$$B = \hat{q}e^{\left(-V/\hat{\beta}\sqrt{n}\right)} \quad \textbf{Equation 42}$$

where

$$\hat{q} = \hat{\alpha}\left(0.10536\right)^{1/\hat{\beta}} \quad \textbf{Equation 43}$$

To calculate the A-basis value, substitute the equation below for the equation above.

$$\hat{q} = \hat{\alpha}(0.01005)^{1/\beta} \quad \textbf{Equation 44}$$

V is the value in Table 2-1 when the sample size is less than 16. For sample sizes of 16 or larger, a numerical approximation to the V values is given in the two equations immediately below.

$$V_B \approx 3.803 + \exp\left[1.79 - 0.516\ln(n) + \frac{5.1}{n-1}\right] \quad \textbf{Equation 45}$$

$$V_A \approx 6.649 + \exp\left[2.55 - 0.526\ln(n) + \frac{4.76}{n}\right] \quad \textbf{Equation 46}$$

This approximation is accurate within 0.5% of the tabulated values for n greater than or equal to 16.

Weibull Dist. K Factors for N<16		
N	B-basis	A-basis
2	690.804	1284.895
3	47.318	88.011
4	19.836	36.895
5	13.145	24.45
6	10.392	19.329
7	8.937	16.623
8	8.047	14.967
9	7.449	13.855
10	6.711	12.573
11	6.477	12.093
12	6.286	11.701
13	6.127	11.375
14	5.992	11.098
15	5.875	10.861

Table 2-1: Weibull Distribution Basis Value Factors

2.1.9.4 Lognormal Distribution

A probability distribution for which the probability that an observation selected at random from this population falls between a and b $\left(0 < a < b < \infty\right)$ is given by the area under the normal distribution between ln(a) and ln(b).

The lognormal distribution is a positively skewed distribution that is simply related to the normal distribution. If something is lognormally distributed, then its logarithm is normally distributed. The natural (base e) logarithm is used.

2.1.9.4.1 Goodness-of-fit test for the Lognormal distribution

In order to test the goodness-of-fit of the lognormal distribution, take the logarithm of the data and perform the Anderson-Darling test for normality from Section 2.1.7. Using the natural logarithm, replace Equation 29 above with Equation 47 below:

$$z_{(i)} = \frac{\ln\left(x_{(i)}\right) - \bar{x}_L}{s_L}, \quad \text{for } i = 1,\ldots,n \qquad \textbf{Equation 47}$$

where $x_{(i)}$ is the i^{th} smallest sample observation, $\bar{x}_L$ and s_L are the mean and standard deviation of the $\ln(x_i)$ values.

The Anderson-Darling statistic is then computed using Equation 30 above and the observed significance level (OSL) is computed using Equation 31 above. This OSL measures the probability of observing an Anderson-Darling statistic at least as extreme as the value calculated if in fact the data are a sample from a lognormal distribution. If OSL ≤ 0.05, one may conclude (at a five percent risk of being in error) that the population is not lognormally distributed. Otherwise, the hypothesis that the population is lognormally distributed is not rejected. For further information on these procedures, see reference 6.

2.1.9.4.2 Basis value calculations for the Lognormal distribution

If the data set is assumed to be from a population with a lognormal distribution, basis values are calculated using the equation above in section 2.1.3. However, the calculations are performed using the logarithms of the data rather than the original observations. The computed basis values are then transformed back to the original units by applying the inverse of the log transformation.

2.1.10 Non-parametric Basis Values

Non-parametric techniques do not assume any particularly underlying distribution for the population the sample comes from. It does require that the batches be similar enough to be grouped together, so the ADK test must have a positive result. While it can be used instead of assuming the normal, lognormal or Weibull distribution, it typically results in lower basis values. One of following two methods should be used, depending on the sample size.

2.1.10.1 Non-parametric Basis Values for large samples

The required sample sizes for this ranking method differ for A and B basis values. A sample size of at least 29 is needed for the B-basis value while a sample size of 299 is required for the A-basis.

To calculate a B-basis value for n > 28, the value of r is determined with the following formulas:

For B-basis values:

$$r_B = \frac{n}{10} - 1.645\sqrt{\frac{9n}{100}} + 0.23 \qquad \textbf{Equation 48}$$

For A-Basis values:

$$r_A = \frac{n}{100} - 1.645\sqrt{\frac{99n}{10,000}} + 0.29 + \frac{19.1}{n} \qquad \textbf{Equation 49}$$

The formula for the A-basis values should be rounded to the nearest integer. This approximation is exact for most values and for a small percentage of values (less than 0.2%), the approximation errs by one rank on the conservative side.

The B-basis value is the r_B^{th} lowest observation in the data set, while the A-basis value is the r_A^{th} lowest observation in the data set. For example, in a sample of size n = 30, the lowest (r = 1) observation is the B-basis value. Further information on this procedure may be found in reference 7.

2.1.10.2 Non-parametric Basis Values for small samples

The Hanson-Koopmans method (references 8 and 9) is used for obtaining a B-basis value for sample sizes not exceeding 28 and A-basis values for sample sizes less than 299. This procedure requires the assumption that the observations are a random sample from a population for which the logarithm of the cumulative distribution function is concave, an assumption satisfied by a large class of probability distributions. There is substantial empirical evidence that suggests that composite strength data satisfies this assumption.

The Hanson-Koopmans B-basis value is:

$$B = x_{(r)}\left[\frac{x_{(1)}}{x_{(r)}}\right]^k \qquad \textbf{Equation 50}$$

The A-basis value is:

$$A = x_{(n)}\left[\frac{x_{(1)}}{x_{(n)}}\right]^k \qquad \textbf{Equation 51}$$

where $x_{(n)}$ is the largest data value, $x_{(1)}$ is the smallest, and $x_{(r)}$ is the r^{th} largest data value. The values of r and k depend on n and are listed in Table 2-2. This method is not used for the B-basis value when $x_{(r)} = x_{(1)}$.

The Hanson-Koopmans method can be used to calculate A-basis values for n less than 299. Find the value k_A corresponding to the sample size n in Table 2-3. For an A-basis value that meets all the requirements of CMH-17 Vol 1, there must be at least five batches represented in the data and at least 55 data points. For a B-basis value, there must be at least three batches represented in the data and at least 18 data points.

B-Basis Hanson-Koopmans Table		
n	r	k
2	2	35.177
3	3	7.859
4	4	4.505
5	4	4.101
6	5	3.064
7	5	2.858
8	6	2.382
9	6	2.253
10	6	2.137
11	7	1.897
12	7	1.814
13	7	1.738
14	8	1.599
15	8	1.540
16	8	1.485
17	8	1.434
18	9	1.354
19	9	1.311
20	10	1.253
21	10	1.218
22	10	1.184
23	11	1.143
24	11	1.114
25	11	1.087
26	11	1.060
27	11	1.035
28	12	1.010

Table 2-2: B-Basis Hanson-Koopmans Table

A-Basis Hanson-Koopmans Table					
n	k	n	k	n	k
2	80.00380	38	1.79301	96	1.32324
3	16.91220	39	1.77546	98	1.31553
4	9.49579	40	1.75868	100	1.30806
5	6.89049	41	1.74260	105	1.29036
6	5.57681	42	1.72718	110	1.27392
7	4.78352	43	1.71239	115	1.25859
8	4.25011	44	1.69817	120	1.24425
9	3.86502	45	1.68449	125	1.23080
10	3.57267	46	1.67132	130	1.21814
11	3.34227	47	1.65862	135	1.20620
12	3.15540	48	1.64638	140	1.19491
13	3.00033	49	1.63456	145	1.18421
14	2.86924	50	1.62313	150	1.17406
15	2.75672	52	1.60139	155	1.16440
16	2.65889	54	1.58101	160	1.15519
17	2.57290	56	1.56184	165	1.14640
18	2.49660	58	1.54377	170	1.13801
19	2.42833	60	1.52670	175	1.12997
20	2.36683	62	1.51053	180	1.12226
21	2.31106	64	1.49520	185	1.11486
22	2.26020	66	1.48063	190	1.10776
23	2.21359	68	1.46675	195	1.10092
24	2.17067	70	1.45352	200	1.09434
25	2.13100	72	1.44089	205	1.08799
26	2.09419	74	1.42881	210	1.08187
27	2.05991	76	1.41724	215	1.07595
28	2.02790	78	1.40614	220	1.07024
29	1.99791	80	1.39549	225	1.06471
30	1.96975	82	1.38525	230	1.05935
31	1.94324	84	1.37541	235	1.05417
32	1.91822	86	1.36592	240	1.04914
33	1.89457	88	1.35678	245	1.04426
34	1.87215	90	1.34796	250	1.03952
35	1.85088	92	1.33944	275	1.01773
36	1.83065	94	1.33120	299	1.00000
37	1.81139				

Table 2-3: A-Basis Hanson-Koopmans Table

2.1.11 Analysis of Variance (ANOVA) Basis Values

ANOVA is used to compute basis values when the batch to batch variability of the data does not pass the ADK test. Since ANOVA makes the assumption that the different batches have equal variances, the data is checked to make sure the assumption is valid. Levene's test for equality of variance is used (see section 2.1.8). If the dataset fails Levene's test, the basis values computed are likely to be conservative. Thus this method can still be used but the values produced will be listed as estimates.

2.1.11.1 Calculation of basis values using ANOVA

The following calculations address batch-to-batch variability. In other words, the only grouping is due to batches and the k-sample Anderson-Darling test (Section 2.1.6) indicates that the batch to batch variability is too large to pool the data. The method is based on the one-way analysis of variance random-effects model, and the procedure is documented in reference 10.

ANOVA separates the total variation (called the sum of squares) of the data into two sources: between batch variation and within batch variation.

First, statistics are computed for each batch, which are indicated with a subscript $\left(n_i, \bar{x}_i, s_i^2\right)$ while statistics that were computed with the entire dataset do not have a subscript. Individual data values are represented with a double subscript, the first number indicated the batch and the second distinguishing between the individual data values within the batch. *k* stands for the number of batches in the analysis. With these statistics, the Sum of Squares Between batches (SSB) and the Total Sum of Squares (SST) are computed:

$$SSB = \sum_{i=1}^{k} n_i \bar{x}_I^2 - n\bar{x}^2 \qquad \textbf{Equation 52}$$

$$SST = \sum_{i=1}^{k} \sum_{j=1}^{n_i} x_{ij}^2 - n\bar{x}^2 \qquad \textbf{Equation 53}$$

The within-batch, or error, sum of squares (SSE) is computed by subtraction

$$SSE = SST - SSB \qquad \textbf{Equation 54}$$

Next, the mean sums of squares are computed:

$$MSB = \frac{SSB}{k-1} \qquad \textbf{Equation 55}$$

$$MSE = \frac{SSE}{n-k} \qquad \textbf{Equation 56}$$

Since the batches need not have equal numbers of specimens, an ‘effective batch size,’ is defined as

$$n' = \frac{n - \frac{1}{n}\sum_{i=1}^{k} n_i^2}{k-1} \qquad \textbf{Equation 57}$$

Using the two mean squares and the effective batch size, an estimate of the population standard deviation is computed:

$$S = \sqrt{\frac{MSB}{n'} + \left(\frac{n'-1}{n'}\right) MSE} \qquad \textbf{Equation 58}$$

Two k-factors are computed using the methods described in section 8.3 of the CMH-17 Vol 1 Handbook using a sample size of n (denoted k_0) and a sample size of k (denoted k_1). Whether this value is an A- or B-basis value depends only on whether k_0 and k_1 are computed for A or B-basis values.

Denote the ratio of mean squares by

$$u = \frac{MSB}{MSE} \qquad \textbf{Equation 59}$$

If u is less than one, it is set equal to one. The tolerance limit factor is

$$T = \frac{k_0 - \frac{k_1}{\sqrt{n'}} + \left(k_1 - k_0\right)\sqrt{\frac{u}{u + n' - 1}}}{1 - \frac{1}{\sqrt{n'}}} \qquad \textbf{Equation 60}$$

The basis value is $\bar{x} - TS$.

The ANOVA method can produce extremely conservative basis values when a small number of batches are available. Therefore, when less than five (5) batches are available and the ANOVA method is used, the basis values produced will be listed as estimates.

2.2 Single Batch and Two Batch Estimates using Modified CV

This method has not been approved for use by the CMH-17 organization. Values computed in this manner are estimates only. It is used only when fewer than three batches are available and no valid B-basis value could be computed using any other method. The estimate is made using the mean of the data and setting the coefficient of variation to 8 percent if it was less than that. A modified standard deviation (S_{adj}) was computed by multiplying the mean by 0.08 and computing the A and B-basis values using this inflated value for the standard deviation.

$$\textbf{Estimated B-Basis} = \bar{X} - k_b S_{adj} = \bar{X} - k_b \cdot 0.08 \cdot \bar{X} \qquad \textbf{Equation 61}$$

2.3 Lamina Variability Method (LVM)

This method has not been approved for use by the CMH-17 organization. Values computed in this manner are estimates only. It is used only when the sample size is less than 16 and no valid B-basis value could be computed using any other method. The prime assumption for applying the LVM is that the intrinsic strength variability of the laminate (small) dataset is no greater than the strength variability of the lamina (large) dataset. This assumption was tested and found to be reasonable for composite materials as documented by Tomblin and Seneviratne [12].

To compute the estimate, the coefficients of variation (CVs) of laminate data are paired with lamina CV's for the same loading condition and environmental condition. For example, the 0º compression lamina CV CTD condition is used with open hole compression CTD condition.

Bearing and in-plane shear laminate CV's are paired with 0º compression lamina CV's. However, if the laminate CV is larger than the corresponding lamina CV, the larger laminate CV value is used.

The LVM B-basis value is then computed as:

LVM Estimated B-Basis = $\bar{X}_1 - K_{(N_1,N_2)} \cdot \bar{X}_1 \cdot \max(CV_1, CV_2)$ **Equation 62**

When used in conjunction with the modified CV approach, a minimum value of 8% is used for the CV.

Mod CV LVM Estimated B-Basis = $\bar{X}_1 - K_{(N_1,N_2)} \cdot \bar{X}_1 \cdot Max(8\%, CV_1, CV_2)$ **Equation 63**

With:

$\bar{X}_1$ the mean of the laminate (small dataset)
N_1 the sample size of the laminate (small dataset)
N_2 the sample size of the lamina (large dataset)
CV_1 is the coefficient of variation of the laminate (small dataset)
CV_2 is the coefficient of variation of the lamina (large dataset)
$K_{(N_1,N_2)}$ is given in Table 2-4

		N1													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
N1+N2-2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	4.508	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	3.827	3.607	0	0	0	0	0	0	0	0	0	0	0	0
	5	3.481	3.263	3.141	0	0	0	0	0	0	0	0	0	0	0
	6	3.273	3.056	2.934	2.854	0	0	0	0	0	0	0	0	0	0
	7	3.134	2.918	2.796	2.715	2.658	0	0	0	0	0	0	0	0	0
	8	3.035	2.820	2.697	2.616	2.558	2.515	0	0	0	0	0	0	0	0
	9	2.960	2.746	2.623	2.541	2.483	2.440	2.405	0	0	0	0	0	0	0
	10	2.903	2.688	2.565	2.484	2.425	2.381	2.346	2.318	0	0	0	0	0	0
	11	2.856	2.643	2.519	2.437	2.378	2.334	2.299	2.270	2.247	0	0	0	0	0
	12	2.819	2.605	2.481	2.399	2.340	2.295	2.260	2.231	2.207	2.187	0	0	0	0
	13	2.787	2.574	2.450	2.367	2.308	2.263	2.227	2.198	2.174	2.154	2.137	0	0	0
	14	2.761	2.547	2.423	2.341	2.281	2.236	2.200	2.171	2.147	2.126	2.109	2.093	0	0
	15	2.738	2.525	2.401	2.318	2.258	2.212	2.176	2.147	2.123	2.102	2.084	2.069	2.056	0
	16	2.719	2.505	2.381	2.298	2.238	2.192	2.156	2.126	2.102	2.081	2.063	2.048	2.034	2.022
	17	2.701	2.488	2.364	2.280	2.220	2.174	2.138	2.108	2.083	2.062	2.045	2.029	2.015	2.003
	18	2.686	2.473	2.348	2.265	2.204	2.158	2.122	2.092	2.067	2.046	2.028	2.012	1.999	1.986
	19	2.673	2.459	2.335	2.251	2.191	2.144	2.108	2.078	2.053	2.032	2.013	1.998	1.984	1.971
	20	2.661	2.447	2.323	2.239	2.178	2.132	2.095	2.065	2.040	2.019	2.000	1.984	1.970	1.958
	21	2.650	2.437	2.312	2.228	2.167	2.121	2.084	2.053	2.028	2.007	1.988	1.972	1.958	1.946
	22	2.640	2.427	2.302	2.218	2.157	2.110	2.073	2.043	2.018	1.996	1.978	1.962	1.947	1.935
	23	2.631	2.418	2.293	2.209	2.148	2.101	2.064	2.033	2.008	1.987	1.968	1.952	1.938	1.925
	24	2.623	2.410	2.285	2.201	2.139	2.092	2.055	2.025	1.999	1.978	1.959	1.943	1.928	1.916
	25	2.616	2.402	2.277	2.193	2.132	2.085	2.047	2.017	1.991	1.969	1.951	1.934	1.920	1.907
	26	2.609	2.396	2.270	2.186	2.125	2.078	2.040	2.009	1.984	1.962	1.943	1.927	1.912	1.900
	27	2.602	2.389	2.264	2.180	2.118	2.071	2.033	2.003	1.977	1.955	1.936	1.920	1.905	1.892
	28	2.597	2.383	2.258	2.174	2.112	2.065	2.027	1.996	1.971	1.949	1.930	1.913	1.899	1.886
	29	2.591	2.378	2.252	2.168	2.106	2.059	2.021	1.990	1.965	1.943	1.924	1.907	1.893	1.880
	30	2.586	2.373	2.247	2.163	2.101	2.054	2.016	1.985	1.959	1.937	1.918	1.901	1.887	1.874
	40	2.550	2.337	2.211	2.126	2.063	2.015	1.977	1.946	1.919	1.897	1.877	1.860	1.845	1.832
	50	2.528	2.315	2.189	2.104	2.041	1.993	1.954	1.922	1.896	1.873	1.853	1.836	1.820	1.807
	60	2.514	2.301	2.175	2.089	2.026	1.978	1.939	1.907	1.880	1.857	1.837	1.819	1.804	1.790
	70	2.504	2.291	2.164	2.079	2.016	1.967	1.928	1.896	1.869	1.846	1.825	1.808	1.792	1.778
	80	2.496	2.283	2.157	2.071	2.008	1.959	1.920	1.887	1.860	1.837	1.817	1.799	1.783	1.769
	90	2.491	2.277	2.151	2.065	2.002	1.953	1.913	1.881	1.854	1.830	1.810	1.792	1.776	1.762
	100	2.486	2.273	2.146	2.060	1.997	1.948	1.908	1.876	1.849	1.825	1.805	1.787	1.771	1.757
	125	2.478	2.264	2.138	2.051	1.988	1.939	1.899	1.867	1.839	1.816	1.795	1.777	1.761	1.747
	150	2.472	2.259	2.132	2.046	1.982	1.933	1.893	1.861	1.833	1.809	1.789	1.770	1.754	1.740
	175	2.468	2.255	2.128	2.042	1.978	1.929	1.889	1.856	1.828	1.805	1.784	1.766	1.750	1.735
	200	2.465	2.252	2.125	2.039	1.975	1.925	1.886	1.853	1.825	1.801	1.781	1.762	1.746	1.732

Table 2-4: B-Basis Factors for Small Datasets Using Variability of Corresponding Large Dataset

2.4 Specification Limits

Specification limits are calculated based in the qualification dataset only. Specification limits are defined as the limits of a 99% confidence interval around a population parameter where the corresponding *z*-values are determined by some specific table (see below) and known as tolerance factors **k**. The population parameters may be the modulus mean, the strength mean or the strength minimum individual of the qualification dataset. In the case of modulus mean, a two-tail confidence interval is used. In case of strength mean and strength minimum individual, a one-tail left confidence interval is used.

Therefore, in order to compute the specification limits we need to compute the confidence intervals around the mean and minimum individual values from the qualification dataset for some specific material property, according to the following formulas. Let us assume the following:

$x = \text{Some Material Strength Property}$
$\overline{x} = \text{Mean of x}$

$S = \text{Standard Deviation of x}$

Then we define:

$W_{\text{mean}} = W_{\text{mean}}$= Specification limit for the mean
$W_{\text{min indiv}} = W_{\text{min indiv}}$ = Specification limit for the minimum individual

We compute these as the following:

$$W_{\text{mean}} = \overline{x} - k_n^{\text{mean}}.S \quad \textbf{Equation 64}$$

$$W_{\text{min indiv}} = \overline{x} - k_n^{\text{min indiv}}.S \quad \textbf{Equation 65}$$

Where the tolerance factor k^{mean} is found in table 8.5.17 in CMH-17 Vol 1 for n=5 and α =0.01 and tolerance factor $k^{\text{min indiv}}$ is found in table 8.5.18 in CMH-17 Vol 1 for n=5 and α =0.01

For modulus properties we define:

W_{lower} = Lower specification limit for the mean of modulus property
W_{upper} = Upper specification limit for the mean of modulus property

We compute these as the following:

$$W_{\text{lower}} = \overline{x} - k.S \quad \textbf{Equation 66}$$

$$W_{\text{upper}} = \overline{x} + k.S \quad \textbf{Equation 67}$$

Where the tolerance factor k is determined by the following equations:

$$k = t_c.\sqrt{(\frac{1}{N} + \frac{1}{n})} \quad \textbf{Equation 68}$$

and

$$t_c = t.INV(\alpha, N) \quad \textbf{Equation 69}$$

Where t.INV is the inverse of the cumulative Student's t-distribution, N=sample size of the qualification dataset, n=5 and α =0.01.

2.4.1 Specification Limits for Program

The specification limits and qualification data statistics are provided in Table 2-5 for strength properties and in Table 2-6 for modulus properties.

Test Property	Test Condition	Mean [ksi]	CV (%)	Mod CV (%)	k_mean	k_min indiv	As-is		Mod CV		Notes
							W_mean [ksi]	W_min indiv [ksi]	W_mean [ksi]	W_min indiv [ksi]	
90° (fill) Compression (FC) Strength Normalized	RTD (70°F)	90.20	5.050	6.525	1.143	3.072	85.00	76.21	83.48	72.13	Qualification Data Only
90° (fill) Tension (FT) Strength Normalized	RTD (70°F)	148.0	4.576	6.288	1.143	3.072	140.3	127.2	137.4	119.5	Qualification Data Only
Short Beam Strength As-Measured	RTD (70°F)	11.23	3.593	6.000	1.143	3.072	10.77	9.989	10.46	9.159	Qualification Data Only

Table 2-5: Specification Limits for Strength Properties

Test Property	Test Condition	Mean [Msi]	CV (%)	Mod CV (%)	t_statistic	As-is		Mod CV		Notes
						Lower Limit [Msi]	Upper Limit [Msi]	Lower Limit [Msi]	Upper Limit [Msi]	
90° (fill) Compression (FC) Modulus Normalized	RTD (70°F)	9.155	2.168	6.000	2.831	8.871	9.439	8.369	9.941	Qualification Data Only
90° (fill) Tension (FT) Modulus Normalized	RTD (70°F)	9.909	2.741	6.000	2.819	9.524	10.29	9.066	10.75	Qualification Data Only

Table 2-6: Specification Limits for Modulus Properties

3. Summary of Results

The basis values for all tests are summarized in the following tables. The NCAMP recommended B-basis values meet all requirements of CMH-17 Vol 1. However, not all test data meets those requirements. The summary tables provide a complete listing of all computed basis values and estimates of basis values. Data that does not meet the requirements of CMH-17 Vol 1 are shown in shaded boxes and labeled as estimates. Basis values computed with the modified coefficient of variation (CV) are presented whenever possible. Basis values and estimates computed without that modification are presented for all tests.

3.1 NCAMP Recommended B-basis Values

The following rules are used in determining what B-basis value, if any, is included in tables Table 3-1 and Table 3-2 of recommended values.

1. Recommended values are NEVER estimates. Only B-basis values that meet all requirements of CMH-17 Vol 1 are recommended.
2. Modified CV basis values are preferred. Recommended values will be the modified CV basis value when available. The CV provided with the recommended basis value will be the one used in the computation of the basis value.
3. Only normalized basis values are given for properties that are normalized.
4. ANOVA B-basis values are not recommended since only three batches of material are available and CMH-17 Vol 1 recommends that no less than five batches be used when computing basis values with the ANOVA method.
5. Basis values of 90% or more of the mean value imply that the CV is unusually low and may not be conservative. Caution is recommended with B-Basis values calculated from CMH-17 STATS when the B-basis value is 90% or more of the average value. Such values will be indicated.
6. If the data appear questionable (e.g. when the CTD-RTD-ETD1-ETW1-ETW2 trend of the basis values is not consistent with the CTD-RTD-ETD1-ETW1-ETW2 trend of the average values), then the B-basis values will not be recommended.

NCAMP Recommended B-Basis Values for
Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC
All B-Basis Values in this Table Meet the Standards for Publication in the CMH-17 Volume 1
Values Are for Normalized Data Unless Noted

Lamina Strength Tests

Environment	Statistic	WT	FT	WC	FC	IPS*		SBS*
						0.2% Offset Strength	Strength at 5% Strain	
CTD (-65°F)	B-basis	140.7	136.4	NA: A	94.36	7.213	NA: A	12.75
	Mean	157.3	152.4	108.0	103.8	7.960	15.63	14.14
	CV	6.000	6.897	7.662	7.103	6.065	4.772	6.000
RTD (70°F)	B-basis	140.4	132.1	86.29	80.91	5.434	10.59	9.833
	Mean	156.7	148.0	95.20	90.20	6.182	11.91	11.23
	CV	6.000	6.288	6.269	6.525	6.000	6.000	6.000
ETD1 (180°F)	B-basis	144.5	139.0	73.66	69.58	NA: A	NA: A	NA: I
	Mean	160.9	154.8	82.57	78.75	5.291	10.25	9.057
	CV	6.101	6.000	6.561	6.206	7.284	12.79	2.844
ETW1 (180°F)	B-basis	144.8	132.4	60.52	60.29	NA: A	NA: A	6.720
	Mean	161.3	148.0	69.42	69.58	4.252	8.302	7.623
	CV	6.000	6.000	6.799	6.994	6.671	11.16	6.000
ETW2 (250°F)	B-basis	144.5	125.6	48.05	49.16	NA: A	NA: A	5.138
	Mean	160.9	141.5	57.10	58.49	3.035	6.260	5.829
	CV	6.000	6.000	7.882	6.548	7.832	12.81	6.000

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA implies that tests were run but data did not meet NCAMP's recommended requirements.
"NA: A" indicates ANOVA with 3 batches. "NA: I" indicates insufficient data points.
* Data is as-measured rather than normalized

Table 3-1: NCAMP Recommended B-Basis Values for Lamina Test Data

NCAMP Recommended B-Basis Values for
Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC
All B-Basis Values in this Table Meet the Standards for Publication in the CMH-17 Volume 1
Values Are for Normalized Data Unless Noted

Laminate Strength Tests

Layup	Environment	Statistic	OHT	OHC	UNT	UNC	FHT	FHC	SSB Proc. C		CAI
									2% Offset Strength	Ultimate Strength	
25/50/25	CTD (-65°F)	B-basis	52.19	44.87	106.1	NA: I	54.55	NA: I			45.94
		Mean	58.29	48.81	118.5	88.61	60.91	90.69			51.12
		CV	6.000	6.000	6.000	4.072	6.000	3.190			6.000
	RTD (70°F)	B-basis	53.16	36.60	104.2	71.02	54.15	68.78	93.04	113.0	38.16
		Mean	59.26	40.54	116.6	78.45	60.51	75.87	103.6	125.0	43.34
		CV	6.000	6.000	6.000	6.415	6.000	6.000	6.404	6.000	6.000
	ETD1 (180°F)	B-basis	53.08	32.52							
		Mean	59.18	36.46							
		CV	6.000	6.000							
	ETW1 (180°F)	B-basis	52.65	28.94	98.59	55.38	55.10	52.24	81.33	95.71	
		Mean	58.75	32.88	111.0	62.81	61.46	59.19	91.87	107.7	
		CV	6.000	6.000	6.236	6.000	6.000	6.930	6.401	6.220	
	ETW2 (250°F)	B-basis	52.25	23.96	NA: A	44.96	53.59	44.16	77.01	88.80	
		Mean	58.35	27.91	104.6	52.40	59.95	51.19	87.55	100.8	
		CV	6.000	6.000	5.193	6.973	6.000	7.237	6.000	6.000	
10/80/10	CTD (-65°F)	B-basis	NA: A	41.31	NA: I	NA: I	53.51	NA: I			
		Mean	50.91	45.92	69.75	60.72	58.59	65.39			
		CV	2.817	6.000	1.364	5.454	6.000	3.206			
	RTD (70°F)	B-basis	39.37	33.33	NA: I	46.85	45.59	49.90*	90.70	111.5	
		Mean	45.04	37.93	65.52	51.25	50.66	54.64*	100.3	123.0	
		CV	6.377	6.000	1.348	6.000	6.000	6.000	6.255	6.000	
	ETD1 (180°F)	B-basis	NA: I	NA: I							
		Mean	41.24	33.72							
		CV	1.758	1.384							
	ETW1 (180°F)	B-basis	33.71	26.48	52.15	34.30	37.57	38.29*	76.44	93.35	
		Mean	38.24	30.04	59.16	38.71	42.65	43.02*	86.09	104.9	
		CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	
	ETW2 (250°F)	B-basis	32.24	22.20	48.54	27.63	34.82	31.32*	70.21	85.74	
		Mean	36.61	25.18	55.06	32.03	39.90	36.05*	79.86	97.32	
		CV	6.047	6.000	6.000	6.000	6.000	6.000	6.000	6.000	
40/20/40	CTD (-65°F)	B-basis	63.07	45.56	124.9	NA: I	66.63	NA: I			
		Mean	71.10	50.61	139.4	93.64	74.12	96.96			
		CV	6.239	6.000	6.000	4.853	6.095	4.416			
	RTD (70°F)	B-basis	64.90	36.22	121.8	75.50	64.68	NA: I	82.64	105.3	
		Mean	72.93	41.26	136.4	83.27	72.17	78.50	92.29	116.5	
		CV	6.000	6.000	6.000	6.414	6.000	4.994	6.449	6.236	
	ETD1 (180°F)	B-basis	NA: I	NA: I							
		Mean	76.71	37.85							
		CV	4.772	1.893							
	ETW1 (180°F)	B-basis	65.60	30.31	124.3	58.25	65.18	55.13	72.49	89.65	
		Mean	74.42	34.39	138.9	66.02	72.54	63.22	82.14	100.8	
		CV	6.000	6.000	6.000	6.334	6.000	6.568	6.551	6.000	
	ETW2 (250°F)	B-basis	65.11	26.63	122.7	49.88	62.81	46.52	65.11	81.01	
		Mean	73.85	30.20	137.2	57.69	70.17	52.84	74.76	92.21	
		CV	6.000	6.000	6.115	6.043	6.000	6.279	6.649	6.000	

Notes: The modified CV B-basis value is recommended when available.
The CV provided corresponds with the B-basis value given.
NA implies that tests were run but data did not meet NCAMP's recommended requirements.
"NA: A" indicates ANOVA with 3 batches. "NA:I" indicates insufficient data points.
Shaded empty boxes indicate that test data is not available for that property and condition.
*In some cases of FHC>UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate to be used for design.

Table 3-2: NCAMP Recommended B-Basis Values for Laminate Test Data

3.2 Lamina and Laminate Summary Tables

Prepreg Material: Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC **Material Specification:** NMS 380/2 **Process Specification:** NPS 83800 **Fabric:** T800HB 6K 40B **Resin:** TC380 **Tg(dry):** 407.0°F **Tg(wet):** 329.8°F **Tg METHOD:** ASTM D7028	**Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC Lamina Properties Summary**

	Lot 1	Lot 2	Lot 3
Date of fiber manufacture	5/1/2023	7/1/2023	1/1/2024
Date of resin manufacture	3/26/2024	5/10/2024	6/12/2024
Date of prepreg manufacture	3/29/2024	5/29/2024	7/13/2024
Date of composite manufacture		7/19/2024 - 5/13/2025	
Date of testing		10/30/2024 - 9/2/2025	
Date of data submittal		9/4/2025	
Date of analysis		9/15/2025	

LAMINA MECHANICAL PROPERTY B-BASIS SUMMARY
Data reported: As-Measured Followed by Normalized Values in Parentheses. Normalizing CPT: 0.008800 in
Values Shown in Shaded Boxes do not Meet CMH-17 Volume 1 Requirements and are Estimates Only
These Values may not be Used for Certification Unless Specifically Allowed by the Certifying Agency

Test Condition	CTD (-65 °F)			RTD (70 °F)			ETD1 (180 °F)			ETW1 (180 °F)			ETW2 (250 °F)		
Property	**B-Basis**	**Modified CV B-basis**	**Mean**	**B-Basis**	**Modified CV B-basis**	**Mean**	**B-Basis**	**Modified CV B-basis**	**Mean**	**B-Basis**	**Modified CV B-basis**	**Mean**	**B-Basis**	**Modified CV B-basis**	**Mean**
F_1^{tu}	118.3	141.4	159.0	149.4	148.5	165.8	134.6	153.8	171.2	155.4	146.7	164.2	150.4	143.0	160.5
(ksi)	(126.8)	(140.7)	(157.3)	(135.5)	(140.4)	(156.7)	(121.1)	(144.5)	(160.9)	(155.7)	(144.8)	(161.3)	(142.2)	(144.5)	(160.9)
E_1^t			10.43			10.73			10.92			10.42			10.25
(Msi)			(10.32)			(10.10)			(10.26)			(10.24)			(10.27)
ν_{12}^t			0.04598			0.04224			0.04034			0.03954			0.03778
F_2^{tu}	122.1	137.5	153.6	145.6	138.0	154.0	149.0	141.4	157.3	142.2	134.7	150.4	134.1	126.4	142.4
(ksi)	(117.2)	(136.4)	(152.4)	(111.2)	(132.1)	(148.0)	(147.3)	(139.0)	(154.8)	(141.7)	(132.4)	(148.0)	(114.9)	(125.6)	(141.5)
E_2^t			10.29			10.32			10.07			10.21			10.09
(Msi)			(10.21)			(9.909)			(9.909)			(10.05)			(10.02)
F_1^{cu}	71.64	NA	109.1	92.95	91.48	101.1	74.99	73.52	83.09	62.93	61.46	71.03	50.85	49.36	59.08
(ksi)	(58.02)	NA	(108.0)	(88.02)	(86.29)	(95.20)	(75.39)	(73.66)	(82.57)	(62.25)	(60.52)	(69.42)	(37.05)	(48.05)	(57.10)
E_1^c			9.569			9.865			9.566			9.872			10.05
(Msi)			(9.469)			(9.235)			(9.586)			(9.655)			(9.698)
F_2^{cu}	96.42	95.09	104.5	82.33	81.01	90.31	71.44	70.15	79.32	61.99	60.67	69.97	43.50	49.69	59.03
(ksi)	(95.61)	(94.36)	(103.8)	(82.14)	(80.91)	(90.20)	(70.79)	(69.58)	(78.75)	(61.52)	(60.29)	(69.58)	(45.30)	(49.16)	(58.49)
E_2^c			9.305			9.162			9.482			9.505			9.395
(Msi)			(9.242)			(9.155)			(9.401)			(9.457)			(9.305)
$F_{12}^{s0.2\%}$ (ksi)	6.086	7.213	7.960	5.796	5.434	6.182	3.240	NA	5.291	2.789	NA	4.252	1.891	NA	3.035
$F_{12}^{s5\%}$ (ksi)	10.80	NA	15.63	11.19	10.59	11.91	2.859	NA	10.25	2.611	NA	8.302	1.868	NA	6.260
G_{12}^s (Msi)			0.6265			0.5510			0.4963			0.4319			0.3069
SBS (ksi)	13.48	12.75	14.14	10.57	9.833	11.23	8.277	6.863	9.057	6.383	6.720	7.623	5.582	5.138	5.829

Table 3-3: Summary of B-Basis Values and B-Estimates for Lamina Tests

Prepreg Material: Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC
Material Specification: NMS 380/2
Process Specification: NPS 83800
Fabric: T800HB 6K 40B **Resin:** TC380

Toray Advanced Composites TC380 T800HB 6K 2x2 Twill 200gsm with 40% RC Laminate Properties Summary

Tg(dry): 407.0°F **Tg(wet):** 329.8°F **Tg METHOD:** ASTM D7028

	Lot 1	Lot 2	Lot 3
Date of fiber manufacture	5/1/2023	7/1/2023	1/1/2024
Date of resin manufacture	3/26/2024	5/10/2024	6/12/2024
Date of prepreg manufacture	3/29/2024	5/29/2024	7/13/2024
Date of composite manufacture		7/19/2024 - 5/13/2025	
Date of testing		10/30/2024 - 9/2/2025	
Date of data submittal		9/4/2025	
Date of analysis		9/15/2025	

LAMINATE MECHANICAL PROPERTY B-BASIS SUMMARY
Data Reported Normalized, Unless Noted, Normalizing CPT: 0.008800 in
Values Shown in Shaded Boxes do not Meet CMH-17 Volume 1 Requirements and are Estimates Only
These Values may not be Used for Certification Unless Specifically Allowed by the Certifying Agency

Test	Property	Layup:		Quasi Isotropic 25/50/25			"Soft" 10/80/10			"Hard" 40/20/40		
		Test Condition	Unit	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean
OHT	Strength	CTD (-65 °F)	(ksi)	52.10	52.19	58.29	42.88	NA	50.91	66.48	63.07	71.10
		RTD (70 °F)		56.70	53.16	59.26	41.04	39.37	45.04	68.30	64.90	72.93
		ETD1 (180 °F)		53.73	53.08	59.18	39.04	31.25	41.24	65.62	58.12	76.71
		ETW1 (180 °F)		56.51	52.65	58.75	32.70	33.71	38.24	71.14	65.60	74.42
		ETW2 (250 °F)		54.59	52.25	58.35	31.11	32.24	36.61	69.98	65.11	73.85
OHC	Strength	CTD (-65 °F)	(ksi)	46.26	44.87	48.81	44.06	41.31	45.92	48.35	45.56	50.61
		RTD (70 °F)		34.49	36.60	40.54	36.07	33.33	37.93	39.01	36.22	41.26
		ETD1 (180 °F)		30.77	32.52	36.46	32.31	25.55	33.72	35.68	28.68	37.85
		ETW1 (180 °F)		31.26	28.94	32.88	24.67	26.48	30.04	32.44	30.31	34.39
		ETW2 (250 °F)		26.49	23.96	27.91	21.74	22.20	25.18	28.17	26.63	30.20
UNT	Strength	CTD (-65 °F)	(ksi)	109.4	106.1	118.5	66.87	52.85	69.75	131.7	124.9	139.4
	Modulus		(Msi)			7.326			4.565			9.311
	Strength	RTD (70 °F)	(ksi)	96.75	104.2	116.6	62.85	49.64	65.52	113.6	121.8	136.4
	Modulus		(Msi)			7.001			4.334			8.988
	Strength	ETW1 (180 °F)	(ksi)	80.63	98.59	111.0	53.51	52.15	59.16	129.5	124.3	138.9
	Modulus		(Msi)			7.035			4.101			9.040
	Strength	ETW2 (250 °F)	(ksi)	68.62	NA	104.6	49.95	48.54	55.06	125.7	122.7	137.2
	Modulus		(Msi)			6.717			3.888			8.999
UNC	Strength	CTD (-65 °F)	(ksi)	77.68	67.14	88.61	50.69	46.00	60.72	79.88	70.95	93.64
	Modulus		(Msi)			6.679			4.355			8.500
	Strength	RTD (70 °F)	(ksi)	73.12	71.02	78.45	47.86	46.85	51.25	77.58	75.50	83.27
	Modulus		(Msi)			6.498			4.083			8.267
	Strength	ETW1 (180 °F)	(ksi)	57.48	55.38	62.81	36.40	34.30	38.71	60.32	58.25	66.02
	Modulus		(Msi)			6.551			3.953			8.524
	Strength	ETW2 (250 °F)	(ksi)	47.07	44.96	52.40	29.41	27.63	32.03	51.96	49.88	57.69
	Modulus		(Msi)			6.490			3.733			8.544
FHT	Strength	CTD (-65 °F)	(ksi)	58.24	54.55	60.91	53.15	53.51	58.59	68.88	66.63	74.12
		RTD (70 °F)		57.84	54.15	60.51	47.90	45.59	50.66	66.93	64.68	72.17
		ETW1 (180 °F)		56.29	55.10	61.46	39.88	37.57	42.65	61.24	65.18	72.54
		ETW2 (250 °F)		55.31	53.59	59.95	37.04	34.82	39.90	61.89	62.81	70.17
FHC	Strength	CTD (-65 °F)	(ksi)	83.79*	NA	90.69*	59.57*	50.87*	65.39*	88.09*	80.90*	96.96*
		RTD (70 °F)		61.28	68.78	75.87	52.43*	49.90*	54.63*	70.22	65.24	78.50
		ETW1 (180 °F)		52.86	52.24	59.19	40.82*	38.29*	43.02*	56.89	55.13	63.22
		ETW2 (250 °F)		45.00	44.16	51.19	29.30	31.32*	36.05*	42.30	46.52	52.84

***In some cases of FHC>UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate to be used for design.**

Table 3-4: Summary of B-Basis Values and B-Estimates for Laminate Tests - Part A

Test	Property	Layup:		Quasi Isotropic 25/50/25			"Soft" 10/80/10			"Hard" 40/20/40		
		Test Condition	Unit	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean	B-value	Mod. CV B-value	Mean
Single Shear Bearing Proc. C	2% Offset Strength	RTD (70 °F)	(ksi)	93.75	93.04	103.6	75.25	90.70	100.3	84.79	82.64	92.29
		ETW1 (180 °F)		68.46	81.33	91.87	81.10	76.44	86.09	74.65	72.49	82.14
		ETW2 (250 °F)		71.49	77.01	87.55	74.61	70.21	79.86	67.27	65.11	74.76
	Ultimate Strength	RTD (70 °F)	(ksi)	119.3	113.0	125.0	102.6	111.5	123.0	88.88	105.3	116.5
		ETW1 (180 °F)		98.76	95.71	107.7	98.51	93.35	104.9	96.00	89.65	100.8
		ETW2 (250 °F)		92.84	88.80	100.8	92.41	85.74	97.32	88.30	81.01	92.21
	Chord Stiffness	RTD (70 °F)	(Msi)			1.502			1.044			1.343
		ETW1 (180 °F)				1.489			1.044			1.335
		ETW2 (250 °F)				1.462			0.9953			1.293
ILT**	Strength	CTD (-65 °F)	(ksi)			15.78						
		RTD (70 °F)				13.20						
		ETW1 (180 °F)				8.404						
	Curved Beam Strength	CTD (-65 °F)	(lb)			558.0						
		RTD (70 °F)				459.8						
		ETW1 (180 °F)				308.0						
CAI	Strength	CTD (-65 °F)	(ksi)	44.79	45.94	51.12						
		RTD (70 °F)		40.84	38.16	43.34						41.52

**The actual layup for ILT is [0]20, (50/0/50). The ILT property is reported as-measured.

Table 3-5: Summary of B-Basis Values and B-Estimates for Laminate Tests - Part B

4. Individual Test Summaries, Statistics, Basis Values and Graphs

Test data for fiber dominated properties was normalized according to nominal cured ply thickness. Both normalized and as-measured statistics were included in the tables, but only the normalized data values were graphed. Test failures, outliers and explanations regarding computational choices were noted in the accompanying text for each test.

All individual specimen results are graphed for each test by batch and environmental condition with a line indicating the recommended basis values for each environmental condition. The data is jittered (moved slightly to the left or right) in order for all specimen values to be clearly visible. The strength values are always graphed on the vertical axis with the scale adjusted to include all data values and their corresponding basis values. The vertical axis may not include zero. The horizontal axis values will vary depending on the data and how much overlapping there was of the data within and between batches. When there was little variation, the batches were graphed from left to right. The environmental conditions were identified by the shape and color of the symbol used to plot the data. Otherwise, the environmental conditions were graphed from left to right and the batches were identified by the shape and color of the symbol.

When a dataset fails the Anderson-Darling k-sample (ADK) test for batch-to-batch variation, an ANOVA analysis is required. In order for B-basis values to be computed using the ANOVA method, data from five batches are required. Since this qualification dataset has only three batches, the basis values computed using ANOVA are considered estimates only. However, the basis values resulting from the ANOVA method using only three batches may be overly conservative. The ADK test is performed again after a transformation of the data according to the assumptions of the modified CV method (see section 2.1.4 for details). If the dataset still passes the ADK test at this point, modified CV basis values are provided. If the dataset does not pass the ADK test after the transformation, estimates may be computed using the modified CV method per the guidelines of CMH-17 Vol 1, found in section 8.4.4 of the Handbook.

4.1 Warp Tension (WT)

Warp Tension data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the CTD, RTD, ETD1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions and the normal method was used for ETW1. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD and ETD1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions and the normal method was used for the remaining conditions. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were no statistical outliers.

Statistics, estimates, and basis values are given for the WT strength data in Table 4-1 and for the modulus data in Table 4-2. The normalized data, B-estimates, and B-basis values are shown graphically in Figure 4-1.

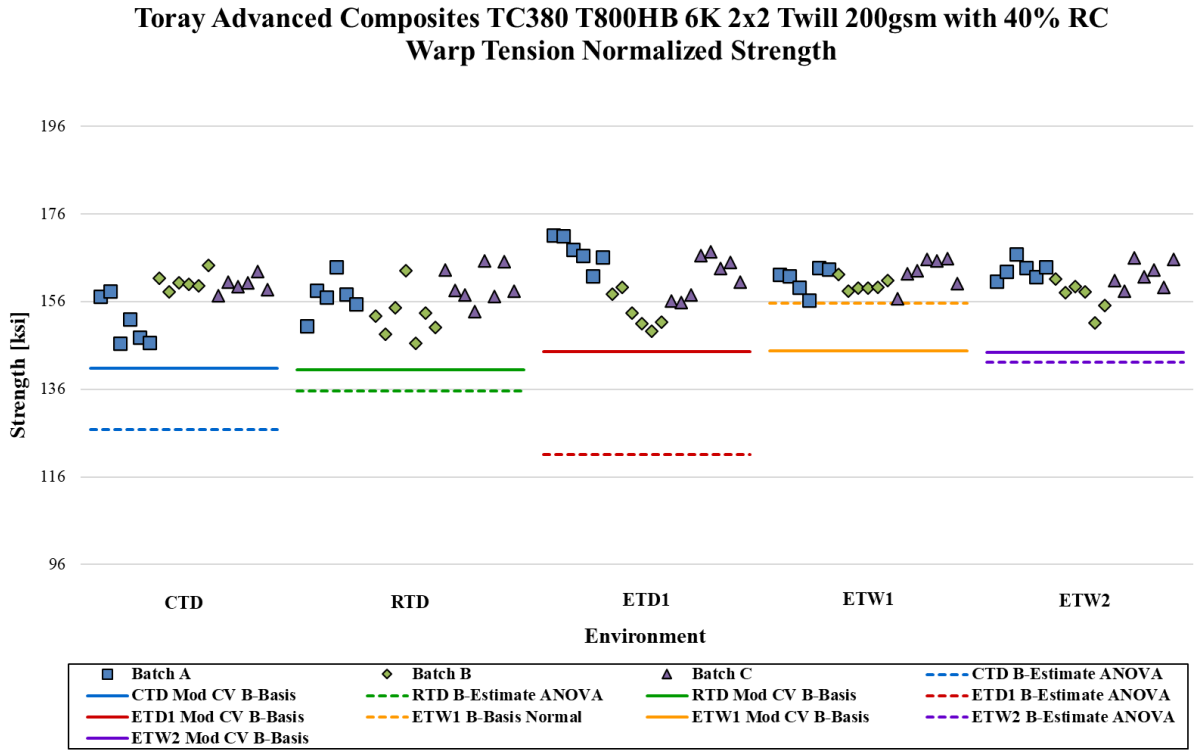

Figure 4-1: Batch Plot for WT Normalized Strength

WT Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	157.3	156.7	160.9	161.3	160.9	159.0	165.8	171.2	164.2	160.5
Std. Dev.	5.370	5.288	6.761	2.867	3.849	6.431	8.665	7.771	4.520	5.169
CV	3.414	3.375	4.201	1.778	2.392	4.045	5.228	4.540	2.753	3.220
Modified CV	6.000	6.000	6.101	6.000	6.000	6.023	6.614	6.270	6.000	6.000
Min	146.5	146.4	149.2	156.3	151.1	145.4	151.1	156.1	156.9	150.2
Max	164.2	165.3	171.2	165.8	166.8	166.5	182.4	186.7	171.8	168.4
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	22	20	19	19	18	22	20	19	19
Basis Values and Estimates										
B-Basis				155.7			149.4		155.4	150.4
B-Estimate	126.8	135.5	121.1		142.2	118.3		134.6		
A-Estimate	105.0	120.5	92.76	151.7	128.9	89.21	137.7	108.5	149.1	143.3
Method	ANOVA	ANOVA	ANOVA	Normal	ANOVA	ANOVA	Normal	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates										
B-Basis	140.7	140.4	144.5	144.8	144.5	141.4	148.5	153.8	146.7	143.0
A-Estimate	129.9	129.6	133.7	134.0	133.7	129.9	137.0	142.3	135.2	131.5
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-1: Statistics and Basis values for WT Strength Data

WT Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	10.32	10.10	10.26	10.24	10.27	10.43	10.73	10.92	10.42	10.25
Std. Dev.	0.1532	0.1165	0.05605	0.07509	0.08261	0.2168	0.3911	0.3321	0.2838	0.2303
CV	1.484	1.154	0.5462	0.7336	0.8041	2.078	3.645	3.042	2.723	2.248
Min	10.04	9.881	10.14	10.08	10.11	10.05	10.09	10.47	9.961	9.827
Max	10.72	10.29	10.37	10.35	10.42	10.83	11.49	11.59	10.92	10.72
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	20	20	19	19	18	20	20	19	19

Table 4-2: Statistics for WT Modulus Data

4.2 Fill Tension (FT)

Fill Tension data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the CTD, RTD, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for ETD1 and ETW1. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that conditions. The remaining conditions met al the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There was one statistical outlier. The lowest value in batch C of the ETW2 condition was a batch and condition outlier in the normalized and as-measured datasets. It was retained for this analysis.

Statistics, estimates and basis values are given for the FT strength data in Table 4-3 and for the modulus data in Table 4-4. The normalized data, B-estimates and the B-basis values are shown graphically in Figure 4-2.

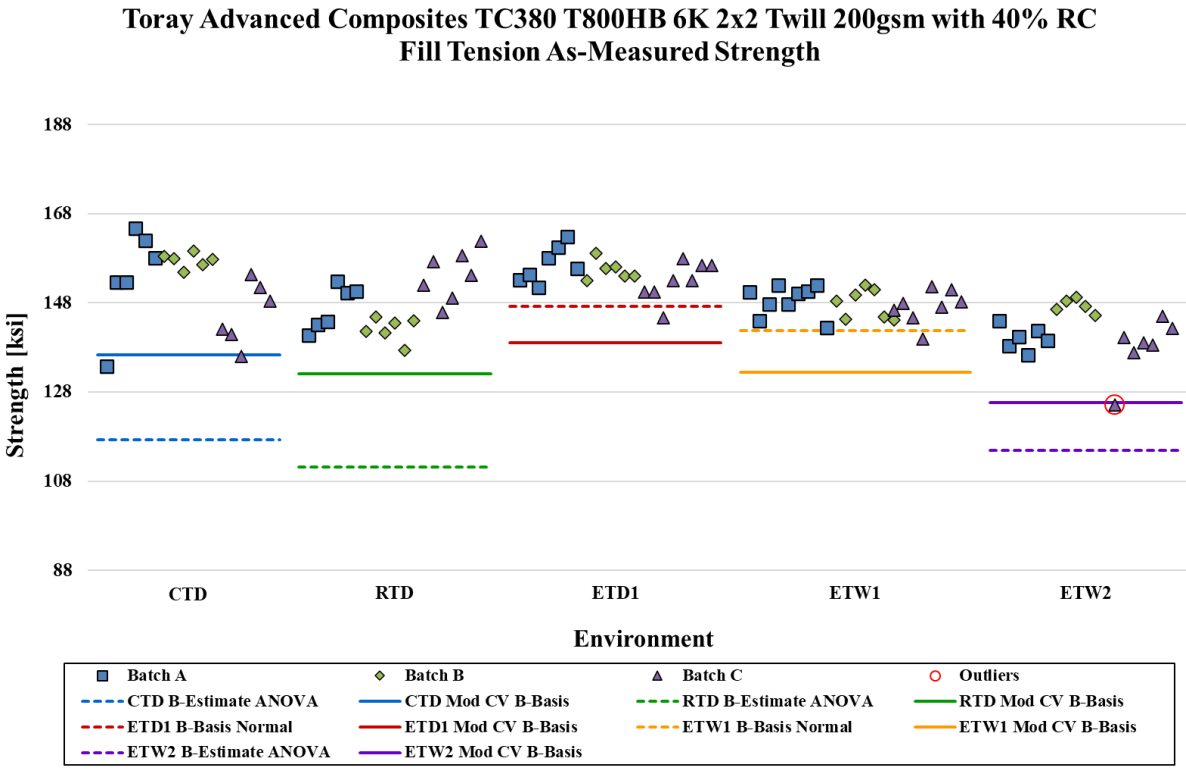

Figure 4-2: Batch Plot for FT Normalized Strength

FT Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	152.4	148.0	154.8	148.0	141.5	153.6	154.0	157.3	150.4	142.4
Std. Dev.	8.828	6.774	3.944	3.371	5.558	8.592	6.318	3.876	3.614	5.450
CV	5.794	4.576	2.548	2.278	3.929	5.595	4.102	2.464	2.403	3.826
Modified CV	6.897	6.288	6.000	6.000	6.000	6.798	6.051	6.000	6.000	6.000
Min	133.8	137.3	144.7	139.9	125.1	135.4	142.7	147.7	142.2	125.6
Max	164.7	161.8	162.8	152.0	149.3	166.7	165.2	164.9	155.4	150.9
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	19	21	23	19	18	19	21	23	19
Basis Values and Estimates										
B-Basis			147.3	141.7			145.6	149.0	142.2	134.1
B-Estimate	117.2	111.2			114.9	122.1				
A-Estimate	92.17	84.94	141.9	137.2	95.91	99.76	140.1	143.4	136.6	128.5
Method	ANOVA	ANOVA	Normal	Normal	ANOVA	ANOVA	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates										
B-Basis	136.4	132.1	139.0	132.4	125.6	137.5	138.0	141.4	134.7	126.4
A-Estimate	125.9	121.7	128.6	121.9	115.1	127.0	127.5	130.9	124.1	115.9
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-3: Statistics and Basis Values for FT Strength Data

FT Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	10.21	9.909	9.909	10.05	10.02	10.29	10.32	10.07	10.21	10.09
Std. Dev.	0.1769	0.2716	0.1520	0.3395	0.3479	0.1879	0.4756	0.1605	0.3568	0.4006
CV	1.733	2.741	1.534	3.378	3.474	1.826	4.610	1.594	3.493	3.972
Min	9.817	9.377	9.687	9.498	9.583	9.879	9.535	9.811	9.576	9.624
Max	10.45	10.47	10.32	10.90	11.22	10.55	11.01	10.49	11.01	11.40
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	19	21	23	19	18	19	21	23	19

Table 4-4: Statistics for FT Modulus Data

4.3 Warp Compression (WC)

Warp Compression data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, the CTD condition failed the ADK test, therefore modified CV basis values were not computed for CTD. The remaining conditions met all the requirements for pooling.

For the as-measured dataset, the CTD conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that conditions. The remaining conditions met all the requirements for pooling. Applying the modified CV, the CTD condition failed the ADK test, therefore modified CV basis values were not computed for CTD. The remaining conditions met all the requirements for pooling.

There were no statistical outliers.

Statistics, basis values and estimates are given for the WC strength data in Table 4-5 and for the modulus data in Table 4-6. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-3.

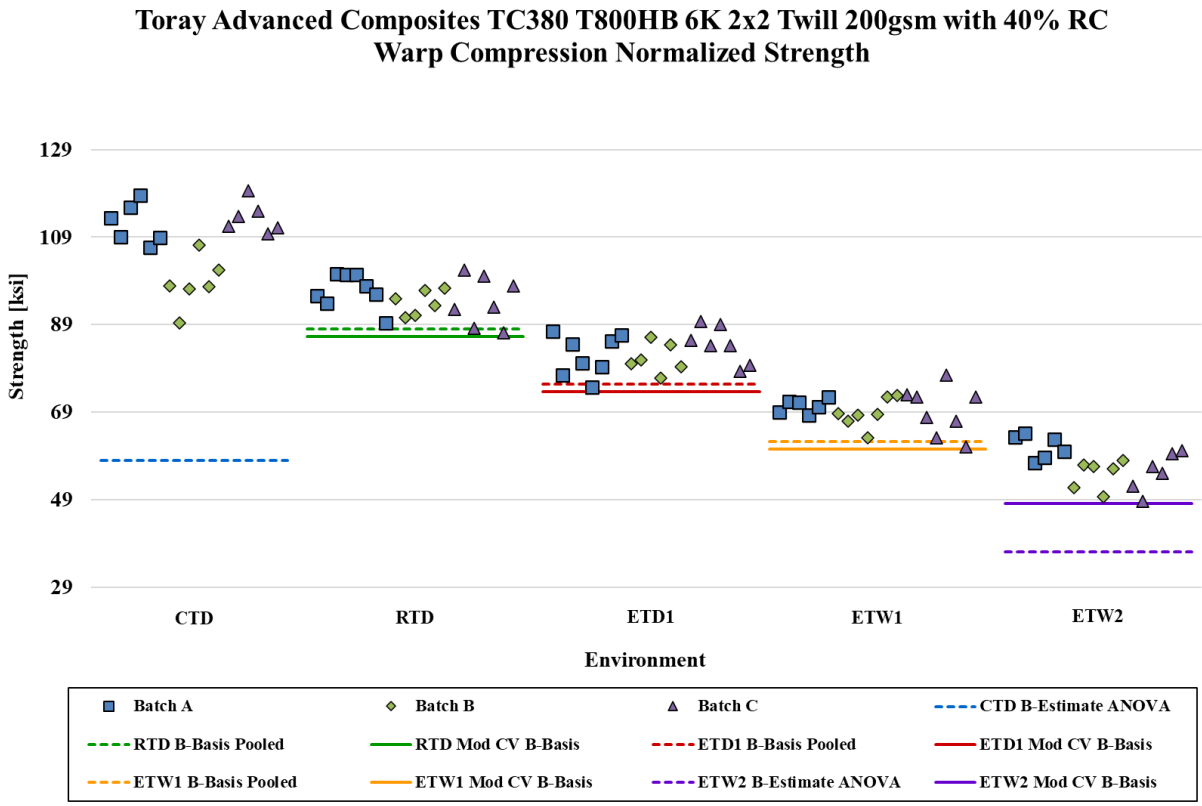

Figure 4-3: Batch Plot for WC Normalized Strength

WC Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	108.0	95.20	82.57	69.42	57.10	109.1	101.1	83.09	71.03	59.08
Std. Dev.	8.275	4.320	4.229	3.887	4.433	7.266	5.868	4.897	3.858	3.929
CV	7.662	4.538	5.122	5.599	7.765	6.663	5.807	5.894	5.432	6.651
Modified CV	7.831	6.269	6.561	6.799	7.882	7.331	6.903	6.947	6.716	7.326
Min	89.34	87.10	74.70	61.15	48.72	92.09	88.94	73.30	62.19	51.66
Max	119.6	101.5	89.76	77.50	64.27	119.7	110.1	93.24	77.59	64.83
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	21	21	21	18	18	21	21	21	18
Basis Values and Estimates										
B-Basis		88.02	75.39	62.25			92.95	74.99	62.93	50.85
B-Estimate	58.02				37.05	71.64				
A-Estimate	22.36	83.18	70.55	57.40	22.76	44.95	87.54	69.58	57.51	45.45
Method	ANOVA	Pooled	Pooled	Pooled	ANOVA	ANOVA	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates										
B-Basis	NA	86.29	73.66	60.52	48.05	NA	91.48	73.52	61.46	49.36
A-Estimate		80.34	67.71	54.56	42.12		85.08	67.12	55.06	42.98
Method		Pooled	Pooled	Pooled	Pooled		Pooled	Pooled	Pooled	Pooled

Table 4-5: Statistics and Basis Values for WC Strength Data

WC Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	9.469	9.235	9.586	9.655	9.698	9.569	9.865	9.566	9.872	10.05
Std. Dev.	0.1593	0.2499	0.1276	0.2016	0.1776	0.1702	0.3037	0.1681	0.2480	0.4831
CV	1.683	2.707	1.331	2.088	1.831	1.778	3.078	1.757	2.513	4.806
Min	9.193	8.807	9.443	9.197	9.347	9.104	9.444	9.340	9.473	9.391
Max	9.700	9.778	9.947	10.03	9.944	9.869	10.44	9.925	10.27	10.90
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18	18	18

Table 4-6: Statistics for WC Modulus Data

4.4 Fill Compression (FC)

Fill Compression data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The results were identical for the normalized and as-measured datasets. The ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The remaining conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were four statistical outliers. The lowest value in batch B of the CTD condition was a batch outlier in the as-measured dataset. The lowest value in batch A of the ETD1 condition was a condition outlier in the as-measured dataset. The lowest value in batch C of the ETW1 condition was a batch and condition outlier in the normalized and as-measured datasets. The lowest value in batch C of the ETW2 condition was a batch and condition outlier in the normalized and as-measured datasets. They were retained for this analysis.

Statistics, basis values and estimates are given for the FC strength data in Table 4-7 and for the modulus data in Table 4-8. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-4.

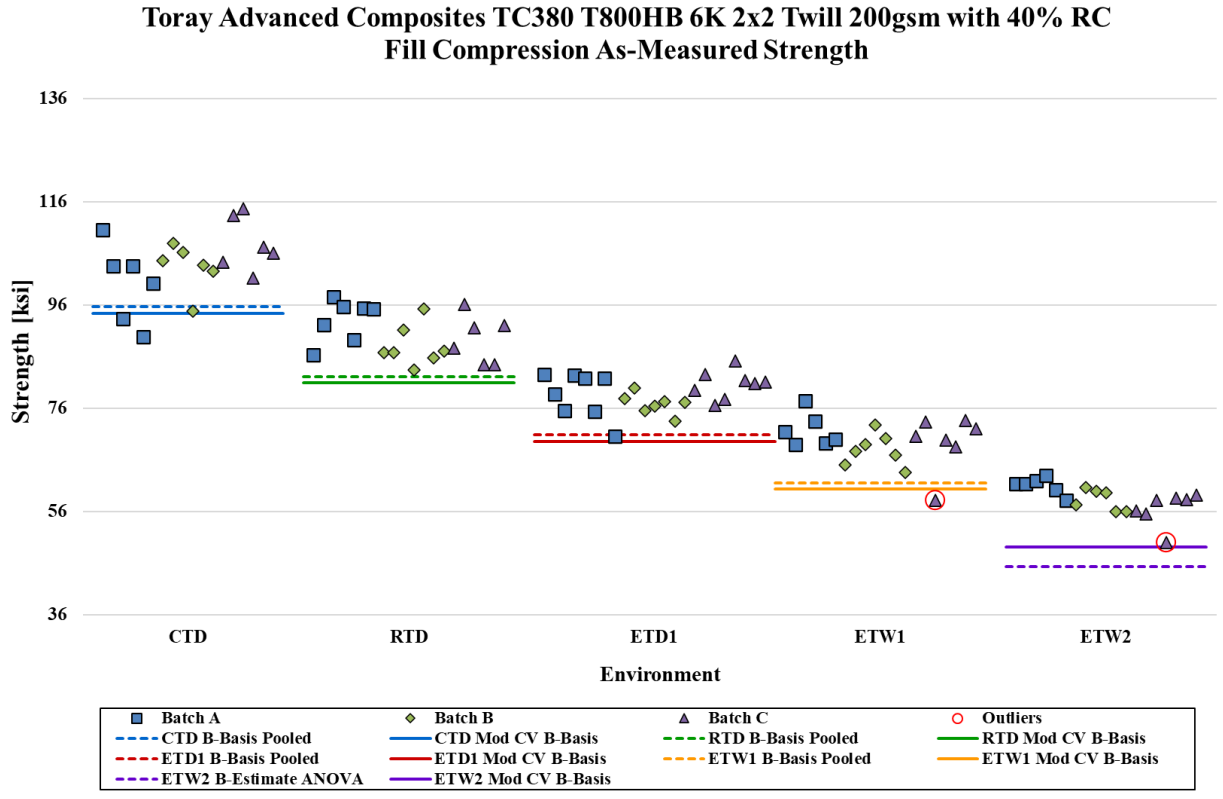

Figure 4-4: Batch Plot for FC Normalized Strength

FC Strength (ksi) As-Measured Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	103.8	90.20	78.75	69.58	58.49	104.5	90.31	79.32	69.97	59.03
Std. Dev.	6.439	4.555	3.474	4.167	2.981	6.703	4.262	3.337	4.023	3.139
CV	6.206	5.050	4.411	5.988	5.097	6.416	4.719	4.207	5.750	5.317
Modified CV	7.103	6.525	6.206	6.994	6.548	7.208	6.360	6.104	6.875	6.659
Min	89.81	83.44	70.52	58.19	50.02	88.81	83.09	69.51	58.33	50.02
Max	114.7	97.61	85.20	77.48	62.97	115.7	96.36	84.54	78.00	63.45
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	20	23	20	19	18	20	23	20	19
Basis Values and Estimates										
B-Basis	95.61	82.14	70.79	61.52		96.42	82.33	71.44	61.99	
B-Estimate					45.30					43.50
A-Estimate	90.27	76.79	65.42	56.17	35.89	91.12	77.02	66.12	56.69	32.42
Method	Pooled	Pooled	Pooled	Pooled	ANOVA	Pooled	Pooled	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates										
B-Basis	94.36	80.91	69.58	60.29	49.16	95.09	81.01	70.15	60.67	49.69
A-Estimate	88.25	74.78	63.43	54.16	43.03	88.96	74.88	63.99	54.54	43.56
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-7: Statistics and Basis Values for FC Strength Data

FC Modulus (Msi) Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	9.242	9.155	9.401	9.457	9.305	9.305	9.162	9.482	9.505	9.395
Std. Dev.	0.1559	0.1985	0.2636	0.1399	0.2373	0.1326	0.2306	0.3219	0.1785	0.2661
CV	1.687	2.168	2.804	1.479	2.550	1.425	2.517	3.395	1.878	2.833
Min	8.949	8.678	8.988	9.212	8.967	9.027	8.699	8.854	9.247	9.007
Max	9.524	9.483	9.865	9.726	9.780	9.470	9.633	9.951	9.817	9.963
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	19	18	18	18	18	19	18	18	18	18

Table 4-8: Statistics for FC Modulus Data

4.5 In-Plane Shear (IPS)

In Plane Shear data is not normalized. 0.2% offset strength, strength at 5% strain and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the 0.2% Offset Strength dataset, the CTD, ETD1, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for RTD. Applying the modified CV, the ETD1, ETW1, and ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for those conditions. The CTD and RTD met all the requirements for pooling.

For the Strength at 5% strain dataset, the CTD, ETD1, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. A-estimates for ETD1, ETW1, and ETW2 were set to zero because the results were negative. The RTD condition failed all the distributions tests, therefore the non-parametric method was used for that conditions. Applying the modified CV, the CTD, ETD1, ETW1, and ETW2 conditions failed the ADK test, therefore modified CV basis values were not computed for those conditions. The normal method was used for RTD.

There was one statistical outlier. The highest value in batch C of the CTD condition was a batch outlier in the 0.2% offset strength and strength at 5% strain datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the IPS strength data in Table 4-9 and for the modulus data in Table 4-10. The as-measured data, B-basis values and B-estimates are shown graphically for 0.2% offset strength in Figure 4-5 and for strength at 5% strain in Figure 4-6.

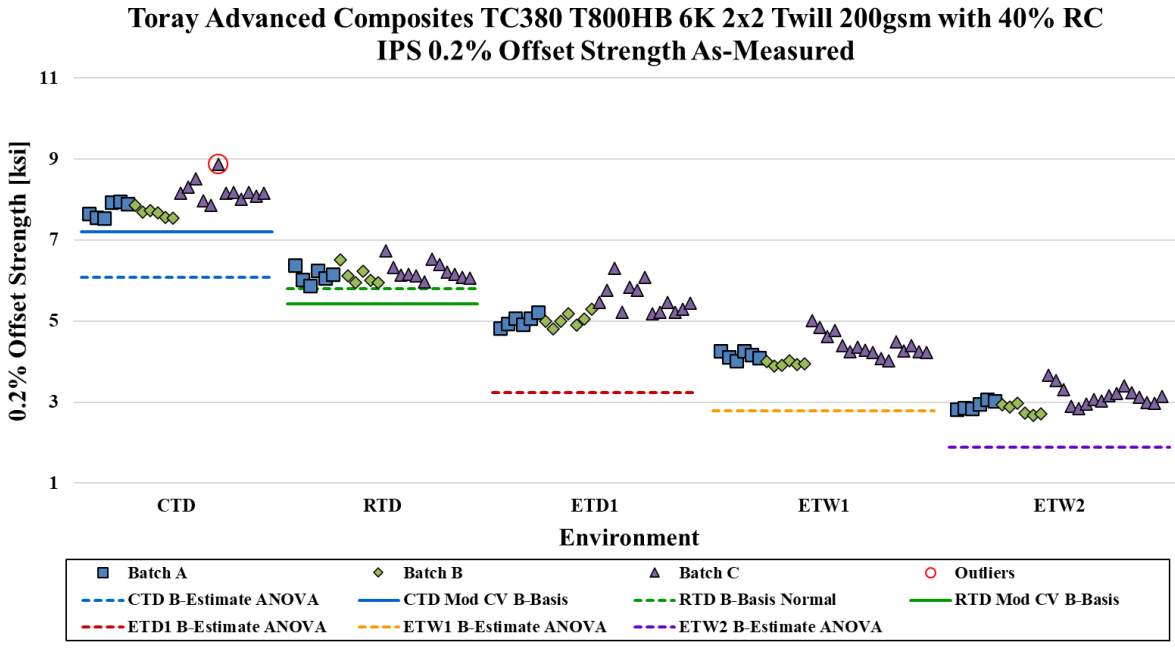

Figure 4-5: Batch Plot for IPS 0.2% Offset Strength

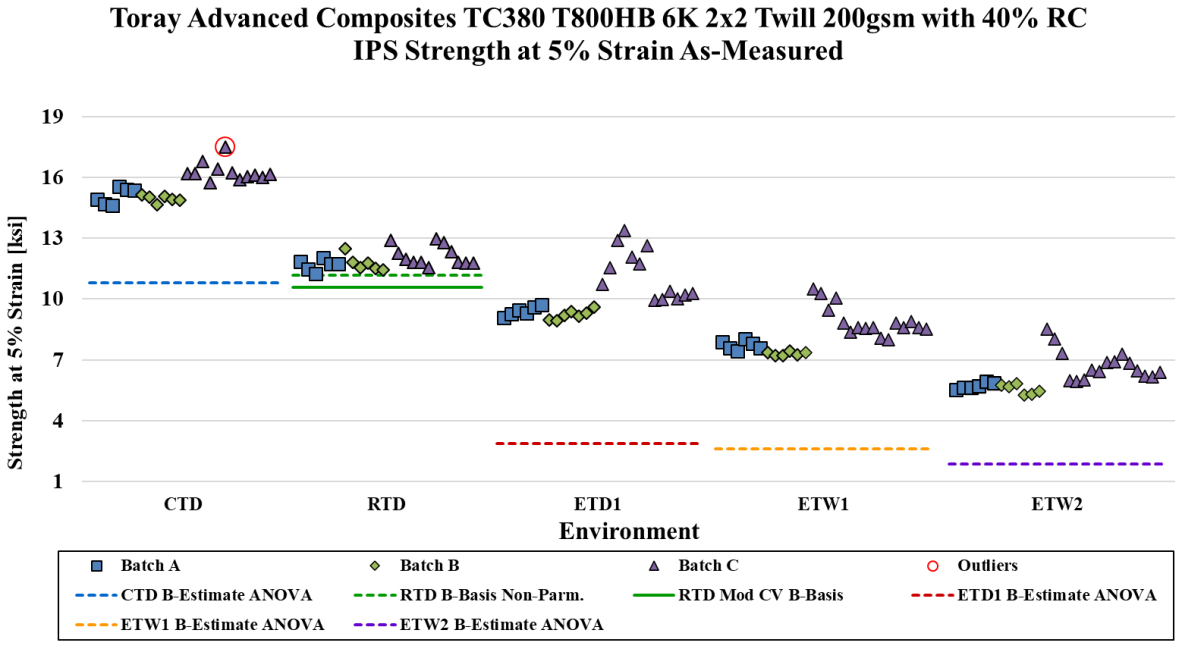

Figure 4-6: Batch Plot for IPS Strength at 5% Strain

IPS (ksi) As-Measured Basis Values and Statistics										
	0.2% Offset Strength					Strength at 5% Strain				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	7.960	6.182	5.291	4.252	3.035	15.63	11.91	10.25	8.302	6.260
Std. Dev.	0.3287	0.2081	0.3854	0.2837	0.2377	0.7456	0.4594	1.310	0.9262	0.8016
CV	4.130	3.366	7.284	6.671	7.832	4.772	3.856	12.79	11.16	12.81
Modified CV	6.065	6.000	7.642	7.336	7.916	6.386	6.000	12.79	11.16	12.81
Min	7.539	5.871	4.809	3.890	2.682	14.58	11.24	8.910	7.187	5.277
Max	8.868	6.732	6.313	5.008	3.673	17.48	12.94	13.37	10.48	8.527
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	24	24	26	28	28	24	24	26	28	28
Basis Values and Estimates										
B-Basis		5.796					11.19			
B-Estimate	6.086		3.240	2.789	1.891	10.80		2.859	2.611	1.868
A-Estimate	4.748	5.520	1.775	1.743	1.073	7.359	9.542	0.000	0.000	0.000
Method	ANOVA	Normal	ANOVA	ANOVA	ANOVA	ANOVA	Non-Parm.	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis	7.213	5.434	NA	NA	NA	NA	10.59	NA	NA	NA
A-Estimate	6.694	4.916					9.641			
Method	Pooled	Pooled					Normal			

Table 4-9: Statistics and Basis Values for IPS Strength Data

IPS Modulus (Msi) As-Measured Statistics					
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	0.6265	0.5510	0.4963	0.4319	0.3069
Std. Dev.	0.02364	0.02036	0.03366	0.02842	0.02038
CV	3.774	3.694	6.784	6.580	6.640
Min	0.5865	0.5238	0.4485	0.3999	0.2747
Max	0.6665	0.6048	0.5903	0.5133	0.3594
No. Batches	3	3	3	3	3
No. Specimens	24	24	25	28	28

Table 4-10: Statistics for IPS Modulus Data

4.6 Lamina Short-Beam Strength (SBS)

The Short Beam Strength data is not normalized. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW2, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

The ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The ETW2 condition failed all the distribution tests, therefore the non-parametric method was used for that condition. The normal method was used for ETD1 and the CTD and RTD conditions met all the requirements for pooling. Applying the modified CV, the CTD and RTD conditions met all the requirements for pooling, and the normal method was used for the remaining conditions.

There was one statistical outlier. The lowest value in batch C of the CTD condition was a condition outlier. It was retained for this analysis.

Statistics, basis values and estimates are given for the SBS data in Table 4-11. The as-measured data, B-estimates and B-basis values are shown graphically in Figure 4-7.

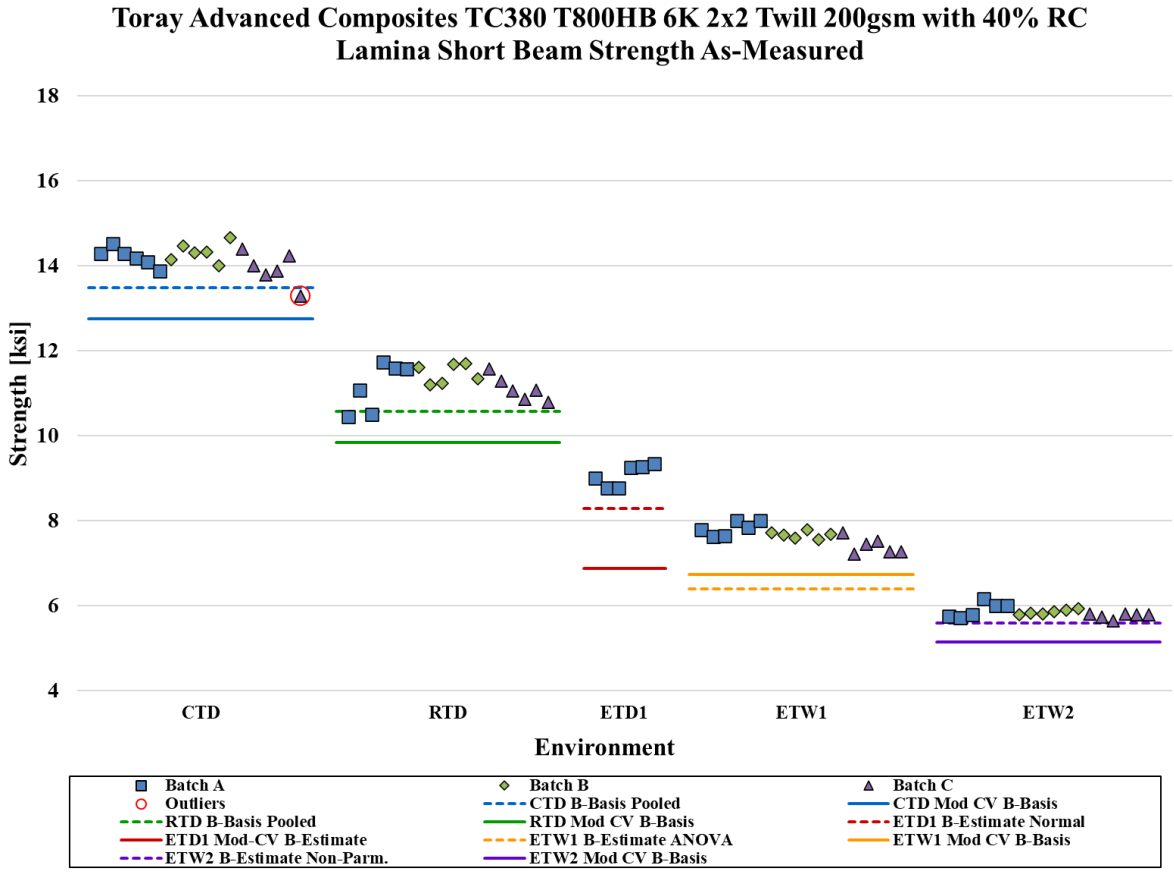

Figure 4-7: Batch Plot for SBS As-Measured

SBS Strength (ksi) As-Measured Basis Values and Statistics					
Environment	**CTD (-65 °F)**	**RTD (70 °F)**	**ETD1 (180 °F)**	**ETW1 (180 °F)**	**ETW2 (250 °F)**
Mean	14.14	11.23	9.057	7.623	5.829
Std. Dev.	0.3196	0.4034	0.2576	0.2247	0.1230
CV	2.260	3.593	2.844	2.947	2.110
Modified CV	6.000	6.000	8.000	6.000	6.000
Min	13.28	10.43	8.759	7.216	5.637
Max	14.65	11.73	9.337	7.991	6.153
No. Batches	3	3	1	3	3
No. Specimens	18	18	6	18	18
Basis Values and Estimates					
B-Basis	13.48	10.57			5.582
B-Estimate			8.277	6.383	
A-Estimate	13.03	10.11	7.723	5.498	4.943
Method	Pooled	Pooled	Normal	ANOVA	Non-Parm.
Modified CV Basis Values and Estimates					
B-Basis	12.75	9.833		6.720	5.138
B-Estimate			6.863		
A-Estimate	11.80	8.884	5.302	6.080	4.649
Method	Pooled	Pooled	Normal	Normal	Normal

Table 4-11: Statistics and Basis Values for SBS Data

4.7 "25/50/25" Unnotched Tension (UNT1)

The UNT1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the RTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for CTD. Applying the modified CV, the ETW2 condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The remaining conditions met all the requirements for pooling.

For the as-measured dataset, the RTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for CTD. Applying the modified CV, the ETW1 and ETW2 conditions failed the ADK test, therefore modified CV basis values were not computed for those condition. The CTD and RTD conditions met all the requirements for pooling.

There were two statistical outliers. The lowest value in batch C of the ETW2 condition was a batch outlier in the normalized and as-measured datasets. The lowest value in batch B of the CTD condition was a batch outlier in the normalized dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNT1 strength data in Table 4-12 and for the modulus data in Table 4-13. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-8.

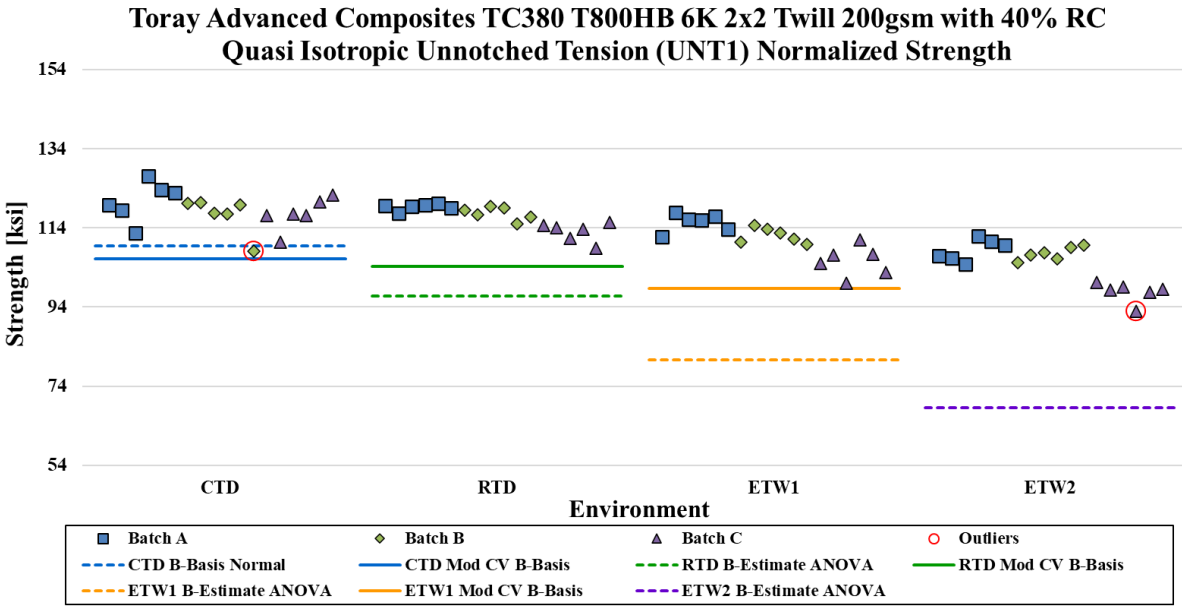

Figure 4-8: Batch Plot for UNT1 Normalized Strength

UNT1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	118.5	116.6	111.0	104.6	119.2	123.0	117.4	102.4
Std. Dev.	4.607	3.231	4.964	5.430	5.104	6.615	7.256	5.897
CV	3.887	2.771	4.472	5.193	4.282	5.377	6.181	5.757
Modified CV	6.000	6.000	6.236	6.597	6.141	6.688	7.090	6.878
Min	108.1	108.8	100.1	92.93	109.5	111.7	106.1	91.18
Max	127.1	120.2	117.9	112.0	129.6	134.3	129.8	111.1
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-Basis	109.4				109.1			
B-Estimate		96.75	80.63	68.62		86.94	76.64	65.90
A-Estimate	103.0	82.57	58.95	42.97	102.0	61.19	47.56	39.82
Method	Normal	ANOVA	ANOVA	ANOVA	Normal	ANOVA	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis	106.1	104.2	98.59	NA	105.0	108.8	NA	NA
A-Estimate	97.82	95.93	90.31		95.35	99.20		
Method	Pooled	Pooled	Pooled		Pooled	Pooled		

Table 4-12: Statistics and Basis Values for UNT1 Strength Data

UNT1 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	7.326	7.001	7.035	6.717	7.367	7.385	7.437	6.580
Std. Dev.	0.1278	0.1098	0.08856	0.1187	0.1892	0.3415	0.2214	0.1581
CV	1.744	1.569	1.259	1.767	2.569	4.624	2.977	2.402
Min	7.133	6.853	6.911	6.494	7.018	7.003	7.129	6.345
Max	7.620	7.198	7.169	6.903	7.687	8.030	7.936	6.880
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18

Table 4-13: Statistics for UNT1 Modulus Data

4.8 "10/80/10" Unnotched Tension (UNT2)

The UNT2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD and RTD conditions consists of a single batch with six specimens, therefore only estimates were computed for those conditions.

For the normalized dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for CTD and RTD. Applying the modified CV, the normal method was used for all conditions.

For the as-measured dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for all conditions.

There was one statistical outlier. The lowest value in batch C of the ETW1 condition was a condition outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNT2 strength data in Table 4-14 and for the modulus data in Table 4-15. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-9.

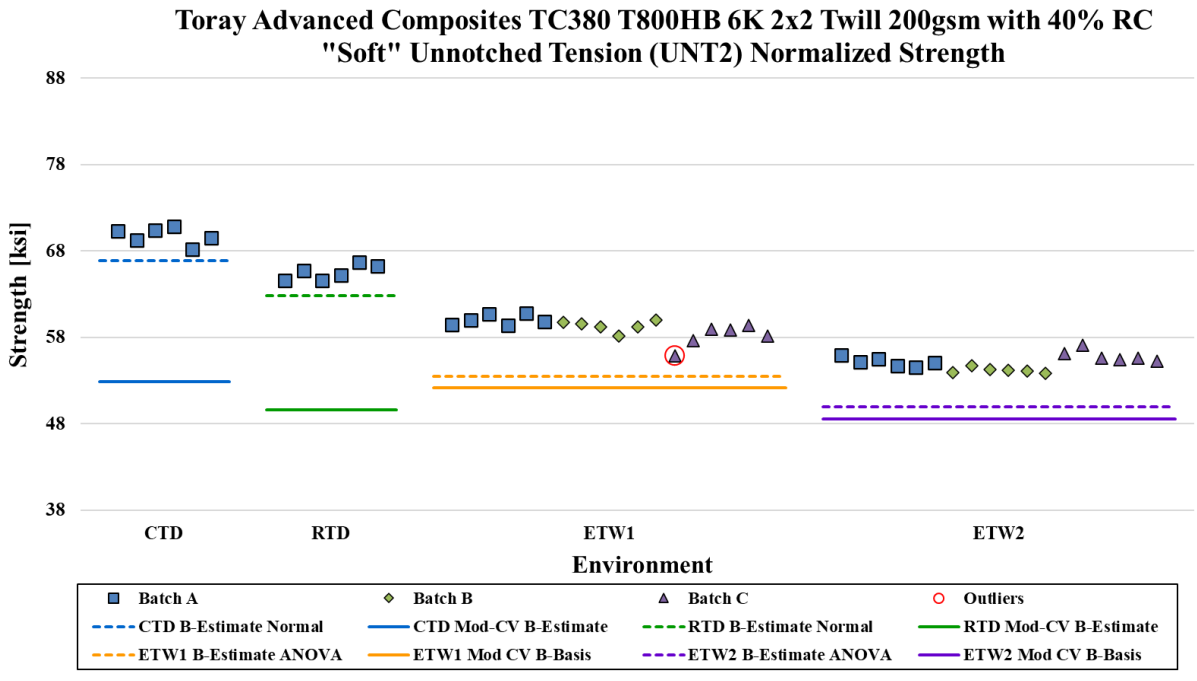

Figure 4-9: Batch Plot for UNT2 Normalized Strength

UNT2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	69.75	65.52	59.16	55.06	70.34	68.89	61.68	54.24
Std. Dev.	0.9512	0.8833	1.176	0.8594	1.157	1.724	1.826	1.305
CV	1.364	1.348	1.988	1.561	1.645	2.503	2.960	2.407
Modified CV	8.000	8.000	6.000	6.000	8.000	8.000	6.000	6.000
Min	68.22	64.55	55.85	53.89	68.51	66.40	58.92	52.25
Max	70.83	66.73	60.84	57.08	71.68	70.65	65.10	56.42
No. Batches	1	1	3	3	1	1	3	3
No. Specimens	6	6	18	18	6	6	18	18
Basis Values and Estimates								
B-Basis							58.07	
B-Estimate	66.87	62.85	53.51	49.95	66.83	63.66		46.21
A-Estimate	64.83	60.94	49.48	46.30	64.34	59.95	55.52	40.49
Method	Normal	Normal	ANOVA	ANOVA	Normal	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-Basis			52.15	48.54			54.37	47.81
B-Estimate	52.85	49.64			53.29	52.19		
A-Estimate	40.83	38.35	47.19	43.91	41.17	40.32	49.19	43.26
Method	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal

Table 4-14: Statistics and Basis Values for UNT2 Strength Data

UNT2 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	4.565	4.334	4.101	3.888	4.603	4.558	4.277	3.831
Std. Dev.	0.1139	0.02900	0.07674	0.1435	0.1364	0.1562	0.1597	0.1759
CV	2.494	0.6691	1.871	3.691	2.964	3.428	3.733	4.592
Min	4.390	4.290	3.952	3.678	4.387	4.356	3.994	3.622
Max	4.690	4.367	4.231	4.210	4.737	4.751	4.551	4.192
No. Batches	1	1	3	3	1	1	3	3
No. Specimens	6	6	18	18	6	6	18	18

Table 4-15: Statistics for UNT2 Modulus Data

4.9 "40/20/40" Unnotched Tension (UNT3)

The UNT3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the results were identical using the original CV and the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There was one statistical outlier. The highest value in batch B of the CTD condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNT3 strength data in Table 4-16 and for the modulus data in Table 4-17. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-10.

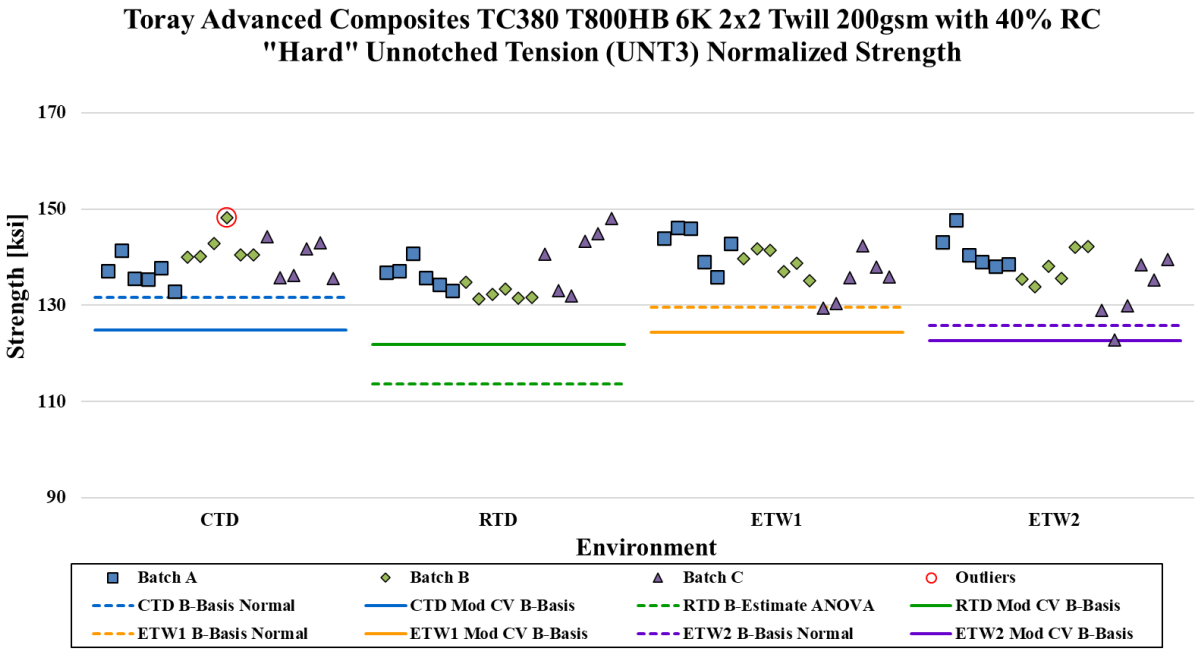

Figure 4-10: Batch Plot for UNT3 Normalized Strength

UNT3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	139.4	136.4	138.9	137.2	138.8	143.2	145.1	133.6
Std. Dev.	3.894	5.090	4.720	5.803	3.301	6.577	6.020	5.147
CV	2.794	3.732	3.399	4.230	2.378	4.594	4.148	3.854
Modified CV	6.000	6.000	6.000	6.115	6.000	6.297	6.074	6.000
Min	132.8	131.4	129.4	122.7	132.7	130.0	136.1	120.9
Max	148.1	148.0	146.2	147.7	145.7	155.6	156.5	143.0
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-Basis	131.7		129.5	125.7	129.4	133.7	135.7	124.1
B-Estimate		113.6						
A-Estimate	126.2	97.36	122.9	117.6	123.1	127.5	129.5	117.9
Method	Normal	ANOVA	Normal	Normal	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates								
B-Basis	124.9	121.8	124.3	122.7	123.9	128.2	130.2	118.6
A-Estimate	115.3	112.3	114.8	113.1	114.0	118.4	120.4	108.8
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-16: Statistics and Basis Values for UNT3 Strength Data

UNT3 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	9.311	8.988	9.040	8.999	9.277	9.439	9.450	8.763
Std. Dev.	0.1600	0.1121	0.1054	0.1180	0.2919	0.3447	0.2789	0.1836
CV	1.718	1.247	1.166	1.311	3.147	3.652	2.951	2.095
Min	8.955	8.850	8.889	8.708	8.711	8.837	8.996	8.393
Max	9.723	9.245	9.349	9.247	9.699	9.932	9.796	9.091
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18

Table 4-17: Statistics for UNT3 Modulus Data

4.10 “25/50/25” Unnotched Compression (UNC1)

The UNC1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the results were the same using the original CV and the modified CV, the RTD, ETW1, and ETW2 conditions met all the requirements for pooling. The normal method was used for CTD.

For the as-measured dataset, the RTD and ETW1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for CTD and ETW2. Applying the modified CV, the RTD, ETW1, and ETW2 conditions met all the requirements for pooling and the normal method was used for CTD

There was one statistical outlier. The lowest value in batch B of the ETW1 condition was a batch outlier in the normalized and as-measured datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNC1 strength data in Table 4-18 and for the modulus data in Table 4-19. The normalized data and B-basis values are shown graphically in Figure 4-11.

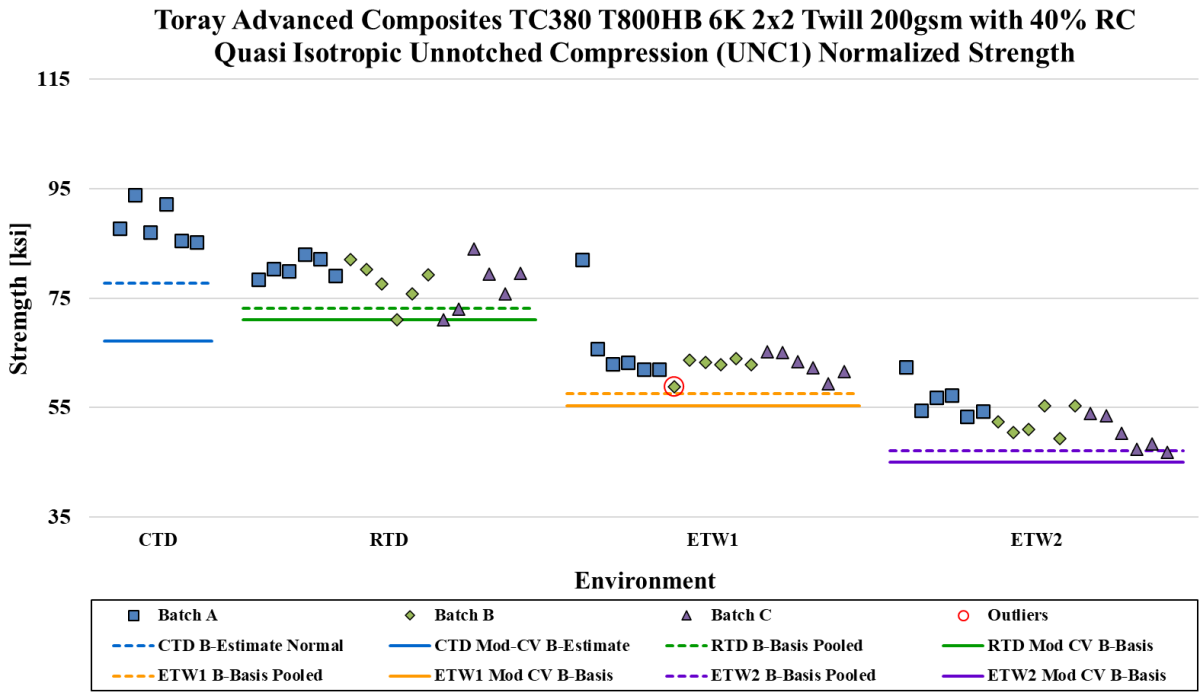

Figure 4-11: Batch Plot for UNC1 Normalized Strength

UNC1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	88.61	78.45	62.81	52.40	91.22	84.00	64.20	52.61
Std. Dev.	3.608	3.789	1.762	3.116	4.000	4.623	3.000	3.051
CV	4.072	4.830	2.804	5.946	4.385	5.504	4.673	5.799
Modified CV	8.000	6.415	6.000	6.973	8.000	6.752	6.336	6.899
Min	85.29	71.08	58.82	46.85	87.32	76.76	58.66	47.56
Max	93.89	84.03	65.74	57.22	96.43	93.42	68.94	56.83
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	6	18	18	18	6	18	18	18
Basis Values and Estimates								
B-Basis		73.12	57.48	47.07				46.58
B-Estimate	77.68				79.10	63.22	48.97	
A-Estimate	69.91	69.57	53.93	43.52	70.49	48.42	38.11	42.31
Method	Normal	Pooled	Pooled	Pooled	Normal	ANOVA	ANOVA	Normal
Modified CV Basis Values and Estimates								
B-Basis		71.02	55.38	44.96		75.95	56.16	44.56
B-Estimate	67.14				69.11			
A-Estimate	51.87	66.06	50.42	40.00	53.40	70.59	50.79	39.20
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	Pooled

Table 4-18: Statistics and Basis Values for UNC1 Strength Data

UNC1 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	6.679	6.498	6.551	6.490	6.875	6.957	6.698	6.516
Std. Dev.	0.06964	0.2224	0.1237	0.08372	0.06087	0.2820	0.3434	0.1026
CV	1.043	3.423	1.889	1.290	0.8854	4.054	5.127	1.574
Min	6.609	6.093	6.341	6.331	6.769	6.402	6.255	6.350
Max	6.788	6.870	6.800	6.648	6.948	7.419	7.403	6.763
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	6	18	18	18	6	18	18	18

Table 4-19: Statistics for UNC1 Modulus Data

4.11 “10/80/10” Unnotched Compression (UNC2)

The UNC2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the ETW2 condition failed the normality test, but the Weibull distribution was a good fit for the dataset. The RTD and ETW1 conditions could not be pooled because the pooled dataset failed the normality test. The normal method was used for CTD, RTD, and ETW1. Applying the modified CV, the normal method was used for CTD and the remaining condition met all the requirements for pooling.

For the as-measured dataset, the RTD and ETW1 conditions met all the requirements for pooling, while the normal method was used for CTD and ETW2. Applying the modified CV, the normal method was used for CTD and the remaining condition met all the requirements for pooling.

There were three statistical outlies. The lowest value in batch C of the ETW1 condition was a batch outlier in the normalized dataset. The lowest value in batch C of the ETW2 condition was a condition outlier in the normalized and as-measured datasets. The lowest value in batch C of the RTD condition was a batch outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the UNC2 strength data in Table 4-20 and for the modulus data in Table 4-21. The normalized data and B-basis values are shown graphically in Figure 4-12.

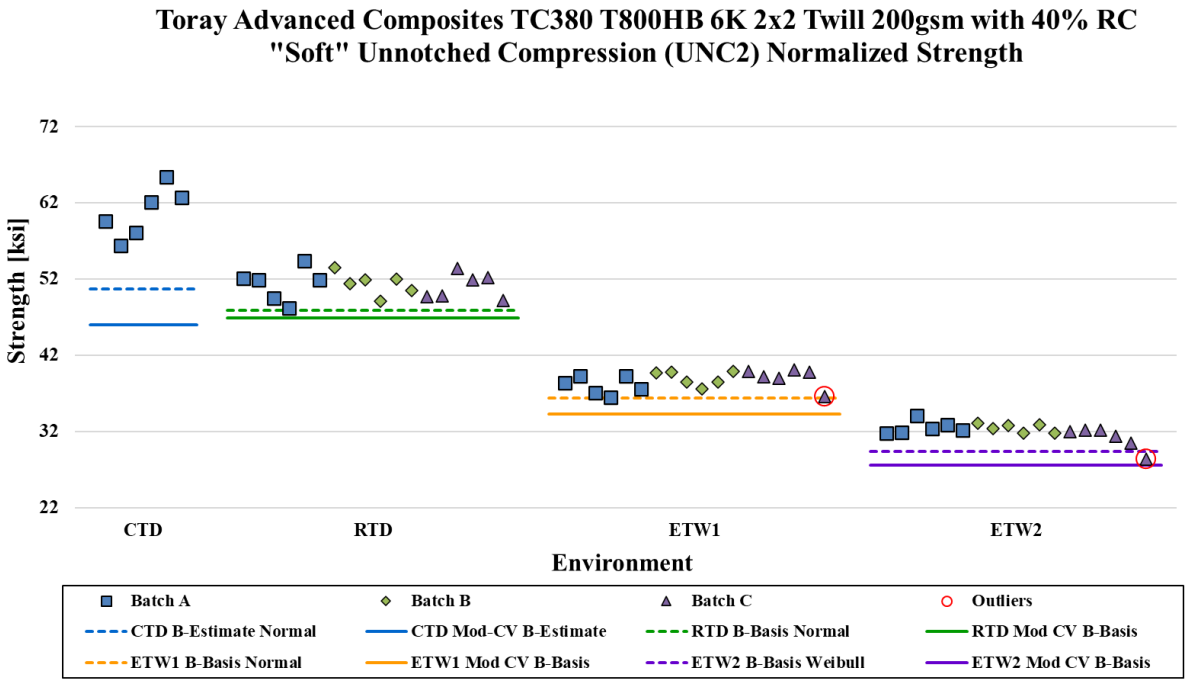

Figure 4-12: Batch Plot for UNC2 Normalized Strength

UNC2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	60.72	51.25	38.71	32.03	62.34	54.60	39.32	32.00
Std. Dev.	3.312	1.715	1.167	1.185	3.815	2.769	2.220	1.084
CV	5.454	3.347	3.014	3.700	6.120	5.071	5.646	3.387
Modified CV	8.000	6.000	6.000	6.000	8.000	6.536	6.823	6.000
Min	56.34	48.19	36.52	28.35	57.39	49.78	36.02	28.74
Max	65.39	54.42	40.12	34.05	67.59	60.27	43.94	33.64
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	6	18	18	18	6	18	18	18
Basis Values and Estimates								
B-Basis		47.86	36.40	29.41		50.03	34.75	29.86
B-Estimate	50.69				50.78			
A-Estimate	43.55	45.47	34.77	26.70	42.57	46.92	31.64	28.35
Method	Normal	Normal	Normal	Weibull	Normal	Pooled	Pooled	Normal
Modified CV Basis Values and Estimates								
B-Basis		46.85	34.30	27.63		49.63	34.35	27.03
B-Estimate	46.00				47.23			
A-Estimate	35.54	43.91	31.37	24.69	36.49	46.32	31.04	23.72
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	Pooled

Table 4-20: Statistics and Basis Values for UNC2 Strength Data

UNC2 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	4.355	4.083	3.953	3.733	4.470	4.350	4.019	3.731
Std. Dev.	0.08246	0.1350	0.09091	0.08619	0.07360	0.2413	0.2676	0.1016
CV	1.893	3.306	2.300	2.309	1.646	5.546	6.658	2.724
Min	4.223	3.841	3.754	3.580	4.398	3.911	3.694	3.573
Max	4.448	4.314	4.112	3.853	4.602	4.734	4.485	3.891
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	6	18	18	18	6	18	18	18

Table 4-21: Statistics for UNC2 Modulus Data

4.12 “40/20/40” Unnotched Compression (UNC3)

The UNC3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength and modulus tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD condition consist of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the results were identical using the original CV and the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

For the as-measured dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

There was one statistical outlier. The highest value in batch A if the ETW2 condition was a condition outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the UNC3 strength data in Table 4-22 and for the modulus data in Table 4-23. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-13.

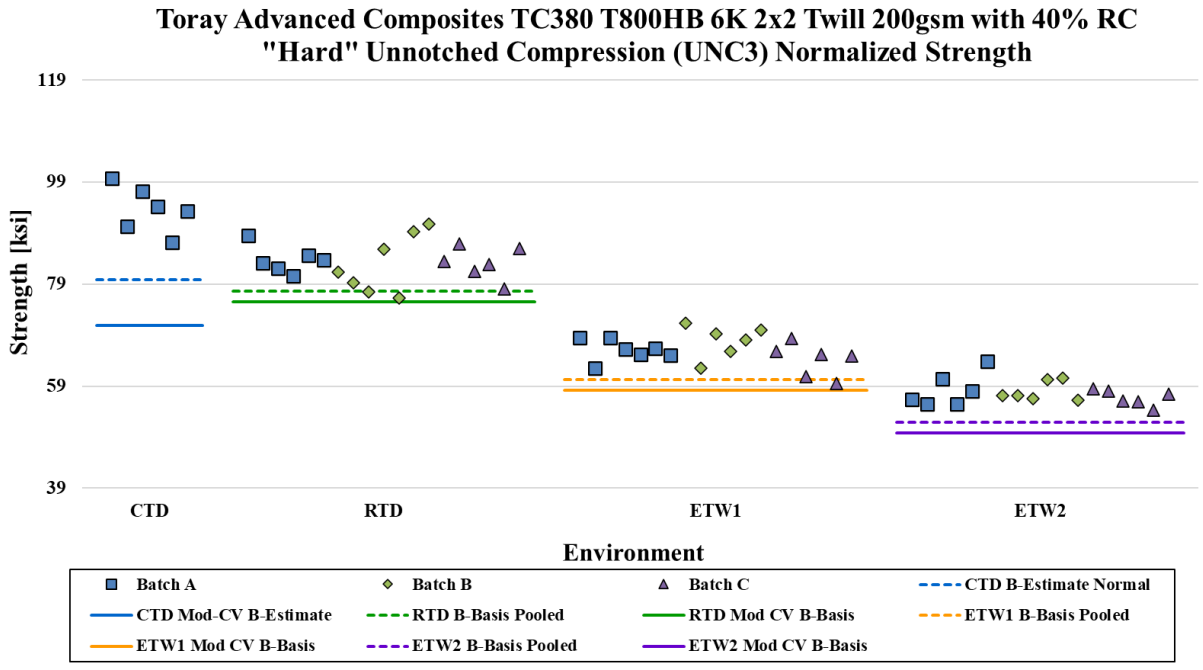

Figure 4-13: Batch Plot for UNC3 Normalized Strength

UNC3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	93.64	83.27	66.02	57.69	96.66	89.40	67.75	57.99
Std. Dev.	4.545	4.021	3.082	2.357	5.175	4.971	4.283	2.052
CV	4.853	4.829	4.668	4.085	5.354	5.561	6.322	3.538
Modified CV	8.000	6.414	6.334	6.043	8.000	6.780	7.161	6.000
Min	87.14	76.35	59.61	54.36	89.81	80.78	59.23	54.91
Max	99.72	90.81	71.31	63.91	104.1	99.27	74.77	63.76
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	6	19	19	18	6	19	19	18
Basis Values and Estimates								
B-Basis		77.58	60.32	51.96		79.71		53.94
B-Estimate	79.88				80.98		45.98	
A-Estimate	70.09	73.76	56.51	48.15	69.84	72.83	30.45	51.07
Method	Normal	Pooled	Pooled	Pooled	Normal	Normal	ANOVA	Normal
Modified CV Basis Values and Estimates								
B-Basis		75.50	58.25	49.88		80.72	59.08	49.27
B-Estimate	70.95				73.23			
A-Estimate	54.82	70.30	53.05	44.68	56.58	74.91	53.26	43.46
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	Pooled

Table 4-22: Statistics and Basis Values for UNC3 Strength Data

UNC3 Modulus (Msi) Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	8.500	8.267	8.524	8.544	8.772	8.892	8.699	8.593
Std. Dev.	0.2185	0.2509	0.1239	0.1789	0.2493	0.2666	0.3653	0.2584
CV	2.571	3.035	1.453	2.093	2.842	2.998	4.200	3.007
Min	8.231	7.763	8.317	8.248	8.531	8.493	8.176	8.208
Max	8.802	8.611	8.756	8.898	9.186	9.440	9.375	9.129
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	6	18	18	18	6	18	18	18

Table 4-23: Statistics for UNC3 Modulus Data

4.13 “25/50/25” Open-Hole Tension (OHT1)

The OHT1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the CTD and ETD1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The ETW1 and ETW2 conditions failed all the distributions tests, therefore the non-parametric method was used for those conditions. The normal method was used for RTD. Applying the modified CV, there were no diagnostic test failures so all the conditions were pooled.

For the as-measured dataset, the CTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The remaining conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures so all the conditions were pooled.

There were two statistical outliers. The lowest value in batch B of the ETW1 condition was a batch outlier in the normalized dataset. The highest value in batch C of the CTD condition was a batch outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the OHT1 strength data in Table 4-24. The normalized data, B-basis values and B-estimates are shown graphically in Figure 4-14.

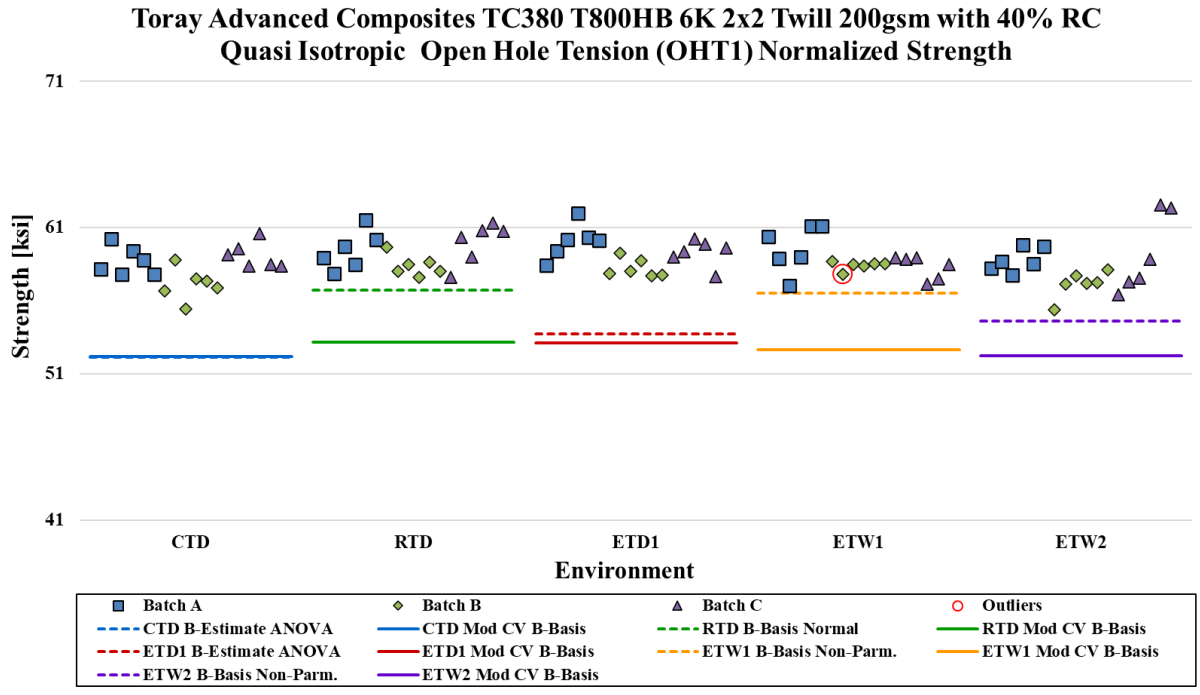

Figure 4-14: Batch Plot for OHT1 Normalized Strength

OHT1 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	58.29	59.26	59.18	58.75	58.35	56.71	59.16	59.10	57.31	56.86
Std. Dev.	1.283	1.297	1.172	1.143	1.835	1.537	1.974	1.920	1.181	2.039
CV	2.200	2.188	1.980	1.946	3.145	2.710	3.337	3.248	2.061	3.586
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Min	55.44	57.58	57.62	57.03	55.39	53.49	56.35	55.82	55.07	53.37
Max	60.57	61.51	61.95	61.11	62.54	60.14	63.07	62.14	59.25	62.03
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates										
B-Basis		56.70		56.51	54.59		56.00	55.94	54.15	53.69
B-Estimate	52.10		53.73			49.05				
A-Estimate	47.69	54.88	49.84	51.43	46.20	43.59	53.91	53.86	52.06	51.61
Method	ANOVA	Normal	ANOVA	Non-Parm.	Non-Parm.	ANOVA	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates										
B-Basis	52.19	53.16	53.08	52.65	52.25	50.70	53.16	53.10	51.31	50.85
A-Estimate	48.20	49.17	49.09	48.67	48.26	46.78	49.23	49.18	47.38	46.93
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-24: Statistics and Basis Values for OHT1 Strength Data

4.14 “10/80/10” Open-Hole Tension (OHT2)

The OHT2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computes for that condition.

For the normalized dataset, the CTD, ETW1, and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The RTD condition failed the normality test, but the lognormal distribution was a good fit for the data. The normal method was used for ETD1. Applying the modified CV, the CTD condition failed the ADK test, therefore modified CV basis values were not computed for that condition. The normal method was used for the remaining conditions.

For the as-measured dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The RTD condition failed all the distributions tests, therefore the non-parametric method was used for that condition. The normal method was used for ETD1. Applying the modified CV, the RTD condition failed the normality test, therefore modified CV basis values were not computes for that condition. The normal method was used for the remaining conditions.

There were three statistical outliers. The highest value in batch B of the CTD condition was a batch outlier in the normalized and as-measured datasets. The lowest value in batch A o f the ETW2 condition was a batch outlier in the normalized dataset. The highest value in batch B of the RTD condition was a batch in the as-measured dataset. Thet were retained for this analysis.

Statistics, basis values and estimates are given for the OHT2 strength data in Table 4-25. The normalized data and B-basis values are shown graphically in Figure 4-15.

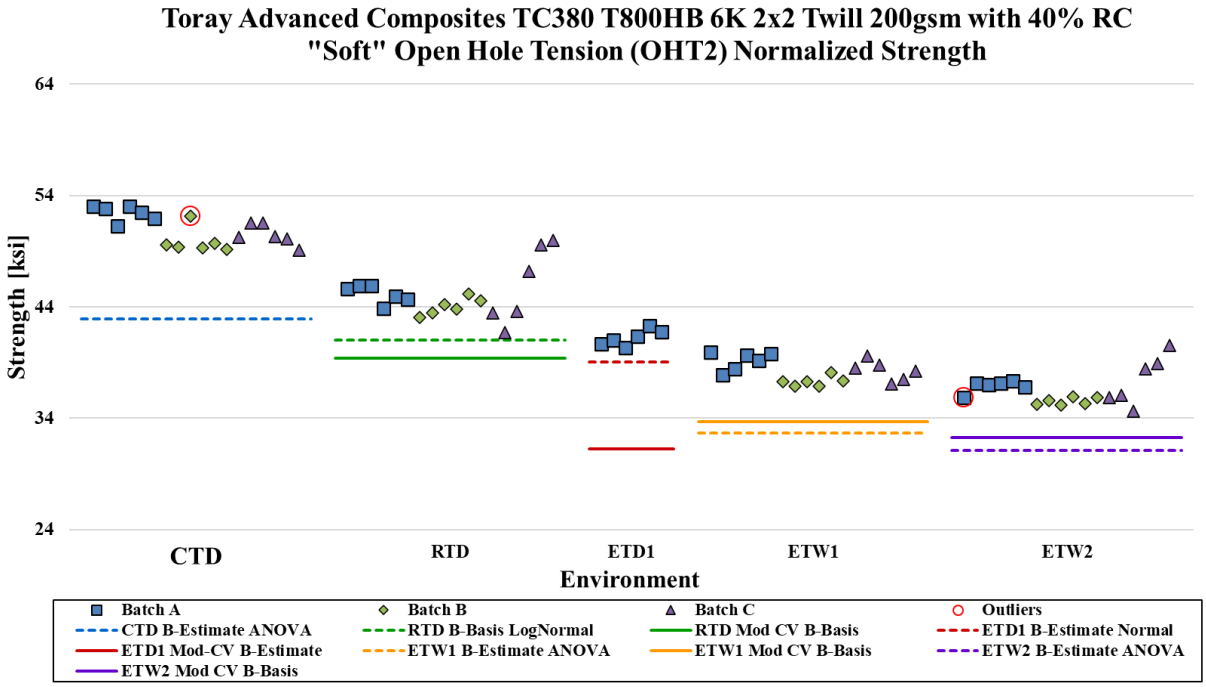

Figure 4-15: Batch Plot for OHT2 Normalized Strength

OHT2 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	50.91	45.04	41.24	38.24	36.61	49.77	44.71	40.97	37.94	35.81
Std. Dev.	1.434	2.141	0.7249	1.054	1.499	1.528	2.449	1.602	1.342	1.576
CV	2.817	4.754	1.758	2.757	4.094	3.069	5.477	3.910	3.537	4.402
Modified CV	6.000	6.377	8.000	6.000	6.047	6.000	6.738	8.000	6.000	6.201
Min	49.06	41.66	40.33	36.87	34.67	47.31	41.70	39.11	35.65	33.77
Max	53.04	49.99	42.30	39.92	40.54	51.85	49.25	43.23	40.21	39.78
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Specimens	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis		41.04					40.93		35.29	
B-Estimate	42.88		39.04	32.70	31.11	41.98		36.12		28.08
A-Estimate	37.15	38.45	37.48	28.74	27.19	36.43	32.51	32.67	33.41	22.56
Method	ANOVA	Log Normal	Normal	ANOVA	ANOVA	ANOVA	Non-Parm.	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates										
B-Basis	NA	39.37		33.71	32.24	43.87	NA		33.44	31.43
B-Estimate			31.25					31.04		
A-Estimate		35.35	24.14	30.50	29.14	39.69		23.98	30.26	28.32
Method		Normal	Normal	Normal	Normal	Normal		Normal	Normal	Normal

Table 4-25: Statistics and Basis Values for OHT2 Strength Data

4.15 “40/20/40” Open-Hole Tension (OHT3)

The OHT3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

The results were identical for the normalized and as-measured dataset, using the original CV and the modified CV. The CTD and RTD conditions met all the requirements for pooling. The normal method was used for the remaining conditions.

There was one statistical outlier. The highest value in batch B of the RTD condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHT3 strength data in Table 4-26. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-16.

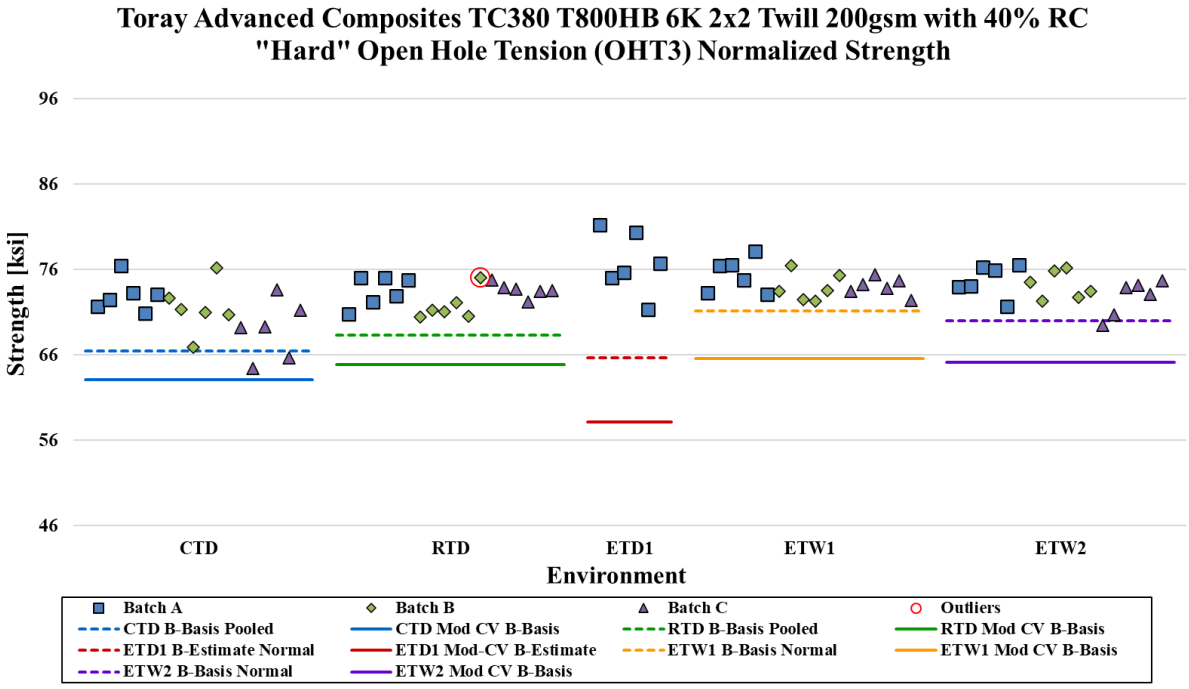

Figure 4-16: Batch Plot for OHT3 Normalized Strength

OHT3 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	71.10	72.93	76.71	74.42	73.85	70.32	72.90	77.71	74.87	73.07
Std. Dev.	3.184	1.656	3.660	1.661	1.961	3.134	2.968	3.870	2.389	1.858
CV	4.478	2.271	4.772	2.233	2.656	4.457	4.072	4.980	3.191	2.543
Modified CV	6.239	6.000	8.000	6.000	6.000	6.229	6.036	8.000	6.000	6.000
Min	64.42	70.42	71.30	72.26	69.49	64.14	68.01	71.89	71.00	69.85
Max	76.41	75.05	81.24	78.09	76.53	76.11	79.31	82.56	78.69	75.91
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Specimens	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis	66.48	68.30		71.14	69.98	64.76	67.34		70.15	69.40
B-Estimate			65.62					65.99		
A-Estimate	63.33	65.16	57.74	68.81	67.24	60.98	63.56	57.66	66.81	66.80
Method	Pooled	Pooled	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal
Modified CV Basis Values and Estimates										
B-Basis	63.07	64.90		65.60	65.11	62.32	64.90		66.00	64.42
B-Estimate			58.12					58.88		
A-Estimate	57.61	59.44	44.91	59.36	58.91	56.88	59.46	45.49	59.71	58.28
Method	Pooled	Pooled	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal

Table 4-26: Statistics and Basis Values for OHT3 Strength Data

4.16 “25/50/25” Filled-Hole Tension (FHT1)

The FHT1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The CTD and RTD conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, so all the conditions were pooled.

For the as-measured dataset, there were no diagnostic test failures so all the conditions were pooled. Applying the modified CV, all the condition could not be pooled because the pooled dataset failed the normality test. The CTD and RTD conditions met all the requirements for pooling and the normal method was used for ETW1 and ETW2.

There were two statistical outliers. The highest value in batch A of the ETW2 condition was a condition outlier in the normalized dataset. The highest value in batch B of the ETW2 condition was a batch and condition outlier in the as-measured dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHT1 strength data in Table 4-27. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-17.

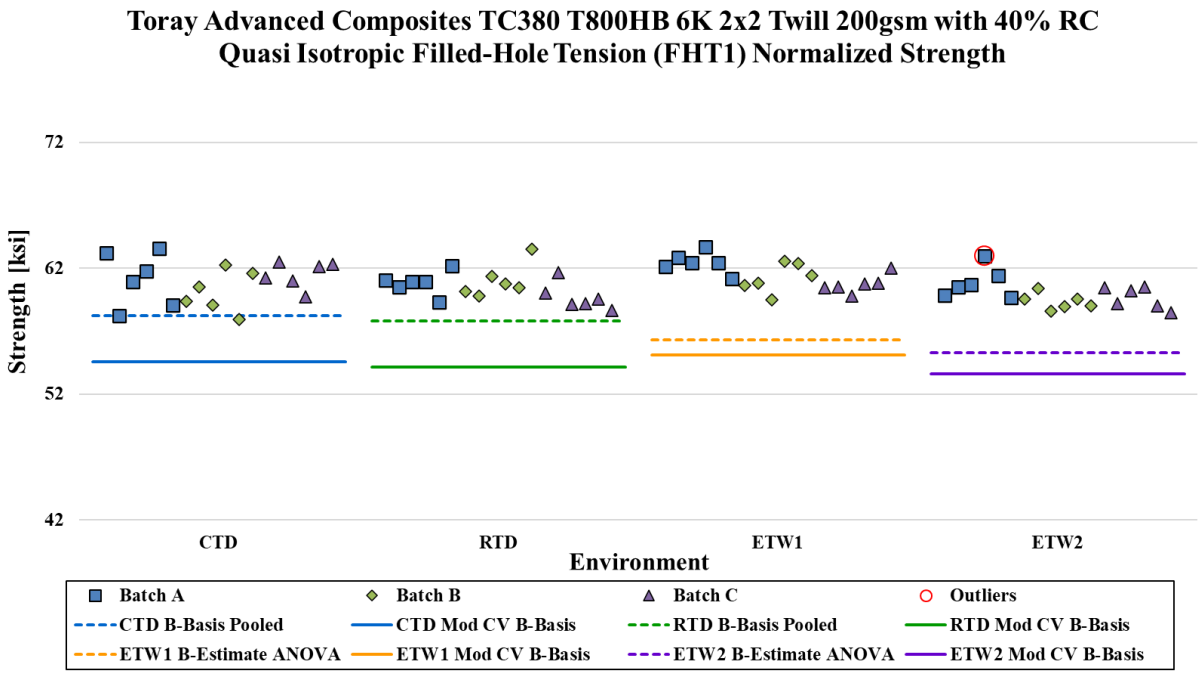

Figure 4-17: Batch Plot for FHT1 Normalized Strength

FHT1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	60.91	60.51	61.46	59.95	59.66	60.69	61.34	59.08
Std. Dev.	1.684	1.211	1.142	1.106	1.900	2.141	2.072	1.764
CV	2.764	2.001	1.859	1.845	3.184	3.528	3.378	2.986
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Min	57.94	58.64	59.50	58.49	56.24	57.38	57.83	57.09
Max	63.56	63.51	63.69	63.00	62.47	64.50	65.29	63.87
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-Basis	58.24	57.84			56.22	57.25	57.89	55.63
B-Estimate			56.29	55.31				
A-Estimate	56.42	56.02	52.61	52.00	53.95	54.97	55.62	53.36
Method	Pooled	Pooled	ANOVA	ANOVA	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates								
B-Basis	54.55	54.15	55.10	53.59	53.09	54.12	54.07	52.08
A-Estimate	50.36	49.96	50.91	49.40	48.61	49.64	48.92	47.12
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Normal	Normal

Table 4-27: Statistics and Basis Values for FHT1 Strength Data

4.17 “10/80/10” Filled-Hole Tension (FHT2)

The FHT2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the CTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTD and ETW1 conditions met all the requirements for pooling. The normal method was used for ETW2. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the CTD and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The RTD and ETW1 conditions met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were three statistical outliers. The highest value in batch B of the CTD condition was a batch outlier in the normalized dataset. The lowest value in batch C of the CTD condition was a batch outlier in the normalized dataset. The highest value in batch C of the ETW2 condition was a condition outlier in the normalized and as-measured datasets. They were retained for this analysis.

Statistics, basis values and estimates are given for the FHT2 strength data in Table 4-28. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-18.

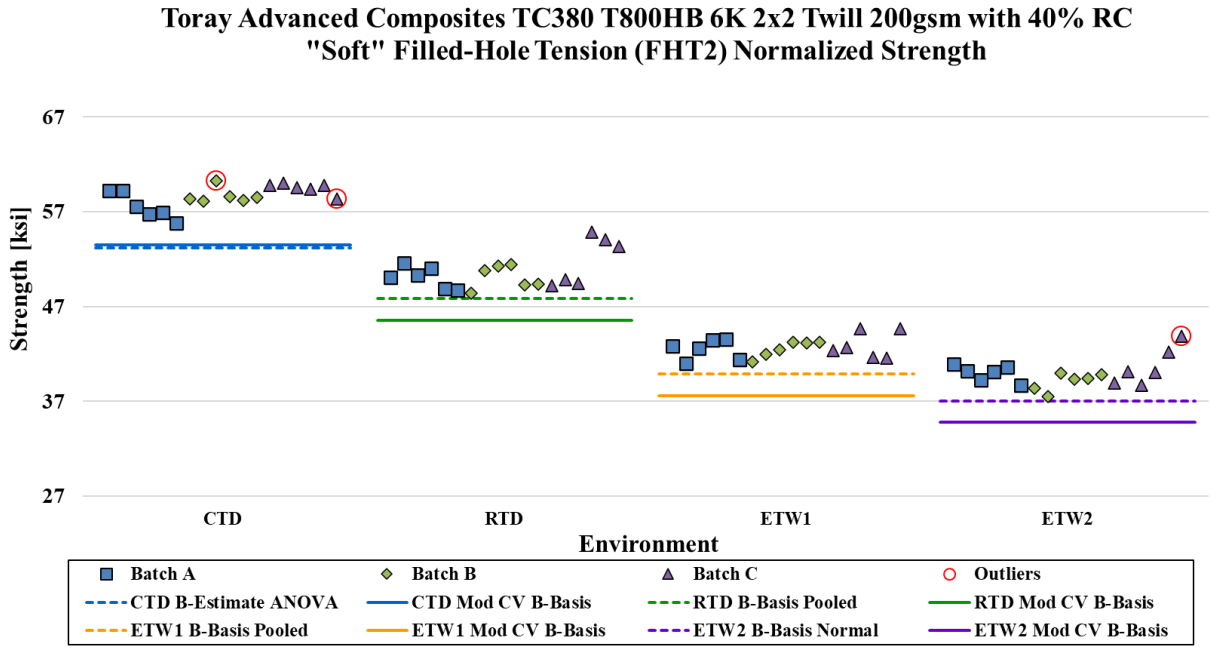

Figure 4-18: Batch plot for FHT2 Normalized Strength

FHT2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	58.59	50.66	42.65	39.90	57.21	50.71	42.49	39.06
Std. Dev.	1.216	1.856	1.083	1.452	1.569	2.769	1.973	1.710
CV	2.075	3.663	2.539	3.638	2.743	5.460	4.643	4.379
Modified CV	6.000	6.000	6.000	6.000	6.000	6.730	6.321	6.189
Min	55.85	48.41	40.99	37.48	54.17	46.91	39.18	37.08
Max	60.27	54.86	44.68	43.87	59.57	56.94	45.92	43.97
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18
Basis Values and Estimates								
B-Basis		47.90	39.88	37.04		46.33	38.11	
B-Estimate	53.15				47.81			31.25
A-Estimate	49.28	46.01	38.00	35.01	41.11	43.35	35.13	25.68
Method	ANOVA	Pooled	Pooled	Normal	ANOVA	Pooled	Pooled	ANOVA
Modified CV Basis Values and Estimates								
B-Basis	53.51	45.59	37.57	34.82	51.94	45.44	37.22	33.79
A-Estimate	50.16	42.24	34.22	31.47	48.46	41.96	33.74	30.31
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-28: Statistics and Basis Values for FHT2 Strength Data

4.18 “40/20/40” Filled-Hole Tension (FHT3)

The FHT3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

For the normalized dataset, the ETW1 and ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The CTD and RTD condition met all the requirements for pooling. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The CTD and RTD condition met all the requirements for pooling and the normal method was used for ETW2. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There was one statistical outlier. The highest value in batch C of the ETW2 condition was a batch outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the FHT3 strength data in Table 4-29. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-19.

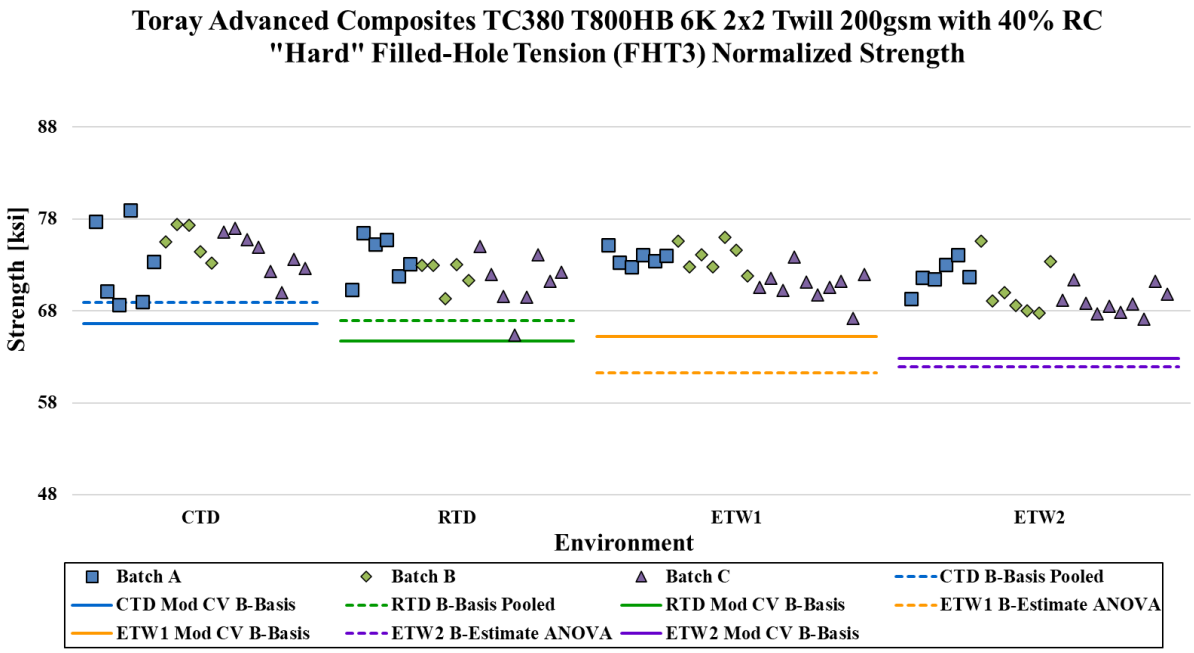

Figure 4-19: Batch plot for FHT3 Normalized Strength

FHT3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	74.12	72.17	72.54	70.17	73.13	71.99	72.55	69.90
Std. Dev.	3.106	2.686	2.110	2.285	3.201	3.469	3.039	2.244
CV	4.191	3.722	2.908	3.256	4.377	4.819	4.188	3.211
Modified CV	6.095	6.000	6.000	6.000	6.189	6.409	6.094	6.000
Min	68.65	65.34	67.17	67.08	66.68	64.98	66.63	66.47
Max	79.00	76.53	76.02	75.55	77.43	80.21	79.42	74.45
No. Batches	3	3	3	3	3	3	3	3
No. Specimens	19	19	23	23	19	19	23	23
Basis Values and Estimates								
B-Basis	68.88	66.93			67.11	65.97		65.70
B-Estimate			61.24	61.89			61.07	
A-Estimate	65.31	63.36	53.16	55.98	63.00	61.86	52.86	62.70
Method	Pooled	Pooled	ANOVA	ANOVA	Pooled	Pooled	ANOVA	Normal
Modified CV Basis Values and Estimates								
B-Basis	66.63	64.68	65.18	62.81	65.49	64.36	65.05	62.40
A-Estimate	61.68	59.73	60.22	57.85	60.46	59.32	59.99	57.34
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-29: Statistics and Basis Values for FHT3 Strength Data

4.19 “25/50/25” Open-Hole Compression (OHC1)

The OHC1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

For the normalized dataset, the RTD and ETD1 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for the remaining conditions. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

For the as-measured dataset, the RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the remaining conditions. Applying the modified CV, there were no diagnostic test failures, therefore all the conditions were pooled.

There were two statistical outliers. The lowest value in batch of the ETW2 condition was a batch and condition outlier in the normalized dataset. The lowest value in batch A of the CTD condition was a batch outlier in the as-measured dataset. They were retained for this analysis,

Statistics, basis values and estimates are given for the OHC1 strength data in Table 4-30. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-20.

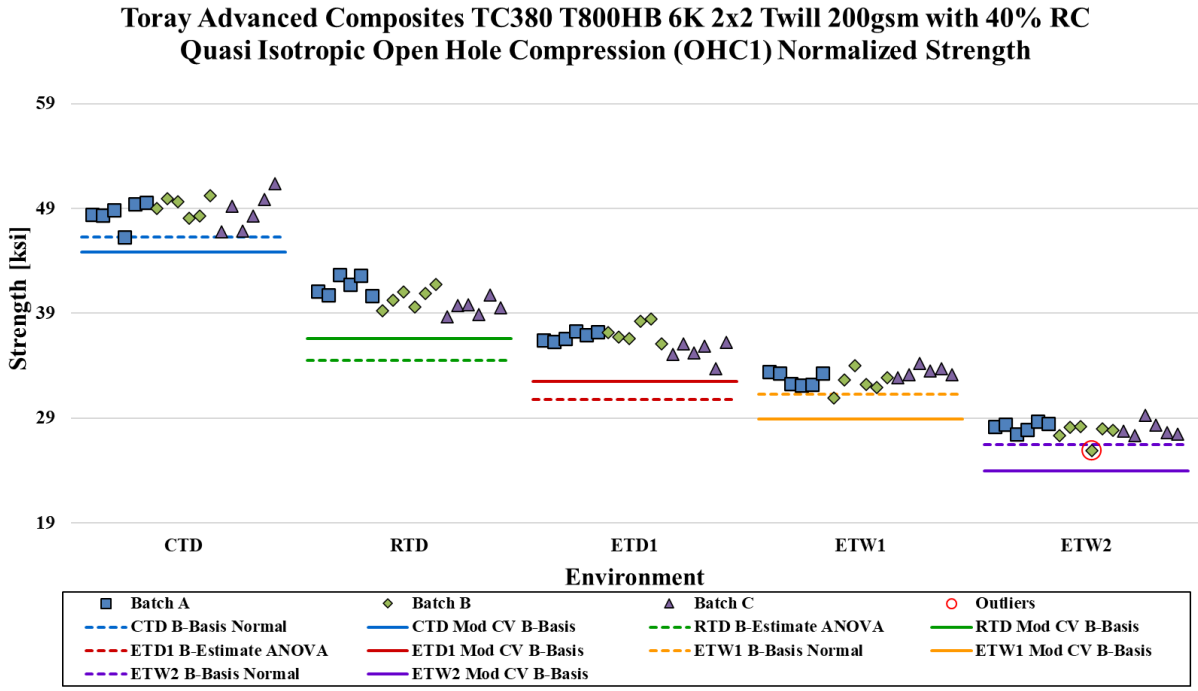

Figure 4-20: Batch Plot for OHC1 Normalized Strength

OHC1 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	48.81	40.54	36.46	32.88	27.91	47.79	40.63	36.55	32.31	27.31
Std. Dev.	1.295	1.188	1.108	0.8218	0.7175	1.328	1.341	1.407	0.8916	0.8030
CV	2.654	2.929	3.040	2.499	2.571	2.780	3.301	3.851	2.759	2.940
Modified CV	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
Min	46.27	38.65	33.74	30.93	25.89	44.53	38.12	33.29	30.80	25.25
Max	51.40	42.66	38.44	34.22	29.30	50.72	43.37	38.58	34.25	29.33
No. Batches	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates										
B-Basis	46.26			31.26	26.49	45.16		33.77	30.55	25.72
B-Estimate		34.49	30.77				34.86			
A-Estimate	44.44	30.18	26.72	30.11	25.49	43.31	30.75	31.80	29.30	24.60
Method	Normal	ANOVA	ANOVA	Normal	Normal	Normal	ANOVA	Normal	Normal	Normal
Modified CV Basis Values and Estimates										
B-Basis	44.87	36.60	32.52	28.94	23.96	43.89	36.73	32.65	28.41	23.41
A-Estimate	42.29	34.02	29.94	26.36	21.39	41.34	34.18	30.10	25.86	20.86
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-30: Statistics and Basis Values for OHC1 Strength Data

4.20 “10/80/10” Open-Hole Compression (OHC2)

The OHC2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the ETW1 and ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The CTD and RTD condition met all the requirements for pooling. The normal method was used for ETD1. Applying the modified CV, the CTD and RTD condition met all the requirements for pooling. The normal method was used for the remaining conditions.

For the as-measured dataset, the CTD, ETW1, and ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for RTD and ETD1. Applying the modified CV, the CTD and RTD condition met all the requirements for pooling. The normal method was used for the remaining conditions.

There was one statistical outlier. The lowest value in batch A of the ETW1 condition was a batch outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHC2 strength data in Table 4-31. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-21.

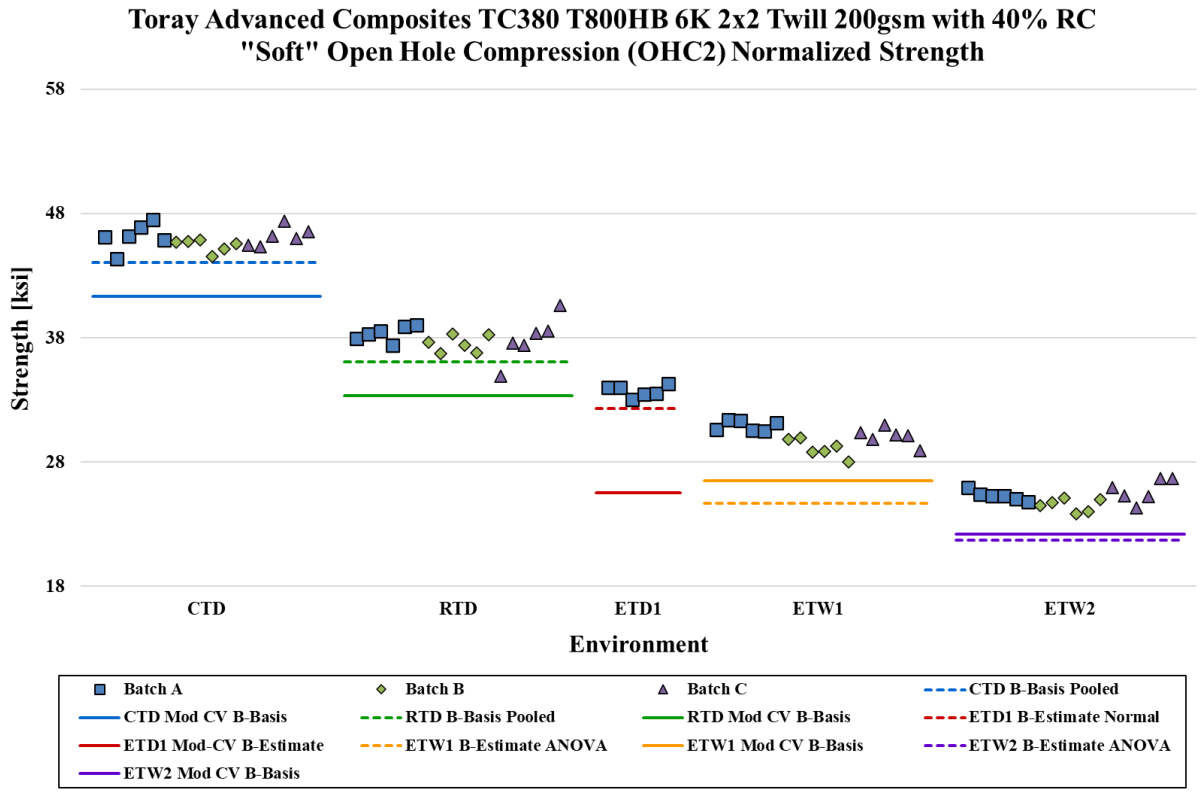

Figure 4-21: Batch Plot for OHC2 Normalized Strength

OHC2 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	45.92	37.93	33.72	30.04	25.18	44.97	37.96	33.74	29.90	24.57
Std. Dev.	0.8362	1.177	0.4666	0.9518	0.7892	0.7919	1.027	1.145	0.6192	0.8042
CV	1.821	3.102	1.384	3.168	3.134	1.761	2.705	3.392	2.071	3.273
Modified CV	6.000	6.000	8.000	6.000	6.000	6.000	6.000	8.000	6.000	6.000
Min	44.35	34.93	33.03	28.03	23.82	43.00	35.78	32.51	28.34	23.26
Max	47.53	40.58	34.32	31.39	26.68	46.46	39.55	35.67	30.91	26.11
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Specimens	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis	44.06	36.07					35.93			
B-Estimate			32.31	24.67	21.74	42.18		30.27	27.31	20.75
A-Estimate	42.79	34.81	31.30	20.84	19.29	40.19	34.49	27.81	25.46	18.02
Method	Pooled	Pooled	Normal	ANOVA	ANOVA	ANOVA	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates										
B-Basis	41.31	33.33		26.48	22.20	40.42	33.41		26.36	21.66
B-Estimate			25.55					25.57		
A-Estimate	38.18	30.20	19.74	23.96	20.08	37.33	30.31	19.75	23.85	19.60
Method	Pooled	Pooled	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal

Table 4-31: Statistics and Basis Values for OHC2 Strength Data

4.21 “40/20/40” Open-Hole Compression (OHC3)

The OHC3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETD1, ETW1, and ETW2.

The ETD1 condition consists of a single batch with six specimens, therefore only estimates were computed for that condition.

The results were identical for the normalized and as-measured dataset, using the original CV and the modified CV. The CTD and RTD conditions met all the requirements for pooling. The normal method was used for the remaining conditions.

There was one statistical outlier. The highest value in batch B of the RTD condition was a condition outlier in the as-measured dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the OHC3 strength data in Table 4-32. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-22.

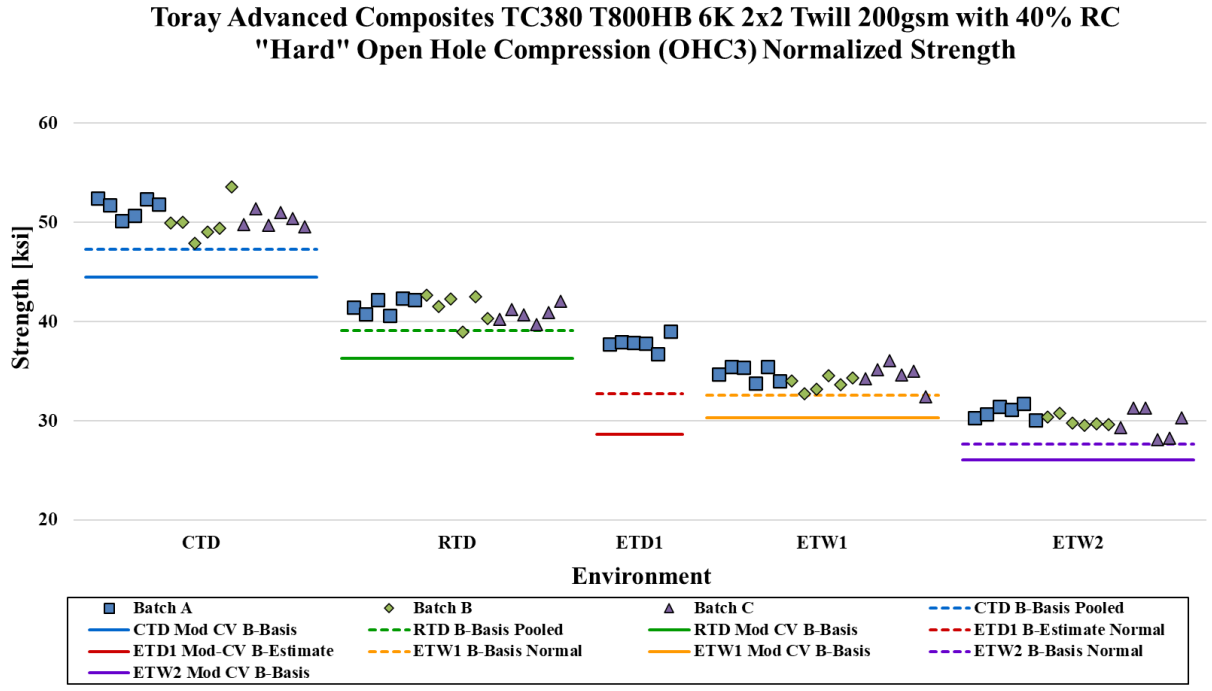

Figure 4-22: Batch Plot for OHC3 Normalized Strength

OHC3 Strength (ksi) Basis Values and Statistics										
	Normalized					As-Measured				
Environment	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETD1 (180 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	50.61	41.26	37.85	34.39	30.20	49.48	41.31	37.76	34.34	29.58
Std. Dev.	1.398	1.055	0.7166	0.9840	1.027	1.178	1.208	1.651	0.8780	0.9667
CV	2.763	2.556	1.893	2.862	3.401	2.381	2.925	4.372	2.557	3.268
Modified CV	6.000	6.000	8.000	6.000	6.000	6.000	6.000	8.000	6.000	6.000
Min	47.92	38.95	36.76	32.47	28.10	47.02	39.70	36.11	32.80	27.66
Max	53.54	42.67	39.01	36.06	31.73	52.33	44.58	40.12	36.08	30.92
No. Batches	3	3	1	3	3	3	3	1	3	3
No. Specimens	18	18	6	18	18	18	18	6	18	18
Basis Values and Estimates										
B-Basis	48.35	39.01		32.44	28.17	47.31	39.13		32.61	27.68
B-Estimate			35.68					32.76		
A-Estimate	46.82	37.47	34.13	31.07	26.74	45.83	37.66	29.20	31.38	26.32
Method	Pooled	Pooled	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal
Modified CV Basis Values and Estimates										
B-Basis	45.56	36.22		30.31	26.63	44.50	36.33		30.28	26.08
B-Estimate			28.68					28.61		
A-Estimate	42.13	32.78	22.15	27.43	24.09	41.11	32.94	22.10	27.39	23.60
Method	Pooled	Pooled	Normal	Normal	Normal	Pooled	Pooled	Normal	Normal	Normal

Table 4-32: Statistics and Basis Values for OHC3 Strength Data

4.22 “25/50/25” Filled-Hole Compression (FHC1)

The FHC1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD condition consists of a single batch with eight specimens, therefore only estimates were computed for that condition.

The results are identical for the normalized and as-measured datasets. The CTD condition failed the normal test but the Weibull distribution was a good fit for the data. The RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for ETW1 and ETW2. Applying the modified CV, the CTD condition failed the normality test, therefore modified CV basis estimates were not computed for that condition. The remaining conditions met all the requirements for pooling.

There was one statistical outlier. The lowest value in batch A of the CTD condition was a batch and condition outlier in the normalized and as-measured datasets. It was retained for this analysis.

Statistics, basis values and estimates are given for the FHC1 strength data in Table 4-33. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-23.

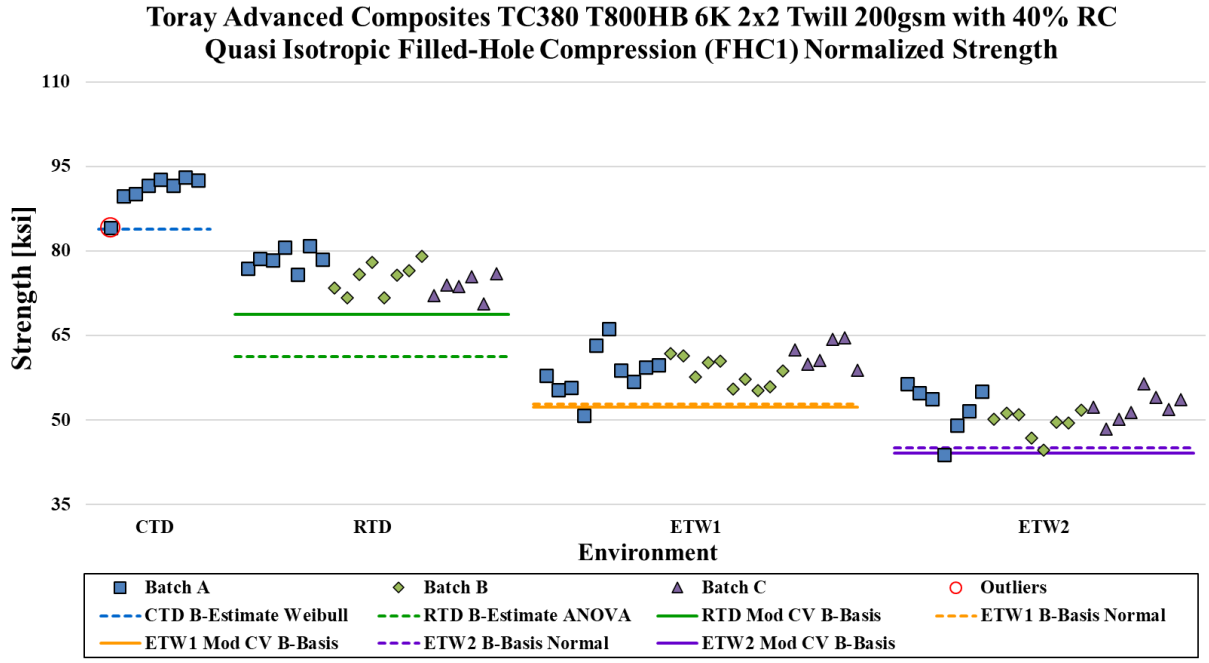

Figure 4-23: Batch plot for FHC1 Normalized Strength

FHC1 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	90.69*	75.87	59.19	51.19	89.09	75.75	59.77	50.37
Std. Dev.	2.893	2.965	3.468	3.315	2.709	2.797	3.125	3.263
CV	3.190	3.907	5.860	6.475	3.041	3.693	5.229	6.478
Modified CV	8.000	6.000	6.930	7.237	8.000	6.000	6.614	7.239
Min	84.15	70.64	50.82	43.91	82.78	71.48	52.87	42.66
Max	93.04	80.89	66.24	56.43	91.18	80.47	65.17	56.30
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	8	21	26	23	8	21	26	23
Basis Values and Estimates								
B-Basis			52.86	45.00			54.07	44.28
B-Estimate	83.79*	61.28			82.92*	60.48		
A-Estimate	76.92	50.87	48.31	40.57	76.71	49.57	49.97	39.91
Method	Weibull	ANOVA	Normal	Normal	Weibull	ANOVA	Normal	Normal
Modified CV Basis Values and Estimates								
B-Basis	NA	68.78	52.24	44.16	NA	68.79	52.94	43.47
A-Estimate		64.02	47.45	39.39		64.12	48.24	38.79
Method		Pooled	Pooled	Pooled		Pooled	Pooled	Pooled

* In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design.

Table 4-33: Statistics and Basis Values for FHC1 Strength Data

4.23 “10/80/10” Filled-Hole Compression (FHC2)

The FHC2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD condition consists of a single batch with seven specimens, therefore only estimates were computed for that condition.

For the normalized dataset, the ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The RTD and ETW1 conditions met all the requirements for pooling. The normal method was used for CTD. Applying the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

For the as-measured dataset, ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for CTD and RTD. Applying the modified CV, the normal method was used for CTD and the remaining conditions met all the requirements for pooling.

There was one statistical outlier. The lowest value in batch B of the ETW1 condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics are given for the FHC2 strength data in Table 4-34. The normalized specimen data are shown graphically in Figure 4-24.

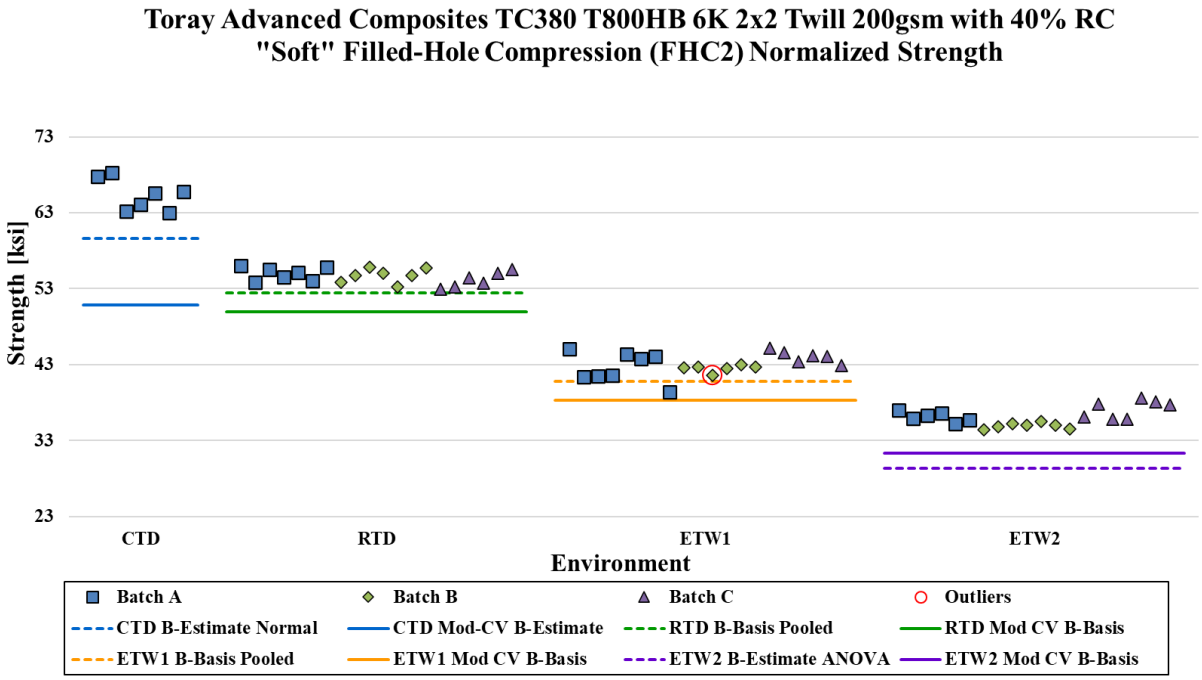

Figure 4-24: Batch plot for FHC2 Normalized Strength

FHC2 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	65.39*	54.63*	43.02*	36.05*	63.74*	54.71*	43.26*	35.25*
Std. Dev.	2.096	0.9642	1.445	1.216	2.182	1.353	1.283	1.416
CV	3.206	1.765	3.360	3.373	3.423	2.472	2.966	4.018
Modified CV	8.000	6.000	6.000	6.000	8.000	6.000	6.000	6.009
Min	63.04	52.97	39.42	34.41	61.52	52.48	40.86	33.42
Max	68.30	55.98	45.12	38.55	67.00	58.27	45.71	38.06
No. Batches	1	3	3	3	1	3	3	3
No. Specimens	7	20	20	20	7	20	20	20
Basis Values and Estimates								
B-Basis		52.43*	40.82*			52.10*		
B-Estimate	59.57*			29.30	57.68*		38.70*	26.79
A-Estimate	55.47	50.93	39.32	24.49	53.42	50.25	35.44	20.75
Method	Normal	Pooled	Pooled	ANOVA	Normal	Normal	ANOVA	ANOVA
Modified CV Basis Values and Estimates								
B-Basis		49.90*	38.29*	31.32*		49.99*	38.55*	30.54*
B-Estimate	50.87*				49.58*			
A-Estimate	40.65	46.72	35.11	28.14	39.62	46.82	35.37	27.36
Method	Normal	Pooled	Pooled	Pooled	Normal	Pooled	Pooled	Pooled

* In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design.

Table 4-34: Statistics and Basis Values for FHC2 Strength Data

4.24 “40/20/40” Filled-Hole Compression (FHC3)

The FHC3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD, RTD, ETW1, and ETW2.

The CTD and RTD conditions consists of two batches with fifteen and fourteen specimens, respectively, therefore only estimates were computed for those conditions.

The results are identical for the normalized and as-measured datasets. The ETW2 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. Applying the modified CV, the normal method was used for all the conditions.

There was one statistical outlier. The lowest value in batch C of the ETW2 condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the FHC3 strength data in Table 4-35. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-25.

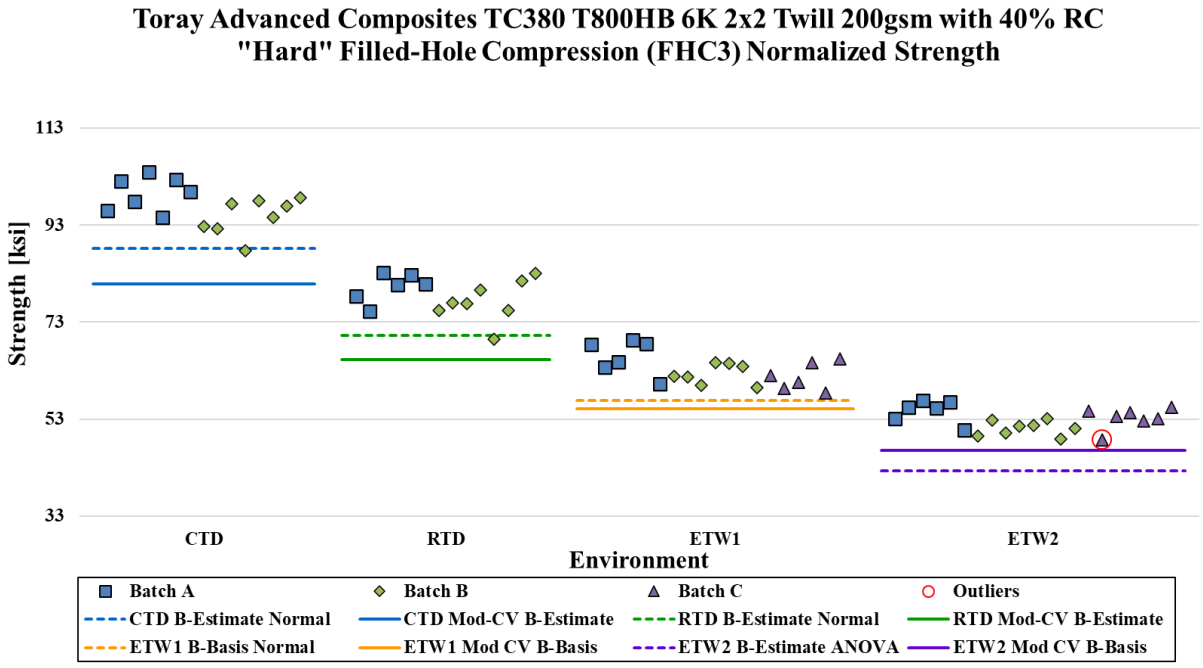

Figure 4-25: Batch Plot for FHC3 Normalized Strength

FHC3 Strength (ksi) Basis Values and Statistics								
	Normalized				As-Measured			
Environment	**CTD (-65 °F)**	**RTD (70 °F)**	**ETW1 (180 °F)**	**ETW2 (250 °F)**	**CTD (-65 °F)**	**RTD (70 °F)**	**ETW1 (180 °F)**	**ETW2 (250 °F)**
Mean	96.96*	78.50	63.22	52.84	94.07	78.07	63.62	51.91
Std. Dev.	4.282	3.920	3.247	2.408	3.344	2.942	2.701	2.524
CV	4.416	4.994	5.135	4.557	3.555	3.769	4.246	4.862
Modified CV	8.000	8.000	6.568	6.279	8.000	8.000	6.123	6.431
Min	87.64	69.40	58.42	48.81	86.66	71.87	58.23	47.98
Max	104.0	83.25	69.28	56.89	98.85	82.31	67.21	56.73
No. Batches	2	2	3	3	2	2	3	3
No. Specimens	15	14	19	21	15	14	19	21
Basis Values and Estimates								
B-Basis			56.89				58.36*	
B-Estimate	88.09*	70.22		42.30	87.14*	71.85		40.31
A-Estimate	81.85	64.41	52.40	34.78	82.27	67.49	54.62	32.04
Method	Normal	Normal	Normal	ANOVA	Normal	Normal	Normal	ANOVA
Modified CV Basis Values and Estimates								
B-Basis			55.13	46.52			56.03	45.55
B-Estimate	80.90*	65.24			78.49*	64.88		
A-Estimate	69.59	55.92	49.38	42.01	67.51	55.61	50.64	41.02
Method	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal

* In some cases, when FHC > UNC, UNC data is recommended for design. The FHC data is for informational purposes only and is not appropriate for design.

Table 4-35: Statistics and Basis Values for FHC3 Strength Data

4.25 “25/50/25” Single-Shear Bearing Proc. C (SSB1)

The SSB1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. 2% offset strength, ultimate strength and chord stiffness tests were conducted in the following environmental conditions: RTD, ETW1, and ETW2.

For the normalized datasets, for the 2% offset strength property, the ETW1 and ETW2 conditions failed the ADK test for batch equivalency. ANOVA was used to compute estimates for those conditions. The normal method was used for RTD. For the ultimate strength dataset, the ETW1 condition failed the normality test, but the lognormal was a good fit for the dataset. The normal method was used for RTD and ETW2. Applying the modified CV, the results were identical for both properties, there were no diagnostic test failures, so all the conditions were pooled for each property.

For the as-measured datasets, the results were identical for both properties, using the original CV and the modified CV. There were no diagnostic test failures so the three conditions were pooled for each property.

There were two statistical outliers. The lowest value in batch B of the RTD condition was a batch outlier in the normalized 2% offset strength dataset. The highest value in batch C of the ETW1 condition was a condition outlier in the normalized ultimate strength dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the SSB1 Proc. C strength data in Table 4-36 and for chord stiffness data in Table 4-37. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-26 and Figure 4-27.

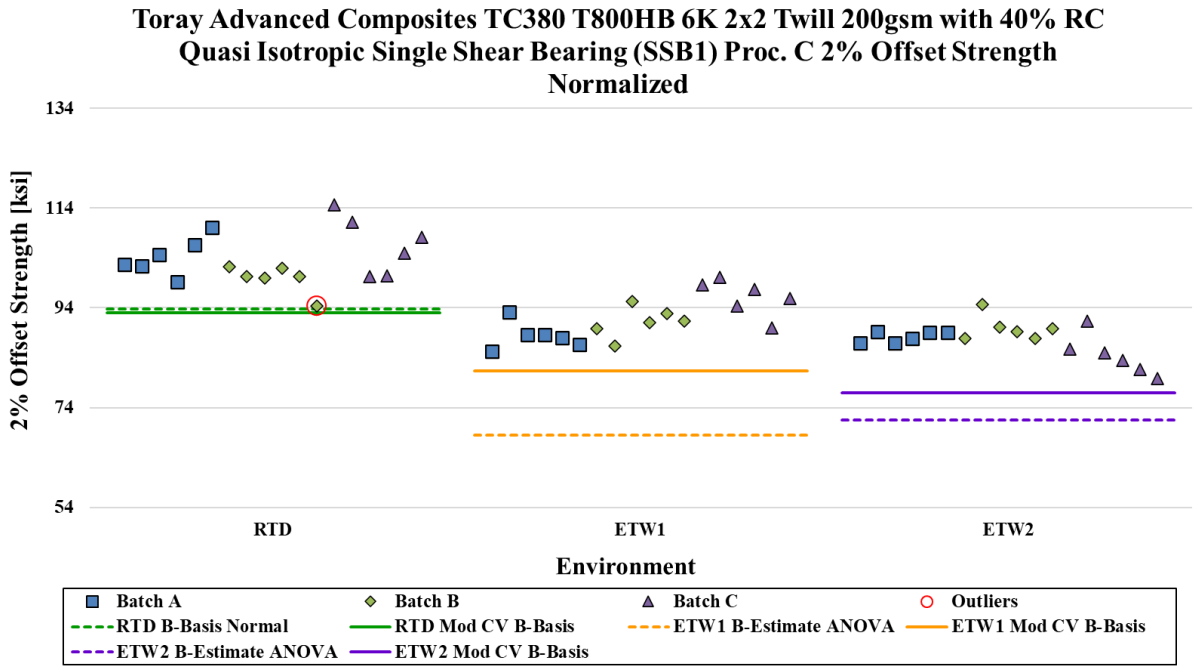

Figure 4-26: Batch Plot for SSB1 Proc. C Normalized 2% Offset Strength

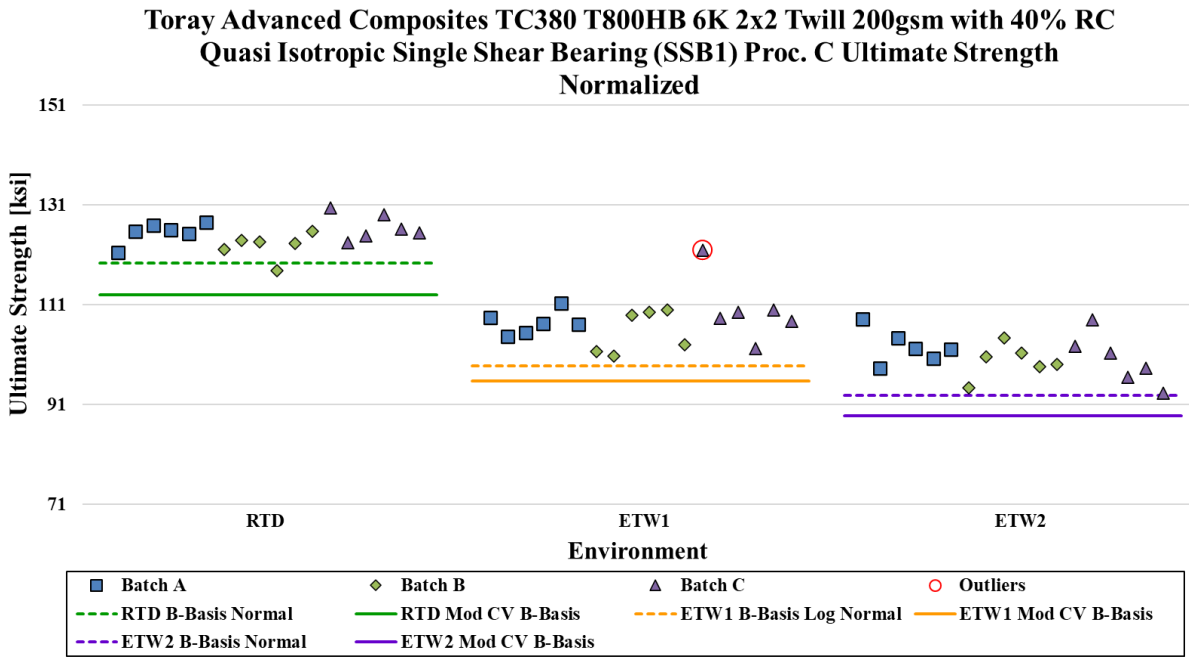

Figure 4-27: Batch Plot for SSB1 Proc. C Normalized Ultimate Strength

SSB1 Proc. C Strength (ksi) Basis Values and Statistics												
	Normalized						As-Measured					
Property	2% Offset Strength			Ultimate Strength			2% Offset Strength			Ultimate Strength		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	103.6	91.87	87.55	125.0	107.7	100.8	110.8	97.94	85.38	133.7	114.9	98.33
Std. Dev.	4.980	4.411	3.500	2.849	4.783	4.029	5.001	4.043	2.872	3.351	5.003	3.967
CV	4.808	4.802	3.998	2.280	4.441	3.997	4.515	4.128	3.363	2.507	4.356	4.034
Modified CV	6.404	6.401	6.000	6.000	6.220	6.000	6.257	6.064	6.000	6.000	6.178	6.017
Min	94.43	85.27	79.91	117.9	100.7	93.28	101.3	88.86	79.61	127.8	105.2	92.33
Max	114.7	100.1	94.68	130.4	122.0	108.2	119.7	104.5	91.36	141.5	125.9	107.3
No. Batches	3	3	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates												
B-Basis	93.75			119.3	98.76	92.84	103.6	90.74	78.18	126.3	107.5	90.96
B-Estimate		68.46	71.49									
A-Estimate	86.78	51.76	60.05	115.4	92.94	87.21	98.75	85.94	73.38	121.4	102.6	86.04
Method	Normal	ANOVA	ANOVA	Normal	Log Normal	Normal	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates												
B-Basis	93.04	81.33	77.01	113.0	95.71	88.80	100.1	87.24	74.68	121.1	102.3	85.82
A-Estimate	86.02	74.31	69.98	105.0	87.70	80.80	92.92	80.11	67.54	112.8	94.00	77.48
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-36: Statistics and Basis Values for SSB1 Proc. C Strength Data

SSB1 Proc. C Chord Stiffness (Msi) Statistics						
	Normalized			As-Measured		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.502	1.489	1.462	1.607	1.589	1.426
Std. Dev.	0.03684	0.04449	0.02272	0.05729	0.07204	0.03631
CV	2.452	2.988	1.555	3.565	4.534	2.546
Min	1.439	1.363	1.416	1.516	1.401	1.366
Max	1.575	1.544	1.493	1.735	1.714	1.487
No. Batches	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18

Table 4-37: Statistics for SSB1 Proc. C Chord Stiffness Data

4.26 “10/80/10” Single-Shear Bearing Proc. C (SSB2)

The SSB2 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. 2% offset strength, ultimate strength and chord stiffness tests were conducted in the following environmental conditions: RTD, ETW1, and ETW2.

For the normalized datasets, the results were identical for both properties. The RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for the ETW1 and ETW2 conditions. Applying the modified CV, there were no diagnostic test failures, therefore the three conditions were pooled for each property.

For the as-measured datasets, for the 2% offset strength dataset, the ETW1 condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. For the ultimate strength dataset, there were no diagnostic test failures, therefore all the conditions were pooled. Applying the modified CV, there results were identical for both properties. There were no diagnostic test failures, there all the conditions were pooled for each property.

There were two statistical outliers. The lowest value in batch A of the ETW1 condition was a batch outlier in the normalized ultimate strength dataset. The lowest value in batch B of the ETW1 condition was a batch outlier in the normalized ultimate strength dataset. They were retained for this analysis.

Statistics, basis values and estimates are given for the SSB2 Proc. C strength data in Table 4-38 and for chord stiffness in Table 4-39. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-28 and Figure 4-29.

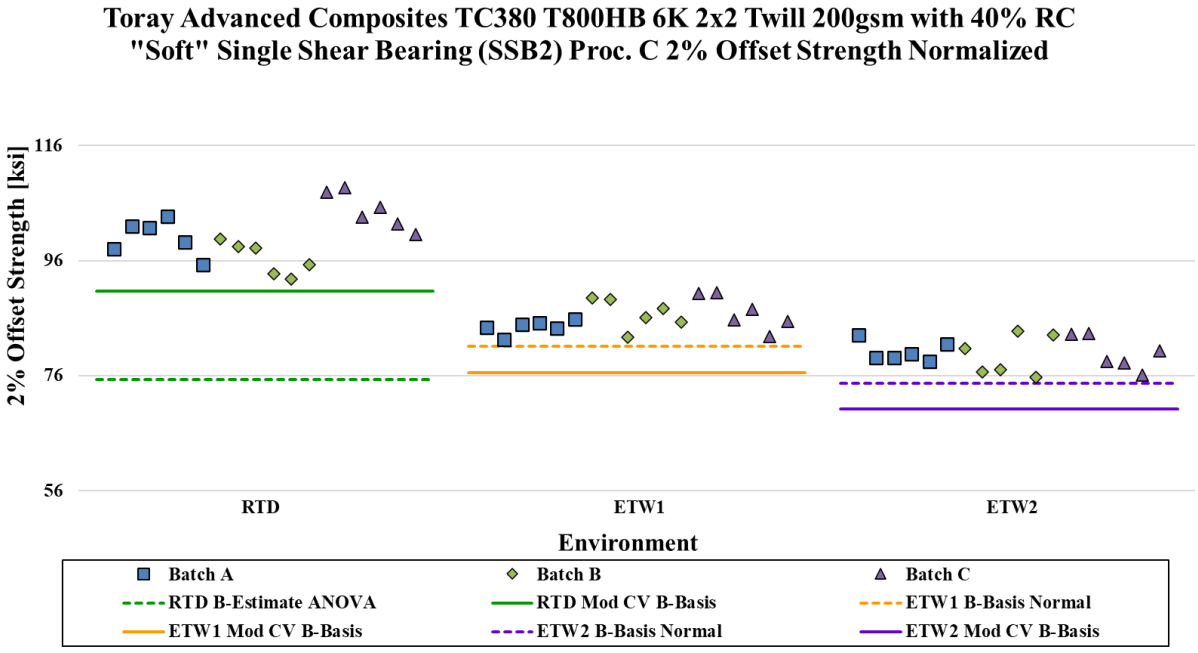

Figure 4-28: Batch Plot for SSB2 Proc. C Normalized 2% Offset Strength

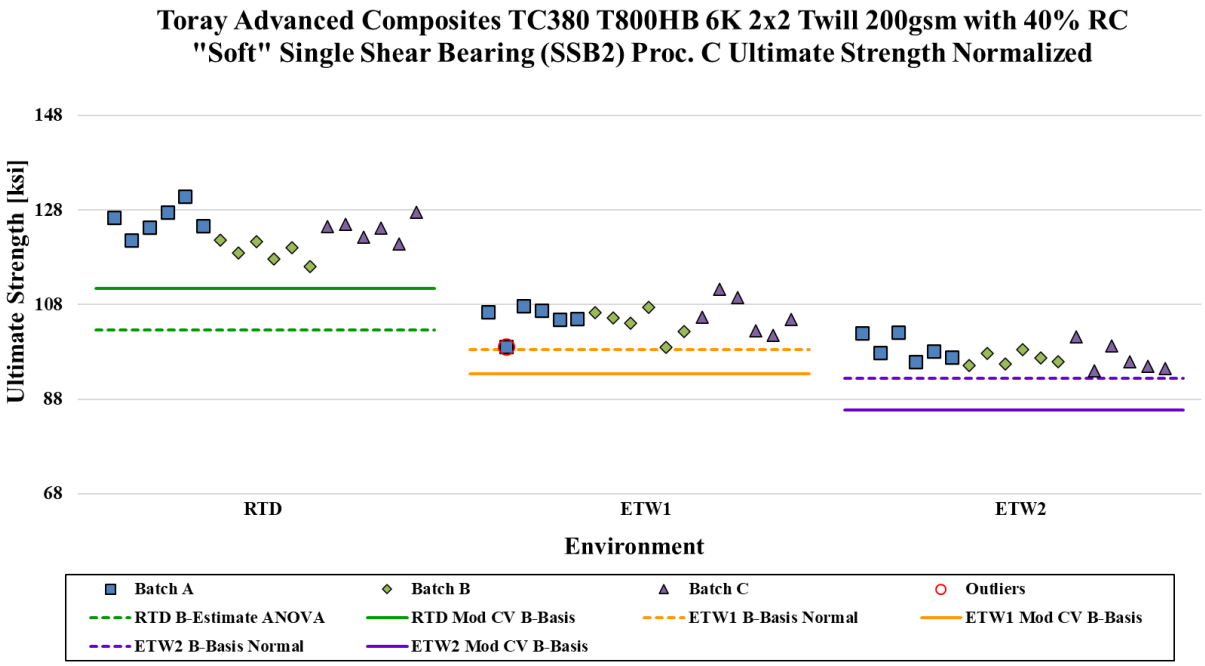

Figure 4-29: Batch Plot for SSB2 Proc. C Normalized Ultimate Strength

SSB2 Proc. C Strength (ksi) Basis Values and Statistics												
	Normalized						As-Measured					
Property	2% Offset Strength			Ultimate Strength			2% Offset Strength			Ultimate Strength		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	100.3	86.09	79.86	123.0	104.9	97.32	106.1	90.32	77.96	130.1	110.1	94.99
Std. Dev.	4.526	2.527	2.658	3.777	3.250	2.486	4.505	3.319	2.961	3.989	3.916	2.414
CV	4.511	2.935	3.328	3.070	3.098	2.554	4.246	3.674	3.798	3.066	3.558	2.542
Modified CV	6.255	6.000	6.000	6.000	6.000	6.000	6.123	6.000	6.000	6.000	6.000	6.000
Min	92.78	82.28	75.77	116.0	98.90	93.95	94.93	84.86	73.88	123.7	104.3	92.23
Max	108.6	90.45	83.73	130.9	111.3	102.1	113.0	96.05	82.81	138.9	116.3	99.82
No. Batches	3	3	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates												
B-Basis		81.10	74.61		98.51	92.41	97.20		72.11	123.9	103.9	88.76
B-Estimate	75.25			102.6				74.14				
A-Estimate	57.35	77.57	70.89	87.94	93.96	88.93	90.90	62.61	67.97	119.7	99.70	84.61
Method	ANOVA	Normal	Normal	ANOVA	Normal	Normal	Normal	ANOVA	Normal	Pooled	Pooled	Pooled
Modified CV Basis Values and Estimates												
B-Basis	90.70	76.44	70.21	111.5	93.35	85.74	96.21	80.44	68.07	118.1	98.11	83.02
A-Estimate	84.26	70.01	63.78	103.7	85.63	78.02	89.62	73.85	61.48	110.2	90.13	75.03
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled

Table 4-38: Statistics and Basis Values for SSB2 Proc. C Strength Data

SSB2 Proc. C Chord Stiffness (Msi) Statistics						
	Normalized			As-Measured		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.044	1.044	0.9953	1.104	1.095	0.9716
Std. Dev.	0.04664	0.03044	0.03249	0.05827	0.05516	0.03643
CV	4.470	2.917	3.264	5.279	5.036	3.749
Min	0.9685	0.9921	0.9243	0.9916	1.005	0.8888
Max	1.172	1.089	1.041	1.227	1.186	1.023
No. Batches	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18

Table 4-39: Statistics for SSB2 Proc. C Chord Stiffness Data

4.27 "40/20/40" Single-Shear Bearing Proc. C (SSB3)

The SSB3 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. 2% offset strength, ultimate strength and chord stiffness tests were conducted in the following environmental conditions: RTD, ETW1, and ETW2.

For the normalized datasets, for the 2% offset strength dataset, there were no diagnostic test failures, therefore all the conditions were pooled. For the ultimate strength dataset, the RTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was used for ETW1 and ETW2. Applying the modified CV, the results were identical for both properties. There were no diagnostic test failures, therefore all the condition were pooled for each property.

For the as-measured datasets, the results were identical for both properties, using the original CV and the modified CV. There were no diagnostic test failures, therefore all the conditions were pooled for each property.

There was one statistical outlier. The lowest value in batch A of the ETW2 condition was a batch outlier in the normalized 2% offset strength dataset. It was retained for this analysis.

Statistics, basis values and estimates are given for the SSB3 Proc. C strength data in Table 4-40 and for stiffness in Table 4-41. The normalized data, B-estimates and B-basis values are shown graphically in Figure 4-30 and Figure 4-31.

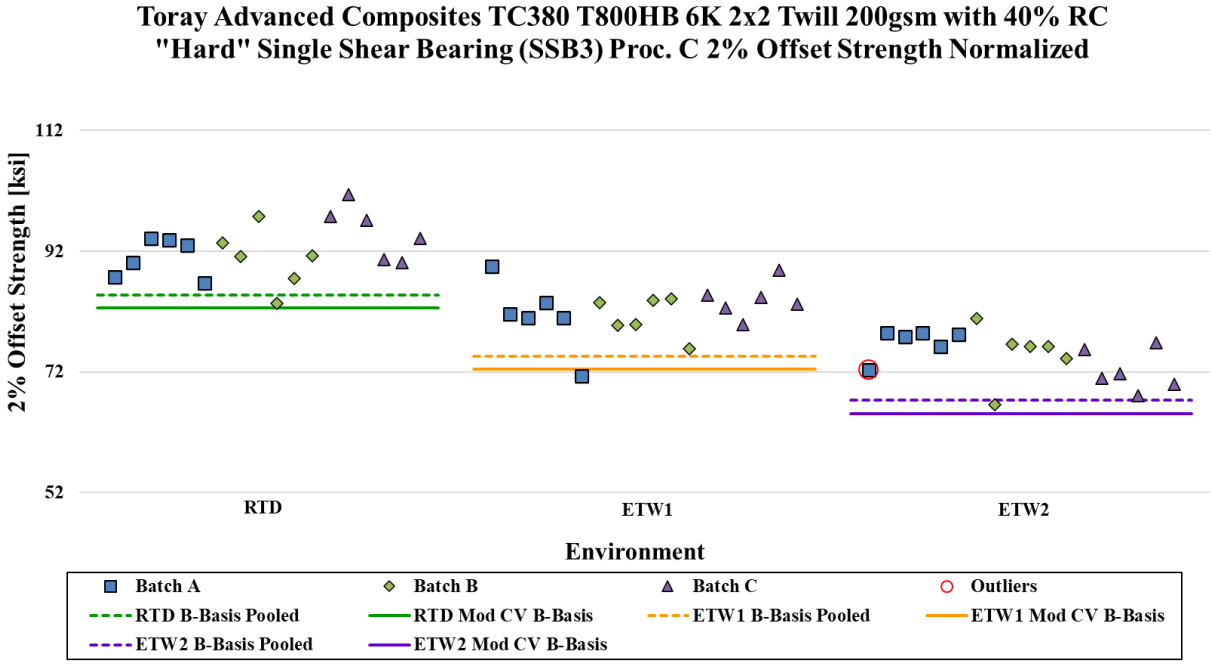

Figure 4-30: Batch Plot for SSB3 Proc. C Normalized 2% Offset Strength

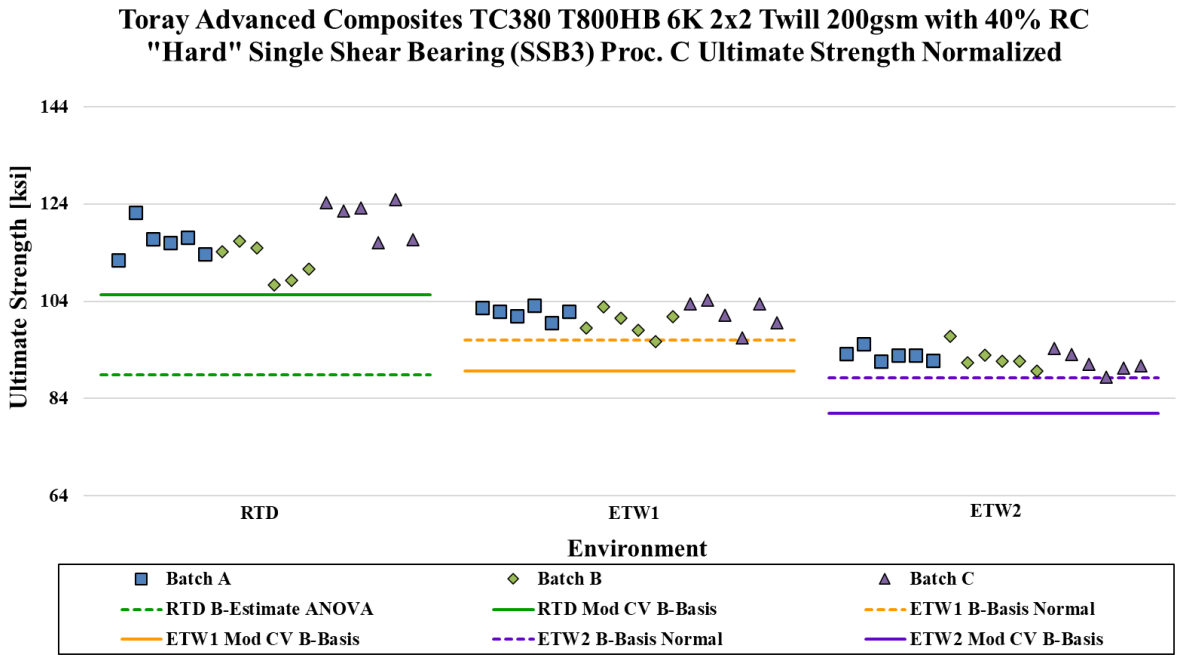

Figure 4-31: Batch Plot for SSB3 Proc. C Normalized Ultimate Strength

SSB3 Proc. C Strength (ksi) Basis Values and Statistics												
	Normalized						As-Measured					
Property	2% Offset Strength			Ultimate Strength			2% Offset Strength			Ultimate Strength		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	92.29	82.14	74.76	116.5	100.8	92.21	97.69	86.75	73.04	123.4	106.6	90.10
Std. Dev.	4.521	4.192	3.961	5.212	2.453	1.981	3.844	3.724	3.725	4.026	3.568	1.935
CV	4.899	5.103	5.298	4.472	2.432	2.148	3.935	4.293	5.099	3.264	3.348	2.148
Modified CV	6.449	6.551	6.649	6.236	6.000	6.000	6.000	6.147	6.550	6.000	6.000	6.000
Min	83.35	71.36	66.59	107.4	95.74	88.47	91.42	78.69	64.28	116.8	99.46	87.05
Max	101.4	89.51	80.88	124.8	104.3	96.80	104.8	93.30	79.32	129.8	112.3	94.93
No. Batches	3	3	3	3	3	3	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18	18	18	18	18	18	18
Basis Values and Estimates												
B-Basis	84.79	74.65	67.27		96.00	88.30	91.03	80.08	66.38	116.4	99.64	86.28
B-Estimate				88.88								
A-Estimate	79.80	69.65	62.27	69.15	92.57	85.53	86.58	75.63	61.93	111.7	94.93	83.57
Method	Pooled	Pooled	Pooled	ANOVA	Normal	Normal	Pooled	Pooled	Pooled	Pooled	Pooled	Normal
Modified CV Basis Values and Estimates												
B-Basis	82.64	72.49	65.11	105.3	89.65	81.01	88.23	77.28	63.58	110.8	93.97	79.42
A-Estimate	76.20	66.05	58.68	97.87	82.17	73.54	81.92	70.97	57.27	102.2	85.40	71.86
Method	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Normal

Table 4-40: Statistics and Basis Values for SSB3 Proc. C Strength Data

SSB3 Proc. C Chord Stiffness (Msi) Statistics						
	Normalized			As-Measured		
Environment	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)	RTD (70 °F)	ETW1 (180 °F)	ETW2 (250 °F)
Mean	1.343	1.335	1.293	1.423	1.412	1.263
Std. Dev.	0.04885	0.04434	0.03853	0.05689	0.07868	0.04555
CV	3.636	3.321	2.981	3.998	5.572	3.606
Min	1.258	1.259	1.202	1.339	1.256	1.169
Max	1.463	1.396	1.357	1.540	1.532	1.341
No. Batches	3	3	3	3	3	3
No. Specimens	18	18	18	18	18	18

Table 4-41: Statistics for SSB3 Proc. C Stiffness Data

4.28 “50/0/50” Interlaminar Tension (ILT)

The ILT data is not normalized. Strength tests were conducted in the following environmental conditions: CTD, RTD, and ETW1.

There was one statistical outlier. The highest value in the CTD condition was an outlier for the ILT strength property, and since only one batch was tested it’s only assessed as a batch outlier.

Summary statistics are presented in Table 4-42 and the as-measured data are displayed graphically in Figure 4-32 and Figure 4-33.

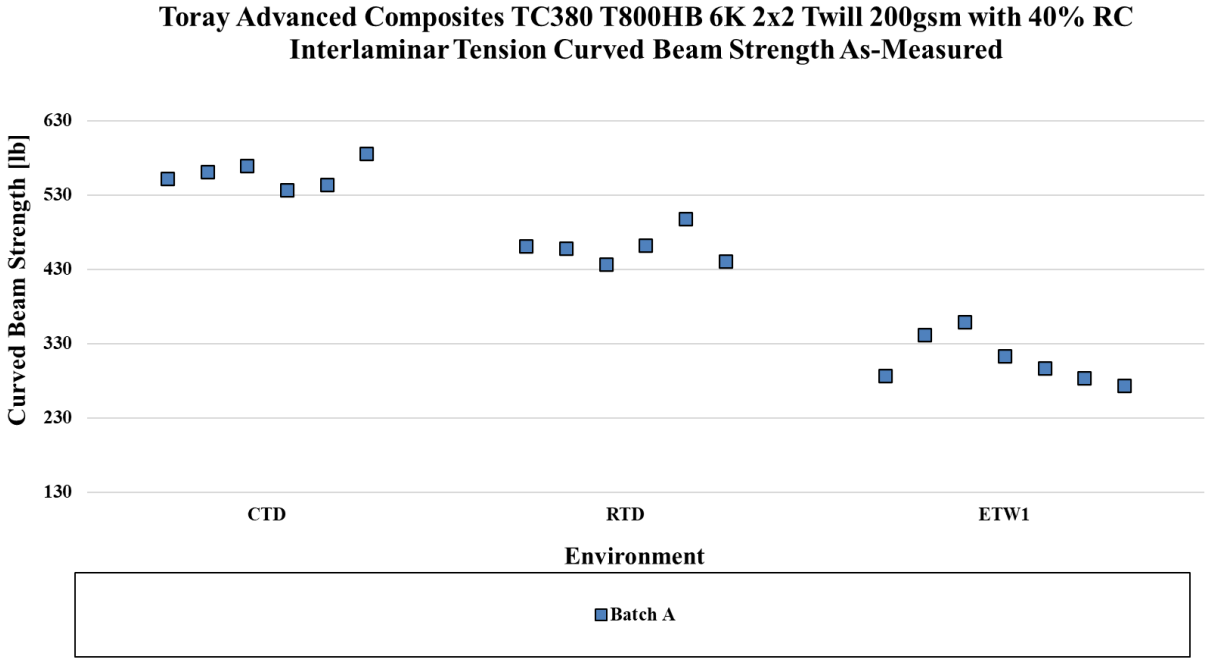

Figure 4-32: Batch Plot for Interlaminar Tension Curved Beam Strength

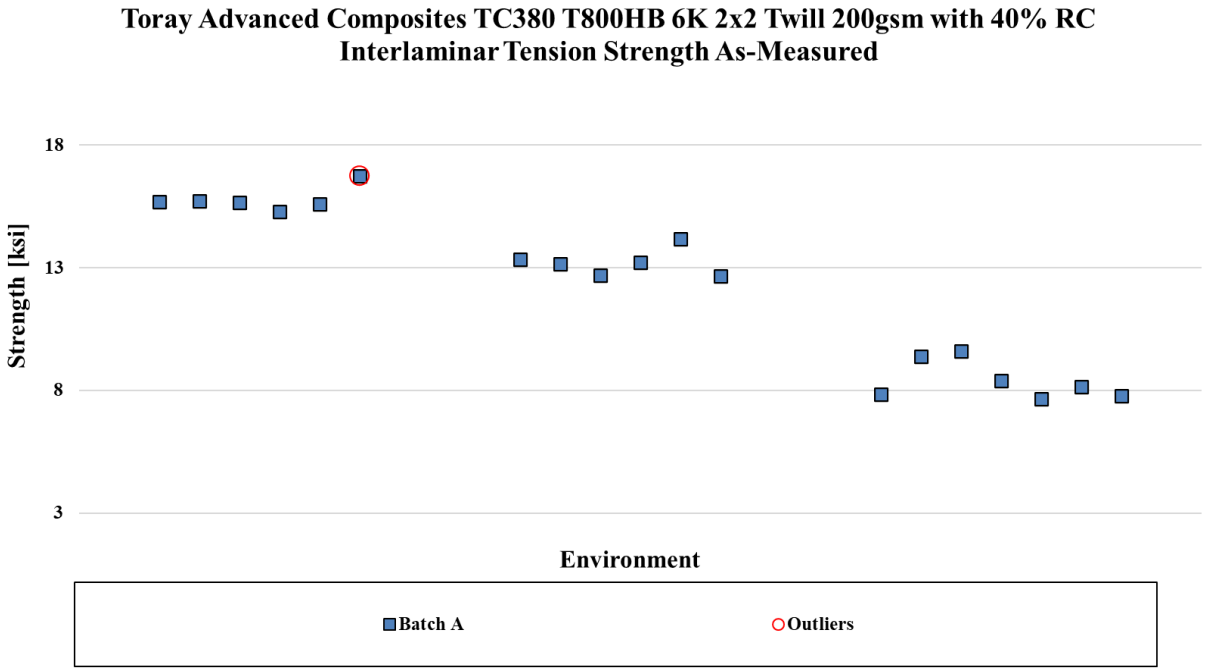

Figure 4-33: Batch Plot for Interlaminar Tension Strength

ILT As-Measured Statistics						
	CBS (lb)			Strength (ksi)		
Environment	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)	CTD (-65 °F)	RTD (70 °F)	ETW1 (180 °F)
Mean	558.0	459.8	308.0	15.78	13.20	8.404
Std. Dev.	17.72	21.76	32.35	0.4936	0.5544	0.7872
CV	3.175	4.731	10.50	3.128	4.198	9.367
Modified CV	8.000	8.000	10.50	8.000	8.000	9.367
Min	536.7	437.2	273.1	15.28	12.65	7.663
Max	585.3	498.4	359.8	16.73	14.17	9.589
No. Batches	1	1	1	1	1	1
No. Specimens	6	6	7	6	6	7

Table 4-42: Statistics for ILT Strength Data

4.29 “25/50/25” Compression After Impact (CAI1)

The CAI1 data is normalized by cured ply thickness. Both normalized and as-measured results are provided. Strength tests were conducted in the following environmental conditions: CTD and RTD.

For the normalized dataset, the CTD condition failed the ADK test for batch equivalency. ANOVA was used to compute estimates for that condition. The normal method was use for RTD. Applying the modified CV, there were no diagnostic test failures, therefore both conditions were pooled.

For the as-measured dataset, the results are identical using the original CV and the modified CV. There were no diagnostic test failures, therefore both conditions were pooled.

There was one statistical outlier. The lowest value in batch A of the RTD condition was a batch outlier in the normalized dataset. It was retained for this analysis.

Statistics, basis values and estimates are presented in Table 4-43 and the data are displayed graphically in Figure 4-34.

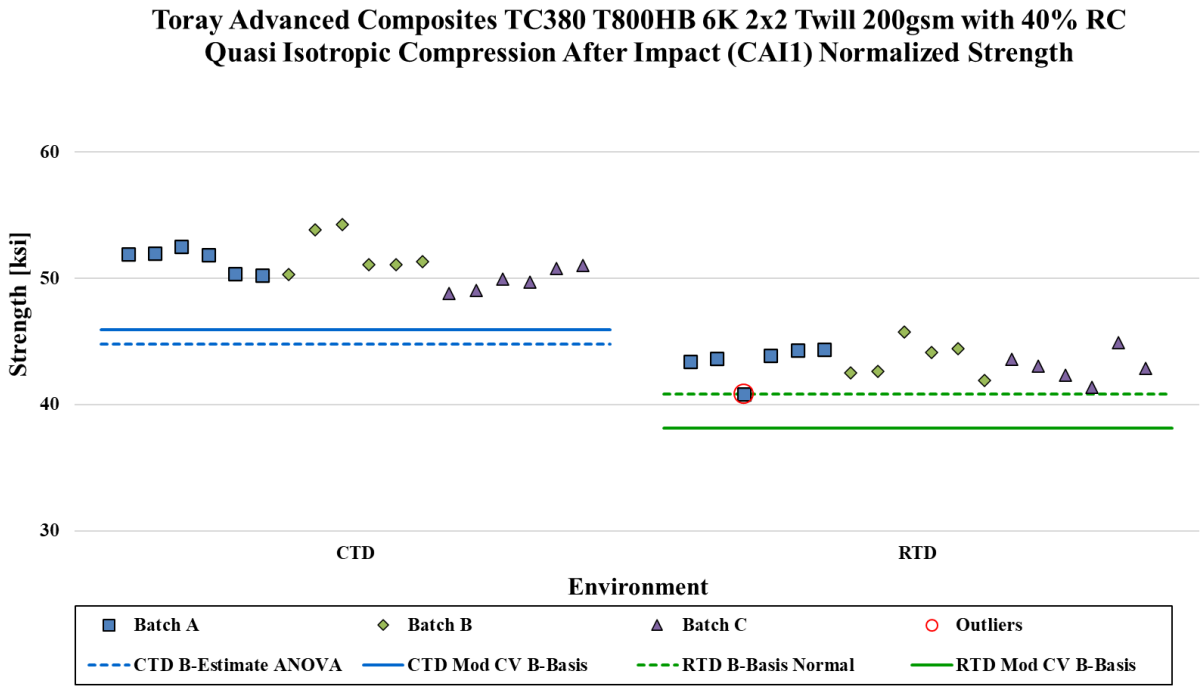

Figure 4-34: Batch Plot for CAI1 Normalized Strength

CAI1 Strength (ksi) Basis Values and Statistics				
	Normalized		As-Measured	
Environment	CTD (-65 °F)	RTD (70 °F)	CTD (-65 °F)	RTD (70 °F)
Mean	51.12	43.34	50.80	43.79
Std. Dev.	1.462	1.265	1.228	1.444
CV	2.860	2.918	2.418	3.297
Modified CV	6.000	6.000	6.000	6.000
Min	48.81	40.87	48.27	40.87
Max	54.29	45.76	53.16	46.81
No. Batches	3	3	3	3
No. Specimens	18	18	18	18
Basis Values and Estimates				
B-Basis		40.84	48.36	41.35
B-Estimate	44.79			
A-Estimate	40.28	39.07	46.70	39.69
Method	ANOVA	Normal	Pooled	Pooled
Modified CV Basis Values and Estimates				
B-Basis	45.94	38.16	45.62	38.61
A-Estimate	42.42	34.63	42.09	35.08
Method	Pooled	Pooled	Pooled	Pooled

Table 4-43: Statistics and Basis Values for CAI1 Strength Data

4.30 “40/20/20” Compression After Impact (CAI3)

The CAI3 data is normalized by cured ply thickness. Both normalized and as-measured statistics are provided. Strength tests were conducted in the following environmental conditions: RTD. With only one batch, basis values were not computed.

Summary statistics are presented in Table 4-44 and the normalized data are displayed graphically in Figure 4-35.

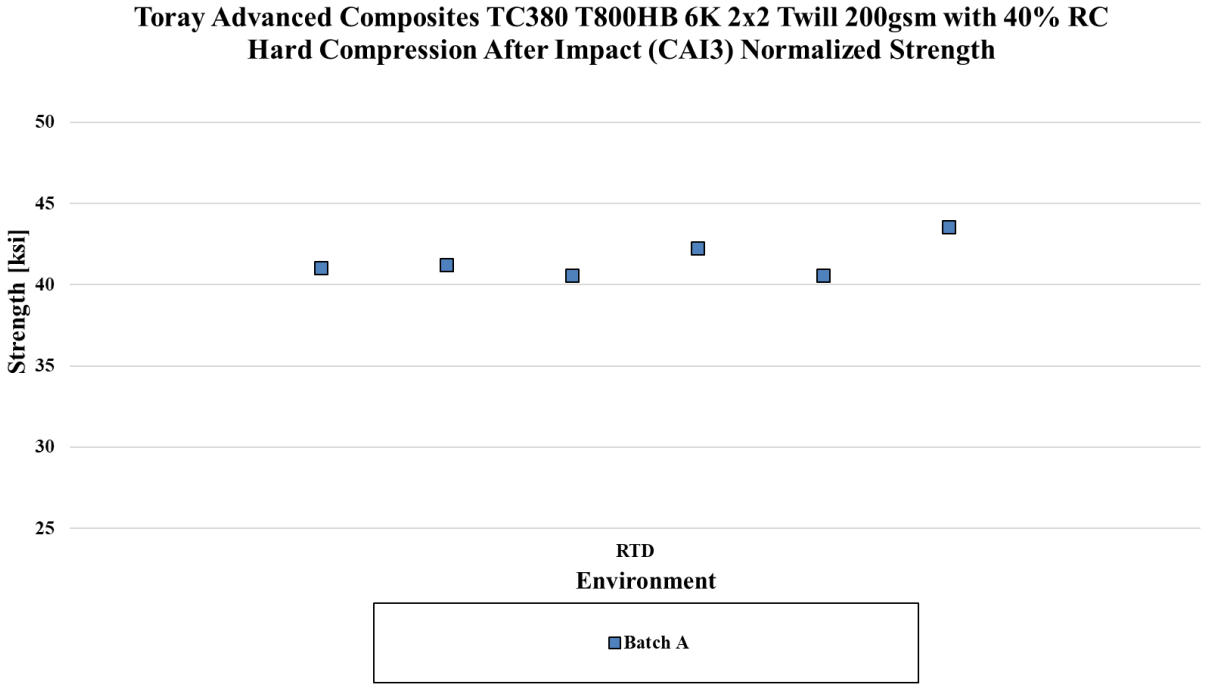

Figure 4-35: Batch Plot for CAI3 Normalized Strength

CAI3 Strength (ksi) Statistics		
	Normalized	As-Measured
Environment	RTD (70 °F)	RTD (70 °F)
Mean	41.52	41.87
Std. Dev.	1.163	0.7245
CV	2.800	1.730
Modified CV	8.000	8.000
Min	40.56	40.76
Max	43.54	42.55
No. Batches	1	1
No. Specimens	6	6

Table 4-44: Statistics for CAI3 Strength Data

5. Outliers

Outliers were identified according to the standards documented in section 2.1.5, which are in accordance with the guidelines developed in section 8.3.3 of the CMH-17 Handbook's Volume 1. An outlier may be an outlier in the normalized data, the as-measured data, or both. A specimen may be an outlier for the batch only (before pooling the three batches within a condition together) or for the condition (after pooling the three batches within a condition together) or both.

Approximately 5 out of 100 specimens will be identified as outliers due to the expected random variation of the data. This test is used only to identify specimens to be investigated for a cause of the extreme observation. Outliers that have an identifiable cause are removed from the dataset as they inject bias into the computation of statistics and basis values. Specimens that are outliers for the condition and in both the normalized and as-measured data are typically more extreme and more likely to have a specific cause and be removed from the dataset than other outliers. Specimens that are outliers only for the batch, but not the condition and specimens that are identified as outliers only for the normalized data or the as-measured data but not both, are typical of normal random variation.

All outliers identified were investigated to determine if a cause could be found. Outliers with causes were removed from the dataset and the remaining specimens were analyzed for this report. Information about specimens that were removed from the dataset along with the cause for removal is documented in the material property data report, NCAMP Test Report CAM-RP-2025-023 Rev -. Outliers for which no causes could be identified are listed in Table 5-1. These outliers were included in the analysis for their respective test properties.

Test	Property	Condition	Batch	Specimen No.	Value	Type	Outlier		
							High/Low	Batch	Condition
FT	Strength	ETW2 (250 °F)	C	TCEUC111E	125.1	Normalized	Low	Yes	Yes
					125.6	As-Measured			
FC	Strength	CTD (-65 °F)	B	TCEZB211B	97.32	As-Measured	Low	Yes	No
		ETD1 (180 °F)	A	TCEZA214C	69.51	As-Measured	Low	No	Yes
		ETW1 (180 °F)	C	TCEZC113D	58.19	Normalized	Low	Yes	Yes
					58.33	As-Measured			
		ETW2 (250 °F)	C	TCEZC114E	50.02	Normalized	Low	Yes	Yes
					50.02	As-Measured			
IPS	0.2% Offset Strength	CTD (-65 °F)	C	TCENC213B	8.868	As-Measured	High	Yes	No
	Strength at 5% Strain	CTD (-65 °F)	C	TCENC213B	17.48	As-Measured	High	Yes	No
SBS	Strength	CTD (-65 °F)	C	TCEQC213B	13.28	As-Measured	Low	No	Yes
UNT1	Strength	ETW2 (250 °F)	C	TCEAC211E	92.93	Normalized	Low	Yes	No
					91.18	As-Measured			
		CTD (-65 °F)	B	TCEAB313B	108.1	Normalized	Low	Yes	No
UNT2	Strength	ETW1 (180 °F)	C	TCEBC111D	55.85	Normalized	Low	No	Yes
UNT3	Strength	CTD (-65 °F)	B	TCECB211B	148.1	Normalized	High	Yes	No
UNC1	Strength	ETW1 (180 °F)	B	TCEWB111D	58.66	As-Measured	Low	Yes	No
					58.82	Normalized			
UNC2	Strength	ETW1 (180 °F)	C	TCEXC213D	36.64	Normalized	Low	Yes	No
		ETW2 (250 °F)	C	TCEXC213E	28.35	Normalized	Low	No	Yes
					28.74	As-Measured			
		RTD (70 °F)	C	TCEXC213A	50.74	As-Measured	Low	Yes	No
UNC3	Strength	ETW2 (250 °F)	A	TCEYA213E	63.76	As-Measured	High	No	Yes
OHT1	Strength	ETW1 (180 °F)	B	TCEDB112D	57.80	Normalized	Low	Yes	No
		CTD (-65 °F)	C	TCEDC211B	60.14	As-Measured	High	Yes	No
OHT2	Strength	CTD (-65 °F)	B	TCEEB113B	52.16	Normalized	High	Yes	No
					50.68	As-Measured			
		ETW2 (250 °F)	A	TCEEA111E	35.86	Normalized	Low	Yes	No
		RTD (70 °F)	B	TCEEB111A	45.36	As-Measured	High	Yes	No
OHT3	Strength	RTD (70 °F)	B	TCEFB213A	75.00	Normalized	High	Yes	No
FHT1	Strength	ETW2 (250 °F)	A	TCE4A211E	63.00	Normalized	High	No	Yes
		ETW2 (250 °F)	B	TCE4B112E	63.87	As-Measured	High	Yes	Yes
FHT2	Strength	CTD (-65 °F)	B	TCE5B113B	60.27	Normalized	High	Yes	No
		CTD (-65 °F)	C	TCE5C213B	58.35	Normalized	Low	Yes	No
		ETW2 (250 °F)	C	TCE5C213E	43.87	Normalized	High	No	Yes
					43.97	As-Measured			
FHT3	Strength	ETW2 (250 °F)	C	TCE6C214E	74.35	As-Measured	High	Yes	No
OHC1	Strength	ETW2 (250 °F)	B	TCEGB211E	25.89	Normalized	Low	Yes	Yes
		CTD (-65 °F)	A	TCEGA211B	44.53	As-Measured	Low	Yes	No
OHC2	Strength	ETW1 (180 °F)	A	TCEHA212D	29.53	As-Measured	Low	Yes	No
OHC3	Strength	RTD (70 °F)	B	TCEIB111A	44.58	As-Measured	High	No	Yes
FHC1	Strength	CTD (-65 °F)	A	TCE7A111B	84.15	Normalized	Low	Yes	Yes
					82.78	As-Measured			
FHC2	Strength	ETW1 (180 °F)	B	TCE8B113D	41.56	Normalized	Low	Yes	No
FHC3	Strength	ETW2 (250 °F)	C	TCE9C112E	48.81	Normalized	Low	Yes	No
SSB1 Proc. C	2% Offset Strength	RTD (70 °F)	B	TCE1B213A	94.43	Normalized	Low	Yes	No
	Ultimate Strength	ETW1 (180 °F)	C	TCE1C111D	122.0	Normalized	High	No	Yes
SSB2 Proc. C	Ultimate Strength	ETW1 (180 °F)	A	TCE2A112D	99.06	Normalized	Low	Yes	No
		ETW1 (180 °F)	B	TCE2B212D	105.6	As-Measured	Low	Yes	No
SSB3 Proc. C	2% Offset Strength	ETW2 (250 °F)	A	TCE3A111E	72.36	Normalized	Low	Yes	No
ILT	Strength	CTD (-65 °F)	A	TCEMA213B	16.73	As-Measured	High	Single Batch	
CAI1	Strength	RTD (70 °F)	A	TCEKA114A	40.87	Normalized	Low	Yes	No

Table 5-1: List of Outliers

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