Method: 2P Weibull distribution and Weighted Least Squares Regression

Contents

Statistical evaluation of failure stresses.

The procedure is as follows:

- Sort the stress at failure for each specimen in increasing order of magnitude: σ_i, where i is the rank number.
- Calculate the probability of failure $P_{f,i}$ for each measured value. Use the following estimator: $P_{f,i} = \frac{i-0.5}{n}$ (*Hazen's probability estimator*) or $P_{f,i} = \frac{i}{n+1}$ (*Mean rank probability estimator*) where n is the number of tested samples.
- Put the Weibull distribution into linearized form. Enter the measured data into the Weibull mesh.
- Fit the data by Weighted Least Squares Regression . Find the slope, the intercept, and the coefficient of determination R^2, coefficient of variation COV and the Anderson Darling goodness of fit metric p_{AD}.
- Calculate the confidence interval CI.
- Determine the Weibull parameters β (shape parameter) and θ (scale parameter).
- Determine the desired fractile value of the bending tensile strength f_y using the regression line and using the confidence interval. In the case of the confidence interval, the target goal seek is used.
- Plot the cumulative distribution function $F(x)$ and the density function $f(x)$.

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> **Note:** You can use the 🚀 **`Live Code`** button in the top right to activate the interactive features and use Python interactively!

Once the "Live Code" is enabled it is advised to **"Run All"** cells first to load all the necessary packages and functions.

Afterwards, any changes can be made in the input form and when the **"Evaluate"** button is clicked the changes are recorded.

Finally, the last two cells can be run individually by clicking on the **"Run"** button to produce the Weibull plots.

▶ Show code cell source

Definition of useful functions:

- Convert failure stress to equivalent failure stress for a constant load given a reference time period.
- Calculation of standard error.
- Confidence interval calculation
- Weibull pdf and cdf distributions
- Calculationf of Anderson Darling goodness of fit metric p_{AD}

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Interactive Data Input

This widget allows users to input datasets, set analysis parameters, and optionally convert failure stress values.

What can be done:

Choose the number of datasets (default: 3).
Enter dataset names and values (comma-separated).
Set target values:

- stress fractile (default: 5%)
- confidence interval: Enter the alpha value. (default: 95%)
- x-limits (default: lower limit = min_stress_level - 20, upper limit =max_stress_level + 20)

Select a probability estimator:

- *(i - 0.5) / n* (*Hazen's probability estimator*)
- *i / (n + 1)* (*Mean rank probability estimator*)

Convert failure stress (optional):

- Toggle conversion of failure stress to equivalent failure stress for a selected reference period ON/OFF, by clicking Yes/No respectively.
- Enter time-to-failure values.
- Choose a reference time period (1s, 3s, 5s, 60s).

How It Works:

1️⃣ Click **"Confirm"** to generate input fields for the failure stress datasets.
2️⃣ *(Optional)* Click **"Yes"** and enter the time-to-failure values corresponding to each failure stress dataset.
3️⃣ Enter values and click **"Evaluate"** to process the data.

> **Note:** The script checks for errors in the input or mismatch in the dimensions between the time-to-failure datasets and the failure stress datasets.

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Enter the data separated by commas, with decimal point (e.g. "1.44, 2.33, 4.22, 3.01,...")

Data protection declaration: The data entered will not be saved or transmitted over the network.

Number of Datasets: 2

Confirm

Name 1: AR-air Values 1: 93.00592096, 168.4571941, 130.8893 69.56877085, 74.69715591, 192.0145

Name 2: AR-tin Values 2: 79.81138916, 109.4920098, 127.2451 80.66631387, 42.88445774, 195.3124

Target stress fractile: 0,05

Target confidence interval: 0,1

Lower x limit: 0

Upper x limit: 0

Probability Estimator:

(i-0.5)/n   i/(n+1)

Convert to equivalent constant failure stress for a reference time period?

No   Yes

Select reference time period[s]: 5

Time to failure 1: 4.525933315, 2.697913735, 3.072665231, 7.005076121, 6.608416492, 6.378624526

Time to failure 2: 3.412987227, 1.950157915, 7.727009354, 5.634417155, 6.117937416, 2.342358471

Evaluate

```
Selected Probility Estimator: (i-0.5)/n
AR-air; n = 30 samples: [194.2578912   53.26219681 105.2809725  106.74093
 105.5981283  187.2480902   56.87943945  72.95842129  65.25731384
  45.61614573  83.11089449  67.22053889 129.8572468  109.5988269
 109.1843532   56.43452966  83.14540165  73.16139321 135.3082157
  93.00592096 168.4571941  130.88936    235.4164091  120.0878419
  69.56877085  74.69715591 192.0145377  171.8313357  165.9220807 ]
AR-tin; n = 30 samples: [110.8304225   90.70751115 110.1536556   75.87602
 101.9558776  105.2832988   72.33515986  75.07886719  40.41758317
 131.7031863  225.3279099   85.34785053 120.5222832  143.1221499
  99.69682147  77.6667107   34.24681032 144.1728737   93.26065363
  79.81138916 109.4920098  127.2451707  131.9984358   80.66631387
  42.88445774 195.3124922  123.9243408  153.8858652   57.1494871 ]

Target stress fractile: 5.0%
Target confidence interval: 95%
Default values for Lower x limit and Upper x limit.

Conversion of failure stress: Yes, Reference time period [s]: 5
AR-air; n = 30; Time to failure values[s]: [7.44896787, 2.176724145, 3.93
The equivalent failure stress for 5 seconds is [166.84  42.36  86.89  88.
  36.2   68.83  54.27 108.66  90.86  90.67  44.96  68.   59.28 113.85
  77.01 143.14 109.6  203.73  99.98  56.07  60.7  164.28 146.48 141.13]
AR-tin; n = 30; Time to failure values[s]: [4.137189315, 3.564582569, 5.2
The equivalent failure stress for 5 seconds is [ 91.75  74.4   92.52  61.
 116.02 195.07  69.81 100.2  120.14  82.09  62.96  26.66 121.27  76.49
  64.91  90.59 107.43 111.07  65.98  33.87 168.13 104.59 130.55  45.66]
```

Launch Thebe

Print to PDF

Start of Statistical evaluation

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```python
if 'stress_values' not in globals() or 'stress_values' not in locals
    print("Please enter all the necessary input data in the above in
else:
    plt.figure(figsize=(10, 6))
    i = 0;
    min_stress_data = 100000
    max_stress_data = -10000

    # Initialize an empty dictionary to store the scale & shape valu
    Weibull_distribution_parameters = {}
    Regression_line_parameters = {}
    for dataset, stress_data in stress_values.items():

        if stress_data.size > 0 and np.any(stress_data != 0):
```

run run all add cell clear

AR-air (n=30)

Fractile [%]	Stress [MPa]	95% CI lower [MPa]	95% CI upper [MPa]
0.8%	10.25	7.56	13.02
5%	24.89	20.73	28.77
50%	86.53	81.73	91.71
Selected 5.0%	24.89	20.73	28.77

AR-air (n=30)

Min Stress [MPa]	Max Stress [MPa]	Mean Stress [MPa]	Coeff. of variation [%]	Goodness of fit, p_{AD}
36.2	203.73	93.05	50.25	14.12

Regression line for "**AR-air**" (**n=30**) is: **y = 2.09x - 9.69; R^2= 0.866**

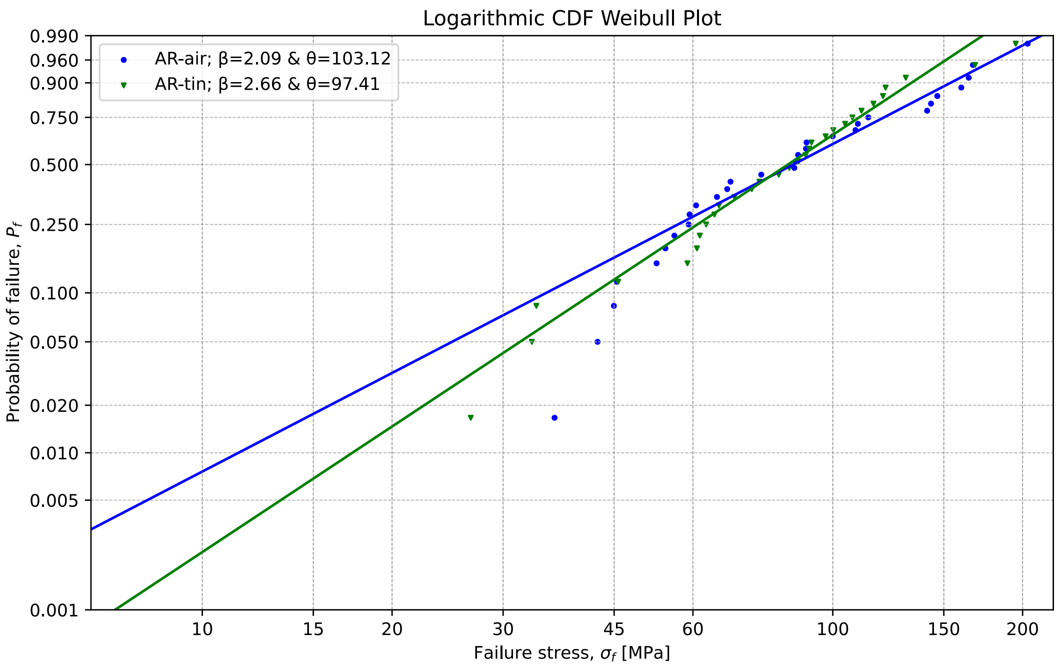
AR-tin (n=30)

Fractile [%]	Stress [MPa]	95% CI lower [MPa]	95% CI upper [MPa]
0.8%	15.9	14.41	17.38
5%	31.92	30.05	33.7
50%	84.88	82.8	87.05
Selected 5.0%	31.92	30.05	33.7

AR-tin (n=30)

Min Stress [MPa]	Max Stress [MPa]	Mean Stress [MPa]	Coeff. of variation [%]	Goodness of fit, p_{AD}
26.66	195.07	87.93	40.46	56.22

Regression line for "**AR-tin**" (**n=30**) is: **y = 2.66x - 12.19; R^2= 0.970**



Plot the cumulative distribution function $F(x)$ and the density function $f(x)$.

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