Using the fde.uwaterloo.ca fatigue database files

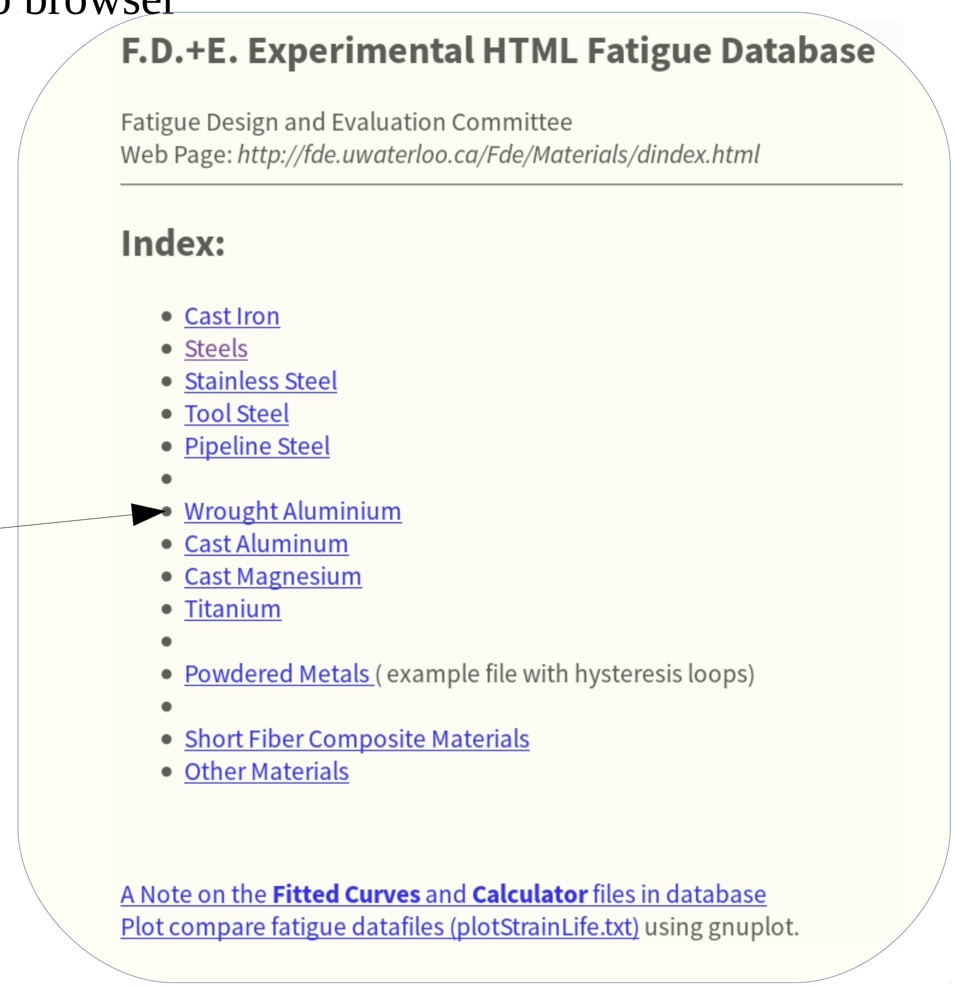
In Chapter 5 Part 0 introduced axial fatigue specimen testing, and a file format for saving the data in a web browser accessible form.

In this sub-section you will learn how to download the files, plot them using the on-line tools, plot them locally using gnuplot, and create a web structure for saving your own data sets.

Step 1 Click on this link: http://fde.uwaterloo.ca/Fde/Materials/dindex.html
or copy link to your web browser

You should get back this page:

Lets get a wrought Aluminum example.
In your web browser Click here



F.A. Conle, July 2017

This page should appear:

AA 7xxx Series Aluminum Fatigue Data file index :

Web Page: *http://fde.uwaterloo.ca/Fde/Material/Alum/AA7xxx/aa7xxx.html*
Updates: Aug.20 1999. Mar1-2009, Oct2010, Jan2012

The files in this directory are offered by the F.D.& E. committee members as a set of example files for the construction of web based material fatigue property databases. They are meant for information and research use only, not for design.

These are individual data set files

- **AA 7005-T5 (Chung/Abel)** Not enough long life data for good Fitted data file.
-
- **AA 7049-T6 (Ramusat/Vidal 1979)** Not enough long life data for good Fitted data file.
-
- **AA 7050-T7351 (Ramusat/Vidal 1979)** Not enough long life data for good Fitted data file.
-
- **AA 7075-T6 (Endo/Morrow 1969)** Not enough long life data for good Fitted data file.
- **AA 7075-T651 (Kurath 1984)** | Fitted | Calculator
- **AA 7075-T651 (Ramusat/Vidal 1979)** Not enough long life data for good Fitted data file.
- **Merged AA 7075-T6xx composed of above 3 files**
  - **Merged AA 7075-T6xx** | Fitted | Calculator | Stress-Strain Simulator
  - Compare plot of Fitted vs Raw Strain-2Nf
  - Compare plot of Fitted vs Raw Neuber-2Nf

3 "

When available a merged file is the best source

Click on the merged file
(In your browser)

Your web browser should return this page

Pick one: # ○FDE_plot # ◉FDE_fit # [Send for Plot] #

This button will return plots of the data

```
#web site: http://www.gnu.org/copyleft/gpl.html
#
# Merged Data File!!   AA7075_T6xx Aluminum Wrought
# -
#See descriptions below
#FileType= strain_life
#DataType= raw
#TIMEcol= 0
#Name= Merged
#NAME= AA7075T6xx
#Name= Aluminum
#Stress_units= mpa
#Strain_units= strain
#Sy=    480     average of (492,468)
#Su=    566     average of (553,578)
#E=    69980.   average of (70000,70953,69010)
#%RA=  35.3     avg.  of (33,37.6)
#BHN= 150  (from Rasmusat/Vidal
#
# Ref.1:  M.Sc. Thesis by P. Kurath Univ. of Illinois.
#
#TotStrain  2Nf  Stress  Mean   Plastic Strain   Initial
#_Amp              Amp   Stress       Amp         Elastic Mod.
0.010       508   543.     0      0.0022        70000.
0.010       568   541      0      0.0022        70000.
0.010       590   540      0      0.0023        70000.
0.0075     1964   515      0      0.0001        70000.
0.0075     2874   503      0      0.00026       70000.
0.0075     2900   507      0      0.0003        70000.
0.0050    36600   356      0      0.            70000.
0.0050    37600   350      0      0.            70000.
0.0050    37600   337      0      0.            70000.
0.0040   106100   279      0      0.            70000.
0.0040   106900   281      0      0.            70000.
0.0040   124800   288      0      0.            70000.
0.0034   833000   239      0      0.            70000.
0.0034   905000   242      0      0.            70000.
0.0029  2499000   197      0      0.            70000.
0.0029  3002100   201      0      0.            70000.
##Su=        83.90 ksi = 578 mpa
```

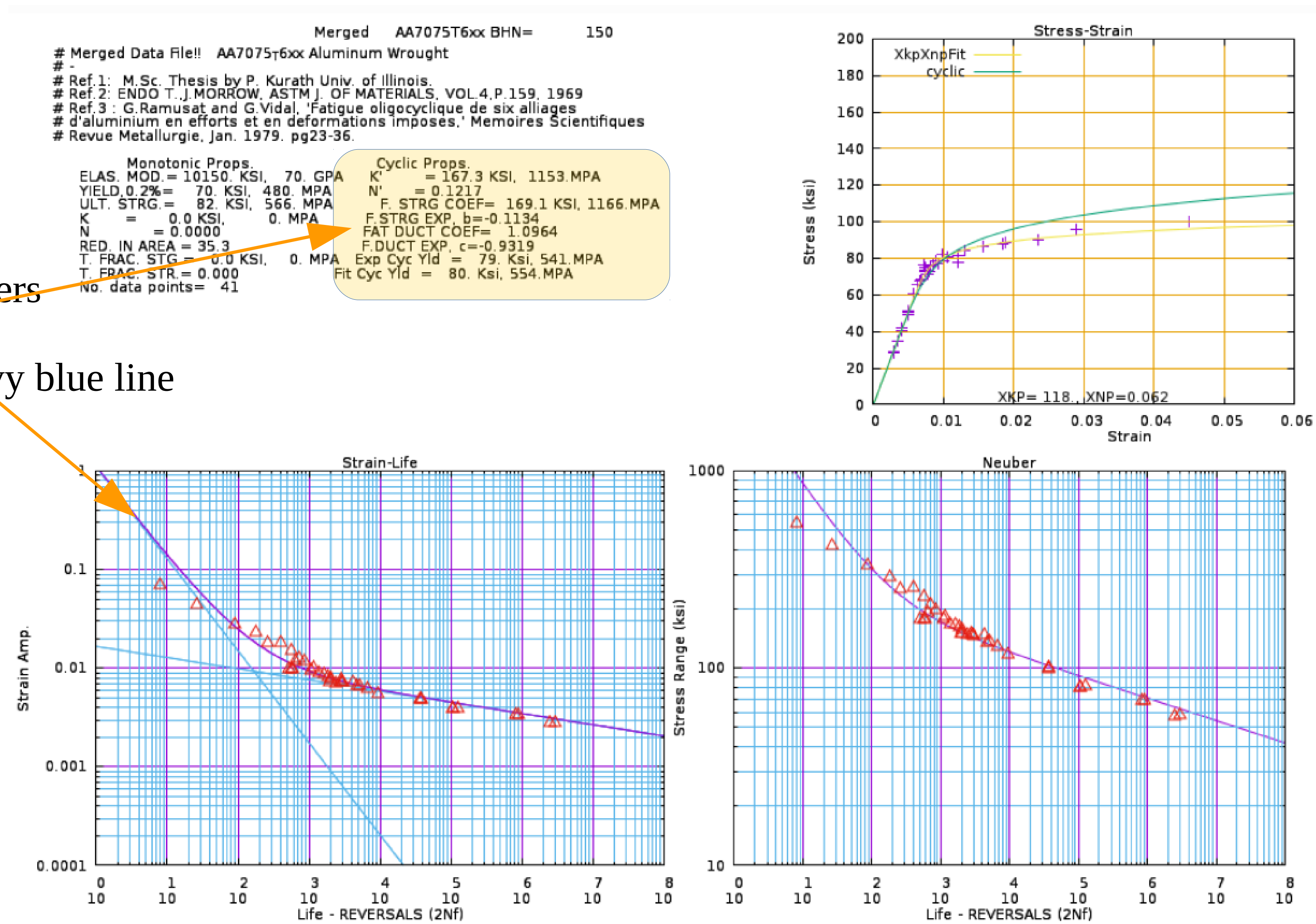
The raw test result data is in this text box

When you click on "Send for plot" the contents of the text box are sent to a U. Waterloo server that decodes it and creates the plots.

In your browser try it now.

The web browser should return a figure as below:

The “traditional fit” is defined by the parameters in this table and appears as the heavy blue line in this figure.



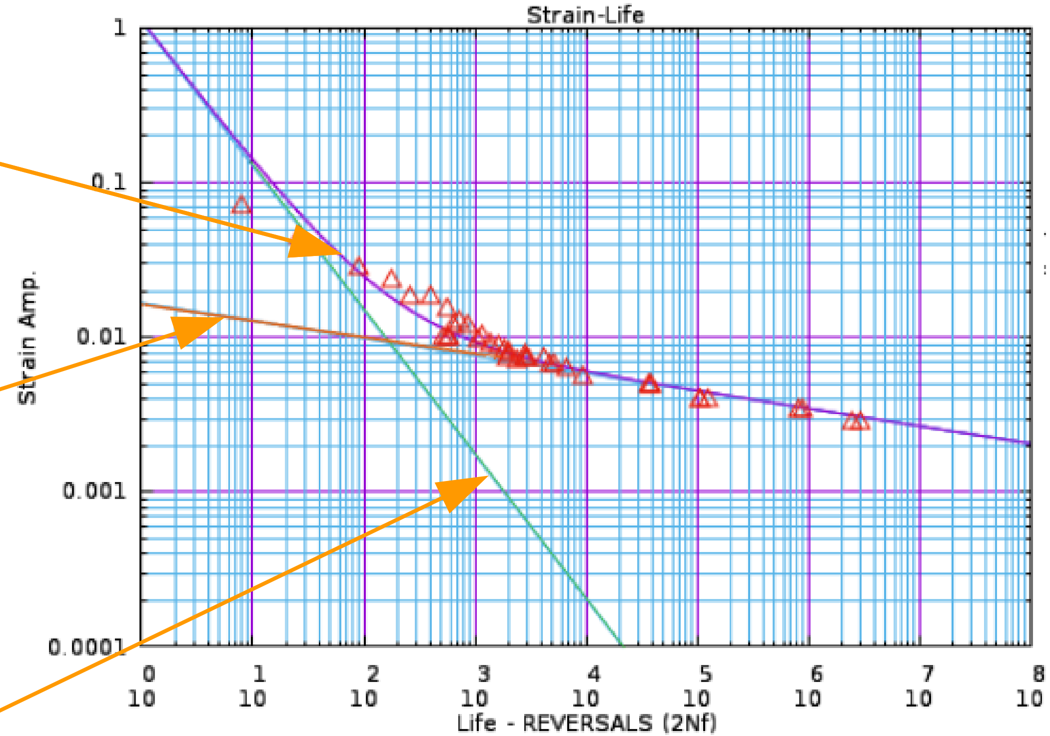
The traditional fit, blue line, is composed of two least squares fit lines that are added vertically to make the curved blue line.

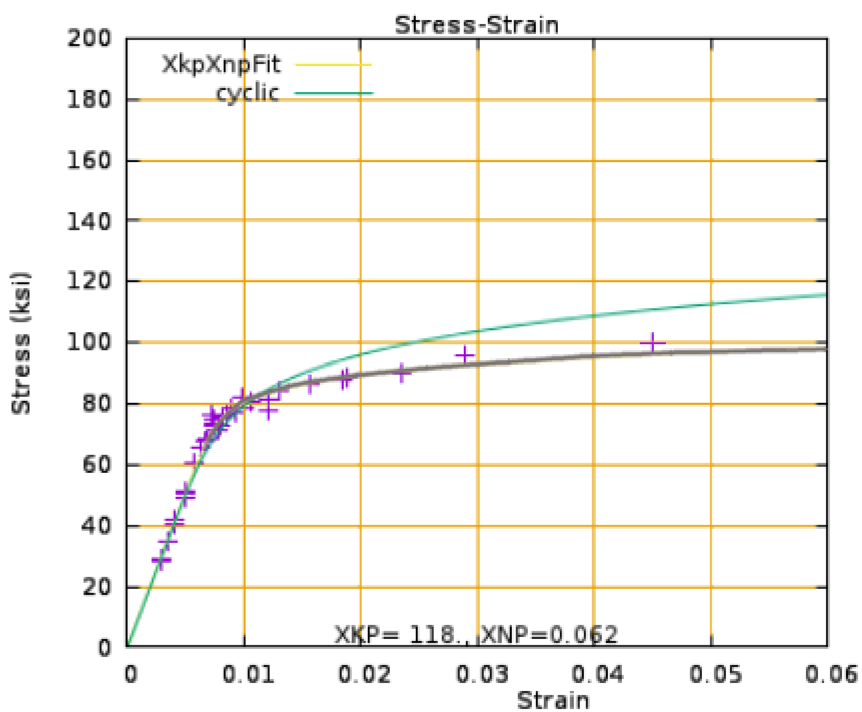
The elastic strain amplitude is fitted vs 2Nf by the brown line

(Elastic Strain = Stress/E)

The plastic strain amplitude is fitted vs. 2Nf and forms the green line

(Plastic Strain = Total Strain - Stress/E)





Since there are only 3 variables in a test; namely Strain, Stress and Life, one can really only do 2 fits without getting into over-constraint problems.

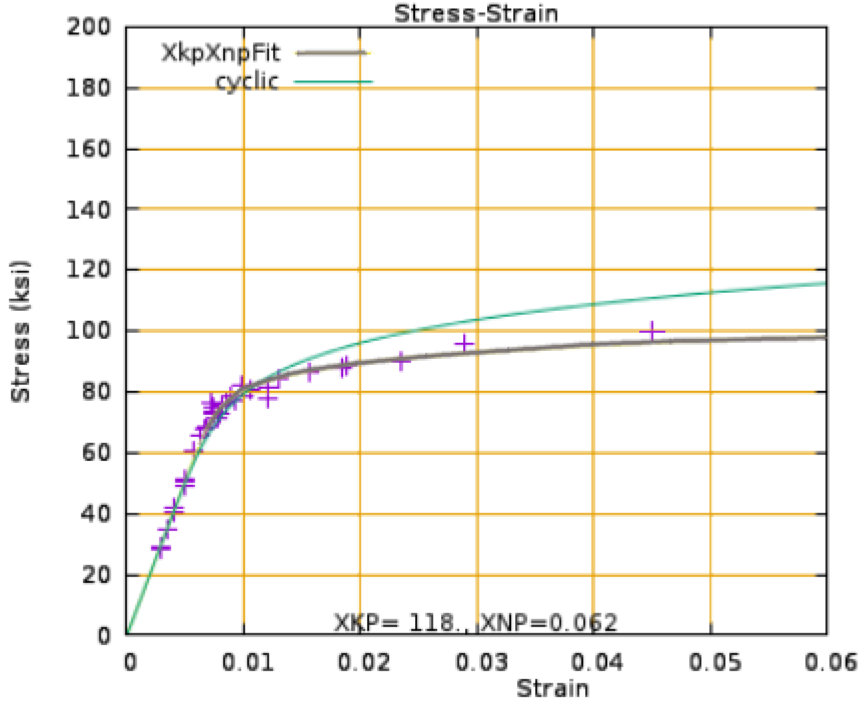
i.e. : we cannot reliably to go from

Life → Strain → Stress → Life

with 3 fits and end up at the same Life.

The cyclic stress-strain curve can be fitted
with the equation of stress ampl. vs plastic strain ampl.:

$$\Delta\sigma/2 = K'(\Delta\varepsilon_p/2)^{n'}$$



and then strain ampl. is related to stress ampl.
with

$$\Delta\varepsilon/2 = \Delta\sigma/2E + (\Delta\sigma/2K')^{1/n'}$$

A number of investigators do this, but such a 3^{rd} fit leads to an over-constrained set of equations.

In order to avoid this some investigators use the formula

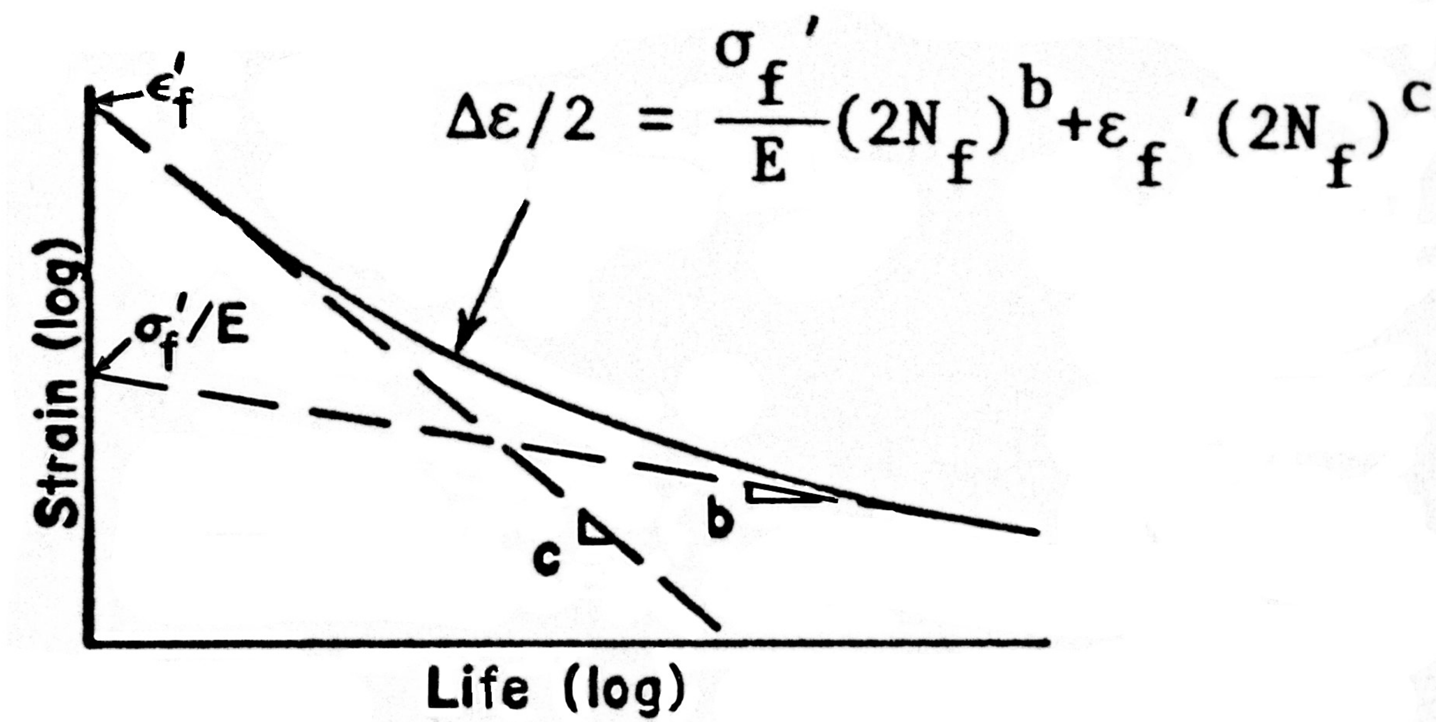
$$n' = b/c$$

$$K' = \sigma_f' / (\varepsilon_f'^{\,n'})$$

which does not always fit the data well.

$$\frac{\Delta\sigma/2}{E} = \frac{\sigma_f'}{E}(2N_f)^b \qquad \Delta\varepsilon_p/2 = \varepsilon_f'(2N_f)^c$$

In the traditional fit he curved line is the vertical addition of the two straight fit lines



It turns out that the traditional fit process is not really necessary. It was invented in the days of hand and slide rule calculations.

An alternate more flexible and accurate method, which we will be using in this course, is simply to represent the curves with:

A digital set of **Strain, Stress, Life** values

Everything else can be computed from these three variables, if one has a further item:

A good value for the **Elastic Modulus** (Emod).

In the past measurements of the material's Emod have been surprisingly poor. Often researchers have reported only a single measurement of the Emod, or just assumed a value from other reports.

In my experience it is best to measure the elastic modulus at the beginning of each fatigue test and then, when all tests are completed, take the average of the measurements as representative for the material.

Creating a "fitted" file: A digital set of **Strain, Stress, Life** values
Method 1

Step 1 : Arrange your fatigue test data into standard SAE format file
Give the file name an .html suffix e.g.: aa7075xxx.html

Example: http://fde.uwaterloo.ca/FatigueClass/FCourseNotes/exampleSAEfile.html.txt

Use the example file as a template. Change the comment, identifier tag values, and raw data to your material results.

The resulting html file should look something like this:

exampleSTDfile.html + (~/Seminars/FCourseDbase) - GVIM

File Edit Tools Syntax Buffers Window Help

```
#<html><title>Material + Cycles File</title><body>
#<FORM METHOD="POST" ACTION="http://mme.uwaterloo.ca/cgi-bin/catgnume">
#<font size="5" color="green"><DL compact> Pick one:
#<input type="radio" name="#saeinput" value="FDE_plot" >FDE_plot
#<input type="radio" name="#saeinput" value="FDE_fit"  checked >FDE_fit
#<input type="submit" value="Send for Plot"></font>
#<br><pre><textarea rows=50 cols=90 name="SAE_Standard_File" >
#Copyright (C) 2011 Fatigue Design + Evaluation Comm. and P.Kurath
# AA7075_T651 Aluminum Wrought
# Ref.:  M.Sc. Thesis by P. Kurath Univ. of Illinois.
# Specimens cut from 6.35mm plate, in rolling direction
#
#FileType= strain_life
#DataType= raw
#TIMEcol= 0
#NAME= AA7075T651
#Name= Aluminum
#NAME= Kurath
#Stress_units= mpa
#Strain_units= strain
#Su=       0
#Sy=       0
#E=    70000.
#%RA=   0
#BHN= 0.
#NO. FAT. PTS.=  16
#TotStrain  2Nf   Stress  Mean    Plastic Strain   Initial
#_Amp              Amp   Stress       Amp         Elastic Mod.
0.010       508   543.      0      0.0022        70000.
0.010       568   541       0      0.0022        70000.
0.010       590   540       0      0.0023        70000.
0.0075     1964   515       0      0.0001        70000.
0.0075     2874   503       0      0.00026       70000.
0.0075     2900   507       0      0.0003        70000.
0.0050    36600   356       0      0.            70000.
0.0050    37600   350       0      0.            70000.
0.0050    37600   337       0      0.            70000.
0.0040   106100   279       0      0.            70000.
0.0040   106900   281       0      0.            70000.
0.0040   124800   288       0      0.            70000.
0.0034   833000   239       0      0.            70000.
0.0034   905000   242       0      0.            70000.
0.0029  2499000   197       0      0.            70000.
0.0029  3002100   201       0      0.            70000.
#</textarea>
#</pre></DL></FORM></body></html>
```

html file header

Comments on material & test

Identifier tags

Raw test data

Tail of html wrapper

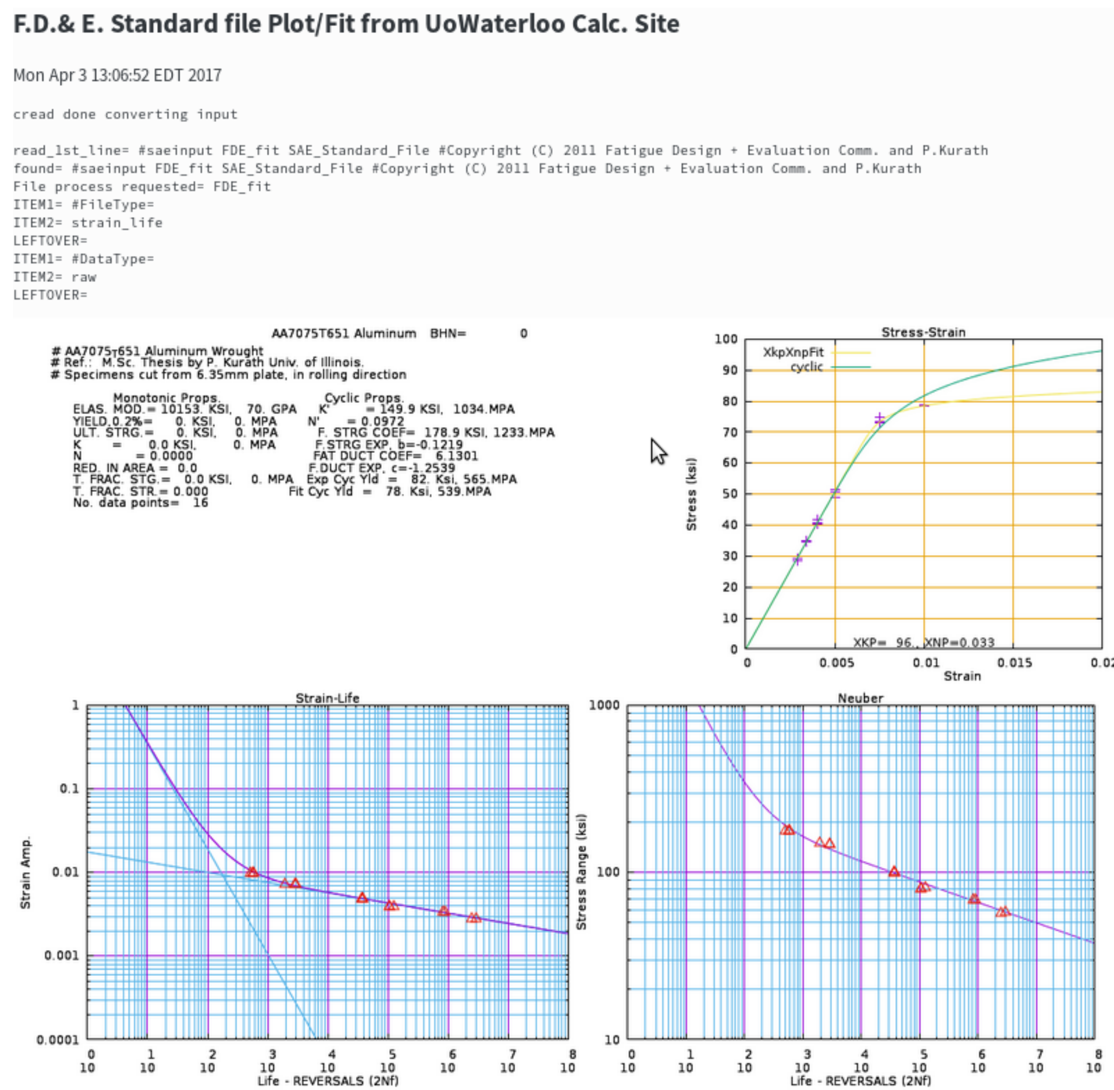
Avoid using Tab character to create this file.

When creating such a file it is often best to edit an existing file. A txt file of the example is here:

http://fde.uwaterloo.ca/FatigueClass/FCourseNotes/exampleSAEfile.html.txt

Step 2 : Open the resulting html file in your web browser and click on the "Send for Plot" button

The web server will return a page that includes a 3 figure image:



more...

Scroll down this page and at the bottom you will find a digitized version of the traditional fit curve.

```
#
# NOTE!! The Following Points are FITTED DATA:#NOTE!! Fitted Stress computed using Experm. K' and n'
#Stress_Units= MPa
# Total Strain   2Nf  Stress  Mean   Plastic Strain   Initial
#    Amp                Amp   Stress      Amp        Elastic Mod.
   6.14771          1   705.4      0.   6.13763     70000. #Fitted_point
   2.58666          2   685.3      0.   2.57687     70000. #Fitted_point
   0.82927          5   659.5      0.   0.81985     70000. #Fitted_point
   0.35496         10   640.8      0.   0.34581     70000. #Fitted_point
   0.15549         20   622.6      0.   0.14660     70000. #Fitted_point
   0.05635         50   599.7      0.   0.04778     70000. #Fitted_point
   0.02909        100   583.2      0.   0.02076     70000. #Fitted_point
   0.01722        200   567.4      0.   0.00911     70000. #Fitted_point
   0.01079        500   546.6      0.   0.00298     70000. #Fitted_point
   0.00865       1000   528.6      0.   0.00110     70000. #Fitted_point
   0.00742       2000   502.4      0.   0.00024     70000. #Fitted_point
   0.00638       5000   445.9      0.   0.00001     70000. #Fitted_point
   0.00579      10000   405.2      0.   0.00000     70000. #Fitted_point
   0.00529      20000   370.4      0.   0.00000     70000. #Fitted_point
   0.00472      50000   330.2      0.   0.00000     70000. #Fitted_point
   0.00433     100000   303.2      0.   0.00000     70000. #Fitted_point
   0.00398     200000   278.5      0.   0.00000     70000. #Fitted_point
   0.00356     500000   249.0      0.   0.00000     70000. #Fitted_point
   0.00327    1000000   228.8      0.  -0.00000     70000. #Fitted_point
   0.00300    2000000   210.2      0.   0.00000     70000. #Fitted_point
   0.00269    5000000   188.0      0.   0.00000     70000. #Fitted_point
   0.00247   10000000   172.8      0.   0.00000     70000. #Fitted_point
   0.00227   20000000   158.8      0.   0.00000     70000. #Fitted_point
   0.00203   50000000   142.0      0.   0.00000     70000. #Fitted_point
   0.00186  100000000   130.5      0.  -0.00000     70000. #Fitted_point
   0.00171  200000000   119.9      0.   0.00000     70000. #Fitted_point
   0.00153  500000000   107.2      0.   0.00000     70000. #Fitted_point
   0.00141 1000000000    98.5      0.   0.00000     70000. #Fitted_point
#
```

Copy and paste the data into a new file.
Example name: newFit.txt

In a gnuplot window plot the data from both the raw test data file and this newFit.txt file.
Use a gnuplot commands such as:

```
set grid
set logscale xy
set yrange  [0.0001:1.0]
set pointsize 1.5
plot "exampleSAEfile.html" using  2:1  with  p  pt 6,  "newFit.txt" u 2:1 w  lp  pt  16
```

Then edit the 2Nf (life) column until the newFit.txt data fits the raw test data.
Save the edited file and check with another plot. This usually is an iterative process.

Change the #DataType= value to “fitted”

```
#FileType= strain_life
#DataType= fitted
#TIMEcol= 0
#NAME= AA7075T651
#Name= Aluminum
#NAME= Kurath
#Stress_units= mpa
#Strain_units= strain
#Su=      580  # mpa, assumed from Endo Morrow data file
#Sy=        0
#E=    70000.
#%RA=    0
#BHN= 0.
#
#NOTE!! The Following Points are <b>FITTED DATA:</b>
#NOTE!! Fitted Stress computed using Experm. K' and n'
#Total Strain   2Nf  Stress  Mean   Plastic Strain   Initial
##   Amp               Amp   Stress       Amp        Elastic Mod.
  0.41           1    801        0      .399        70000. # from EndoMorrow
   0.01079       500    546.6      0.    0.00298     70000. #Fitted_point
   0.00865      1000    528.6      0.    0.00110     70000. #Fitted_point
   0.00742      2000    502.4      0.    0.00024     70000. #Fitted_point
   0.00638      5000    445.9      0.    0.00001     70000. #Fitted_point
   0.00579     10000    405.2      0.    0.0         70000. #Fitted_point
   0.00529     20000    370.4      0.    0.0         70000. #Fitted_point
   0.00472     50000    330.2      0.    0.0         70000. #Fitted_point
   0.00433    100000    303.2      0.    0.0         70000. #Fitted_point
   0.00398    200000    278.5      0.    0.0         70000. #Fitted_point
   0.00356    500000    249.0      0.    0.0         70000. #Fitted_point
   0.00327   1000000    228.8      0.    0.0         70000. #Fitted_point
   0.00300   2000000    210.2      0.    0.0         70000. #Fitted_point
   0.00269   5000000    188.0      0.    0.0         70000. #Fitted_point
   0.00247  10000000    172.8      0.    0.0         70000. #Fitted_point
#
```

In this case I have not changed the fit very much; only the tensile fracture point, and deleted the life points where there is no raw test data.

As long as you keep the StressAmpl. and StrainAmpl. the same, you can change the fatigue life points to any value that better fits the raw data. In this case no changes were necessary.

If you want to add a point make sure that the stress and strain values fit the cyclic stress-strain curve.

The advantage of using a digital fitted curve:

1. Flexibility. We can fit odd shaped curves such as periodic overload tests or composite materials data.

2. Computationally fast: We can use the fitted curves in spread sheets, cyclic stress-srain deformation models, or any fatigue calculation program.

   No complicated (and slow) equations needs to be solved. Solution is by linear interpolation for stress versus strain or by log-log interpolation for strain vs. life or stress vs. life or any other derived term vs. life.

3. The listed values or other derived terms can be easily plotted.

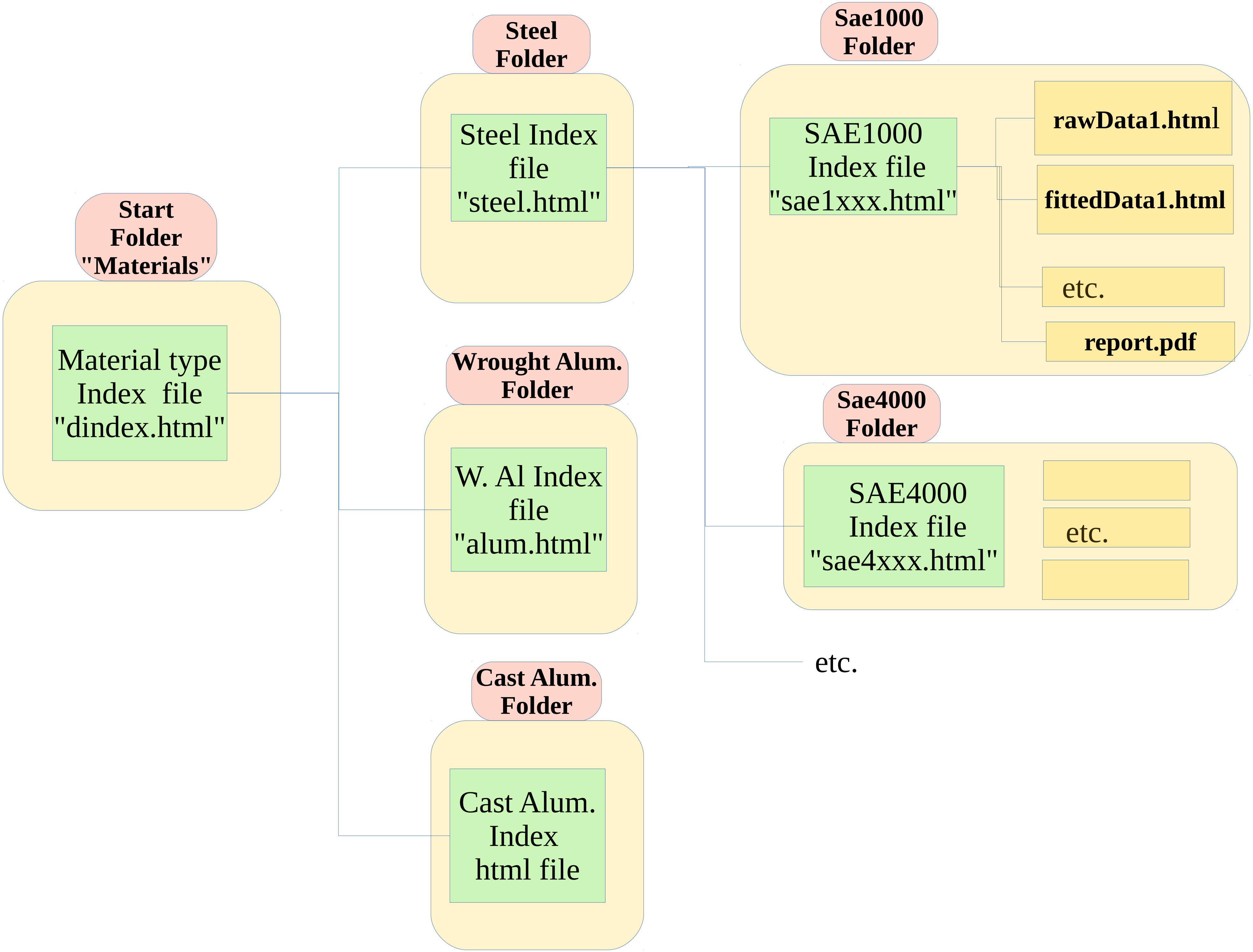
Creating a simple Folder or Web database

There are a number of more "sophisticated" ways to organize such a database structure, and the author has created several such versions in the past, but although its fun programming, it was basically a waste of effort. Experience shows that what 99% of the fatigue/durability users want is a data file/plot for the material name that they have, and, if there is no direct match, a nearest or "best" fit. No one ever uses the search options for values of Su (ultimate Stress), Sy(yield) etc. This is from an observation of hundreds of verbal requests by engineers over a period of more than 25 years. The best policy in a fatigue related database is to keep things very simple. Such simplicity can be achieved by placing each raw and fitted html file into its own folder, or a folder that contains all data sets of the same material.

The following list structure lets a user achieve the same search objective. When no exact match can be found for the requirements, the subsequent search for "next best or equivalent material" can be fairly difficult to solve without expert help.

Database Structure:

A very simple form of fatigue material property database can be constructed by linking from an index file to a tree of other folders and files:



Start Folder "Materials"
Material type Index file "dindex.html"
Steel Folder
Steel Index file "steel.html"
Wrought Alum. Folder
W. Al Index file "alum.html"
Cast Alum. Folder
Cast Alum. Index html file
Sae1000 Folder
SAE1000 Index file "sae1xxx.html"
rawData1.html
fittedData1.html
etc.
report.pdf
Sae4000 Folder
SAE4000 Index file "sae4xxx.html"
etc.
etc.

Commands to make such a folder structure:

1. Make a folder "tree"

While in some base folder issue the following commands:

```
mkdir Materials
cd Materials
 mkdir   Steel     Alum     CastAlum
 cd Steel
 mkdir    Sae1000    Sae4000
 cd ../../
 cd Alum
 mkdir   AA1xxx    AA2xxx    AA7xxx
```

You could also create these in any GUI (graphical User Interface) window.

2. Move your raw data and fitted html files into the lowest level folders such as Sae1000 or AA7xxx

3. Edit or copy some index files into the upper folders.

For example the file located here:

http://fde.uwaterloo.ca/FatigueClass/Notes/dindex.txt

can be placed into the top folder "Materials" Once in that folder rename it to an html suffix

```
mv dindex.txt  dindex.html
```

4 Similarly place the following files into the subfolders

Save:

http://fde.uwaterloo.ca/FatigueClass/Notes/steel.txt

as:

Materials/Steel/steel.html

Commands to make such a folder structure (continued)

4 cont'd

Save: http://fde.uwaterloo.ca/FatigueClass/Notes/steel.txt
as: Materials/Alum/alum.html

Save: http://fde.uwaterloo.ca/FatigueClass/Notes/sae1xxx.txt
as: Materials/Steel/Sae1xxx/sae1xxx.html