Report UGAL – project D3T4H2S
Implementation aspects of stress-strain characteristics' regression models for composite materials

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Part I: **The modeling of the stress-strain characteristic -including the "damaged" zone**

Part II: **Machine Learning Predictions for the Comparative Mechanical Analysis of Composite Laminates with Various Fiber Orientations**

Contents

I. The modeling of the stress-strain characteristic -including the "damaged" zone

Work periods:

March 10 – 15, 2024
I worked with Mostapha, Sirine, etc, to model the stress-strain curve, including the damaged zone.
Preparation of data.

March 15- May 10, 2024
Publication of the article supported by the project D3T4H2S**:**
Mînzu, V.; Arama, I.; Rusu, E. *Machine Learning Algorithms That Emulate Controllers Based on Particle Swarm Optimization*—An Application to a Photobioreactor for Algal Growth. Processes 2024, 12, 991. https://doi.org/10.3390/pr12050991

May 10 – June 15, 2024
I resumed the subject and wrote the major part of the scripts.
August 10 - 31, 2024

Summary
1. Data preparation.
2. ML Model for a single composite material.
3. Description of the stress-strain dependence for a given composite
4. Construction of a joint ML Model for PA6 and PA12
5. Predictions for PA11 using the joint ML Model

I.1. Data Preparation

Details about the script `Table6_12_11B.m`.
(Script 1)

The files "PA6.xlsx", "PA12.xlsx," and "PA11.xlsx" have been supplied by Sirine SAYED as results of simulations carried out with the DIGIMAT platform.
The matrix parameters made with PA6 and PA12 are in the "Demanded Data.sxls" file.

Table T6 is loaded from the Excel file "PA6.xlsx". The import options are modified such that the type of variables would be "double."

Table T61 keeps the first two columns of T6.

Table T6m is T61 modified, i.e., the columns are renamed (interchanged because of an existing editing error inside the supplied files). The plotting represents the function stress=f(strain).

The parameters of the matrix made by PA6 are organized as constant columns. The variable LoadD (load direction) will be "categorical" and constant, that is, LD11.

With the new 9 variables, we supplemented the table T6m and obtained the table T6mB.

I repeated in the sequel all the actions constructing table T6mB, but this time for T12mB.

Tables legend:
T6 – table resulting from "PA6.xlsx": 6 load directions; 6 pairs (strain, stress), 12 columns and 201 lines.
T61 – table resulting from T61, which keeps only the two first columns.
T6m -table with the two columns of T61 whose variables' names are switched.
T6mB – table with 11 columns resulting from T6m by completion at left with 9 columns. It results in 11 columns:
`LoadD, Vf, Density, Em, Poisson, YieldS, Hm, He, Lhm, Strain11, Stress11`

For the tables resulting from tables T12 and T11, the names' significance is kept (only T111 became T11r).

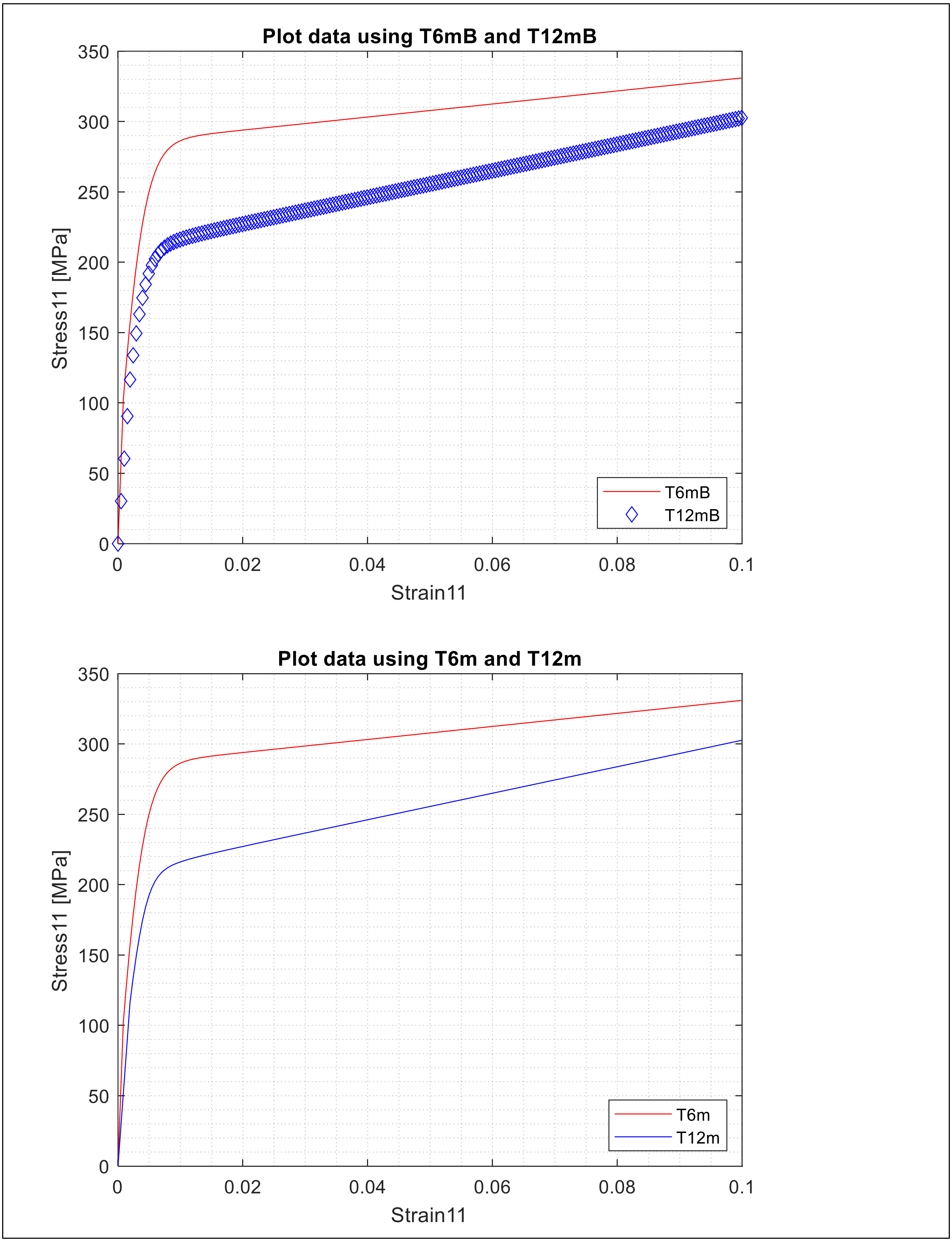
Details about the script `TablesTrainTest.m`.
(Script 2)

This script creates the tables for training and testing, whatever the ML algorithm will be.

Data are loaded from the workspace "WsT6T12.mat", which contains the tables "T6m", "T6mB", "T12m", and "T12mB".

```
***************** T6mB

10×11 table

 LoadD   Density    Em    Poisson   YieldS   Hm    He    Lhm   Vf    Strain11      Stress11
 _____   ________   ____  _______   ______   ____  ____  ____  ___   __________    __________

 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6      5e-14      6.0014e-09
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6     0.0005      60.014
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6   0.00085301     102.38
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.001353      129.17
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.001853      153.49
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.002353      175.29
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.002853      194.54
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.003353      211.3
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.003853      225.68
 LD11    1.14e-09   3000   0.37       25     3000  0.17  1000  0.6    0.004353      237.84

***************** T12mB
  Name       Size        Bytes  Class    Attributes
  T12mB      201x11      19660  table

*****************
  6×11 table
 LoadD   Density    Em    Poisson   YieldS   Hm    He    Lhm   Vf    Strain11     Stress11
 _____   ________   ____  _______   ______   ____  ____  ____  ___   _________    _________

 LD11    1.01e-09   1935   0.36       23     1800  0.27  1500  0.6     5e-14     3.021e-09
 LD11    1.01e-09   1935   0.36       23     1800  0.27  1500  0.6    0.0005      30.21
 LD11    1.01e-09   1935   0.36       23     1800  0.27  1500  0.6    0.001       60.42
 LD11    1.01e-09   1935   0.36       23     1800  0.27  1500  0.6    0.0015      90.629
 LD11    1.01e-09   1935   0.36       23     1800  0.27  1500  0.6   0.0019301    116.61
 LD11    1.01e-09   1935   0.36       23     1800  0.27  1500  0.6   0.0024301    133.88
```

Figures (1) and (2) depict the function Stress=f(Strain) for PA6, using T6mB and T6m, respectively. The curves are identical, which must be verified, as well as for PA12.


Plot data using T6mB and T12mB
Stress11 [MPa]
350
300
250
200
150
100
50
0
0
0.02
0.04
0.06
0.08
0.1
Strain11
T6mB
T12mB
Plot data using T6m and T12m
Stress11 [MPa]
350
300
250
200
150
100
50
0
0
0.02
0.04
0.06
0.08
0.1
Strain11
T6m
T12m

T6m1 is a new table obtained from T6m, to which a categorical column containing the value "PA6" is added first.

Two tables, **DTrain** and **DTest**, are constructed using lines from T6m1. The latter's lines are added alternatively to DTrain and DTest by four, respectively, one. Finally, tables DTrain and DTest have **161 and 40 lines**, respectively.

```
**************************Train
    Matrix      Strain11       Stress11
    ______     __________     __________

     PA6             5e-14    6.0014e-09
     PA6            0.0005        60.014
     PA6        0.00085301        102.38
     PA6          0.001353        129.17
     PA6          0.002353        175.29

**************155:161
    Matrix     Strain11     Stress11
    ______     ________     ________

     PA6       0.095853      329.1
     PA6       0.096353     329.33
     PA6       0.097353     329.79
     PA6       0.097853     330.03
     PA6       0.098353     330.26
     PA6       0.098853     330.49
     PA6       0.099853     330.95

**************************Test
    Matrix     Strain11     Stress11
    ______     ________     ________

     PA6       0.001853     153.49
     PA6       0.004353     237.84
     PA6       0.006853     273.07
     PA6       0.009353     284.93
     PA6       0.011853     289.06
     PA6       0.014353     291.02
     PA6       0.016853     292.39
     PA6       0.019353     293.61
     PA6       0.021853     294.78
     PA6       0.024353     295.95

>> size(D6Train)
   161     3
>> size(D6Test)
    40     3
```

The tables T6m1, D6Train, and D6Test are saved in the workspace **WsTrainTestPA6**.
For PA12, we can create similar tables and save them in a similar workspace.

I.2. ML Model for a single composite material

Details about the script `PA6Model_SW.m`.
(Script 3)

The first try refers to a linear model for PA6 using the Step Wise technique. The obtained model **`mdlsw`** is used to predict the stress values for the strain values belonging to **`D6Test`**. The result is compared to the values from the column **`D6Test.Stress11.`**

The matrix **`MatC`** and table **`TableC`** are created for comparison. The predictions are not so accurate at the extremities of the strain's range, and we will try to construct a Regression Neural Network using the tables determined before.

```
>> PA6Model_SW
1. Adding Strain11, FStat = 104.439, pValue = 3.668277e-19

Linear regression model:
    Stress11 ~ 1 + Strain11

Estimated Coefficients:
                   Estimate      SE      tStat       pValue   
                   ________    ______    ______    ___________

    (Intercept)     252.83     5.2728    47.949    1.8763e-96
    Strain11        936.55     91.643     10.22    3.6683e-19


Number of observations: 161, Error degrees of freedom: 159
Root Mean Squared Error: 33.8
R-squared: 0.396,  Adjusted R-squared: 0.393
F-statistic vs. constant model: 104, p-value = 3.67e-19
MatC=[(1:40)' D6Test.Stress11 StressPred]
    i      Stress11    StressPred
    __     ________    __________

     1      153.49       254.56  
     2      237.84        256.9  
     3      273.07       259.24  
     4      284.93       261.59  
     5      289.06       263.93  
     6      291.02       266.27  
     7      292.39       268.61  
     8      293.61       270.95  
     9      294.78       273.29  
    10      295.95       275.63  
    11      297.11       277.97  
    12      298.27       280.32  
    13      299.43       282.66  
    14      300.59          285  
    15      301.75       287.34  
    16       302.9       289.68  
    17      304.06       292.02  
    18      305.22       294.36  
    19      306.38       296.71  
    20      307.54       299.05  
    21       308.7       301.39  
    22      309.86       303.73  
    23      311.02       306.07  
    24      312.18       308.41  
    25      313.34       310.75  
    26      314.49        313.1  
    27      315.65       315.44  
    28      316.81       317.78  
    29      317.97       320.12  
    30      319.13       322.46  
    31      320.29        324.8  
```

```
    32      321.45       327.14
    33      322.61       329.48
    34      323.77       331.83
    35      324.93       334.17
    36      326.09       336.51
    37      327.24       338.85
    38       328.4       341.19
    39      329.56       343.53
    40      330.72       345.87

>>
```

Details about the script `trainRegNN4`.
(Script 4)

For PA6, we created an RNN with the help of the Regression Learner app of MATLAB system, and we have developed a few regression models saved into the work session **`PA6Session.mat`**, including the RNN model 4.

The function **`trainRegNN4`** generates a trained ML model, which is an RNN. The `fitrnet` function is called with the following parameters.

```
regressionNeuralNetwork = fitrnet(...
    predictors, ...
    response, ...
    'LayerSizes', 226, ...
    'Activations', 'relu', ...
    'Lambda', 6.366956171376093e-08, ...
    'IterationLimit', 1000, ...
    'Standardize', true);
```

For PA12, we can similarly create an RNN.

Details about the script `PA6DamageRNN4`.
Script 5

The script trains model 4, which was developed in the **`PA6Session.mat`** session, and evaluates the predictions for the dataset **`D6Test`**. It makes two general actions:
1.- Calling the training function **`trainRegNN4`** (Script 4), which generates the Regression NN called **`mdlNN4`**;

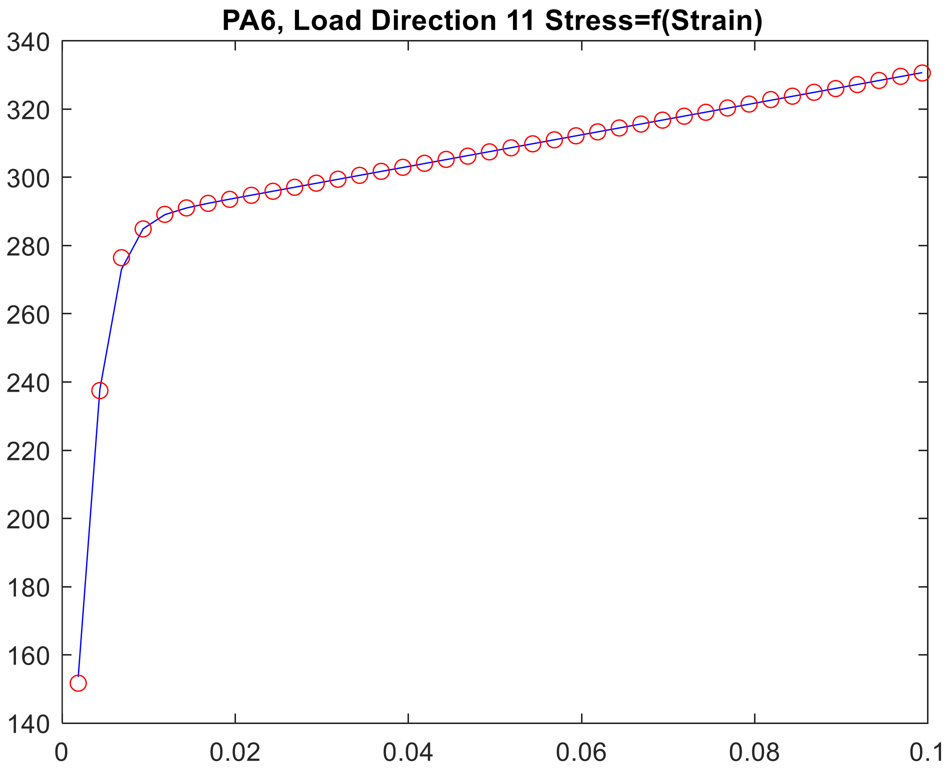
```
>> whos mdlNN4
  Name         Size                Bytes  Class     Attributes

  mdlNN4       1x1                 76964  struct
```

2.- Calling the prediction function of the RNN, **`mdlNN4.predictFcn,`** calculates the 40 predictions for the set **`D6Test`**, which are included in the vector **`StressPred.`** Matrix MatD and table TabD are constructed to display simultaneously the real and predicted stress values.

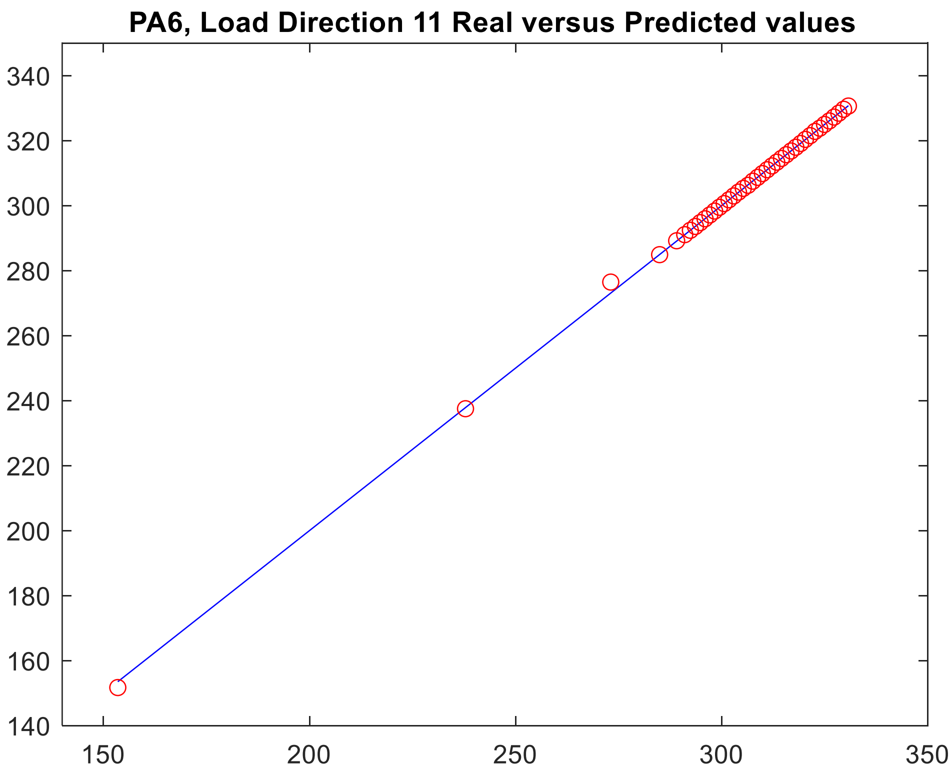
```
vrmse=
       1.4922

RMSEValid=
      0.24295

    Nr     RealValue      NN4
    __     _________     ______

     1      153.49       151.69
     2      237.84       237.48
     3      273.07       276.44
     4      284.93       284.89
     5      289.06       289.16
     6      291.02       291.04
```

```
      7      292.39      292.38
      8      293.61      293.56
      9      294.78      294.74
     10      295.95      295.92
     11      297.11       297.1
     12      298.27       298.3
     13      299.43      299.46
     14      300.59       300.6
     15      301.75      301.77
     16       302.9      302.95
     17      304.06      304.13
     18      305.22      305.28
     19      306.38      306.22
     20      307.54      307.48
     21       308.7      308.66
     22      309.86      309.84
     23      311.02      311.01
     24      312.18      312.19
     25      313.34      313.34
     26      314.49      314.49
     27      315.65      315.64
     28      316.81      316.78
     29      317.97      317.93
     30      319.13      319.09
     31      320.29      320.35
     32      321.45       321.5
     33      322.61      322.81
     34      323.77       323.8
     35      324.93      324.95
     36      326.09      326.04
     37      327.24      327.21
     38       328.4      328.42
     39      329.56      329.61
     40      330.72      330.61
>>
```

The script also plots two figures. The first depicts two functions in the same picture: real and predicted stress values versus the strain. The second presents the predicted and real values of the stress versus the real values of the stress.


PA6, Load Direction 11 Stress=f(Strain)
340
320
300
280
260
240
220
200
180
160
140
0
0.02
0.04
0.06
0.08
0.1

****


PA6, Load Direction 11 Real versus Predicted values
340
320
300
280
260
240
220
200
180
160
140
150
200
250
300
350

Script 6: S6.m

Script 6 tests an individual prediction given the composite material code and the strain value. A table "tabj" with a single line is constructed, which contains, for example, PA6 and the strain value x1. Then, the prediction function is called to return the stress value.

I. 3. Description of the stress-strain dependence for a given composite material.

Representation of the function stress-strain:

- A vector of pairs (strain, stress) for a sufficient number of points resulting from DIGIMAT simulation; the number of points must be adapted to the application at hand.
- A vector of pairs (strain, stress), including all angular points until rupture.
- The prediction function that is an object of the composite material's ML model.

Considering the graphic representation of the measurements or simulations, the most natural way to represent the stress's dependence upon the strain is to encode this graphic representation such that it can be reproduced at each point.
To do that, we can assemble the work's features already presented. The most important are given hereafter:

- 1 The file **`PA6.xlsx`** includes the strain and stress values along the simulations for different load directions.
- 2 The values in this file allow the construction of an ML regression model, which "learns" the dependence mentioned above (the stress's dependence upon the strain). The ML model can be of any kind among those that can be constructed.
- 3 Whatever the model is, it has a prediction function that allows us to specify a stress value for a given strain value.

These three aspects suggest that we can use the prediction function to represent the stress-strain dependence as it is given in file **`PA6.xlsx`** when the accuracy of this function is very good (at least acceptable).
In general, the prediction function is a method of the object ML model (in our case, `mdlNN4`). For different applications, we could describe the stress-strain dependence as a function in the classical form

stress= f(strain, ML_model, other parameters).

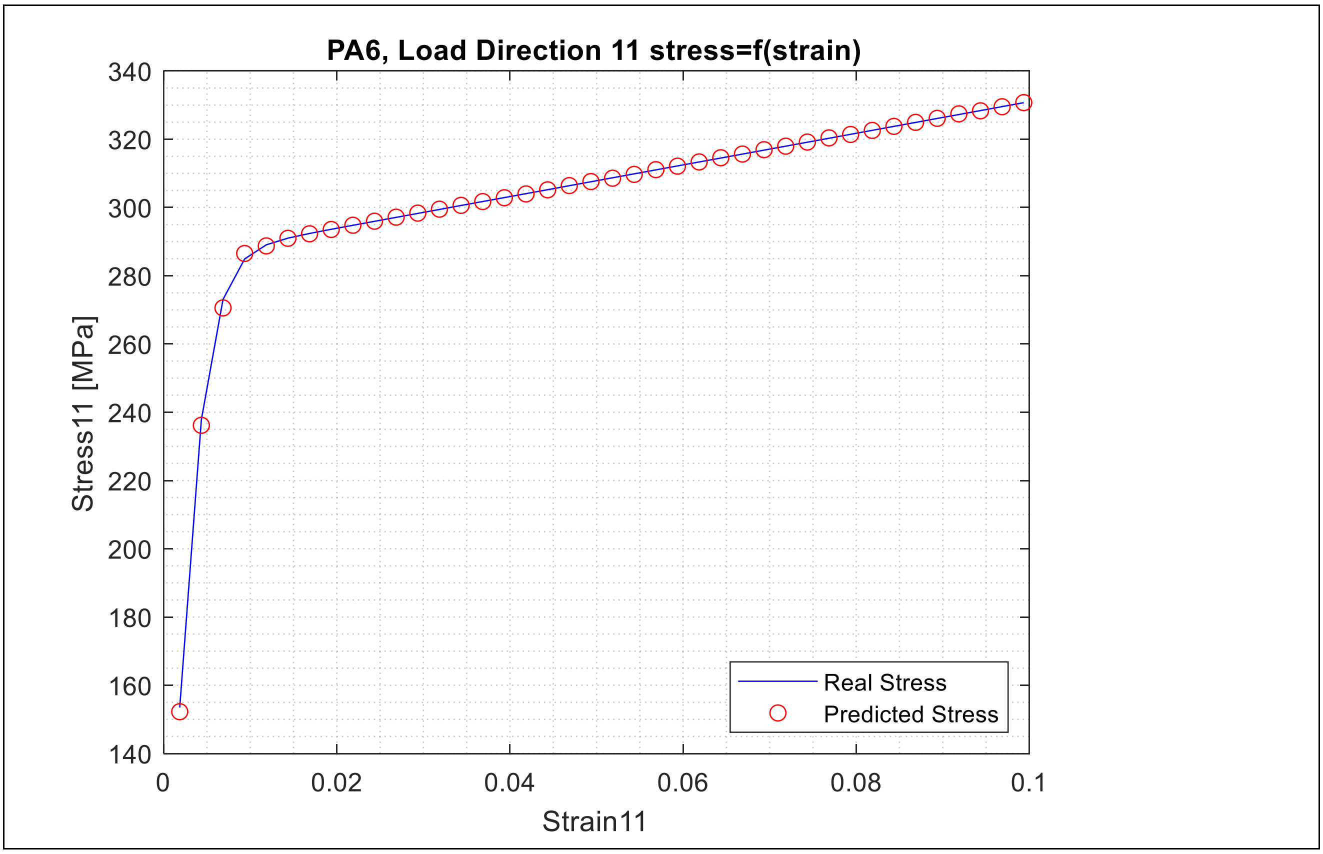
NB: ***Function `F_PA6` is another expression of the prediction method belonging to the model object; this method takes the form of a classical function y=f(x, ...).***

Script 7 presents a function, F_PA6, for a material's matrix PA6 and whatever ML model.

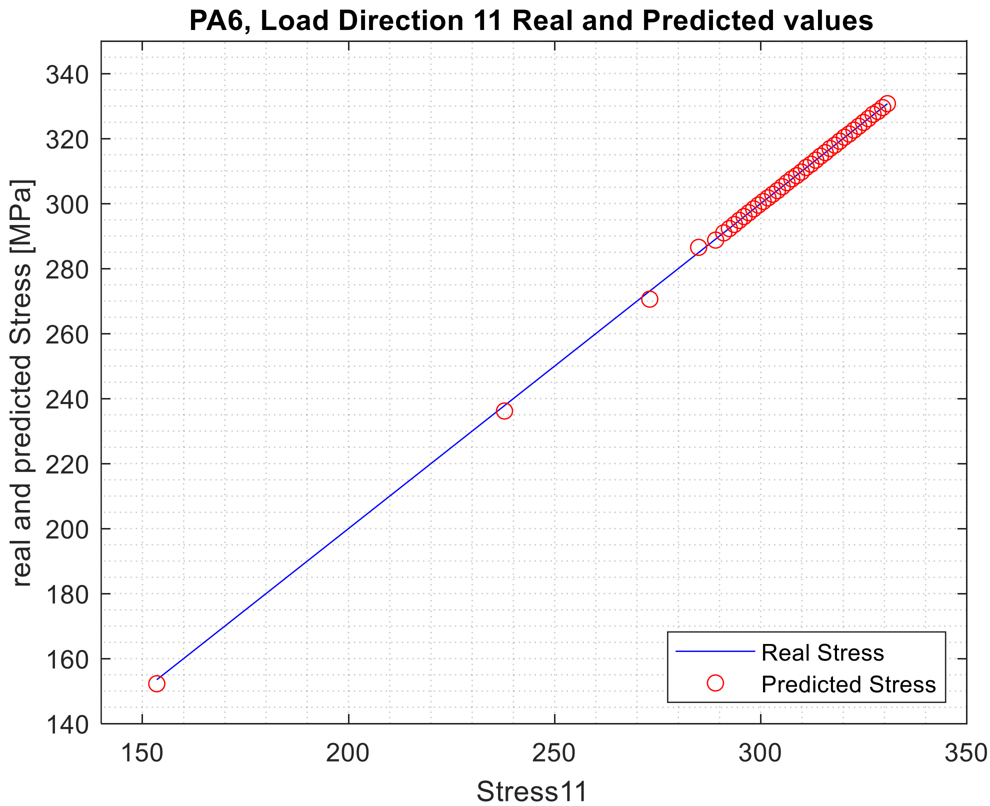
```
function stress=F_PA6(strain,mdl)
     %strain: the strain's value
     %mdl: the ML model as an object reference.
  tabj=table('Size',[1,2],'VariableTypes',{'categorical','double'},...
  'VariableNames',{'Matrix','Strain11'});
  tabj{1,2}=strain;
  tabj{1,1}="PA6";
  stress=mdl.predictFcn(tabj);
end
```

Such a function could be modified to add the matrix type (`PA6`, `PA12`,...) or the load direction to its arguments.
Although tables `D6Train` and `D6Test` have a categorical column indicating the matrix type, in the current version, the training of the ML model does not consider it.
Currently, our work is directed toward using as simple models as possible.

The first test of the `F_PA6` function. Details about the script `TestFunctionPA6`.
This script (**Script 8**) shows how **`F_PA6`** calculates the stress for each strain value in Table D6Test.
The matrix MatD6 stores only the numerical part of Table D6Test. The first column is the strain, and the second is the real stress. The function **`F_PA6`** calculates the predicted stress value individually.
The matrix MATE contains the data necessary to compare the real and predicted values of the stress. Table TabD is created to display the matrix MATE.
Script 8 also plots two figures. Figure(1) depicts two functions in the same picture: real and predicted stress values versus the strain.
Figure (1)



Figure(2) presents the predicted and real values of the stress versus the real values of the strain against the records.



FOLDER: WorkMTLB2

I.4. Construction of a joint ML Model for PA6 and PA12

I resumed the subject, and I revised the 8 scripts already written.

Tables legend:
T6 – table resulting from "PA6.xlsx": 6 load directions; 6 pairs (strain, stress), 12 columns.
T61 – The table resulting from T61 only contains the two first columns.
T6m -table with the two columns of T61 whose variables' names are switched.
T6mB – table with 11 columns resulting from T6m by completion at left with 9 columns. It results in 11 columns:
`LoadD, Vf, Density, Em, Poisson, YieldS, Hm, He, Lhm, Strain11, Stress11`

The names' significance is kept for the tables resulting from tables T12 and T11 (only T111 became T11r).

General Approach

Our previous work proved that ML models for composite materials with PA6 and PA12 can be constructed. Because the composite material with PA11 uses the same fiber as the other two materials, we shall investigate the following approach to predict the stress for PA11:

- We shall construct a single ML model for both composite materials, with PA6 and PA12.
- We hypothesize that composite material with PA11 is subjected to the same ML model because it uses the same fiber. We then shall test if the predictions made with this model fit with the real values of the stress.

Details concerning the script `S9_BigDataSet.m`

Script 9 aims to create a big common data set and the tables for training and testing this common model. The first action is to join the matrices representing T6mB and T12mB.

The workspace `"WsT6T12.mat"` is loaded to access tables T6mB and T12mB.

`Mat6` - matrix that is the image of table T6mB after eliminating the first 2 columns, which contain LoadD and Vf values

A line selection from Mat6 is generated. It contains lines 1, 2, 3, 6, 9,..., 201 of Mat6, i.e. 69 lines. The selection is called `Mat6s` and will generate the data set based on its perturbed lines.

To generate the perturbations, a vector **dv** is prepared to contain 2% of the values of the first seven elements of the current line.

A new matrix, **`Mat6b`**, is constructed by adding three perturbed lines for each line of **`Mat6s`**.

It results in a matrix having 276 lines.

```
>> S9_BigDataSet
  Name          Size             Bytes  Class    Attributes
  T6mB        201x11             19660  table

****************** T6mB

ans =  10×11 table (fragment)
```

LoadD	Vf	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.001353	129.17
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.001853	153.49
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.002353	175.29
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.002853	194.54
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.003353	211.3
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.003853	225.68
LD11	0.6	1.14e-09	3000	0.37	25	3000	0.17	1000	0.004353	237.84

```
****************** T12mB
  Name          Size             Bytes  Class    Attributes
  T12mB       201x11             19660  table


ans =  6×11 table (fragment)
```

LoadD	Vf	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
LD11	0.6	1.01e-09	1935	0.36	23	1800	0.27	1500	5e-14	3.021e-09
LD11	0.6	1.01e-09	1935	0.36	23	1800	0.27	1500	0.0005	30.21
LD11	0.6	1.01e-09	1935	0.36	23	1800	0.27	1500	0.001	60.42
LD11	0.6	1.01e-09	1935	0.36	23	1800	0.27	1500	0.0015	90.629
LD11	0.6	1.01e-09	1935	0.36	23	1800	0.27	1500	0.0019301	116.61
LD11	0.6	1.01e-09	1935	0.36	23	1800	0.27	1500	0.0024301	133.88

LoadD	Vf	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11

```
LD11     0.6    1.14e-09    3000     0.37        25      3000    0.17    1000      5e-14      6.0014e-09

****************** Mat6
  Name        Size            Bytes  Class     Attributes
  Mat6      201x9             14472  double

Matrix Mat6s contains the lines 1,2,3,6,...,201 of Mat6:


  Name        Size            Bytes  Class     Attributes
  Mat6s      69x9              4968  double
```

1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38
1.14e-09	3000	0.37	25	3000	0.17	1000	0.002353	175.29
1.14e-09	3000	0.37	25	3000	0.17	1000	0.003853	225.68
1.14e-09	3000	0.37	25	3000	0.17	1000	0.005353	256.33
1.14e-09	3000	0.37	25	3000	0.17	1000	0.006853	273.07
1.14e-09	3000	0.37	25	3000	0.17	1000	0.008353	281.68
1.14e-09	3000	0.37	25	3000	0.17	1000	0.009853	286.1
1.14e-09	3000	0.37	25	3000	0.17	1000	0.011353	288.5
1.14e-09	3000	0.37	25	3000	0.17	1000	0.012853	289.97
1.14e-09	3000	0.37	25	3000	0.17	1000	0.014353	291.02
1.14e-09	3000	0.37	25	3000	0.17	1000	0.015853	291.88
1.14e-09	3000	0.37	25	3000	0.17	1000	0.017353	292.64
1.14e-09	3000	0.37	25	3000	0.17	1000	0.018853	293.37
1.14e-09	3000	0.37	25	3000	0.17	1000	0.020353	294.08
1.14e-09	3000	0.37	25	3000	0.17	1000	0.021853	294.78
1.14e-09	3000	0.37	25	3000	0.17	1000	0.023353	295.48
1.14e-09	3000	0.37	25	3000	0.17	1000	0.024853	296.18
1.14e-09	3000	0.37	25	3000	0.17	1000	0.026353	296.88
1.14e-09	3000	0.37	25	3000	0.17	1000	0.027853	297.57
1.14e-09	3000	0.37	25	3000	0.17	1000	0.029353	298.27
1.14e-09	3000	0.37	25	3000	0.17	1000	0.030853	298.96
1.14e-09	3000	0.37	25	3000	0.17	1000	0.032353	299.66
1.14e-09	3000	0.37	25	3000	0.17	1000	0.033853	300.35
1.14e-09	3000	0.37	25	3000	0.17	1000	0.035353	301.05
1.14e-09	3000	0.37	25	3000	0.17	1000	0.036853	301.75
1.14e-09	3000	0.37	25	3000	0.17	1000	0.038353	302.44
1.14e-09	3000	0.37	25	3000	0.17	1000	0.039853	303.14
1.14e-09	3000	0.37	25	3000	0.17	1000	0.041353	303.83
1.14e-09	3000	0.37	25	3000	0.17	1000	0.042853	304.53
1.14e-09	3000	0.37	25	3000	0.17	1000	0.044353	305.22
1.14e-09	3000	0.37	25	3000	0.17	1000	0.045853	305.92

1.14e-09	3000	0.37	25	3000	0.17	1000	0.047353	306.61
1.14e-09	3000	0.37	25	3000	0.17	1000	0.048853	307.31
1.14e-09	3000	0.37	25	3000	0.17	1000	0.050353	308
1.14e-09	3000	0.37	25	3000	0.17	1000	0.051853	308.7
1.14e-09	3000	0.37	25	3000	0.17	1000	0.053353	309.39
1.14e-09	3000	0.37	25	3000	0.17	1000	0.054853	310.09
1.14e-09	3000	0.37	25	3000	0.17	1000	0.056353	310.79
1.14e-09	3000	0.37	25	3000	0.17	1000	0.057853	311.48
1.14e-09	3000	0.37	25	3000	0.17	1000	0.059353	312.18
1.14e-09	3000	0.37	25	3000	0.17	1000	0.060853	312.87
1.14e-09	3000	0.37	25	3000	0.17	1000	0.062353	313.57
1.14e-09	3000	0.37	25	3000	0.17	1000	0.063853	314.26
1.14e-09	3000	0.37	25	3000	0.17	1000	0.065353	314.96
1.14e-09	3000	0.37	25	3000	0.17	1000	0.066853	315.65
1.14e-09	3000	0.37	25	3000	0.17	1000	0.068353	316.35
1.14e-09	3000	0.37	25	3000	0.17	1000	0.069853	317.04
1.14e-09	3000	0.37	25	3000	0.17	1000	0.071353	317.74
1.14e-09	3000	0.37	25	3000	0.17	1000	0.072853	318.44
1.14e-09	3000	0.37	25	3000	0.17	1000	0.074353	319.13
1.14e-09	3000	0.37	25	3000	0.17	1000	0.075853	319.83
1.14e-09	3000	0.37	25	3000	0.17	1000	0.077353	320.52
1.14e-09	3000	0.37	25	3000	0.17	1000	0.078853	321.22
1.14e-09	3000	0.37	25	3000	0.17	1000	0.080353	321.91
1.14e-09	3000	0.37	25	3000	0.17	1000	0.081853	322.61
1.14e-09	3000	0.37	25	3000	0.17	1000	0.083353	323.3
1.14e-09	3000	0.37	25	3000	0.17	1000	0.084853	324
1.14e-09	3000	0.37	25	3000	0.17	1000	0.086353	324.69
1.14e-09	3000	0.37	25	3000	0.17	1000	0.087853	325.39
1.14e-09	3000	0.37	25	3000	0.17	1000	0.089353	326.09
1.14e-09	3000	0.37	25	3000	0.17	1000	0.090853	326.78
1.14e-09	3000	0.37	25	3000	0.17	1000	0.092353	327.48
1.14e-09	3000	0.37	25	3000	0.17	1000	0.093853	328.17
1.14e-09	3000	0.37	25	3000	0.17	1000	0.095353	328.87
1.14e-09	3000	0.37	25	3000	0.17	1000	0.096853	329.56
1.14e-09	3000	0.37	25	3000	0.17	1000	0.098353	330.26
1.14e-09	3000	0.37	25	3000	0.17	1000	0.099853	330.95

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Mat6b

1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
1.1341e-09	2988.1	0.36563	24.738	3046.1	0.17286	1011.3	5e-14	6.0014e-09
1.1282e-09	3010	0.36559	24.627	3022.5	0.17279	1010	5e-14	6.0014e-09
1.1547e-09	2967	0.36832	24.919	3052.3	0.16732	1001.3	5e-14	6.0014e-09
1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
1.1455e-09	2973.6	0.36553	24.908	2983.5	0.1677	1015.7	0.0005	60.014

```
  1.1373e-09      3020.4     0.36571      24.971        2946     0.16997      990.79      0.0005      60.014
  1.1484e-09      3029.8      0.3684      25.059      3027.9     0.17076      1003.2      0.0005      60.014
    1.14e-09        3000        0.37          25        3000        0.17        1000  0.00085301      102.38
  1.1204e-09      2984.9      0.3631      24.906        3019     0.17051        1019  0.00085301      102.38
  1.1373e-09      3033.3     0.37103      24.521      3001.5     0.16937      988.79  0.00085301      102.38
  1.1277e-09      2992.6     0.37621      24.819      2974.1     0.16907      999.97  0.00085301      102.38
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    1.14e-09        3000        0.37          25        3000        0.17        1000    0.092353      327.48
  1.1445e-09      2996.3     0.37234      24.761      2974.1      0.1713      1018.9    0.092353      327.48
  1.1301e-09      3042.5     0.37594      25.338      3030.3     0.16836      1017.9    0.092353      327.48
  1.1558e-09      3041.1      0.3741      24.974      3042.1     0.17292      980.97    0.092353      327.48
    1.14e-09        3000        0.37          25        3000        0.17        1000    0.093853      328.17
  1.1504e-09        2996     0.37135      25.484      3041.6     0.17324      993.79    0.093853      328.17
  1.1298e-09        2978     0.36758      25.048      2974.2     0.17283      1006.8    0.093853      328.17
   1.153e-09        2962     0.36469      24.556      3014.2     0.17061         995    0.093853      328.17
    1.14e-09        3000        0.37          25        3000        0.17        1000    0.095353      328.87
  1.1182e-09      2959.1      0.3701      25.287      3031.4     0.17295      1011.8    0.095353      328.87
  1.1379e-09      2981.3     0.36457      25.061      2964.9      0.1674      1010.7    0.095353      328.87
  1.1381e-09      3027.1     0.36418      24.939      3006.9     0.17242      1016.5    0.095353      328.87
    1.14e-09        3000        0.37          25        3000        0.17        1000    0.096853      329.56
  1.1332e-09      2984.7     0.36411      25.158      2966.3     0.17249      995.74    0.096853      329.56
  1.1379e-09      2961.8      0.3636      25.285      3036.2     0.16975      1014.1    0.096853      329.56
  1.1457e-09      2961.7     0.36305       24.63      2977.9     0.17157      1010.9    0.096853      329.56
    1.14e-09        3000        0.37          25        3000        0.17        1000    0.098353      330.26
   1.124e-09      3035.5     0.36505      25.217      2949.4     0.16928      1012.6    0.098353      330.26
  1.1414e-09      3053.7     0.36729      25.078      2962.8     0.16927        1020    0.098353      330.26
  1.1329e-09        3049     0.37293       24.53      2997.8      0.1712       996.1    0.098353      330.26
    1.14e-09        3000        0.37          25        3000        0.17        1000    0.099853      330.95
  1.1242e-09      3007.3     0.37665      25.459      3058.8     0.17228      1006.2    0.099853      330.95
  1.1568e-09      3043.7     0.37388      24.665      2949.5     0.17006      983.72    0.099853      330.95
  1.1372e-09      2977.4     0.36821      25.496      3044.3     0.17305      990.17    0.099853      330.95
```

Matrices **Mat12, Mat12s**, and **Mat12b** are constructed similarly starting from **T12mB**.

```
**************************************Mat12
  Name          Size            Bytes  Class     Attributes
  Mat12       201x9             14472  double
```

Matrix **Mat12s** contains the lines 1,2,3,6,...,201 of Mat12:

```
  Name          Size            Bytes  Class     Attributes
  Mat12s       69x9              4968  double
```

1.01e-09	1935	0.36	23	1800	0.27	1500	5e-14	3.021e-09
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0005	30.21
1.01e-09	1935	0.36	23	1800	0.27	1500	0.001	60.42
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0024301	133.88
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0039301	174.71
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0054301	197.85
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0069301	208.4
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0084301	213.27
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0099301	216.09
1.01e-09	1935	0.36	23	1800	0.27	1500	0.01143	218.17
1.01e-09	1935	0.36	23	1800	0.27	1500	0.01293	219.94
1.01e-09	1935	0.36	23	1800	0.27	1500	0.01443	221.58
1.01e-09	1935	0.36	23	1800	0.27	1500	0.01593	223.13
1.01e-09	1935	0.36	23	1800	0.27	1500	0.01743	224.65
1.01e-09	1935	0.36	23	1800	0.27	1500	0.01893	226.13
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02043	227.59
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02193	229.04
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02343	230.48
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02493	231.91
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02643	233.34
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02793	234.76
1.01e-09	1935	0.36	23	1800	0.27	1500	0.02943	236.18
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03093	237.6
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03243	239.02
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03393	240.44
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03543	241.86
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03693	243.27
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03843	244.69
1.01e-09	1935	0.36	23	1800	0.27	1500	0.03993	246.1
1.01e-09	1935	0.36	23	1800	0.27	1500	0.04143	247.52
1.01e-09	1935	0.36	23	1800	0.27	1500	0.04293	248.93
1.01e-09	1935	0.36	23	1800	0.27	1500	0.04443	250.35
1.01e-09	1935	0.36	23	1800	0.27	1500	0.04593	251.76
1.01e-09	1935	0.36	23	1800	0.27	1500	0.04743	253.17
1.01e-09	1935	0.36	23	1800	0.27	1500	0.04893	254.59
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05043	256
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05193	257.41
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05343	258.83
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05493	260.24
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05643	261.65
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05793	263.07
1.01e-09	1935	0.36	23	1800	0.27	1500	0.05943	264.48
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06093	265.89
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06243	267.3
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06393	268.72

1.01e-09	1935	0.36	23	1800	0.27	1500	0.06543	270.13
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06693	271.54
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06843	272.96
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06993	274.37
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07143	275.78
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07293	277.19
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07443	278.61
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07593	280.02
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07743	281.43
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07893	282.84
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08043	284.26
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08193	285.67
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08343	287.08
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08493	288.49
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08643	289.91
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08793	291.32
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08943	292.73
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09093	294.14
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09243	295.56
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09393	296.97
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09543	298.38
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09693	299.79
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09843	301.21
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09993	302.62

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Mat12b

1.01e-09	1935	0.36	23	1800	0.27	1500	5e-14	3.021e-09
9.9176e-10	1960.7	0.36272	23.088	1779.5	0.27038	1473.3	5e-14	3.021e-09
1.0072e-09	1911.1	0.35752	23.403	1825	0.26738	1492.6	5e-14	3.021e-09
1.0194e-09	1956.8	0.35297	22.744	1768.8	0.27222	1522.6	5e-14	3.021e-09
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0005	30.21
1.001e-09	1949.9	0.3548	22.885	1824.2	0.27211	1511.7	0.0005	30.21
1.0243e-09	1919.1	0.36217	22.815	1832	0.27303	1519.5	0.0005	30.21
1.0195e-09	1957.7	0.35863	22.66	1775.5	0.27342	1471.8	0.0005	30.21
1.01e-09	1935	0.36	23	1800	0.27	1500	0.001	60.42
1.0118e-09	1960	0.36646	22.963	1769	0.27024	1481.8	0.001	60.42
1.0019e-09	1971.8	0.35518	23.255	1788.6	0.26972	1476	0.001	60.42
9.9223e-10	1963	0.35382	23.352	1792.4	0.26935	1491	0.001	60.42
1.01e-09	1935	0.36	23	1800	0.27	1500	0.0024301	133.88
9.9111e-10	1952.5	0.35789	23.13	1819.6	0.27191	1499.2	0.0024301	133.88
1.0226e-09	1902.2	0.35321	22.939	1774.3	0.27333	1470.1	0.0024301	133.88
9.9369e-10	1928.9	0.35619	23.42	1790.7	0.26991	1486.1	0.0024301	133.88

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1.01e-09	1935	0.36	23	1800	0.27	1500	0.08793	291.32
1.0009e-09	1920.7	0.36308	23.066	1801.1	0.27084	1470.3	0.08793	291.32
1.004e-09	1938.5	0.35413	22.791	1806.5	0.26465	1471.8	0.08793	291.32
1.005e-09	1909.1	0.35721	22.788	1786.1	0.27091	1502.3	0.08793	291.32
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08943	292.73
1.0217e-09	1925.1	0.36363	23.14	1803.7	0.27379	1495.5	0.08943	292.73
1.013e-09	1955.8	0.36057	23.446	1771.6	0.26785	1492.8	0.08943	292.73
1.0089e-09	1913.5	0.35742	22.749	1765.6	0.26477	1517	0.08943	292.73
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09093	294.14
9.9055e-10	1966.2	0.35563	23.1	1801.6	0.27223	1491.2	0.09093	294.14
1.0205e-09	1935.4	0.36383	22.874	1830.6	0.27433	1503.1	0.09093	294.14
1.0108e-09	1910.2	0.36157	23.21	1827.1	0.26971	1515.1	0.09093	294.14
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09243	295.56
9.9711e-10	1898	0.35466	23.331	1821.4	0.26663	1480.3	0.09243	295.56
1.0171e-09	1927.3	0.36627	22.978	1793	0.26665	1490.2	0.09243	295.56
1.0076e-09	1907	0.36692	22.944	1821.9	0.27343	1483.9	0.09243	295.56
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09393	296.97
1.0157e-09	1916.3	0.35459	22.914	1768.9	0.26579	1501.8	0.09393	296.97
9.9834e-10	1898.3	0.36712	23.225	1834.7	0.27487	1498.3	0.09393	296.97
1.0297e-09	1962.3	0.35725	23.416	1772.2	0.26587	1470	0.09393	296.97
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09543	298.38
1.002e-09	1924.9	0.35453	23.195	1832.9	0.26808	1517.3	0.09543	298.38
1.0169e-09	1904.8	0.36323	23.352	1764	0.2657	1492.2	0.09543	298.38
1.0268e-09	1973.6	0.35526	22.699	1771.4	0.27115	1494.7	0.09543	298.38
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09693	299.79
1.0001e-09	1911.9	0.3555	23.353	1809.5	0.27132	1509.5	0.09693	299.79
9.9695e-10	1944.7	0.36542	22.704	1810.5	0.27415	1485	0.09693	299.79
1.0135e-09	1934	0.36488	22.588	1817.2	0.27059	1495.8	0.09693	299.79
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09843	301.21
1.0213e-09	1927	0.35794	23.147	1792.4	0.26653	1473.3	0.09843	301.21
9.9978e-10	1966.1	0.36695	22.985	1774.4	0.27013	1529.6	0.09843	301.21
1.0206e-09	1971.1	0.36619	22.758	1771	0.26903	1477.9	0.09843	301.21
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09993	302.62
1.0203e-09	1923.2	0.35928	22.723	1817	0.2668	1516.1	0.09993	302.62
9.9955e-10	1943.8	0.35778	23.205	1772.4	0.26655	1481.6	0.09993	302.62
1.0044e-09	1927.6	0.35605	23.156	1832.9	0.26926	1518.2	0.09993	302.62

Script 9 joins the lines of Mat6b and Mat12b and constructs matrix Mat6_12b having 552 lines.
The latter is converted in table **Tab6_12b**.

Tab6_12b

Density	**Em**	**Poisson**	**YieldS**	**Hm**	**He**	**Lhm**	**Strain11**	**Stress11**

1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
1.1341e-09	2988.1	0.36563	24.738	3046.1	0.17286	1011.3	5e-14	6.0014e-09
1.1282e-09	3010	0.36559	24.627	3022.5	0.17279	1010	5e-14	6.0014e-09
1.1547e-09	2967	0.36832	24.919	3052.3	0.16732	1001.3	5e-14	6.0014e-09
1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
1.1455e-09	2973.6	0.36553	24.908	2983.5	0.1677	1015.7	0.0005	60.014
1.1373e-09	3020.4	0.36571	24.971	2946	0.16997	990.79	0.0005	60.014
1.1484e-09	3029.8	0.3684	25.059	3027.9	0.17076	1003.2	0.0005	60.014
1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38
1.1204e-09	2984.9	0.3631	24.906	3019	0.17051	1019	0.00085301	102.38
1.1373e-09	3033.3	0.37103	24.521	3001.5	0.16937	988.79	0.00085301	102.38
1.1277e-09	2992.6	0.37621	24.819	2974.1	0.16907	999.97	0.00085301	102.38
1.14e-09	3000	0.37	25	3000	0.17	1000	0.002353	175.29
1.1543e-09	2968.2	0.36293	24.801	2975.8	0.17222	985.46	0.002353	175.29
1.1543e-09	3043.3	0.37078	24.519	3000.9	0.17145	1007.9	0.002353	175.29
1.1579e-09	3024.1	0.37647	24.511	3038.4	0.16683	1000.6	0.002353	175.29
1.14e-09	3000	0.37	25	3000	0.17	1000	0.003853	225.68
1.147e-09	3030.5	0.36674	25.103	3046.7	0.17097	1011.4	0.003853	225.68
1.1396e-09	2988.4	0.37559	25.208	3039.2	0.16667	983.82	0.003853	225.68
1.142e-09	3042.7	0.36651	25.276	3016.6	0.17153	1015.8	0.003853	225.68
1.14e-09	3000	0.37	25	3000	0.17	1000	0.005353	256.33
1.1522e-09	2964.8	0.36324	24.654	3026.2	0.16747	988.83	0.005353	256.33
1.1379e-09	2995.8	0.36393	25.007	2949.2	0.16773	1009.9	0.005353	256.33
1.1325e-09	2976.6	0.37472	25.482	3056.3	0.17052	989.34	0.005353	256.33

....

....

....

1.01e-09	1935	0.36	23	1800	0.27	1500	0.06693	271.54
1.0105e-09	1936.9	0.35955	23.422	1825.6	0.2679	1513.2	0.06693	271.54
1.0243e-09	1920.1	0.35506	22.611	1817.9	0.27037	1497.2	0.06693	271.54
1.0218e-09	1913.2	0.35721	23.213	1797.1	0.26897	1485.1	0.06693	271.54
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06843	272.96
1.0133e-09	1958.9	0.35353	22.677	1799.4	0.27423	1488.8	0.06843	272.96
1.0012e-09	1901.3	0.35367	23.073	1824.3	0.26835	1490.9	0.06843	272.96
9.9148e-10	1926.6	0.36527	22.563	1776.3	0.27357	1470.8	0.06843	272.96
1.01e-09	1935	0.36	23	1800	0.27	1500	0.06993	274.37
1.0087e-09	1960.7	0.36576	23.006	1824.4	0.27073	1516.4	0.06993	274.37
1.0024e-09	1904.6	0.3628	23.222	1792.6	0.26834	1473.3	0.06993	274.37
1.0049e-09	1924.7	0.35689	23.381	1811.5	0.2692	1507.5	0.06993	274.37
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07143	275.78
1.014e-09	1972.2	0.36381	23.201	1827.4	0.26472	1504.3	0.07143	275.78
1.0291e-09	1937.6	0.3537	23.06	1780.4	0.26936	1475.9	0.07143	275.78
9.9494e-10	1958.3	0.35647	23	1801.7	0.26481	1522.6	0.07143	275.78

1.01e-09	1935	0.36	23	1800	0.27	1500	0.07293	277.19
1.0084e-09	1972.1	0.361	23.344	1781.4	0.26587	1479.1	0.07293	277.19
9.922e-10	1911.8	0.3653	23.249	1831.1	0.26547	1474.2	0.07293	277.19
1.0293e-09	1936.7	0.36414	22.825	1772.5	0.26984	1494.9	0.07293	277.19
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07443	278.61
1.0268e-09	1908.6	0.35573	22.678	1833	0.27269	1482.4	0.07443	278.61
1.0167e-09	1913.3	0.35927	23.405	1805.9	0.2662	1507.8	0.07443	278.61
9.9725e-10	1902.7	0.35588	23.024	1812	0.26956	1482.9	0.07443	278.61
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07593	280.02
9.987e-10	1965.2	0.35714	22.77	1828.6	0.26589	1509.9	0.07593	280.02
1.003e-09	1921.5	0.36469	23.046	1810.4	0.27373	1505.7	0.07593	280.02
1.0032e-09	1912.7	0.36181	22.782	1834.2	0.26634	1517.7	0.07593	280.02
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07743	281.43
1.0271e-09	1932.4	0.36164	22.918	1833.8	0.27165	1516.3	0.07743	281.43
1.0066e-09	1907.8	0.35992	23.321	1812.8	0.26942	1499.8	0.07743	281.43
9.9611e-10	1950.3	0.35575	23.163	1773	0.27103	1516.4	0.07743	281.43
1.01e-09	1935	0.36	23	1800	0.27	1500	0.07893	282.84
1.0132e-09	1949.2	0.35895	22.795	1834.4	0.27502	1513.7	0.07893	282.84
1.0191e-09	1946.2	0.35404	23.026	1825.3	0.26687	1519.6	0.07893	282.84
9.9814e-10	1933.1	0.35712	22.857	1830.8	0.26493	1513.2	0.07893	282.84
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08043	284.26
1.005e-09	1941.8	0.35755	23.336	1825.6	0.27052	1472.6	0.08043	284.26
1.0114e-09	1960.2	0.36095	22.742	1787.3	0.2653	1492.4	0.08043	284.26
1.0002e-09	1916.5	0.3596	22.627	1768.5	0.27342	1474.1	0.08043	284.26
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08193	285.67
1.0018e-09	1957.3	0.35937	23.377	1803.6	0.26924	1493.9	0.08193	285.67
9.9236e-10	1951.7	0.36317	23.222	1813.6	0.26741	1470.6	0.08193	285.67
1.0039e-09	1965.7	0.3635	22.81	1777.3	0.26636	1474.5	0.08193	285.67
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08343	287.08
1.0075e-09	1917.3	0.35621	22.675	1797.9	0.27247	1493.5	0.08343	287.08
9.961e-10	1907.3	0.36583	22.864	1775.5	0.27402	1518.2	0.08343	287.08
1.0195e-09	1934.4	0.35859	23.334	1777	0.2746	1519.3	0.08343	287.08
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08493	288.49
1.0175e-09	1932.6	0.36559	23.444	1766.3	0.27351	1509.6	0.08493	288.49
1.0079e-09	1940.7	0.36429	23.122	1820.9	0.26524	1493.4	0.08493	288.49
1.0068e-09	1947.7	0.36194	23.354	1808	0.27125	1522.6	0.08493	288.49
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08643	289.91
1.0208e-09	1954.4	0.35446	22.728	1772.4	0.27369	1492.9	0.08643	289.91
1.0081e-09	1902	0.35316	23.424	1775.4	0.27468	1484.2	0.08643	289.91
9.9285e-10	1948.4	0.35401	22.597	1814.1	0.26462	1479.4	0.08643	289.91
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08793	291.32
1.0009e-09	1920.7	0.36308	23.066	1801.1	0.27084	1470.3	0.08793	291.32
1.004e-09	1938.5	0.35413	22.791	1806.5	0.26465	1471.8	0.08793	291.32
1.005e-09	1909.1	0.35721	22.788	1786.1	0.27091	1502.3	0.08793	291.32
1.01e-09	1935	0.36	23	1800	0.27	1500	0.08943	292.73

1.0217e-09	1925.1	0.36363	23.14	1803.7	0.27379	1495.5	0.08943	292.73
1.013e-09	1955.8	0.36057	23.446	1771.6	0.26785	1492.8	0.08943	292.73
1.0089e-09	1913.5	0.35742	22.749	1765.6	0.26477	1517	0.08943	292.73
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09093	294.14
9.9055e-10	1966.2	0.35563	23.1	1801.6	0.27223	1491.2	0.09093	294.14
1.0205e-09	1935.4	0.36383	22.874	1830.6	0.27433	1503.1	0.09093	294.14
1.0108e-09	1910.2	0.36157	23.21	1827.1	0.26971	1515.1	0.09093	294.14
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09243	295.56
9.9711e-10	1898	0.35466	23.331	1821.4	0.26663	1480.3	0.09243	295.56
1.0171e-09	1927.3	0.36627	22.978	1793	0.26665	1490.2	0.09243	295.56
1.0076e-09	1907	0.36692	22.944	1821.9	0.27343	1483.9	0.09243	295.56
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09393	296.97
1.0157e-09	1916.3	0.35459	22.914	1768.9	0.26579	1501.8	0.09393	296.97
9.9834e-10	1898.3	0.36712	23.225	1834.7	0.27487	1498.3	0.09393	296.97
1.0297e-09	1962.3	0.35725	23.416	1772.2	0.26587	1470	0.09393	296.97
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09543	298.38
1.002e-09	1924.9	0.35453	23.195	1832.9	0.26808	1517.3	0.09543	298.38
1.0169e-09	1904.8	0.36323	23.352	1764	0.2657	1492.2	0.09543	298.38
1.0268e-09	1973.6	0.35526	22.699	1771.4	0.27115	1494.7	0.09543	298.38
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09693	299.79
1.0001e-09	1911.9	0.3555	23.353	1809.5	0.27132	1509.5	0.09693	299.79
9.9695e-10	1944.7	0.36542	22.704	1810.5	0.27415	1485	0.09693	299.79
1.0135e-09	1934	0.36488	22.588	1817.2	0.27059	1495.8	0.09693	299.79
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09843	301.21
1.0213e-09	1927	0.35794	23.147	1792.4	0.26653	1473.3	0.09843	301.21
9.9978e-10	1966.1	0.36695	22.985	1774.4	0.27013	1529.6	0.09843	301.21
1.0206e-09	1971.1	0.36619	22.758	1771	0.26903	1477.9	0.09843	301.21
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09993	302.62
1.0203e-09	1923.2	0.35928	22.723	1817	0.2668	1516.1	0.09993	302.62
9.9955e-10	1943.8	0.35778	23.205	1772.4	0.26655	1481.6	0.09993	302.62
1.0044e-09	1927.6	0.35605	23.156	1832.9	0.26926	1518.2	0.09993	302.62

I.5. Predictions for PA11 using the joint ML Model

I.5.1 Regression Model using a wide Regression Neural Network.

-Details concerning the script "`S10_Training.m`" -

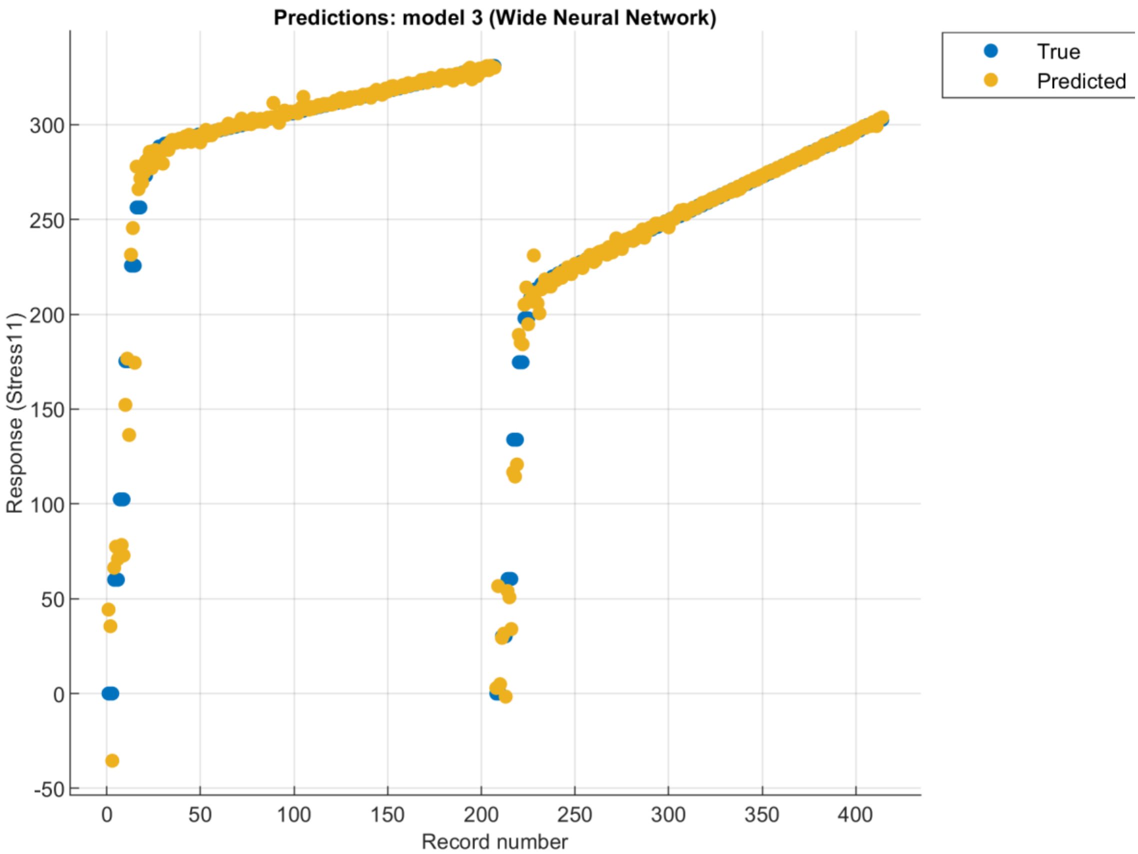
With the help of the Regression Learner app of MATLAB system, we have developed a few regression models saved in the work session Session**`PA6_12_11_unu.mat`**, including the RNN (**wide NN, intern model #3**).

The function **`trainRegMod5`** generates a trained ML model, an RNN (wide NN). The `fitrnet` function is called with the following parameters.

```
regressionNeuralNetwork = fitrnet(...
    predictors, ...
    response, ...
    'LayerSizes', 100, ...
    'Activations', 'relu', ...
    'Lambda', 0, ...
    'IterationLimit', 1000, ...
    'Standardize', true);
```

The tables used in this script are recovered from the workspace `WsTab61211.mat`, which contains the following data.

The global data set: `Tab6_12_11;`
Training data: `Tab6_12_11train;`
Testing data: `Tab6_12_11test;`



The big data set Tab6_12_11 is:

```
******  Tab6_12_11:
```

lines=564

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1	1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
2	1.1544e-09	3048.7	0.36448	25.413	3015.9	0.16726	991.14	0	0
3	1.1421e-09	3054.9	0.37688	24.658	3056.5	0.17311	999.42	0	0
4	1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0
5	1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
6	1.1188e-09	3041.9	0.37642	25.179	3030.9	0.17165	995.69	0.0005	60.014
7	1.1471e-09	2960.5	0.37305	24.532	2973.2	0.16691	983.89	0.0005	60.014
8	1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014
9	1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38
10	1.1521e-09	3035.4	0.36537	24.99	2993.5	0.17099	1008.4	0.00085301	102.38
11	1.1516e-09	2973.1	0.37266	25.155	2959.5	0.16741	999.93	0.00085301	102.38
12	1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38
13	1.14e-09	3000	0.37	25	3000	0.17	1000	0.002353	175.29
14	1.1491e-09	3046.9	0.3768	25.047	2956.6	0.16762	990.3	0.002353	175.29
15	1.1555e-09	2970.5	0.37465	24.744	3051.5	0.16898	987.86	0.002353	175.29

################################ (Datele de mai jos nu se prea potrivesc)

****** Tab6_12_11train:

lines=423

Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
1.1544e-09	3048.7	0.36448	25.413	3015.9	0.16726	991.14	0	0
1.1421e-09	3054.9	0.37688	24.658	3056.5	0.17311	999.42	0	0
1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
1.1188e-09	3041.9	0.37642	25.179	3030.9	0.17165	995.69	0.0005	60.014
1.1471e-09	2960.5	0.37305	24.532	2973.2	0.16691	983.89	0.0005	60.014
1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38
1.1521e-09	3035.4	0.36537	24.99	2993.5	0.17099	1008.4	0.00085301	102.38
1.1516e-09	2973.1	0.37266	25.155	2959.5	0.16741	999.93	0.00085301	102.38

################################

****** Tab6_12_11test:

lines=141

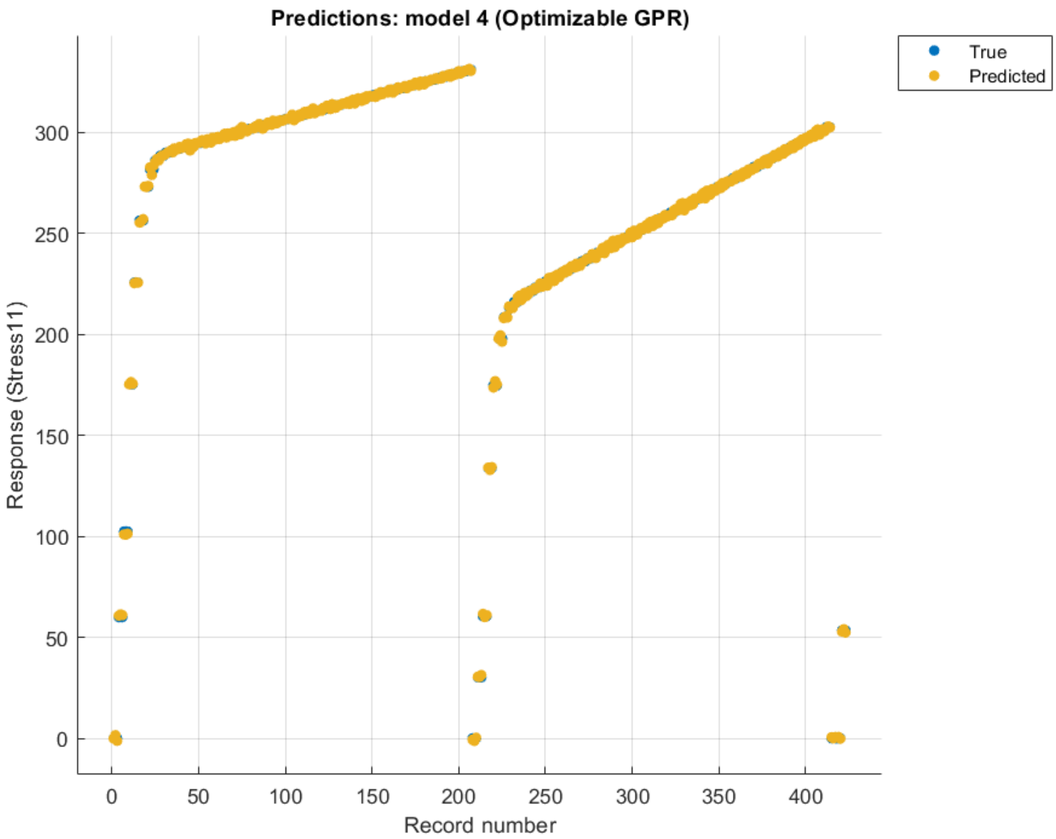
Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0
1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014
1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38
1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29
1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68
1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33
1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07
1.135e-09	2969	0.36858	24.596	2955.8	0.17301	1018.2	0.008353	281.68
1.1512e-09	2962.7	0.37276	24.684	2984.2	0.17085	1011.2	0.009853	286.1
1.1415e-09	2982.1	0.3765	25.376	3006	0.17083	1003.5	0.011353	288.5
1.1585e-09	3057.6	0.3691	24.611	2971	0.16938	1003.8	0.012853	289.97
1.1505e-09	2998.6	0.37116	24.737	2995.1	0.17315	1001.9	0.014353	291.02
1.1325e-09	3021.6	0.36462	25.221	2952.8	0.17105	999.77	0.015853	291.88

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	PredNew
1	1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09	9.976
2	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419	29.106
3	1.03e-09	1250	0.37	51	1500	0.28	1680	0.001	106.84	48.236
4	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0015	160.26	67.367
5	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0016863	180.16	75.34
6	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0021863	204.59	101.02
7	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0026863	225.24	126.7
8	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0031863	241.99	152.38
9	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0036863	255.01	178.06
10	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0041863	264.69	203.73
11	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0046863	271.64	229.41
12	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0051863	276.51	255.09
13	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0056863	279.88	280.77
14	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0061863	282.22	306.45
15	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0066863	283.88	332.13
16	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0071863	285.1	334.89
17	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0076863	286.04	336.37
18	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0081863	286.8	337.86

Details concerning the script `S11_trainMod7.m`

This script trains and uses Model 7 (GPR-Gaussian Process Regression) generated inside session "`SessionPA6_12_11_doi`" (intern model nr 4).

I.5.2 Regression Model using GPR-Gaussian Process Regression



Using function `Mod7trainGPR` and the training data, model `mdlGPR7` is trained.

The prediction function of this model, mdlGPR7, is called for the testing data, and the vector StressPred is generated. The latter fits very well with Stress11 values (APPENDIX A – execution listing of script S11_trainMod7.m).

Table Tab11b is constructed by removing the first two columns of table T11mB. Table TFV is generated by retaining 42 lines of table T11mB. The prediction function will use table TFV to predict the stress for data points characterizing PA11 at first view. Unfortunately, the fit is unacceptable this time; the column Difference proves that (APPENDIX A).

Details concerning the script `S12_trainMod8.m`

SCRIPT 12

This script trains and uses Model 8 (Regression Neural Network) generated inside session "`SessionPA6_12_11_doi`" (intern model nr 5, which is a wide NN).

The tables used for training and testing are the same as those presented for SCRIPT 11. Using function Mod8trainRNN and the training data, model mdlRNN8 is trained.

```
vrmse=
        11.844
RMSEValid=
        3.9232
```

The prediction function of this model, mdlGPR8, is called for the testing data, and the vector StressPred is generated. The latter fits well with Stress11 values (APPENDIX B – execution listing of script S12_trainMod8.m).

Tables Tab11b and TFV are constructed in the same way. The prediction function will use table TFV to predict the stress for data points characterizing PA11 at first view. Unfortunately, the fit is unacceptable this time; the column Difference proves that.

Details concerning the script `S14_trainMod9.m`

SCRIPT 14
This script trains and uses Model 9 (Regression Neural Network) generated inside session `"SessionPA6_12_11_doi"` (intern model nr 11, which is a **medium NN**).

The tables for training and testing are the same as those presented before.
Using function `Mod9trainRNN` and the training data, model `mdlRNN9` is trained:

```
vrmse=
       21.358

RMSEValid=
       3.3474
```

Using the same table TFV as before, the predictions for the two data sets are listed in the same tables (APPENDIX C – execution listing of script S14_trainMod9.m).
Although the RMSEValid is better (3.3474) than the previous models, the predictions for the "unseen" data sets are worse.

Details concerning the script `S16_trainMod27.m`

SCRIPT 16
This script trains and uses Model 27 (Regression Neural Network) generated inside session `"SessionPA6_12_11_doi"` (intern model nr 27, which is a **wide NN**).

```
          regressionNeuralNetwork = fitrnet(...
              predictors, ...
              response, ...
              'LayerSizes', 100, ...
              'Activations', 'relu', ...
              'Lambda', 0, ...
              'IterationLimit', 2000, ...
              'Standardize', true);
```

The tables for training and testing are the same as those presented before.
Using function Mod9trainRNN and the training data, model mdlRNN9 is trained:

```
vrmse=
       13.202

RMSEValid=
       3.3768
```

Using the same table TFV as before, the predictions for the two data sets are listed in the same tables (APPENDIX D – execution listing of script S16_trainMod27.m).
Although the vrmse is better (13.202) than the previous models, the predictions for the "unseen" data sets are unacceptable.

I.6. Provisional Conclusion

1. It is not possible to make predictions for PA11 using the joint LM model (MPA6_PA12) without data points concerning PA11. If this were possible, it would be possible for any composite material with the same fiber (! ?)

2. We have predictions for PA11, but they are inaccurate if we consider a few data points (e.g., 3).
3. To increase the accuracy, we have to add more data points, for example, to the end of the strain's range.
4. This is work to do in the next future.

II. Machine Learning Predictions for the Comparative Mechanical Analysis of Composite Laminates with Various Fiber Orientations

July 15 - August 10, 2024
September 1st–October 7, 2024
December 25, 2024 – January 25, 2025

I researched this topic, aiming also to write a publishable study.

II.1. Introduction

This work addresses the complex behavior of composite laminates under varied layer orientations during tensile tests, focusing on carbon fiber and epoxy matrix composites. Data characterizing the mechanical load behavior is obtained using twelve composite laminates with different layer orientations and the DIGIMAT-VA software. First, this data was used to elaborate a complex comparative analysis of composite laminates from the perspective of materials science. Composite laminates belong to three classes: unidirectional, off-axis-oriented, and symmetrically balanced laminates, each having a specific behavior. From the perspective of designing a new material, a prediction model faster than the finite element analysis is needed to apply this comparative analysis's conclusions. This paper proposes several machine learning prediction models, among which a Regression Neural Network performs best, that can effectively replace costly simulations of tensile tests. The prediction model returns the stress-strain characteristic of the elastic zone given the new layer orientations. These models were implemented in the MATLAB system, and their running proved good models' generalization power and accuracy. Even specimens with randomly oriented layers were successfully tested. Thereby, specialists in composite materials can look for new stratification combinations and predict mechanical load responses efficiently until the desired behavior is achieved.

The implementation of ML models is the goal of section I.2. Special attention was paid to the implementation aspects, illustrated using specific datasets, to help the interested reader understand and eventually construct their model. This section explains how ML algorithms can be harnessed to train and test the dataset characterizing a specific specimen. Among the algorithms we implemented, we present three along with their models: Multiple Linear Regression, Support Vector Machine, and Regression Neural Network. The details in this section (and section II.3) relate to models' implementation using the MATLAB system [38–39]. Predicted and actual values are compared for both the training and test processes. Statistics for the training and test process results are provided for all five constructed ML models.

Section 5 first aims to prove the generalization power of the prediction models constructed in the previous section context. The generalization power of an ML prediction model (RNN2, a Regression Neural Network [39] developed in section 4) is evaluated using data points the algorithm has never encountered; these points are not part of the training or test datasets.

Subsection II.2.1 addresses the cases where new combinations share the same structure as a specimen used in the model construction, differing only in a few layer orientations. A variable parametrizes the set of new stratification combinations. We can determine the optimal characteristic of stress versus strain by predicting all new stratification combinations and conducting a mechanical analysis, which allows us to find the best parameter value. This procedure can be regarded as an optimization tool for a design problem.

In subsection II.2.2, the generalization power of RNN2 is evaluated under a tougher context: specimens with randomly generated layer orientations. To stay within the generalization area of the ML model, we first selected four base specimens (to make this presentation easy to follow) subjected to tensile tests, contributing to the dataset used for training the RNN2 model. These specimens exhibit different behaviors in the stress-strain space.

Each layer's orientation is independently modified using a uniformly distributed perturbation. The resulting specimens, with randomly generated orientations, are significantly different from the basic ones but remain within the representation area of the model. Then, we compare the predictions for these specimens with the results of DIGIMAT simulations. The comparison shows that the prediction accuracy is greatly satisfactory for the new randomly generated specimens; RNN2 has very good generalization power. However, the ML model must be properly employed under some constraints. For example, in this stage, the strain values must be inside the range corresponding to the elasticity zone.

II.2. Implementation of Machine Learning Models

This section is dedicated to the intricate process of generating ML models for the stress-strain dependence during the tensile test of different specimens. The initial step consists of preparing the dataset for the learning process; it is followed by constructing different parametric and nonparametric ML models.

As mentioned, the main objective is to construct ML models that would apprehend all the measurements described before and predict the Stress value for any pattern (combination of orientations) and a given Strain value. Our work's specific objectives were set with the anticipation of achieving this ultimate goal in mind:

1. Generate a dataset of significant size. This dataset will be used to construct the ML model, enabling it to provide a generalized response for any pattern and an appropriate Strain value.
2. Construct a parametric model (e.g., multiple linear regression) that is easy to understand and apply and can be compared with the following models.
3. Construct some nonparametric models (SVM, decision trees, Gaussian process regression, and neural networks), analyze their accuracy, and compare them to the parametric model. Out of many ML models investigated, we chose to present two nonparametric models (SVM and Regression NN). The last ones yielded four trained and tested models, the most effective and appropriate to the considered data set.
4. Carefully select the most accurate parametric models that could be used in further research, providing a solid foundation for future studies.

Remark 1: For our problem, many SVM and Regression NN models could be constructed, some of them having potentially superior capabilities to predict the behavior of the stencils. Our objective was not to find their best but to validate our approach: to prove that ML models can accurately predict stress-strain behavior.

II.2.1. Data Preparation

As presented before, the data obtained using the synergistic combination of numerical/ experimental investigations are processed to generate the data set needed for the ML models' construction. This data set is used for the training and testing phases of the considered ML model.

To describe our approach, we consider in the sequel the data collected from twelve specimens' tests, which were loaded within different stress and strain ranges. Linear segments approximated the results, as shown in Figure 21.

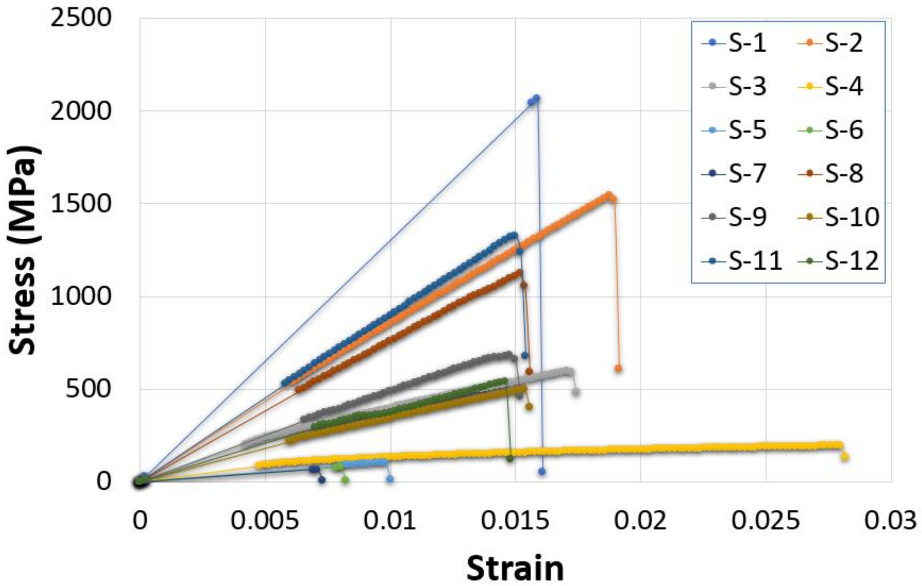


Figure 21. The stress-strain dependence during the tensile test of the twelve specimens.

The table below shows the minimum and maximum limits of the stress and strain parameters for the twelve specimens.

Strain (min)	Strain (max)	Stress (min)	Stress (max)

S-1	0	0.01587015	0	2064.24019
S-2	0	0.01874477	0	1540.16043
S-3	0	0.01705347	0	593.258184
S-4	0	0.02798728	0	192.457154
S-5	0	0.00981914	0	101.786008
S-6	0	0.00803761	0	77.3136431
S-7	0	0.00709987	0	63.9780266
S-8	0	0.01537992	0	1121.76279
S-9	0	0.01478241	0	680.072911
S-10	0	0.01536462	0	499.329696
S-11	0	0.01499824	0	1327.03122
S-12	0	0.0146055	0	540.079359

Table 21. Limits of Strain and Stress Values

Every specimen is composed of 16 composite layers having different orientations. The following sequence could characterize a specimen state during the tensile test:

$$\alpha_1, \alpha_2, \ldots, \alpha_{16}, (\text{strain}(Sk, j), \text{stress}(Sk, j)), j=1, \ldots, M \qquad (*1)$$

This sequence is related to our objective, which is to predict the *stress* value for the specimen having the sixteen orientations and loaded with the given *strain* value. Our approach is based on supervised learning algorithms, so the *stress* value is the label of each data point.

The data-generating process must use a probability distribution that fulfills the independent and identical distribution assumptions. The training and test sets will be generated independently using the same probability distribution.

Each of the twelve tested specimens has a specific angle combination α_i, i=1,…,16, that will be called a *pattern*. For example, the specimen denoted S8 has the *pattern*:

[0. 45. 0. 90. 0. -45. 0. 45. 45. 0. -45. 0. 90. 0. 45. 0.]; (*2)

For each specimen Sk, Sk=1,…,12, we dispose of M pairs of values

(*strain*(Sk, j), *stress*(Sk, j)), j=1, …, M,

obtained by simulations or tensile tests. The M data points corresponding to the specimen Sk have the following structure:

$\alpha_1, \alpha_2, \ldots, \alpha_{16}$, (strain(Sk, j), stress(Sk, j)), j=1, …, M.

We have considered that a uniformly distributed noise perturbs the patterns; that is, it affects each orientation angle with a value belonging to [-d, d] (e.g., d=2 grads). This perturbation models the imprecision in achieving the layer's orientation but also diversifies the orientation values to make the generalization possible. For example, one of the M data points generated by specimen S8 is the following:

[1.391 45.331 0.34471 91.703 0.30031 -46.96 1.2375 45.435
44.92 0.92624 -45.968 -0.075 88.909 -1.8056 43.677 -0.96621
0.0051266 393.11].

The last elements are the strain and stress values, 0.0051266 and 393.11 MPa, respectively.

Finally, our dataset would have 12·M data points. In our tests, we have considered M equals 30, which means that the data-generating process yielded 360 data points used for both the training and testing phases. This data set, called in our programs BigData, supplied the data for the tables TableTrain and TableTest, devoted to the training and test phases. The M data points corresponding to each specimen are split into two parts, included in TableTrain and TableTest, containing p·M (e.g., p=80%) and (1-p)·M data points, respectively.

Validation sets and k-fold cross-validation were also used in the learning process when obtaining certain ML models that use hyperparameter optimization.

II.2.2. Construction of ML Models

II.2.2.1 A multiple linear regression model

The first ML model constructed to fit the data set is parametric: a multiple linear regression model that allows the possibility of including nonlinear terms as the interactions, that is, the product of predictor variables. The model maintains its linearity about its coefficients.

Out of the linear regression models developed in our work, we present only that based on the step-wise regression strategy. The latter consists of adding or removing features from a constant model. In the MATLAB system used in our implementation, this strategy is implemented by a specialized function `step-wise` (T), which returns a model that fits the dataset in T.

The features of this model are named $x_1,\ldots,x_{16}$ for the orientations $\alpha_1, \alpha_2,\ldots, \alpha_{16}$, and `St` and `Ss` for the Strain and Stress, respectively. Appendix A describes the results obtained using the step-wise regression strategy. One of the best linear regression models for stress has the following structure:

```
Ss ~ 1 + x1 + x2 + x9 + x12 + x13 + St +
     + x1*x9 + x1*St + x2*x13 + x2*St + x9*St + x12*St + x13*St
```

Besides the intercept and terms corresponding to six predictors, all the other terms are interactions of the predictors. Its coefficients are given in Appendix A as well. Figure 22 presents the predicted and training values for all 300 training records (data points). Figure 23 shows a global image of the model's generalization efficiency using the 60 data points.

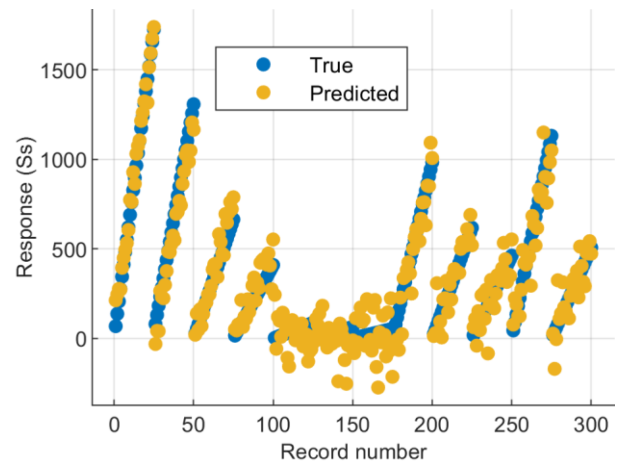


Figure 22. Predicted versus real values for the training data set

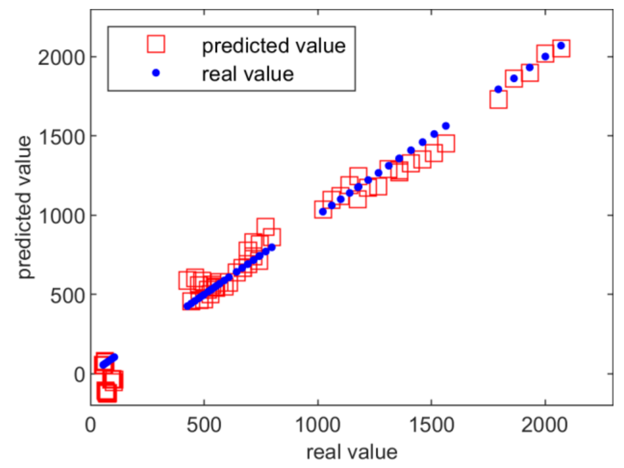


Figure 23. Predicted versus real values for the test data set

Usually, the training and test process results can be characterized by statistics, allowing the ML models constructed using the same data set to be compared. The statistics given in Table 22 for different ML models are the Root mean squared error (RMSE), R-squared, and Mean absolute error (MAE) values (see [77]).

	Statistics	**SW Linear Regression**	**SVM Regression 1**	**SVM Regression 2**	**RNN1**	**RNN2**
Training results	RMSE	52.045	34.93	46.903	41.135	6.375
	R-Squared	0.98	0.99	0.98	0.99	1.
	MAE	37.42	28.324	31.44	19.132	3.9465
Test results	RMSE	91.091	52.108	86.383	99.206	34.385
	R-Squared	0.97	0.99	0.98	0.97	1.
	MAE	66.667	43.38	66.255	67.875	19.829
Model size		22 kB	16 kB	40 kB	8 kB	1 MB

Table 22. Statistics of the training and test process results and model size for different ML models.

Let's notice the statistics characterizing the Step-Wise Linear Regression model presented in this sub-section, given in the column **SW Linear Regression**. These will allow us to ascertain the superiority of the next proposed ML models. Besides the first column, Table 22 also presents the statistics of the four trained and tested ML models described in the next subsections. The model size is also given.

Although the regression model has good predictions for most specimens, it does not give good predictions for those with a small stress range; their behavior is not accurately "learned." Figures 22 and 23 show certain data points for which the predicted Stress value is negative. There are ten such data points, which we shall call critical, corresponding to the specimens whose Stress range is very narrow. These bad predictions are given in Table 23.

Stress True value	90.999	94.498	97.997	101.5	105.	67.043	69.621	72.2	74.779	77.357
Stress Predicted value	-46.32	-23.93	-29.72	-18.4	-27.3	-83.92	-118.7	-102.	-121.2	-129.2

Table 23. The set of the worst predictions made by the SW Linear Regression Model.

This fact led to investigating *nonparametric* ML models capable of overpassing this drawback.

Remark 2: Besides ameliorating the statistics, improving the critical data points' predictions was challenging for the new ML models. The following subsections present only models with better prediction capabilities, including the critical data points.

II.2.2.2 Support Vector Machine Models

Support Vector Machine generated good ML models for our problem. Out of the SVM models constructed in our work, we present, in the sequel, only two SVM models responding to our objectives. The first SVM Model, called **SVM Regression 1**, has a cubic Kernel function and a set of intern Hyperparameters (as defined within MATLAB system Polynomial Order, Standardize, KernelScale, BoxConstraint, Epsilon. Appendix A gives details concerning the Hyperparameters of the SVM Regression 1.

This model was trained and tested using the Regression Learner application, which led to the results presented in Table 22, column **SVM Regression 1**. The RMSE values are smaller than those of the **SW linear Regression** model, proving that the SVM works better. Figures 24 and 25 illustrate this statement if compared to Figures 22 and 23.

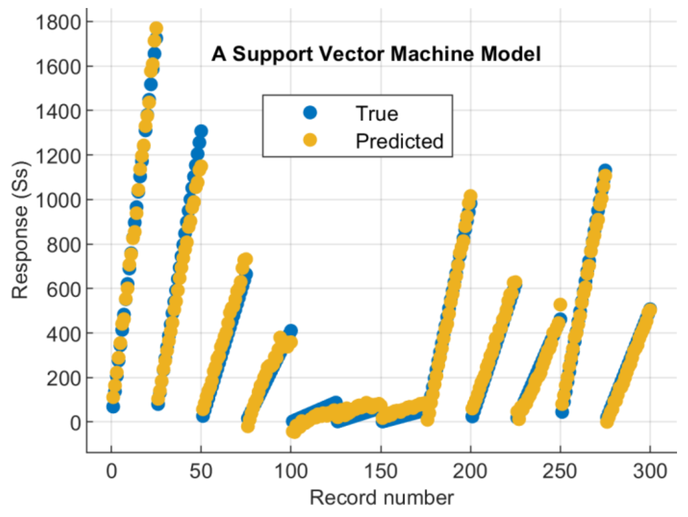


Figure 24. Predicted versus real values for the training data set - SVM Regression 1

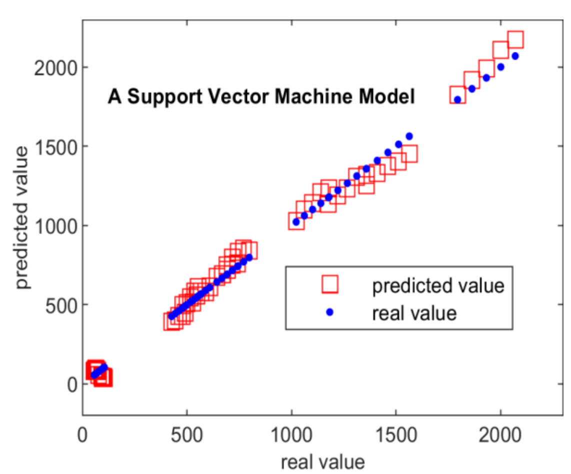


Figure 25. Predicted versus real values for the test data set - SVM Regression 1

The predictions for the critical data points are given in Table 24. Although they are not very good, they are better than those in Table 23, at least because they are positive.

Stress True value	90.999	94.498	97.997	101.5	105.	67.043	69.621	72.2	74.779	77.357

Stress Predicted value	47.679	35.616	39.292	42.684	34.877	82.007	89.711	81.055	81.242	56.943

Table 24. The set of the critical predictions made by the SVM Model 1.

We also constructed another SVM model that predicts very well the critical data points, whose statistics are given in a column called **SVM Regression 2**. The Hyperparameters' Model is the following:

Preset: Optimisable SVM,
Kernel function: Quadratic
Kernel scale: Automatic.

The training process uses Bayesian optimization to optimize the combination of hyperparameters.

Table 25 shows excellent predictions for the critical data points, but the statistics corresponding to this new SVM model are inferior to those of the **SVM Regression 1.**

Stress True value	90.999	94.498	97.997	101.5	105.	67.043	69.621	72.2	74.779	77.357
Stress Predicted value	93.074	95.691	100.18	105.26	110.17	68.82	71.944	74.032	77.312	80.144

Table 25. The set of the critical predictions made by the SVM Model 2.

Moreover, the new model size, 40 kB, is larger than the first. In conclusion, owing to most of its characteristics, the **SVM Regression 1** model can be considered better than the second one.

II.2.2.3 Regression Neural Network Models

This subsection presents two other nonparametric ML models using Regression Neural Networks. The first one uses a Narrow Neural Network in MATLAB system terminology. Its statistics are shown in column **RNN 1** of Table 22.

Details concerning the model RNN 1 are given in Appendix A. The hyperparameters are optimized using heuristic procedures. The RMSE and MAE values are better than the previous models in Table 22, showing better predicting accuracy. Moreover, the model's size is the smallest of all presented ML models, having 8 kB.

The predicted Stress values for the critical data points are very good, like those presented in Table 25, proving that this problem is also solved.

The more accurate prediction is obtained using another Regression NN, the **RNN 2** model, whose statistics are displayed in the last column of Table 22. Details concerning the model **RNN 2** are given in Appendix A. It is an RNN with 3 layers whose hyperparameters are found using Bayesian optimization.

Table 26 shows that the predictions for the critical data points are very good, the best in comparison with the previous models.

Stress True value	90.999	94.498	97.997	101.5	105.	67.043	69.621	72.2	74.779	77.357
Stress Predicted value	92.233	96.111	102.73	107.33	113.38	67.583	70.387	73.247	76.896	80.282

Table 26. The set of the critical predictions made by the RNN 2.

The price to pay for the very good accuracy of RNN 2 is the larger size of the model, which is 1 MB.

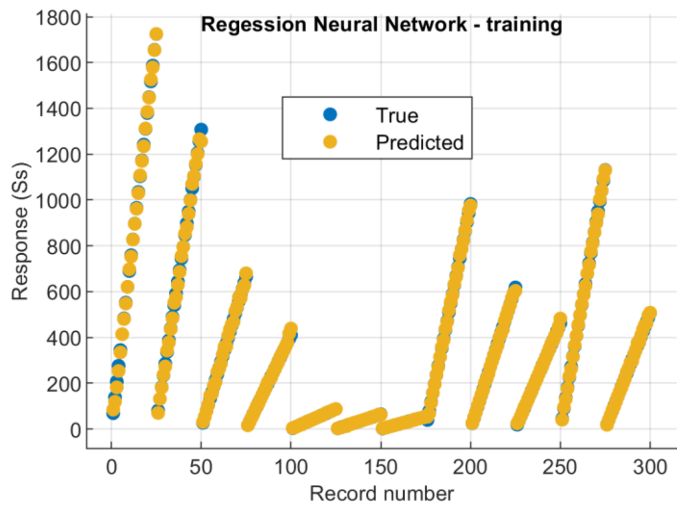


Figure 26. Predicted versus real values - the training of RNN2

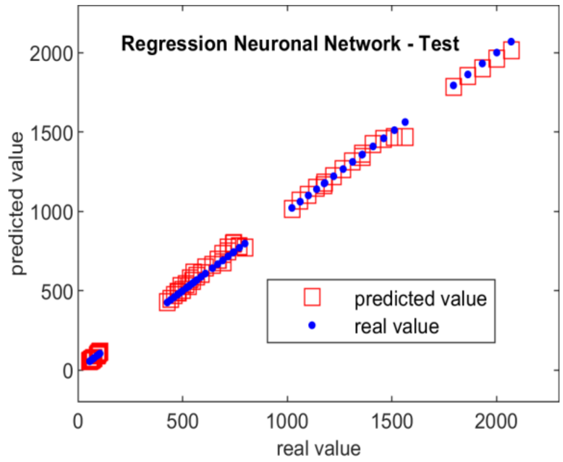


Figure 27. Predicted versus real values - the test of RNN2

Figures 26 and 27 show the efficiency of the training and test processes, respectively, and prove that RNN2 is the more accurate ML model for the given data set. According to how the ML model is used, RNN1 can replace RNN2 and be a good solution for our prediction problem due to its small model size and good accuracy.

APPENDIX A

<u>Details concerning the SW Linear Regression model</u>

The regression model is obtained using the step-wise function:

```
model ← stepwise(T)
```

This function carries out the following actions:

```
1. Adding x1, FStat = 227.8572, pValue = 1.239117e-38
2. Adding St, FStat = 216.2564, pValue = 3.720389e-37
3. Adding x1:St, FStat = 367.5712, pValue = 8.032568e-54
4. Adding x12, FStat = 53.9613, pValue = 2.01116e-12
5. Adding x12:St, FStat = 95.8075, pValue = 9.11615e-20
6. Adding x13, FStat = 236.636, pValue = 1.49516e-39
7. Adding x13:St, FStat = 148.9911, pValue = 5.765152e-28
8. Adding x12:x13, FStat = 72.9692, pValue = 7.48834e-16
9. Adding x9, FStat = 65.4199, pValue = 1.66602e-14
10. Adding x9:St, FStat = 36.892, pValue = 3.92447e-09
11. Adding x2, FStat = 16.1382, pValue = 7.52075e-05
12. Adding x1:x9, FStat = 14.5624, pValue = 0.000166095
13. Adding x1:x12, FStat = 5.6396, pValue = 0.018218
14. Adding x2:St, FStat = 5.2191, pValue = 0.023075
15. Removing x12:x13, FStat = 0.24892, pValue = 0.61822

Linear regression model:
Ss~ 1 + x1 + x2 + x9 + x12 + x13 + St +
         x1*x9 + x1*St + x2*x13 + x2*St + x9*St + x12*St + x13*St

Estimated Coefficients:
```

	Estimate	SE	tStat	pValue
(Intercept)	66.289	16.348	4.0548	6.4742e-05
x1	-1.0564	0.90931	-1.1618	0.24629
x2	5.299	1.5056	3.5196	0.00050263
x9	-2.1988	0.58916	-3.7322	0.000229

x12	-1.5438	0.30825	-5.0083	9.6246e-07
x13	0.42446	0.401	1.0585	0.29071
St	1.2418e+05	1901.7	65.3	7.0906e-174
x1:x9	0.04764	0.012162	3.9171	0.00011217
x1:St	-1320.7	54.246	-24.346	1.1118e-71
x2:x13	-0.065347	0.01489	-4.3885	1.607e-05
x2:St	-176.64	54.038	-3.2687	0.0012122
x9:St	-170.77	29.761	-5.7382	2.4366e-08
x12:St	666.06	38.01	17.523	3.3209e-47
x13:St	-307.24	37.886	-8.1096	1.5046e-14

Details concerning the SVM Regression 1

```
Hyperparameters Model:
     Preset Quadratic SVM
     Kernel function: Cubic
     Kernel scale 3.001
     Box constraint: Automatic
     Epsilon Auto
     Standardisation data: Yes
     Optimiser: Not applicable
```

Details concerning model RNN 1

Hyperparameters Model:

```
     Preset Narrow NN
     Number of fully connected layers 1
     First Layer size 10
     Activation ReLU
     Iteration limit 1000
     Regularisation strength (lambda) 0
     Standardisation data: Yes
     Optimiser: Not Applicable
```

Details concerning model RNN 2

```
     Preset Optimizable NN
     Iteration limit: 1000
     Optimiser: Bayesian optimisation
```

The training of RNN 2 is made using the `fitrnet` function:

```
     RegNN = fitrnet(...
         predictors, ...
         response, ...
         'LayerSizes', [166 280 298], ...
         'Activations', 'relu', ...
         'Lambda', 3.6315e-08, ...
         'IterationLimit', 1000, ...
         'Standardise', true);
```

Details about **`ART_RezSimRand.m`**

I wrote the script `ART_RezSimRand.m`, which generates Figures 53 and 54 used in the common article. It uses the simulations made with DIGIMAT VA, compares them with the ML predictions, and contains 3 parts.

Part I reads the tables resulting from DIGIMAT simulations, which are included in the Exel files "PAT2.xlsx", "PAT6.xlsx", "PAT9.xlsx", and "PAT11.xlsx". These tables have two columns: strain and stress. The same files contain the tables Strain – Stress produced by the ML prediction (that I have already sent to the partners). All tables are saved in the workspace **`RezSimS2_S6_S9_S11.m`**.

```
save('RezSimS2_S6_S9_S11','S2sim','S2ML','S6sim','S6ML','S9sim','S9ML',
'S11sim','S11ML');
```

This part is executed at the beginning of the work. After that, it is transformed into a comment, including the instruction "save."

Part II can be executed without Part I. In this case, Part I is transformed into a comment. The main objective is to plot two figures. Figure 53 will plot the simulated and predicted stress values versus the strain values for the four specimens randomly generated. For the same specimens, Figure 54 will plot the relative prediction errors.

The usual preparatives are carried out to predict the stress values for the strain values given by the simulations with DIGIMAT.

Details about **`ART5_Tabel_DIFF`**

This script must be run only after executing the script `ART3_Gen4SpecRand` that initializes the workspace.
Its objective is twofold:
-to generate the table containing the orientations of the four specimens randomly generated;
-to generate the ART_Figure58, which depicts the sixteen angles of the specimen NEW2.

NB: Table 5.1 uses the notations PAT2, for what is named PATTERN(2,:) inside the script, and NEW2, for what is denoted by PAT2 (random specimen) in the script, and so on.

The variables `DIFF2, DIFF6, DIFF9, and DIFF11` store the differences between the orientations of the new and base patterns; these differences are uniformly distributed in the range [-4, +4] grades.
The matrix "ang" contains the 12 lines representing the four specimens and will be used to generate Table 5.1.
The matrix "ang" is transformed into a table, TAB2, and each line receives a name using the object attribute "Properties."

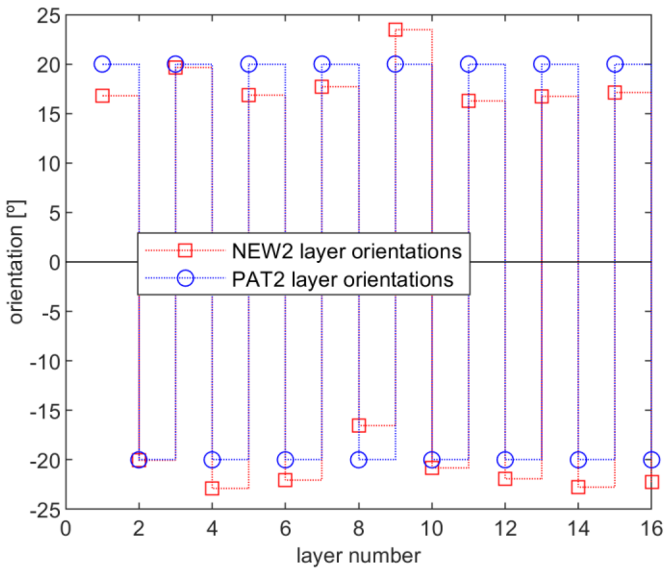
Table 5.1 is generated by displaying columns 1-8 and 7-16 separately.

	ang1	ang2	ang3	ang4	ang5	ang6	ang7	ang8
PAT2	20.00	-20.00	20.00	-20.00	20.00	-20.00	20.00	-20.00
NEW2	16.80	-20.05	19.67	-22.92	16.85	-22.06	17.68	-16.53
DIFF2	-3.20	-0.05	-0.33	-2.92	-3.15	-2.06	-2.32	3.47
PAT6	70.00	-70.00	70.00	-70.00	70.00	-70.00	70.00	-70.00
NEW6	71.47	-69.27	68.30	-70.32	73.18	-71.33	67.00	-68.95
DIFF6	1.47	0.73	-1.70	-0.32	3.18	-1.33	-3.00	1.05
PAT9	45.00	0.00	-45.00	90.00	45.00	0.00	-45.00	90.00
NEW9	46.59	3.31	-42.30	88.52	48.57	-1.31	-44.54	88.57
DIFF9	1.59	3.31	2.70	-1.48	3.57	-1.31	0.46	-1.43
PAT11	0.00	30.00	0.00	90.00	0.00	-30.00	0.00	30.00
NEW11	-3.49	26.87	-0.14	89.83	2.48	-33.05	3.61	32.53
DIFF11	-3.49	-3.13	-0.14	-0.17	2.48	-3.05	3.61	2.53

	ang9	ang10	ang11	ang12	ang13	ang14	ang15	ang16
PAT2	20.00	-20.00	20.00	-20.00	20.00	-20.00	20.00	-20.00
NEW2	23.49	-20.79	16.26	-21.91	16.71	-22.76	17.14	-22.26
DIFF2	3.49	-0.79	-3.74	-1.91	-3.29	-2.76	-2.86	-2.26
PAT6	70.00	-70.00	70.00	-70.00	70.00	-70.00	70.00	-70.00
NEW6	69.55	-73.38	67.92	-67.99	73.58	-72.32	69.08	-70.79
DIFF6	-0.45	-3.38	-2.08	2.01	3.58	-2.32	-0.92	-0.79
PAT9	90.00	-45.00	0.00	45.00	90.00	-45.00	0.00	45.00

NEW9	90.23	-48.59	3.12	45.28	92.95	-41.92	-1.90	42.29
DIFF9	0.23	-3.59	3.12	0.28	2.95	3.08	-1.90	-2.71
PAT11	30.00	0.00	-30.00	0.00	90.00	0.00	30.00	0.00
NEW11	29.95	1.22	-28.86	-0.13	92.30	-0.28	26.92	-0.82
DIFF11	-0.05	1.22	1.14	-0.13	2.30	-0.28	-3.08	-0.82

Table 5.1 The layers' orientations of the basic and new random specimens and their differences.



ART_Figure58. The layers' orientations of the specimen NEW2 in comparison with the PAT2.

II.3 Forecasting New Stratification Combinations

This section will present how to exploit the ML models presented in Section 4, that is, to replicate and predict the behavior of carbon fiber-epoxy composites for different orientations, including novel stratification combinations.

II.3.1 Stress-strain predictions for new combinations

So far, the generalization accuracy of ML models has been tested using the testing datasets reserved for this objective. The testing dataset comes from the same initial traction tests; they have the same real physical support. The generalization power of the ML model would be proven for data points that the model has never "seen"; that is, they belong neither to the training data nor the test data.

The RNN2 model was used as the most performant ML model for stress prediction in our tests.

This subsection considers the case when a new combination has the same structure as one that already contributed to the ML model construction, differing from this in only a few layer orientations. For example, we can generate novel stratification combinations derived from the S8's pattern as "neighbors" of this one: the middle sequence 45/45 is replaced by α/α. The new pattern, denoted Snew, is given below:

Snew = [0/45/0/90/0/-45/0/α/α/0/-45/0/90/0/45/0].

Under this hypothesis, the ML model can cover and predict the new combination's behavior.

Four values (denoted α) have been considered that generated the four stratifications presented below for the composite materials. Figure 50 presents the predicted and real Stress values for α=45° and, for comparison, the predicted and simulated Stress values for α=40°. The blue curve is shorter because it stops at the beginning of the damaged zone; the Digimat VA simulation program can determine the latter. Currently, the predictions do not consider the damaged zones.

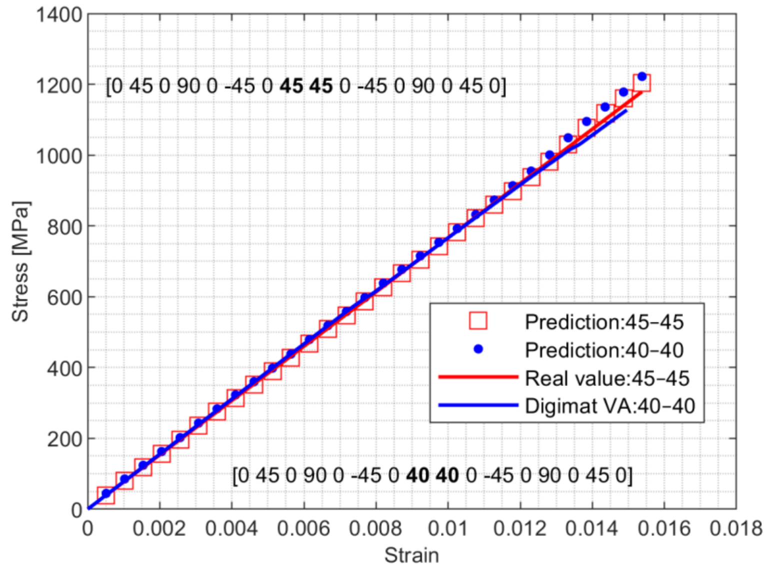


Figure 51. Predicted and real/simulated Stress values for α=45° and α=40°.

Figure 51 presents the predicted and simulated Stress values for α=20° and, for comparison, α=30°. The continuous blue and red curves are shorter because they stop at the beginning of the damaged zone.

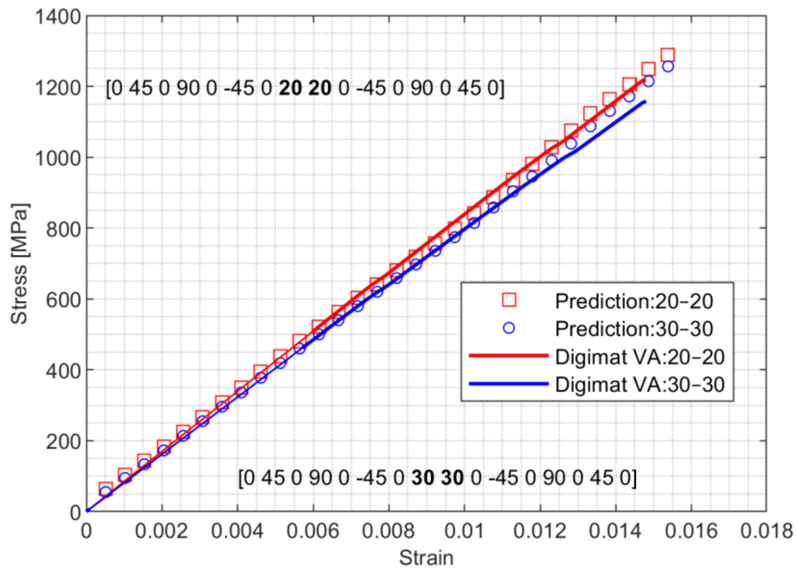


Figure 52. Predicted and simulated Stress values for α=20° and α=30°.

Figures 51 and 52 involve the following remark.

Remark 3. Two aspects can be stated:

- The predictions made by the ML model are very good inside the considered elasticity zones.
- Predictions give more significant errors at the end of the elasticity zones while remaining within acceptable limits.

Beyond the opportunity to compare predictions to real/simulated values, these examples based on the Snew pattern suggest how to solve a possible peculiar problem that seeks the most resistant stratification having a given pattern.

II 3.2 Stress-strain predictions for new random combinations

In this part of our work, we considered specimens with randomly generated layer orientations, which, in other words, did not contribute to the dataset used to construct the ML model. Then, we compared the predictions for these specimens made by the ML model with DIGIMAT simulation results. Only four specimens with randomly generated combinations are considered to make this presentation easy to follow.

To remain inside the ML model's generalization area, we first chose four base specimens submitted to tensile tests, PAT2, PAT6, PAT9, and PAT11, that contributed to the dataset used to train the ML model. They have different behaviors in the space Strain−stress. Each layer orientation of these specimens was modified independently using a uniformly distributed perturbation in the range [-4°, +4°]. The resulting specimens with randomly generated orientations are NEW2, NEW6, NEW9, and NEW11, which are quite different from the initial ones but remain in the model representation area. For example, Figure 53bis shows the sixteen orientation values of NEW2 and base specimen PAT2.

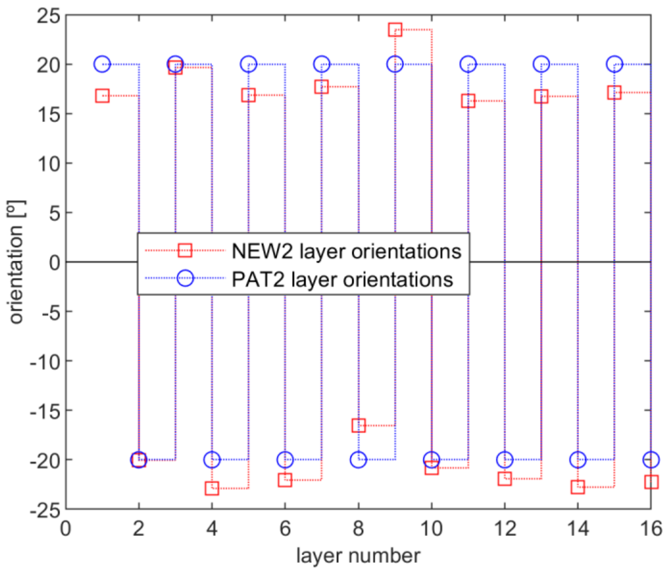


Figure 53bis. Layer orientations of NEW2 and PAT2

Table A1 in APPENDIX B gives the layer orientations for all the base and perturbated specimens and the difference between them (DIFF2, DIFF6, DIFF9, DIFF11). Because the base specimens contributed to the dataset used to train and test the ML model, their stress predictions given strain values are already accurate. The accuracy of the stress prediction must be verified for the new specimens by comparing them with the values given by the DIGIMAT simulations.

Figure 5.3 presents all the curves obtained through simulation and prediction and ascertains the very good prediction accuracy of the ML model made for the four new specimens. The pairs of curves having the same color prove that there is a small prediction error for all strain values.

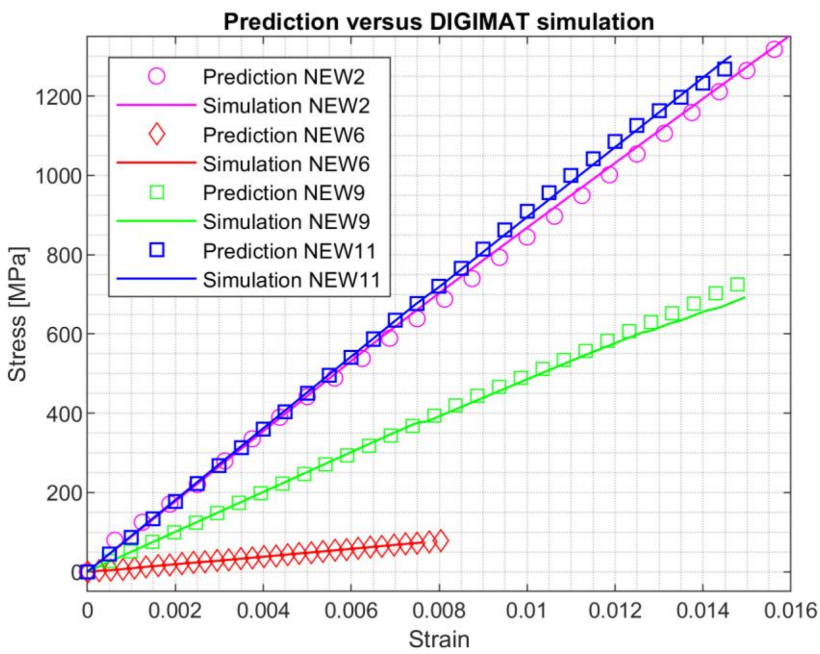


Figure 53. Comparison between the predicted and DIGIMAT values for the four randomly generated specimens.

To zoom in on the prediction error, Figure 54 shows the prediction relative error in a certain number of points situated in the Strain range considered in Figure 53.

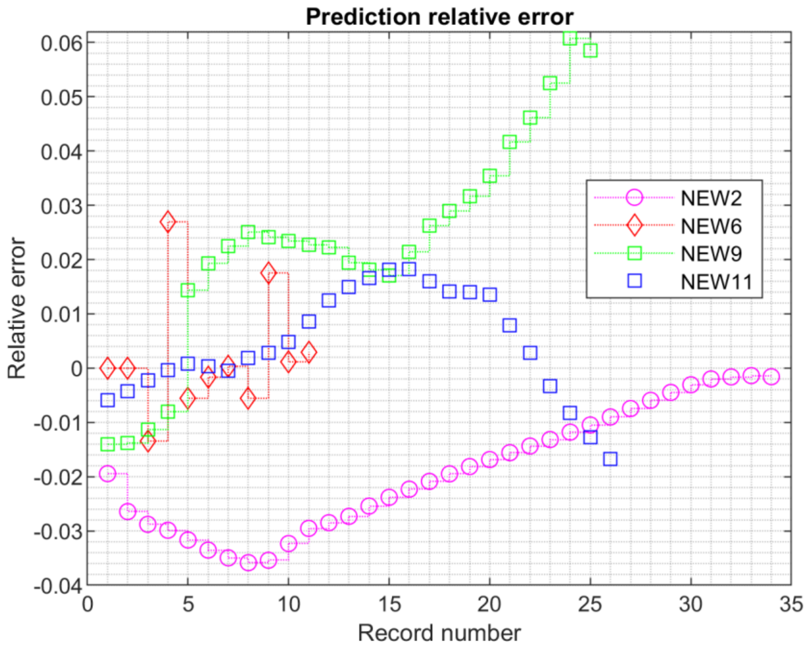


Figure 54. Relative prediction errors for the four randomly generated specimens.

The following equation gives the prediction relative error:

$$\text{prediction relative error} = \frac{\text{predicted stress value - simulated stress value}}{\text{simulated stress value}}$$

The relative error is placed in the interval [-0.04, 0.06], which means the prediction accuracy is greatly satisfactory. The proposed ML model has a good generalization power if it is appropriately employed, that is,

- the specimens are inside the ML model representation domain and
- the strain values are inside the range corresponding to the elasticity zone.

Generally, there is no procedure to verify if the first constraint is rigorously met. Depending on the dataset and practical application, the user can consider a priori a certain ML model representation domain and estimate if this constraint is met. After that, reliable predictions can be made.

APPENDIX A

execution listing of script S11_trainMod7.m

```
>> S11_trainMod7
The training data set Tab6_12_11train is:

ans =

   423     9
```

Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
1.1544e-09	3048.7	0.36448	25.413	3015.9	0.16726	991.14	0	0
1.1421e-09	3054.9	0.37688	24.658	3056.5	0.17311	999.42	0	0
1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
1.1188e-09	3041.9	0.37642	25.179	3030.9	0.17165	995.69	0.0005	60.014
1.1471e-09	2960.5	0.37305	24.532	2973.2	0.16691	983.89	0.0005	60.014
1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38
1.1521e-09	3035.4	0.36537	24.99	2993.5	0.17099	1008.4	0.00085301	102.38
1.1516e-09	2973.1	0.37266	25.155	2959.5	0.16741	999.93	0.00085301	102.38
1.14e-09	3000	0.37	25	3000	0.17	1000	0.002353	175.29
1.1491e-09	3046.9	0.3768	25.047	2956.6	0.16762	990.3	0.002353	175.29
1.1555e-09	2970.5	0.37465	24.744	3051.5	0.16898	987.86	0.002353	175.29
1.14e-09	3000	0.37	25	3000	0.17	1000	0.003853	225.68
1.159e-09	2974.3	0.37381	25.254	2985.7	0.17046	983.03	0.003853	225.68
1.1197e-09	3003.7	0.37413	25.434	2955.6	0.17047	998.78	0.003853	225.68
1.14e-09	3000	0.37	25	3000	0.17	1000	0.005353	256.33
1.1447e-09	2971.6	0.37228	25.189	3029.8	0.16966	983.35	0.005353	256.33
1.1276e-09	3049.6	0.36486	25.326	3004.6	0.17337	983.13	0.005353	256.33
1.14e-09	3000	0.37	25	3000	0.17	1000	0.006853	273.07
1.1211e-09	2988	0.36645	25.3	2991.8	0.17279	987.27	0.006853	273.07
1.1292e-09	2957.5	0.36461	25.369	3009.6	0.17034	985.8	0.006853	273.07
1.14e-09	3000	0.37	25	3000	0.17	1000	0.008353	281.68
1.1228e-09	2962.1	0.36615	24.917	2946	0.17274	1017.8	0.008353	281.68
1.1396e-09	2998.7	0.3676	25.4	2984.3	0.16736	1011.2	0.008353	281.68

1.14e-09	3000	0.37	25	3000	0.17	1000	0.009853	286.1
1.1434e-09	2947.2	0.36607	24.853	3038.5	0.1667	981.72	0.009853	286.1
1.1249e-09	3017.9	0.37343	25.148	2994.1	0.17032	991.85	0.009853	286.1
1.14e-09	3000	0.37	25	3000	0.17	1000	0.011353	288.5
1.1209e-09	3051.5	0.37408	24.987	2992.3	0.16964	992.25	0.011353	288.5
1.1404e-09	3001.3	0.3747	25.295	3017.3	0.16917	1012.5	0.011353	288.5
1.14e-09	3000	0.37	25	3000	0.17	1000	0.012853	289.97
1.1267e-09	2976.1	0.36957	24.73	3041.3	0.16792	989.04	0.012853	289.97
1.125e-09	2967.3	0.36905	24.811	3050.8	0.16953	987.39	0.012853	289.97
1.14e-09	3000	0.37	25	3000	0.17	1000	0.014353	291.02
1.1292e-09	3012.3	0.37313	24.722	2954.1	0.16862	992.75	0.014353	291.02
1.1365e-09	3000.9	0.36387	24.762	3036.1	0.1668	1017.2	0.014353	291.02
1.14e-09	3000	0.37	25	3000	0.17	1000	0.015853	291.88
1.141e-09	2967.8	0.36984	25.124	3021.5	0.16929	994.7	0.015853	291.88
1.1623e-09	2944.5	0.3757	25.413	3035.5	0.16727	990.47	0.015853	291.88
1.14e-09	3000	0.37	25	3000	0.17	1000	0.017353	292.64
1.1527e-09	3025.8	0.37598	25.391	2980.1	0.17135	987.91	0.017353	292.64
1.1186e-09	3029.3	0.37	24.98	3048.6	0.17075	1004.7	0.017353	292.64
1.14e-09	3000	0.37	25	3000	0.17	1000	0.018853	293.37
1.1395e-09	2960.2	0.37708	25.213	3000.1	0.1698	982.38	0.018853	293.37
1.1483e-09	2945.1	0.36366	25.022	2951.6	0.17216	1012.7	0.018853	293.37
1.14e-09	3000	0.37	25	3000	0.17	1000	0.020353	294.08
1.1379e-09	2991.9	0.37481	24.583	2956	0.16778	995.64	0.020353	294.08
1.1551e-09	3036.4	0.36349	24.899	3003.2	0.16943	1006.3	0.020353	294.08
1.14e-09	3000	0.37	25	3000	0.17	1000	0.021853	294.78
1.1342e-09	2963.8	0.36985	24.839	3054.2	0.17286	982.11	0.021853	294.78
1.1508e-09	2972.3	0.36886	25.048	3053.1	0.16944	1019.3	0.021853	294.78
1.14e-09	3000	0.37	25	3000	0.17	1000	0.023353	295.48
1.123e-09	3059.9	0.36513	24.533	3007.3	0.1726	1006.8	0.023353	295.48
1.1259e-09	2984.3	0.36942	25.482	2958.8	0.17242	1005.8	0.023353	295.48
1.14e-09	3000	0.37	25	3000	0.17	1000	0.024853	296.18
1.1347e-09	3010	0.36633	24.79	3014.1	0.1684	1013	0.024853	296.18
1.162e-09	3027.6	0.36769	25.084	2952.9	0.17276	1015.2	0.024853	296.18
1.14e-09	3000	0.37	25	3000	0.17	1000	0.026353	296.88
1.1254e-09	2990.7	0.36399	25.099	2996.5	0.17133	1008	0.026353	296.88
1.1463e-09	2944	0.36362	24.82	3003.7	0.17105	996.3	0.026353	296.88
1.14e-09	3000	0.37	25	3000	0.17	1000	0.027853	297.57
1.1527e-09	2990.8	0.36394	24.766	2958.4	0.16851	997.6	0.027853	297.57
1.1412e-09	2994.9	0.37556	25.018	3053.2	0.17094	1018.3	0.027853	297.57
1.14e-09	3000	0.37	25	3000	0.17	1000	0.029353	298.27

1.1274e-09	3020.1	0.3751	24.844	3033.7	0.17119	980.27	0.029353	298.27
1.1447e-09	2986.4	0.37616	24.501	2995.5	0.16949	998.44	0.029353	298.27
1.14e-09	3000	0.37	25	3000	0.17	1000	0.030853	298.96
1.1388e-09	2958.3	0.36765	25.107	2963	0.17162	989.71	0.030853	298.96
1.159e-09	2972.3	0.37393	24.689	2974.5	0.16722	1003	0.030853	298.96
1.14e-09	3000	0.37	25	3000	0.17	1000	0.032353	299.66
1.1603e-09	2965.1	0.3731	24.736	2954.3	0.17073	998.01	0.032353	299.66
1.1381e-09	3019.4	0.374	24.85	3019.4	0.16943	1013.7	0.032353	299.66
1.14e-09	3000	0.37	25	3000	0.17	1000	0.033853	300.35
1.1317e-09	2954.3	0.37651	25.146	2997.5	0.17095	1001.8	0.033853	300.35
1.1467e-09	3005.3	0.37327	25.022	3059.2	0.16809	984.23	0.033853	300.35
1.14e-09	3000	0.37	25	3000	0.17	1000	0.035353	301.05
1.1524e-09	3051.9	0.377	24.692	2956.7	0.17133	983.75	0.035353	301.05
1.1412e-09	3003.6	0.37534	24.985	2987.2	0.17117	1009.7	0.035353	301.05
1.14e-09	3000	0.37	25	3000	0.17	1000	0.036853	301.75
1.1283e-09	2993.1	0.37278	24.859	3028.4	0.16928	1007.3	0.036853	301.75
1.1493e-09	2993.1	0.36289	24.831	2990.9	0.16844	987.88	0.036853	301.75
1.14e-09	3000	0.37	25	3000	0.17	1000	0.038353	302.44
1.1516e-09	2985.3	0.3658	25.29	3053.9	0.16883	1006.9	0.038353	302.44
1.1372e-09	3040	0.37398	24.667	3043.4	0.17333	1000.6	0.038353	302.44
1.14e-09	3000	0.37	25	3000	0.17	1000	0.039853	303.14
1.1532e-09	2978.2	0.3705	24.59	2953.4	0.16753	1007.1	0.039853	303.14
1.1398e-09	2962.8	0.36993	24.648	2946.6	0.17238	1002.4	0.039853	303.14
1.14e-09	3000	0.37	25	3000	0.17	1000	0.041353	303.83
1.1567e-09	3013.5	0.37725	25.028	2997.5	0.17205	989.11	0.041353	303.83
1.1399e-09	3048.1	0.3711	25.345	3028.6	0.17058	989.87	0.041353	303.83
1.14e-09	3000	0.37	25	3000	0.17	1000	0.042853	304.53
1.1523e-09	3009.8	0.37634	25.08	2942	0.16742	1014.5	0.042853	304.53
1.1393e-09	3041.4	0.3657	25.052	3015.6	0.16682	1004.6	0.042853	304.53
1.14e-09	3000	0.37	25	3000	0.17	1000	0.044353	305.22
1.1258e-09	2945.1	0.372	24.782	3004.6	0.17133	999.96	0.044353	305.22
1.1416e-09	2993.4	0.36443	24.99	3042.4	0.17254	990.81	0.044353	305.22
1.14e-09	3000	0.37	25	3000	0.17	1000	0.045853	305.92
1.122e-09	2957	0.36506	25.121	3008.8	0.16695	1017.2	0.045853	305.92
1.1504e-09	3028.5	0.36354	25.36	3052.1	0.17329	1014.4	0.045853	305.92
1.14e-09	3000	0.37	25	3000	0.17	1000	0.047353	306.61
1.1309e-09	2975.5	0.36753	24.967	3017.8	0.16677	1013.7	0.047353	306.61
1.1427e-09	3042.5	0.36775	24.946	2946.5	0.1678	1006.5	0.047353	306.61
1.14e-09	3000	0.37	25	3000	0.17	1000	0.048853	307.31
1.1303e-09	2989.7	0.36948	25.264	3038.2	0.16728	987.12	0.048853	307.31

1.1336e-09	2946.8	0.37032	24.836	2961.1	0.16802	1016.2	0.048853	307.31
1.14e-09	3000	0.37	25	3000	0.17	1000	0.050353	308
1.1256e-09	3011.7	0.36704	24.634	2965.5	0.17269	982.86	0.050353	308
1.1283e-09	2946.5	0.36914	24.513	3047.7	0.16794	983.73	0.050353	308
1.14e-09	3000	0.37	25	3000	0.17	1000	0.051853	308.7
1.1308e-09	2945.6	0.37008	25.261	3015.7	0.16721	983.23	0.051853	308.7
1.1526e-09	3048.6	0.3705	24.609	3039.1	0.1689	991.76	0.051853	308.7
1.14e-09	3000	0.37	25	3000	0.17	1000	0.053353	309.39
1.1495e-09	3033.8	0.36686	25.193	3006.8	0.1693	982.46	0.053353	309.39
1.1528e-09	2980.5	0.3716	25.241	2952.6	0.16747	1002	0.053353	309.39
1.14e-09	3000	0.37	25	3000	0.17	1000	0.054853	310.09

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9.9555e-10	1902.2	0.36346	22.96	1812.1	0.27215	1504.3	0.09243	295.56
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09393	296.97
1.0187e-09	1920.1	0.36246	23.14	1802.2	0.27232	1500.3	0.09393	296.97
1.0095e-09	1934.8	0.36628	22.898	1772.4	0.2672	1511.1	0.09393	296.97
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09543	298.38
1.0098e-09	1946.7	0.36351	22.818	1770.5	0.27352	1493.4	0.09543	298.38
1.0211e-09	1910.2	0.35437	23.373	1827.1	0.2754	1521.9	0.09543	298.38
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09693	299.79
1.0271e-09	1940	0.35901	22.851	1815.9	0.26475	1492.4	0.09693	299.79
1.0271e-09	1938.6	0.35962	22.997	1786.2	0.27487	1528.9	0.09693	299.79
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09843	301.21
1.0192e-09	1937.3	0.36474	23.011	1803.7	0.2669	1505.3	0.09843	301.21
9.9557e-10	1900.3	0.36264	23.1	1779.8	0.26899	1507.8	0.09843	301.21
1.01e-09	1935	0.36	23	1800	0.27	1500	0.09993	302.62
1.0167e-09	1897.7	0.35452	23.416	1834.3	0.26493	1499.6	0.09993	302.62
1.0247e-09	1915.1	0.36481	23.289	1809.3	0.26462	1492.8	0.09993	302.62
1.03e-09	1250	0.37	51	1500	0.28	1680	0	0
1.0444e-09	1242.9	0.3663	51.064	1478.5	0.27976	1707.2	0	0
1.0327e-09	1259.3	0.37103	51.838	1525.5	0.28142	1672.6	0	0
1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09
1.0211e-09	1274.3	0.37461	51.613	1496.3	0.28098	1689.4	5e-14	5.3419e-09
1.0478e-09	1248.3	0.36628	51.786	1480.7	0.28463	1696.1	5e-14	5.3419e-09
1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419
1.0375e-09	1229.2	0.36385	51.487	1491	0.27603	1657.3	0.0005	53.419
1.0417e-09	1238	0.36733	51.601	1501.1	0.28184	1701.3	0.0005	53.419

The testing data set Tab6_12_11test is:

Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0
1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014
1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38
1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29
1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68
1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33
1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07
1.135e-09	2969	0.36858	24.596	2955.8	0.17301	1018.2	0.008353	281.68
1.1512e-09	2962.7	0.37276	24.684	2984.2	0.17085	1011.2	0.009853	286.1
1.1415e-09	2982.1	0.3765	25.376	3006	0.17083	1003.5	0.011353	288.5
1.1585e-09	3057.6	0.3691	24.611	2971	0.16938	1003.8	0.012853	289.97
1.1505e-09	2998.6	0.37116	24.737	2995.1	0.17315	1001.9	0.014353	291.02
1.1325e-09	3021.6	0.36462	25.221	2952.8	0.17105	999.77	0.015853	291.88
1.1564e-09	3036.7	0.37114	24.683	2968.8	0.17263	981.15	0.017353	292.64
1.1501e-09	2958	0.37236	25.019	3056.8	0.17101	1012	0.018853	293.37
1.1458e-09	2975	0.36899	24.515	3058.1	0.16774	984.25	0.020353	294.08
1.1309e-09	3024.1	0.37246	25.039	3023.8	0.17113	987.13	0.021853	294.78
1.1344e-09	2962.9	0.36894	24.982	2954.5	0.17061	989.05	0.023353	295.48
1.1545e-09	2971.3	0.3714	24.523	2991	0.16873	986.46	0.024853	296.18
1.1546e-09	3026.2	0.37694	25.031	2979	0.16732	1004.4	0.026353	296.88
1.1282e-09	3021.1	0.36688	25.172	3023.4	0.16706	990.19	0.027853	297.57
1.1523e-09	2978.7	0.37421	24.971	2944.3	0.1678	1008.9	0.029353	298.27
1.1484e-09	3005.6	0.3689	25.144	3017.7	0.17122	1005.4	0.030853	298.96
1.1552e-09	2970.8	0.37168	25.082	3004.9	0.17252	990.59	0.032353	299.66
1.1222e-09	2947.6	0.36859	24.948	2983.9	0.17179	1005.1	0.033853	300.35
1.1409e-09	2981.7	0.36482	25.086	2971.5	0.1669	1010.2	0.035353	301.05
1.1547e-09	2991.6	0.37574	24.891	3032.3	0.1693	1012.3	0.036853	301.75
1.1575e-09	3010.6	0.36489	24.7	2988.8	0.17169	1013	0.038353	302.44
1.1596e-09	3023.6	0.37123	25.315	3045.5	0.17332	980.02	0.039853	303.14
1.1476e-09	2950	0.37186	25.161	3027.6	0.17266	1019.3	0.041353	303.83
1.1337e-09	2945.9	0.36985	24.693	2954.8	0.168	985.86	0.042853	304.53
1.1267e-09	3007.8	0.37208	24.917	2964.7	0.17305	983.28	0.044353	305.22
1.153e-09	3001.6	0.36523	24.899	2956.1	0.16681	1017.6	0.045853	305.92
1.1323e-09	3047.8	0.36435	25.488	3004.8	0.17141	1020	0.047353	306.61
1.148e-09	2996.2	0.3761	24.604	3029.5	0.17161	1002.5	0.048853	307.31

1.1312e-09	2994.7	0.3641	25.495	2979.9	0.16862	982.48	0.050353	308
1.1512e-09	2941.2	0.36332	25.168	3012.4	0.17018	1009.2	0.051853	308.7
1.1393e-09	3046.9	0.37442	25.234	2946.2	0.1671	983.54	0.053353	309.39
1.1507e-09	3056.5	0.37543	24.586	2984	0.16911	1007.4	0.054853	310.09
1.1218e-09	2975.3	0.36611	25.031	2951	0.16936	984.19	0.056353	310.79
1.1536e-09	2998.5	0.37398	24.896	2972.8	0.16685	1006.9	0.057853	311.48
1.1414e-09	2953.1	0.37195	24.626	2956.1	0.16727	985.68	0.059353	312.18
1.1426e-09	2977.6	0.36506	25.122	3058.6	0.16776	990.31	0.060853	312.87
1.1306e-09	3003.7	0.37492	25.097	2980.2	0.16863	998.1	0.062353	313.57
1.1282e-09	3031.7	0.37384	25.241	3029.2	0.16732	1007.3	0.063853	314.26
1.1189e-09	3037.1	0.37368	24.62	3003	0.16882	1001.9	0.065353	314.96
1.1515e-09	2967.4	0.36355	25.267	3020.5	0.17146	1005.7	0.066853	315.65
1.1334e-09	3059.6	0.36592	25.152	3012.6	0.16923	985.69	0.068353	316.35
1.1212e-09	3016.8	0.36527	24.545	3026.8	0.16896	1006.4	0.069853	317.04
1.1276e-09	3036.5	0.37719	24.53	3004.3	0.16719	1012.1	0.071353	317.74
1.1221e-09	3014	0.37651	24.854	2989.3	0.17329	1017.8	0.072853	318.44
1.1438e-09	3001.4	0.36382	25.22	3059.5	0.16901	1018.9	0.074353	319.13
1.1191e-09	2985.4	0.37302	25.23	2966.9	0.16843	1006.9	0.075853	319.83
1.1192e-09	3006.9	0.37403	24.812	2961.5	0.1689	988.41	0.077353	320.52
1.1595e-09	3050.1	0.37316	25.118	2981.2	0.17296	984.99	0.078853	321.22
1.1361e-09	2999.1	0.37288	25.473	2979.3	0.1723	1009.6	0.080353	321.91
1.1498e-09	3042.7	0.36677	25.231	2956.5	0.17229	985.54	0.081853	322.61
1.148e-09	2983.3	0.37178	25.311	2942.3	0.16717	1019	0.083353	323.3
1.1194e-09	2981.1	0.37349	25.295	3005.4	0.17127	1015.7	0.084853	324
1.1498e-09	3040.7	0.36901	24.971	3007.3	0.16843	1010	0.086353	324.69
1.1619e-09	2974.4	0.37445	25.396	3011.7	0.17261	1017.7	0.087853	325.39
1.1598e-09	3020.2	0.36566	25.154	2948.6	0.16937	1006.7	0.089353	326.09
1.1427e-09	3011.9	0.3648	25.4	2994	0.168	1016	0.090853	326.78
1.1489e-09	3040.1	0.37162	25.075	2979.1	0.1697	1008.6	0.092353	327.48
1.1352e-09	2987.8	0.37023	25.158	3054.1	0.17151	996	0.093853	328.17
1.1432e-09	3059.6	0.37079	25.015	2979.7	0.16952	999.67	0.095353	328.87
1.1402e-09	3013.5	0.37473	25.032	2964.2	0.16969	997.12	0.096853	329.56
1.1379e-09	2986.4	0.37408	25.234	2991.6	0.17132	1017.8	0.098353	330.26
1.1271e-09	3008.6	0.36441	25.171	3012	0.16698	982.25	0.099853	330.95
1.0208e-09	1962	0.366	23.448	1800.4	0.26753	1476	0	0
1.0113e-09	1939.2	0.36259	22.878	1781.2	0.27085	1522	0.0005	30.21
1.0018e-09	1929.2	0.35452	22.995	1814.9	0.26723	1517.1	0.001	60.42
1.0093e-09	1925.4	0.36034	22.784	1768.9	0.26931	1480.4	0.0024301	133.88
1.0258e-09	1962.6	0.3586	22.833	1807.8	0.27443	1524.5	0.0039301	174.71
9.9177e-10	1939.1	0.35676	22.762	1781.5	0.26626	1527.4	0.0054301	197.85

1.0206e-09	1955.3	0.3611	23.228	1810.5	0.26593	1500.3	0.0069301	208.4
9.908e-10	1948.3	0.36486	23.434	1768.1	0.26946	1504.9	0.0084301	213.27
1.0036e-09	1968.5	0.35843	22.791	1774.9	0.26889	1492.5	0.0099301	216.09
1.0236e-09	1971.5	0.36499	23.006	1784.1	0.27266	1484.2	0.01143	218.17
1.0297e-09	1903.3	0.35742	23.01	1768.4	0.27244	1503.4	0.01293	219.94
1.0016e-09	1962.1	0.36593	23.128	1782.4	0.26556	1520.3	0.01443	221.58
1.0169e-09	1940.5	0.35524	22.676	1798.3	0.27441	1503.1	0.01593	223.13
1.0135e-09	1928.3	0.35725	22.783	1818.6	0.27535	1481.2	0.01743	224.65
1.0201e-09	1899.3	0.36643	23.243	1804.2	0.26659	1499.9	0.01893	226.13
1.0287e-09	1937.7	0.36668	22.646	1767.7	0.26789	1504.8	0.02043	227.59
1.0011e-09	1911.6	0.35561	22.841	1827.4	0.26969	1494.2	0.02193	229.04
1.0262e-09	1950.6	0.35824	23.216	1832.7	0.27046	1502.4	0.02343	230.48
1.0192e-09	1923.7	0.36404	22.942	1795.4	0.26513	1473	0.02493	231.91
1.0269e-09	1908.8	0.36311	23.072	1795.2	0.27415	1493.6	0.02643	233.34
1.0119e-09	1924.9	0.3558	22.946	1832.8	0.26594	1498.2	0.02793	234.76
9.9609e-10	1959.7	0.3618	23.219	1822	0.26533	1527	0.02943	236.18
1.0256e-09	1927.9	0.35332	23.226	1775.1	0.26615	1506.4	0.03093	237.6
1.0231e-09	1960.4	0.35702	22.825	1801.7	0.26811	1519.9	0.03243	239.02
1.0204e-09	1942.9	0.36514	23.449	1830.9	0.26902	1470	0.03393	240.44
1.0119e-09	1923.1	0.36177	23.273	1817.7	0.26596	1519.3	0.03543	241.86
1.0137e-09	1908.9	0.36487	22.694	1800.2	0.27539	1491.3	0.03693	243.27
1.0275e-09	1955.4	0.3647	23.068	1821.1	0.26815	1483.4	0.03843	244.69
1.014e-09	1958.3	0.35431	23.296	1824.6	0.26843	1495.8	0.03993	246.1
1.01e-09	1936.7	0.3541	23.372	1827.7	0.26934	1516.9	0.04143	247.52
1.005e-09	1971.7	0.3668	23.132	1825.9	0.26894	1507.9	0.04293	248.93
1.0162e-09	1904.7	0.35332	23.109	1804.8	0.27499	1514.8	0.04443	250.35
9.9903e-10	1946.8	0.35375	22.793	1784.3	0.2741	1496.7	0.04593	251.76
1.0079e-09	1899	0.3602	22.915	1771.8	0.26957	1497.1	0.04743	253.17
9.9788e-10	1929.4	0.35523	23.232	1790.5	0.27477	1471	0.04893	254.59
1.0161e-09	1963.2	0.35361	23.292	1802.1	0.2721	1482.7	0.05043	256
9.9816e-10	1956.3	0.36596	23.26	1785.3	0.26624	1520.9	0.05193	257.41
1.0011e-09	1948.6	0.36581	23.376	1817.8	0.26741	1511.4	0.05343	258.83
1.0292e-09	1899.1	0.3575	23.435	1790.3	0.26794	1477.3	0.05493	260.24
9.9974e-10	1941.3	0.3663	22.584	1767.9	0.26482	1510.9	0.05643	261.65
1.0194e-09	1946.7	0.36023	22.84	1811.6	0.26587	1478.9	0.05793	263.07
1.0062e-09	1968.9	0.35648	23.031	1832.7	0.26749	1485	0.05943	264.48
1.0236e-09	1967.6	0.35997	22.795	1811	0.27451	1500.6	0.06093	265.89
1.0012e-09	1908.3	0.35281	22.801	1803.7	0.27401	1472.5	0.06243	267.3
1.0096e-09	1950.1	0.35872	22.572	1785.1	0.27326	1490.8	0.06393	268.72
1.0118e-09	1943.2	0.36375	23.327	1791.6	0.26551	1514	0.06543	270.13

1.0076e-09	1908.4	0.35749	22.829	1828.4	0.26727	1488.6	0.06693	271.54
1.0262e-09	1928.8	0.35796	22.99	1782.4	0.27464	1498	0.06843	272.96
1.024e-09	1948.9	0.35477	23.33	1778.4	0.27116	1502.6	0.06993	274.37
9.9258e-10	1910.5	0.36341	23.181	1819.9	0.27002	1495.5	0.07143	275.78
9.8992e-10	1903.1	0.35655	22.561	1794.5	0.26828	1502.5	0.07293	277.19
9.9317e-10	1918	0.35924	23.081	1827.2	0.26967	1496.2	0.07443	278.61
1.0277e-09	1907.1	0.35847	23.442	1810.4	0.27428	1498.9	0.07593	280.02
9.9124e-10	1964.9	0.35636	22.548	1822.7	0.26612	1522.8	0.07743	281.43
9.9107e-10	1961	0.36483	22.586	1803.3	0.27479	1489.3	0.07893	282.84
1.0079e-09	1959.5	0.35422	23.331	1766	0.27431	1524	0.08043	284.26
1.0011e-09	1941.4	0.35886	22.625	1765.7	0.2699	1486.7	0.08193	285.67
1.028e-09	1951.6	0.36258	23.423	1819.8	0.27116	1526.9	0.08343	287.08
1.0122e-09	1961.8	0.35868	22.965	1823.5	0.2753	1501.4	0.08493	288.49
9.9221e-10	1947.2	0.36561	22.641	1795.5	0.26763	1529.1	0.08643	289.91
9.9291e-10	1933	0.36482	22.972	1793.8	0.27003	1477.5	0.08793	291.32
1.0011e-09	1925.7	0.36525	22.926	1781.3	0.27105	1498.8	0.08943	292.73
1.0015e-09	1901.6	0.35402	22.603	1793.5	0.26593	1496.6	0.09093	294.14
1.0152e-09	1964.2	0.36234	23.345	1797.7	0.26613	1474.1	0.09243	295.56
1.0237e-09	1971.4	0.3559	23.24	1806.1	0.26895	1500.6	0.09393	296.97
9.9129e-10	1938.5	0.36717	23.01	1826.9	0.26536	1529.3	0.09543	298.38
1.0105e-09	1973.1	0.35936	22.932	1779.4	0.26669	1520	0.09693	299.79
1.0122e-09	1906.2	0.35524	22.541	1794.1	0.26988	1479.6	0.09843	301.21
1.0263e-09	1949	0.35826	23.121	1781.5	0.27077	1528.9	0.09993	302.62
1.0341e-09	1227.7	0.36823	51.784	1484.9	0.27496	1696.6	0	0
1.0129e-09	1251.4	0.37463	51.434	1485.2	0.28208	1712.1	5e-14	5.3419e-09
1.0474e-09	1230.9	0.36621	50.751	1516	0.28135	1672.2	0.0005	53.419

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vrmse=
      0.7573

RMSEValid=
     0.38761
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Nr	**Density**	**Em**	**Poisson**	**YieldS**	**Hm**	**He**	**Lhm**	**Strain11**	**Stress11**	**StressPred**
1	1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0	-0.72849
2	1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014	61.518
3	1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38	101.05
4	1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29	175.53

5	1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68	225.67
6	1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33	254.81
7	1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07	273.44
8	1.135e-09	2969	0.36858	24.596	2955.8	0.17301	1018.2	0.008353	281.68	280.06
9	1.1512e-09	2962.7	0.37276	24.684	2984.2	0.17085	1011.2	0.009853	286.1	284.22
10	1.1415e-09	2982.1	0.3765	25.376	3006	0.17083	1003.5	0.011353	288.5	288.18
11	1.1585e-09	3057.6	0.3691	24.611	2971	0.16938	1003.8	0.012853	289.97	289.43
12	1.1505e-09	2998.6	0.37116	24.737	2995.1	0.17315	1001.9	0.014353	291.02	290.06
13	1.1325e-09	3021.6	0.36462	25.221	2952.8	0.17105	999.77	0.015853	291.88	291.19
14	1.1564e-09	3036.7	0.37114	24.683	2968.8	0.17263	981.15	0.017353	292.64	291.96
15	1.1501e-09	2958	0.37236	25.019	3056.8	0.17101	1012	0.018853	293.37	293.56
16	1.1458e-09	2975	0.36899	24.515	3058.1	0.16774	984.25	0.020353	294.08	294.85
17	1.1309e-09	3024.1	0.37246	25.039	3023.8	0.17113	987.13	0.021853	294.78	295.42
18	1.1344e-09	2962.9	0.36894	24.982	2954.5	0.17061	989.05	0.023353	295.48	294.95
19	1.1545e-09	2971.3	0.3714	24.523	2991	0.16873	986.46	0.024853	296.18	296.05
20	1.1546e-09	3026.2	0.37694	25.031	2979	0.16732	1004.4	0.026353	296.88	297.84
21	1.1282e-09	3021.1	0.36688	25.172	3023.4	0.16706	990.19	0.027853	297.57	299.06
22	1.1523e-09	2978.7	0.37421	24.971	2944.3	0.1678	1008.9	0.029353	298.27	297.78
23	1.1484e-09	3005.6	0.3689	25.144	3017.7	0.17122	1005.4	0.030853	298.96	299.27
24	1.1552e-09	2970.8	0.37168	25.082	3004.9	0.17252	990.59	0.032353	299.66	299.39
25	1.1222e-09	2947.6	0.36859	24.948	2983.9	0.17179	1005.1	0.033853	300.35	299.11
26	1.1409e-09	2981.7	0.36482	25.086	2971.5	0.1669	1010.2	0.035353	301.05	301.17
27	1.1547e-09	2991.6	0.37574	24.891	3032.3	0.1693	1012.3	0.036853	301.75	301.73
28	1.1575e-09	3010.6	0.36489	24.7	2988.8	0.17169	1013	0.038353	302.44	301.62
29	1.1596e-09	3023.6	0.37123	25.315	3045.5	0.17332	980.02	0.039853	303.14	304.02
30	1.1476e-09	2950	0.37186	25.161	3027.6	0.17266	1019.3	0.041353	303.83	302.45
31	1.1337e-09	2945.9	0.36985	24.693	2954.8	0.168	985.86	0.042853	304.53	303.9
32	1.1267e-09	3007.8	0.37208	24.917	2964.7	0.17305	983.28	0.044353	305.22	305
33	1.153e-09	3001.6	0.36523	24.899	2956.1	0.16681	1017.6	0.045853	305.92	305.76
34	1.1323e-09	3047.8	0.36435	25.488	3004.8	0.17141	1020	0.047353	306.61	306.43
35	1.148e-09	2996.2	0.3761	24.604	3029.5	0.17161	1002.5	0.048853	307.31	307.07
36	1.1312e-09	2994.7	0.3641	25.495	2979.9	0.16862	982.48	0.050353	308	308.48
37	1.1512e-09	2941.2	0.36332	25.168	3012.4	0.17018	1009.2	0.051853	308.7	307.69
38	1.1393e-09	3046.9	0.37442	25.234	2946.2	0.1671	983.54	0.053353	309.39	309.98
39	1.1507e-09	3056.5	0.37543	24.586	2984	0.16911	1007.4	0.054853	310.09	309.89
40	1.1218e-09	2975.3	0.36611	25.031	2951	0.16936	984.19	0.056353	310.79	310.47
41	1.1536e-09	2998.5	0.37398	24.896	2972.8	0.16685	1006.9	0.057853	311.48	311.01
42	1.1414e-09	2953.1	0.37195	24.626	2956.1	0.16727	985.68	0.059353	312.18	312.26
43	1.1426e-09	2977.6	0.36506	25.122	3058.6	0.16776	990.31	0.060853	312.87	314.17
44	1.1306e-09	3003.7	0.37492	25.097	2980.2	0.16863	998.1	0.062353	313.57	313.44
45	1.1282e-09	3031.7	0.37384	25.241	3029.2	0.16732	1007.3	0.063853	314.26	315.06
46	1.1189e-09	3037.1	0.37368	24.62	3003	0.16882	1001.9	0.065353	314.96	315.39
47	1.1515e-09	2967.4	0.36355	25.267	3020.5	0.17146	1005.7	0.066853	315.65	315.59
48	1.1334e-09	3059.6	0.36592	25.152	3012.6	0.16923	985.69	0.068353	316.35	317.6
49	1.1212e-09	3016.8	0.36527	24.545	3026.8	0.16896	1006.4	0.069853	317.04	317.38

50	1.1276e-09	3036.5	0.37719	24.53	3004.3	0.16719	1012.1	0.071353	317.74	318.03
51	1.1221e-09	3014	0.37651	24.854	2989.3	0.17329	1017.8	0.072853	318.44	317.84
52	1.1438e-09	3001.4	0.36382	25.22	3059.5	0.16901	1018.9	0.074353	319.13	319.29
53	1.1191e-09	2985.4	0.37302	25.23	2966.9	0.16843	1006.9	0.075853	319.83	319.29
54	1.1192e-09	3006.9	0.37403	24.812	2961.5	0.1689	988.41	0.077353	320.52	320.64
55	1.1595e-09	3050.1	0.37316	25.118	2981.2	0.17296	984.99	0.078853	321.22	320.94
56	1.1361e-09	2999.1	0.37288	25.473	2979.3	0.1723	1009.6	0.080353	321.91	321.29
57	1.1498e-09	3042.7	0.36677	25.231	2956.5	0.17229	985.54	0.081853	322.61	322.71
58	1.148e-09	2983.3	0.37178	25.311	2942.3	0.16717	1019	0.083353	323.3	322.73
59	1.1194e-09	2981.1	0.37349	25.295	3005.4	0.17127	1015.7	0.084853	324	324.05
60	1.1498e-09	3040.7	0.36901	24.971	3007.3	0.16843	1010	0.086353	324.69	325.32
61	1.1619e-09	2974.4	0.37445	25.396	3011.7	0.17261	1017.7	0.087853	325.39	325.1
62	1.1598e-09	3020.2	0.36566	25.154	2948.6	0.16937	1006.7	0.089353	326.09	325.66
63	1.1427e-09	3011.9	0.3648	25.4	2994	0.168	1016	0.090853	326.78	326.93
64	1.1489e-09	3040.1	0.37162	25.075	2979.1	0.1697	1008.6	0.092353	327.48	327.04
65	1.1352e-09	2987.8	0.37023	25.158	3054.1	0.17151	996	0.093853	328.17	328.54
66	1.1432e-09	3059.6	0.37079	25.015	2979.7	0.16952	999.67	0.095353	328.87	329.35
67	1.1402e-09	3013.5	0.37473	25.032	2964.2	0.16969	997.12	0.096853	329.56	329.31
68	1.1379e-09	2986.4	0.37408	25.234	2991.6	0.17132	1017.8	0.098353	330.26	329.85
69	1.1271e-09	3008.6	0.36441	25.171	3012	0.16698	982.25	0.099853	330.95	331.33
70	1.0208e-09	1962	0.366	23.448	1800.4	0.26753	1476	0	0	0.4573
71	1.0113e-09	1939.2	0.36259	22.878	1781.2	0.27085	1522	0.0005	30.21	29.859
72	1.0018e-09	1929.2	0.35452	22.995	1814.9	0.26723	1517.1	0.001	60.42	61.265
73	1.0093e-09	1925.4	0.36034	22.784	1768.9	0.26931	1480.4	0.0024301	133.88	133.33
74	1.0258e-09	1962.6	0.3586	22.833	1807.8	0.27443	1524.5	0.0039301	174.71	173.34
75	9.9177e-10	1939.1	0.35676	22.762	1781.5	0.26626	1527.4	0.0054301	197.85	197.16
76	1.0206e-09	1955.3	0.3611	23.228	1810.5	0.26593	1500.3	0.0069301	208.4	209.42
77	9.908e-10	1948.3	0.36486	23.434	1768.1	0.26946	1504.9	0.0084301	213.27	213.29
78	1.0036e-09	1968.5	0.35843	22.791	1774.9	0.26889	1492.5	0.0099301	216.09	215.08
79	1.0236e-09	1971.5	0.36499	23.006	1784.1	0.27266	1484.2	0.01143	218.17	218.71
80	1.0297e-09	1903.3	0.35742	23.01	1768.4	0.27244	1503.4	0.01293	219.94	218.75
81	1.0016e-09	1962.1	0.36593	23.128	1782.4	0.26556	1520.3	0.01443	221.58	221.89
82	1.0169e-09	1940.5	0.35524	22.676	1798.3	0.27441	1503.1	0.01593	223.13	221.93
83	1.0135e-09	1928.3	0.35725	22.783	1818.6	0.27535	1481.2	0.01743	224.65	224.61
84	1.0201e-09	1899.3	0.36643	23.243	1804.2	0.26659	1499.9	0.01893	226.13	226.43
85	1.0287e-09	1937.7	0.36668	22.646	1767.7	0.26789	1504.8	0.02043	227.59	226.98
86	1.0011e-09	1911.6	0.35561	22.841	1827.4	0.26969	1494.2	0.02193	229.04	229.48
87	1.0262e-09	1950.6	0.35824	23.216	1832.7	0.27046	1502.4	0.02343	230.48	231.12
88	1.0192e-09	1923.7	0.36404	22.942	1795.4	0.26513	1473	0.02493	231.91	232.98
89	1.0269e-09	1908.8	0.36311	23.072	1795.2	0.27415	1493.6	0.02643	233.34	232.43
90	1.0119e-09	1924.9	0.3558	22.946	1832.8	0.26594	1498.2	0.02793	234.76	236.86
91	9.9609e-10	1959.7	0.3618	23.219	1822	0.26533	1527	0.02943	236.18	237.27
92	1.0256e-09	1927.9	0.35332	23.226	1775.1	0.26615	1506.4	0.03093	237.6	237.82
93	1.0231e-09	1960.4	0.35702	22.825	1801.7	0.26811	1519.9	0.03243	239.02	239.7
94	1.0204e-09	1942.9	0.36514	23.449	1830.9	0.26902	1470	0.03393	240.44	241.97

95	1.0119e-09	1923.1	0.36177	23.273	1817.7	0.26596	1519.3	0.03543	241.86	243.18
96	1.0137e-09	1908.9	0.36487	22.694	1800.2	0.27539	1491.3	0.03693	243.27	242.7
97	1.0275e-09	1955.4	0.3647	23.068	1821.1	0.26815	1483.4	0.03843	244.69	246.57
98	1.014e-09	1958.3	0.35431	23.296	1824.6	0.26843	1495.8	0.03993	246.1	247.69
99	1.01e-09	1936.7	0.3541	23.372	1827.7	0.26934	1516.9	0.04143	247.52	248.05
100	1.005e-09	1971.7	0.3668	23.132	1825.9	0.26894	1507.9	0.04293	248.93	249.47
101	1.0162e-09	1904.7	0.35332	23.109	1804.8	0.27499	1514.8	0.04443	250.35	249.61
102	9.9903e-10	1946.8	0.35375	22.793	1784.3	0.2741	1496.7	0.04593	251.76	250.69
103	1.0079e-09	1899	0.3602	22.915	1771.8	0.26957	1497.1	0.04743	253.17	252.37
104	9.9788e-10	1929.4	0.35523	23.232	1790.5	0.27477	1471	0.04893	254.59	254.35
105	1.0161e-09	1963.2	0.35361	23.292	1802.1	0.2721	1482.7	0.05043	256	256.48
106	9.9816e-10	1956.3	0.36596	23.26	1785.3	0.26624	1520.9	0.05193	257.41	257.57
107	1.0011e-09	1948.6	0.36581	23.376	1817.8	0.26741	1511.4	0.05343	258.83	259.74
108	1.0292e-09	1899.1	0.3575	23.435	1790.3	0.26794	1477.3	0.05493	260.24	260.19
109	9.9974e-10	1941.3	0.3663	22.584	1767.9	0.26482	1510.9	0.05643	261.65	261.65
110	1.0194e-09	1946.7	0.36023	22.84	1811.6	0.26587	1478.9	0.05793	263.07	264.64
111	1.0062e-09	1968.9	0.35648	23.031	1832.7	0.26749	1485	0.05943	264.48	265.98
112	1.0236e-09	1967.6	0.35997	22.795	1811	0.27451	1500.6	0.06093	265.89	265.99
113	1.0012e-09	1908.3	0.35281	22.801	1803.7	0.27401	1472.5	0.06243	267.3	267.15
114	1.0096e-09	1950.1	0.35872	22.572	1785.1	0.27326	1490.8	0.06393	268.72	268.54
115	1.0118e-09	1943.2	0.36375	23.327	1791.6	0.26551	1514	0.06543	270.13	271
116	1.0076e-09	1908.4	0.35749	22.829	1828.4	0.26727	1488.6	0.06693	271.54	272.32
117	1.0262e-09	1928.8	0.35796	22.99	1782.4	0.27464	1498	0.06843	272.96	272.19
118	1.024e-09	1948.9	0.35477	23.33	1778.4	0.27116	1502.6	0.06993	274.37	274.39
119	9.9258e-10	1910.5	0.36341	23.181	1819.9	0.27002	1495.5	0.07143	275.78	275.97
120	9.8992e-10	1903.1	0.35655	22.561	1794.5	0.26828	1502.5	0.07293	277.19	276.77
121	9.9317e-10	1918	0.35924	23.081	1827.2	0.26967	1496.2	0.07443	278.61	279.13
122	1.0277e-09	1907.1	0.35847	23.442	1810.4	0.27428	1498.9	0.07593	280.02	279.73
123	9.9124e-10	1964.9	0.35636	22.548	1822.7	0.26612	1522.8	0.07743	281.43	281.93
124	9.9107e-10	1961	0.36483	22.586	1803.3	0.27479	1489.3	0.07893	282.84	282.58
125	1.0079e-09	1959.5	0.35422	23.331	1766	0.27431	1524	0.08043	284.26	283.46
126	1.0011e-09	1941.4	0.35886	22.625	1765.7	0.2699	1486.7	0.08193	285.67	285.59
127	1.028e-09	1951.6	0.36258	23.423	1819.8	0.27116	1526.9	0.08343	287.08	286.98
128	1.0122e-09	1961.8	0.35868	22.965	1823.5	0.2753	1501.4	0.08493	288.49	288.74
129	9.9221e-10	1947.2	0.36561	22.641	1795.5	0.26763	1529.1	0.08643	289.91	289.85
130	9.9291e-10	1933	0.36482	22.972	1793.8	0.27003	1477.5	0.08793	291.32	291.54
131	1.0011e-09	1925.7	0.36525	22.926	1781.3	0.27105	1498.8	0.08943	292.73	292.02
132	1.0015e-09	1901.6	0.35402	22.603	1793.5	0.26593	1496.6	0.09093	294.14	294.06
133	1.0152e-09	1964.2	0.36234	23.345	1797.7	0.26613	1474.1	0.09243	295.56	296.13
134	1.0237e-09	1971.4	0.3559	23.24	1806.1	0.26895	1500.6	0.09393	296.97	297.51
135	9.9129e-10	1938.5	0.36717	23.01	1826.9	0.26536	1529.3	0.09543	298.38	298.95
136	1.0105e-09	1973.1	0.35936	22.932	1779.4	0.26669	1520	0.09693	299.79	299.86
137	1.0122e-09	1906.2	0.35524	22.541	1794.1	0.26988	1479.6	0.09843	301.21	301.11
138	1.0263e-09	1949	0.35826	23.121	1781.5	0.27077	1528.9	0.09993	302.62	302
139	1.0341e-09	1227.7	0.36823	51.784	1484.9	0.27496	1696.6	0	0	0.39246

140	1.0129e-09	1251.4	0.37463	51.434	1485.2	0.28208	1712.1	5e-14	5.3419e-09	-0.16096
141	1.0474e-09	1230.9	0.36621	50.751	1516	0.28135	1672.2	0.0005	53.419	52.746

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	PredNew	Diff
1	1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09	0.17029	0.17029
2	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419	53.04	-0.37902
3	1.03e-09	1250	0.37	51	1500	0.28	1680	0.001	106.84	96.942	-9.8978
4	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0031863	241.99	198.01	-43.981
5	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0056863	279.88	229.39	-50.49
6	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0081863	286.8	233.96	-52.844
7	1.03e-09	1250	0.37	51	1500	0.28	1680	0.010686	289.55	234.38	-55.166
8	1.03e-09	1250	0.37	51	1500	0.28	1680	0.013186	291.88	233.18	-58.703
9	1.03e-09	1250	0.37	51	1500	0.28	1680	0.015686	294.16	231.33	-62.833
10	1.03e-09	1250	0.37	51	1500	0.28	1680	0.018186	296.44	231.7	-64.741
11	1.03e-09	1250	0.37	51	1500	0.28	1680	0.020686	298.71	231.91	-66.795
12	1.03e-09	1250	0.37	51	1500	0.28	1680	0.023186	300.98	234.39	-66.593
13	1.03e-09	1250	0.37	51	1500	0.28	1680	0.025686	303.25	237.47	-65.781
14	1.03e-09	1250	0.37	51	1500	0.28	1680	0.028186	305.52	239.59	-65.927
15	1.03e-09	1250	0.37	51	1500	0.28	1680	0.030686	307.79	241	-66.789
16	1.03e-09	1250	0.37	51	1500	0.28	1680	0.033186	310.06	240.12	-69.938
17	1.03e-09	1250	0.37	51	1500	0.28	1680	0.035686	312.32	237.67	-74.651
18	1.03e-09	1250	0.37	51	1500	0.28	1680	0.038186	314.59	235.02	-79.567
19	1.03e-09	1250	0.37	51	1500	0.28	1680	0.040686	316.86	233.69	-83.17
20	1.03e-09	1250	0.37	51	1500	0.28	1680	0.043186	319.13	234.88	-84.255
21	1.03e-09	1250	0.37	51	1500	0.28	1680	0.045686	321.4	235.08	-86.323
22	1.03e-09	1250	0.37	51	1500	0.28	1680	0.048186	323.67	238.88	-84.791
23	1.03e-09	1250	0.37	51	1500	0.28	1680	0.050686	325.94	246	-79.939
24	1.03e-09	1250	0.37	51	1500	0.28	1680	0.053186	328.21	250.35	-77.86
25	1.03e-09	1250	0.37	51	1500	0.28	1680	0.055686	330.48	251.72	-78.759
26	1.03e-09	1250	0.37	51	1500	0.28	1680	0.058186	332.75	252.57	-80.178
27	1.03e-09	1250	0.37	51	1500	0.28	1680	0.060686	335.02	256.31	-78.706
28	1.03e-09	1250	0.37	51	1500	0.28	1680	0.063186	337.29	259.89	-77.402
29	1.03e-09	1250	0.37	51	1500	0.28	1680	0.065686	339.55	261.91	-77.64
30	1.03e-09	1250	0.37	51	1500	0.28	1680	0.068186	341.82	261.91	-79.908
31	1.03e-09	1250	0.37	51	1500	0.28	1680	0.070686	344.09	263.11	-80.978
32	1.03e-09	1250	0.37	51	1500	0.28	1680	0.073186	346.36	264.65	-81.714
33	1.03e-09	1250	0.37	51	1500	0.28	1680	0.075686	348.63	268.2	-80.427
34	1.03e-09	1250	0.37	51	1500	0.28	1680	0.078186	350.9	272.64	-78.26
35	1.03e-09	1250	0.37	51	1500	0.28	1680	0.080686	353.17	277.27	-75.901
36	1.03e-09	1250	0.37	51	1500	0.28	1680	0.083186	355.44	280.52	-74.921
37	1.03e-09	1250	0.37	51	1500	0.28	1680	0.085686	357.71	283.36	-74.347

38	1.03e-09	1250	0.37	51	1500	0.28	1680	0.088186	359.98	285.88	-74.103
39	1.03e-09	1250	0.37	51	1500	0.28	1680	0.090686	362.25	286.97	-75.284
40	1.03e-09	1250	0.37	51	1500	0.28	1680	0.093186	364.52	288.45	-76.072
41	1.03e-09	1250	0.37	51	1500	0.28	1680	0.095686	366.78	292.72	-74.059
42	1.03e-09	1250	0.37	51	1500	0.28	1680	0.098186	369.05	297.45	-71.605

APPENDIX B

execution listing of script S12_trainMod8.m

```
>> S12_trainMod8
The training data set Tab6_12_11train is:
nline=
   423
```

Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1.14e-09	3000	0.37	25	3000	0.17	1000	5e-14	6.0014e-09
1.1544e-09	3048.7	0.36448	25.413	3015.9	0.16726	991.14	0	0
1.1421e-09	3054.9	0.37688	24.658	3056.5	0.17311	999.42	0	0
1.14e-09	3000	0.37	25	3000	0.17	1000	0.0005	60.014
1.1188e-09	3041.9	0.37642	25.179	3030.9	0.17165	995.69	0.0005	60.014
1.1471e-09	2960.5	0.37305	24.532	2973.2	0.16691	983.89	0.0005	60.014
1.14e-09	3000	0.37	25	3000	0.17	1000	0.00085301	102.38

....

....

1.03e-09	1250	0.37	51	1500	0.28	1680	0	0
1.0444e-09	1242.9	0.3663	51.064	1478.5	0.27976	1707.2	0	0
1.0327e-09	1259.3	0.37103	51.838	1525.5	0.28142	1672.6	0	0
1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09
1.0211e-09	1274.3	0.37461	51.613	1496.3	0.28098	1689.4	5e-14	5.3419e-09
1.0478e-09	1248.3	0.36628	51.786	1480.7	0.28463	1696.1	5e-14	5.3419e-09
1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419
1.0375e-09	1229.2	0.36385	51.487	1491	0.27603	1657.3	0.0005	53.419
1.0417e-09	1238	0.36733	51.601	1501.1	0.28184	1701.3	0.0005	53.419

```
The testing data set Tab6_12_11test is:
nline=
   141
```

Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11
1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0
1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014
1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38
1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29
1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68
1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33
1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07
....								
....								
1.0263e-09	1949	0.35826	23.121	1781.5	0.27077	1528.9	0.09993	302.62
1.0341e-09	1227.7	0.36823	51.784	1484.9	0.27496	1696.6	0	0
1.0129e-09	1251.4	0.37463	51.434	1485.2	0.28208	1712.1	5e-14	5.3419e-09
1.0474e-09	1230.9	0.36621	50.751	1516	0.28135	1672.2	0.0005	53.419

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	StressPred
1	1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0	18.292
2	1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014	53.18
3	1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38	80.648
4	1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29	180.54
5	1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68	232.35
6	1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33	230.04
7	1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07	273.31
8	1.135e-09	2969	0.36858	24.596	2955.8	0.17301	1018.2	0.008353	281.68	282.72
9	1.1512e-09	2962.7	0.37276	24.684	2984.2	0.17085	1011.2	0.009853	286.1	284.05
10	1.1415e-09	2982.1	0.3765	25.376	3006	0.17083	1003.5	0.011353	288.5	285.1
11	1.1585e-09	3057.6	0.3691	24.611	2971	0.16938	1003.8	0.012853	289.97	283.05
12	1.1505e-09	2998.6	0.37116	24.737	2995.1	0.17315	1001.9	0.014353	291.02	289.94
13	1.1325e-09	3021.6	0.36462	25.221	2952.8	0.17105	999.77	0.015853	291.88	290.53
14	1.1564e-09	3036.7	0.37114	24.683	2968.8	0.17263	981.15	0.017353	292.64	291.32
15	1.1501e-09	2958	0.37236	25.019	3056.8	0.17101	1012	0.018853	293.37	293.98
16	1.1458e-09	2975	0.36899	24.515	3058.1	0.16774	984.25	0.020353	294.08	293.24

17	1.1309e-09	3024.1	0.37246	25.039	3023.8	0.17113	987.13	0.021853	294.78	294.98
18	1.1344e-09	2962.9	0.36894	24.982	2954.5	0.17061	989.05	0.023353	295.48	295.32
19	1.1545e-09	2971.3	0.3714	24.523	2991	0.16873	986.46	0.024853	296.18	295.94
20	1.1546e-09	3026.2	0.37694	25.031	2979	0.16732	1004.4	0.026353	296.88	298.04
21	1.1282e-09	3021.1	0.36688	25.172	3023.4	0.16706	990.19	0.027853	297.57	296.61
22	1.1523e-09	2978.7	0.37421	24.971	2944.3	0.1678	1008.9	0.029353	298.27	298.91
23	1.1484e-09	3005.6	0.3689	25.144	3017.7	0.17122	1005.4	0.030853	298.96	298.98
24	1.1552e-09	2970.8	0.37168	25.082	3004.9	0.17252	990.59	0.032353	299.66	299.55
25	1.1222e-09	2947.6	0.36859	24.948	2983.9	0.17179	1005.1	0.033853	300.35	300.78
26	1.1409e-09	2981.7	0.36482	25.086	2971.5	0.1669	1010.2	0.035353	301.05	301.19
27	1.1547e-09	2991.6	0.37574	24.891	3032.3	0.1693	1012.3	0.036853	301.75	302.24
28	1.1575e-09	3010.6	0.36489	24.7	2988.8	0.17169	1013	0.038353	302.44	303.02
29	1.1596e-09	3023.6	0.37123	25.315	3045.5	0.17332	980.02	0.039853	303.14	302.28
30	1.1476e-09	2950	0.37186	25.161	3027.6	0.17266	1019.3	0.041353	303.83	304.62
31	1.1337e-09	2945.9	0.36985	24.693	2954.8	0.168	985.86	0.042853	304.53	304.34
32	1.1267e-09	3007.8	0.37208	24.917	2964.7	0.17305	983.28	0.044353	305.22	305.01
33	1.153e-09	3001.6	0.36523	24.899	2956.1	0.16681	1017.6	0.045853	305.92	306.48
34	1.1323e-09	3047.8	0.36435	25.488	3004.8	0.17141	1020	0.047353	306.61	306.95
35	1.148e-09	2996.2	0.3761	24.604	3029.5	0.17161	1002.5	0.048853	307.31	307.7
36	1.1312e-09	2994.7	0.3641	25.495	2979.9	0.16862	982.48	0.050353	308	307.11
37	1.1512e-09	2941.2	0.36332	25.168	3012.4	0.17018	1009.2	0.051853	308.7	308.9
38	1.1393e-09	3046.9	0.37442	25.234	2946.2	0.1671	983.54	0.053353	309.39	308.74
39	1.1507e-09	3056.5	0.37543	24.586	2984	0.16911	1007.4	0.054853	310.09	310.54
40	1.1218e-09	2975.3	0.36611	25.031	2951	0.16936	984.19	0.056353	310.79	310.44
41	1.1536e-09	2998.5	0.37398	24.896	2972.8	0.16685	1006.9	0.057853	311.48	311.79
42	1.1414e-09	2953.1	0.37195	24.626	2956.1	0.16727	985.68	0.059353	312.18	312.05
43	1.1426e-09	2977.6	0.36506	25.122	3058.6	0.16776	990.31	0.060853	312.87	312.06
44	1.1306e-09	3003.7	0.37492	25.097	2980.2	0.16863	998.1	0.062353	313.57	313.58
45	1.1282e-09	3031.7	0.37384	25.241	3029.2	0.16732	1007.3	0.063853	314.26	314.13
46	1.1189e-09	3037.1	0.37368	24.62	3003	0.16882	1001.9	0.065353	314.96	315.09
47	1.1515e-09	2967.4	0.36355	25.267	3020.5	0.17146	1005.7	0.066853	315.65	315.52
48	1.1334e-09	3059.6	0.36592	25.152	3012.6	0.16923	985.69	0.068353	316.35	315.44
49	1.1212e-09	3016.8	0.36527	24.545	3026.8	0.16896	1006.4	0.069853	317.04	317
50	1.1276e-09	3036.5	0.37719	24.53	3004.3	0.16719	1012.1	0.071353	317.74	318.24
51	1.1221e-09	3014	0.37651	24.854	2989.3	0.17329	1017.8	0.072853	318.44	319.56
52	1.1438e-09	3001.4	0.36382	25.22	3059.5	0.16901	1018.9	0.074353	319.13	319
53	1.1191e-09	2985.4	0.37302	25.23	2966.9	0.16843	1006.9	0.075853	319.83	320.24
54	1.1192e-09	3006.9	0.37403	24.812	2961.5	0.1689	988.41	0.077353	320.52	320.47
55	1.1595e-09	3050.1	0.37316	25.118	2981.2	0.17296	984.99	0.078853	321.22	321
56	1.1361e-09	2999.1	0.37288	25.473	2979.3	0.1723	1009.6	0.080353	321.91	322.51
57	1.1498e-09	3042.7	0.36677	25.231	2956.5	0.17229	985.54	0.081853	322.61	322
58	1.148e-09	2983.3	0.37178	25.311	2942.3	0.16717	1019	0.083353	323.3	324.12
59	1.1194e-09	2981.1	0.37349	25.295	3005.4	0.17127	1015.7	0.084853	324	324.76
60	1.1498e-09	3040.7	0.36901	24.971	3007.3	0.16843	1010	0.086353	324.69	324.69
61	1.1619e-09	2974.4	0.37445	25.396	3011.7	0.17261	1017.7	0.087853	325.39	324.04

62	1.1598e-09	3020.2	0.36566	25.154	2948.6	0.16937	1006.7	0.089353	326.09	324.6
63	1.1427e-09	3011.9	0.3648	25.4	2994	0.168	1016	0.090853	326.78	327.02
64	1.1489e-09	3040.1	0.37162	25.075	2979.1	0.1697	1008.6	0.092353	327.48	326.54
65	1.1352e-09	2987.8	0.37023	25.158	3054.1	0.17151	996	0.093853	328.17	329.86
66	1.1432e-09	3059.6	0.37079	25.015	2979.7	0.16952	999.67	0.095353	328.87	328.56
67	1.1402e-09	3013.5	0.37473	25.032	2964.2	0.16969	997.12	0.096853	329.56	329.91
68	1.1379e-09	2986.4	0.37408	25.234	2991.6	0.17132	1017.8	0.098353	330.26	330.16
69	1.1271e-09	3008.6	0.36441	25.171	3012	0.16698	982.25	0.099853	330.95	330.55
70	1.0208e-09	1962	0.366	23.448	1800.4	0.26753	1476	0	0	-8.69
71	1.0113e-09	1939.2	0.36259	22.878	1781.2	0.27085	1522	0.0005	30.21	26.483
72	1.0018e-09	1929.2	0.35452	22.995	1814.9	0.26723	1517.1	0.001	60.42	55.76
73	1.0093e-09	1925.4	0.36034	22.784	1768.9	0.26931	1480.4	0.0024301	133.88	125.62
74	1.0258e-09	1962.6	0.3586	22.833	1807.8	0.27443	1524.5	0.0039301	174.71	176.49
75	9.9177e-10	1939.1	0.35676	22.762	1781.5	0.26626	1527.4	0.0054301	197.85	208.16
76	1.0206e-09	1955.3	0.3611	23.228	1810.5	0.26593	1500.3	0.0069301	208.4	201.51
77	9.908e-10	1948.3	0.36486	23.434	1768.1	0.26946	1504.9	0.0084301	213.27	213.62
78	1.0036e-09	1968.5	0.35843	22.791	1774.9	0.26889	1492.5	0.0099301	216.09	217.54
79	1.0236e-09	1971.5	0.36499	23.006	1784.1	0.27266	1484.2	0.01143	218.17	216.55
80	1.0297e-09	1903.3	0.35742	23.01	1768.4	0.27244	1503.4	0.01293	219.94	222.11
81	1.0016e-09	1962.1	0.36593	23.128	1782.4	0.26556	1520.3	0.01443	221.58	218.82
82	1.0169e-09	1940.5	0.35524	22.676	1798.3	0.27441	1503.1	0.01593	223.13	226.78
83	1.0135e-09	1928.3	0.35725	22.783	1818.6	0.27535	1481.2	0.01743	224.65	227.48
84	1.0201e-09	1899.3	0.36643	23.243	1804.2	0.26659	1499.9	0.01893	226.13	221.67
85	1.0287e-09	1937.7	0.36668	22.646	1767.7	0.26789	1504.8	0.02043	227.59	228.4
86	1.0011e-09	1911.6	0.35561	22.841	1827.4	0.26969	1494.2	0.02193	229.04	223.5
87	1.0262e-09	1950.6	0.35824	23.216	1832.7	0.27046	1502.4	0.02343	230.48	233.99
88	1.0192e-09	1923.7	0.36404	22.942	1795.4	0.26513	1473	0.02493	231.91	228.43
89	1.0269e-09	1908.8	0.36311	23.072	1795.2	0.27415	1493.6	0.02643	233.34	239.03
90	1.0119e-09	1924.9	0.3558	22.946	1832.8	0.26594	1498.2	0.02793	234.76	234.89
91	9.9609e-10	1959.7	0.3618	23.219	1822	0.26533	1527	0.02943	236.18	239.07
92	1.0256e-09	1927.9	0.35332	23.226	1775.1	0.26615	1506.4	0.03093	237.6	231.81
93	1.0231e-09	1960.4	0.35702	22.825	1801.7	0.26811	1519.9	0.03243	239.02	233.88
94	1.0204e-09	1942.9	0.36514	23.449	1830.9	0.26902	1470	0.03393	240.44	242.38
95	1.0119e-09	1923.1	0.36177	23.273	1817.7	0.26596	1519.3	0.03543	241.86	243.54
96	1.0137e-09	1908.9	0.36487	22.694	1800.2	0.27539	1491.3	0.03693	243.27	242.09
97	1.0275e-09	1955.4	0.3647	23.068	1821.1	0.26815	1483.4	0.03843	244.69	245.61
98	1.014e-09	1958.3	0.35431	23.296	1824.6	0.26843	1495.8	0.03993	246.1	248.45
99	1.01e-09	1936.7	0.3541	23.372	1827.7	0.26934	1516.9	0.04143	247.52	249.73
100	1.005e-09	1971.7	0.3668	23.132	1825.9	0.26894	1507.9	0.04293	248.93	250.59
101	1.0162e-09	1904.7	0.35332	23.109	1804.8	0.27499	1514.8	0.04443	250.35	250.09
102	9.9903e-10	1946.8	0.35375	22.793	1784.3	0.2741	1496.7	0.04593	251.76	251.59
103	1.0079e-09	1899	0.3602	22.915	1771.8	0.26957	1497.1	0.04743	253.17	251.99
104	9.9788e-10	1929.4	0.35523	23.232	1790.5	0.27477	1471	0.04893	254.59	254.85
105	1.0161e-09	1963.2	0.35361	23.292	1802.1	0.2721	1482.7	0.05043	256	256.77
106	9.9816e-10	1956.3	0.36596	23.26	1785.3	0.26624	1520.9	0.05193	257.41	257.86

107	1.0011e-09	1948.6	0.36581	23.376	1817.8	0.26741	1511.4	0.05343	258.83	260.26
108	1.0292e-09	1899.1	0.3575	23.435	1790.3	0.26794	1477.3	0.05493	260.24	260
109	9.9974e-10	1941.3	0.3663	22.584	1767.9	0.26482	1510.9	0.05643	261.65	260.54
110	1.0194e-09	1946.7	0.36023	22.84	1811.6	0.26587	1478.9	0.05793	263.07	263.6
111	1.0062e-09	1968.9	0.35648	23.031	1832.7	0.26749	1485	0.05943	264.48	267.4
112	1.0236e-09	1967.6	0.35997	22.795	1811	0.27451	1500.6	0.06093	265.89	265.06
113	1.0012e-09	1908.3	0.35281	22.801	1803.7	0.27401	1472.5	0.06243	267.3	266.95
114	1.0096e-09	1950.1	0.35872	22.572	1785.1	0.27326	1490.8	0.06393	268.72	267.78
115	1.0118e-09	1943.2	0.36375	23.327	1791.6	0.26551	1514	0.06543	270.13	270.06
116	1.0076e-09	1908.4	0.35749	22.829	1828.4	0.26727	1488.6	0.06693	271.54	273.12
117	1.0262e-09	1928.8	0.35796	22.99	1782.4	0.27464	1498	0.06843	272.96	272.4
118	1.024e-09	1948.9	0.35477	23.33	1778.4	0.27116	1502.6	0.06993	274.37	273.96
119	9.9258e-10	1910.5	0.36341	23.181	1819.9	0.27002	1495.5	0.07143	275.78	276.22
120	9.8992e-10	1903.1	0.35655	22.561	1794.5	0.26828	1502.5	0.07293	277.19	276.67
121	9.9317e-10	1918	0.35924	23.081	1827.2	0.26967	1496.2	0.07443	278.61	279.78
122	1.0277e-09	1907.1	0.35847	23.442	1810.4	0.27428	1498.9	0.07593	280.02	280.28
123	9.9124e-10	1964.9	0.35636	22.548	1822.7	0.26612	1522.8	0.07743	281.43	282.86
124	9.9107e-10	1961	0.36483	22.586	1803.3	0.27479	1489.3	0.07893	282.84	282.34
125	1.0079e-09	1959.5	0.35422	23.331	1766	0.27431	1524	0.08043	284.26	282.49
126	1.0011e-09	1941.4	0.35886	22.625	1765.7	0.2699	1486.7	0.08193	285.67	284.52
127	1.028e-09	1951.6	0.36258	23.423	1819.8	0.27116	1526.9	0.08343	287.08	288.64
128	1.0122e-09	1961.8	0.35868	22.965	1823.5	0.2753	1501.4	0.08493	288.49	289.43
129	9.9221e-10	1947.2	0.36561	22.641	1795.5	0.26763	1529.1	0.08643	289.91	290.53
130	9.9291e-10	1933	0.36482	22.972	1793.8	0.27003	1477.5	0.08793	291.32	291.37
131	1.0011e-09	1925.7	0.36525	22.926	1781.3	0.27105	1498.8	0.08943	292.73	292.2
132	1.0015e-09	1901.6	0.35402	22.603	1793.5	0.26593	1496.6	0.09093	294.14	292.89
133	1.0152e-09	1964.2	0.36234	23.345	1797.7	0.26613	1474.1	0.09243	295.56	296.24
134	1.0237e-09	1971.4	0.3559	23.24	1806.1	0.26895	1500.6	0.09393	296.97	297.36
135	9.9129e-10	1938.5	0.36717	23.01	1826.9	0.26536	1529.3	0.09543	298.38	300.03
136	1.0105e-09	1973.1	0.35936	22.932	1779.4	0.26669	1520	0.09693	299.79	299.49
137	1.0122e-09	1906.2	0.35524	22.541	1794.1	0.26988	1479.6	0.09843	301.21	299.57
138	1.0263e-09	1949	0.35826	23.121	1781.5	0.27077	1528.9	0.09993	302.62	301.7
139	1.0341e-09	1227.7	0.36823	51.784	1484.9	0.27496	1696.6	0	0	28.172
140	1.0129e-09	1251.4	0.37463	51.434	1485.2	0.28208	1712.1	5e-14	5.3419e-09	-2.8941
141	1.0474e-09	1230.9	0.36621	50.751	1516	0.28135	1672.2	0.0005	53.419	34.053

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	PredNew	Diff
1	1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09	10.84	10.84
2	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419	30.353	-23.066
3	1.03e-09	1250	0.37	51	1500	0.28	1680	0.001	106.84	49.865	-56.975
4	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0031863	241.99	135.19	-106.8

5	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0056863	279.88	234.37	-45.51
6	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0081863	286.8	329.29	42.494
7	1.03e-09	1250	0.37	51	1500	0.28	1680	0.010686	289.55	349	59.454
8	1.03e-09	1250	0.37	51	1500	0.28	1680	0.013186	291.88	338.61	46.731
9	1.03e-09	1250	0.37	51	1500	0.28	1680	0.015686	294.16	329.24	35.084
10	1.03e-09	1250	0.37	51	1500	0.28	1680	0.018186	296.44	319.9	23.462
11	1.03e-09	1250	0.37	51	1500	0.28	1680	0.020686	298.71	310.28	11.567
12	1.03e-09	1250	0.37	51	1500	0.28	1680	0.023186	300.98	300.45	-0.52945
13	1.03e-09	1250	0.37	51	1500	0.28	1680	0.025686	303.25	290.75	-12.501
14	1.03e-09	1250	0.37	51	1500	0.28	1680	0.028186	305.52	284.32	-21.204
15	1.03e-09	1250	0.37	51	1500	0.28	1680	0.030686	307.79	303.8	-3.9939
16	1.03e-09	1250	0.37	51	1500	0.28	1680	0.033186	310.06	325.4	15.342
17	1.03e-09	1250	0.37	51	1500	0.28	1680	0.035686	312.32	347.01	34.688
18	1.03e-09	1250	0.37	51	1500	0.28	1680	0.038186	314.59	341.89	27.303
19	1.03e-09	1250	0.37	51	1500	0.28	1680	0.040686	316.86	336.79	19.925
20	1.03e-09	1250	0.37	51	1500	0.28	1680	0.043186	319.13	333.7	14.574
21	1.03e-09	1250	0.37	51	1500	0.28	1680	0.045686	321.4	334.77	13.368
22	1.03e-09	1250	0.37	51	1500	0.28	1680	0.048186	323.67	336.26	12.589
23	1.03e-09	1250	0.37	51	1500	0.28	1680	0.050686	325.94	337.09	11.153
24	1.03e-09	1250	0.37	51	1500	0.28	1680	0.053186	328.21	337.92	9.7104
25	1.03e-09	1250	0.37	51	1500	0.28	1680	0.055686	330.48	339.45	8.9681
26	1.03e-09	1250	0.37	51	1500	0.28	1680	0.058186	332.75	340.25	7.4957
27	1.03e-09	1250	0.37	51	1500	0.28	1680	0.060686	335.02	341.04	6.0234
28	1.03e-09	1250	0.37	51	1500	0.28	1680	0.063186	337.29	341.85	4.5559
29	1.03e-09	1250	0.37	51	1500	0.28	1680	0.065686	339.55	342.75	3.2033
30	1.03e-09	1250	0.37	51	1500	0.28	1680	0.068186	341.82	343.95	2.135
31	1.03e-09	1250	0.37	51	1500	0.28	1680	0.070686	344.09	345.34	1.2459
32	1.03e-09	1250	0.37	51	1500	0.28	1680	0.073186	346.36	346.69	0.32845
33	1.03e-09	1250	0.37	51	1500	0.28	1680	0.075686	348.63	347.67	-0.95599
34	1.03e-09	1250	0.37	51	1500	0.28	1680	0.078186	350.9	349.3	-1.5996
35	1.03e-09	1250	0.37	51	1500	0.28	1680	0.080686	353.17	350.7	-2.4695
36	1.03e-09	1250	0.37	51	1500	0.28	1680	0.083186	355.44	351.76	-3.6763
37	1.03e-09	1250	0.37	51	1500	0.28	1680	0.085686	357.71	352.83	-4.8831
38	1.03e-09	1250	0.37	51	1500	0.28	1680	0.088186	359.98	353.92	-6.0614
39	1.03e-09	1250	0.37	51	1500	0.28	1680	0.090686	362.25	355.65	-6.5966
40	1.03e-09	1250	0.37	51	1500	0.28	1680	0.093186	364.52	357.39	-7.1319
41	1.03e-09	1250	0.37	51	1500	0.28	1680	0.095686	366.78	359.12	-7.6571
42	1.03e-09	1250	0.37	51	1500	0.28	1680	0.098186	369.05	361.23	-7.82

APPENDIX C

execution listing of script S14_trainMod9.m

>> S14_trainMod9

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	StressPred
1	1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0	19.277
2	1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014	59.026
3	1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38	84.021
4	1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29	172.96
5	1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68	236.56
6	1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33	243.2
7	1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07	269.57
8	1.135e-09	2969	0.36858	24.596	2955.8	0.17301	1018.2	0.008353	281.68	284.63
9	1.1512e-09	2962.7	0.37276	24.684	2984.2	0.17085	1011.2	0.009853	286.1	285.89
10	1.1415e-09	2982.1	0.3765	25.376	3006	0.17083	1003.5	0.011353	288.5	287.28
11	1.1585e-09	3057.6	0.3691	24.611	2971	0.16938	1003.8	0.012853	289.97	289.76
12	1.1505e-09	2998.6	0.37116	24.737	2995.1	0.17315	1001.9	0.014353	291.02	289.93
13	1.1325e-09	3021.6	0.36462	25.221	2952.8	0.17105	999.77	0.015853	291.88	289.88
14	1.1564e-09	3036.7	0.37114	24.683	2968.8	0.17263	981.15	0.017353	292.64	291.26
15	1.1501e-09	2958	0.37236	25.019	3056.8	0.17101	1012	0.018853	293.37	293.33
16	1.1458e-09	2975	0.36899	24.515	3058.1	0.16774	984.25	0.020353	294.08	293.04
17	1.1309e-09	3024.1	0.37246	25.039	3023.8	0.17113	987.13	0.021853	294.78	294.56
18	1.1344e-09	2962.9	0.36894	24.982	2954.5	0.17061	989.05	0.023353	295.48	295.81
19	1.1545e-09	2971.3	0.3714	24.523	2991	0.16873	986.46	0.024853	296.18	295.23
20	1.1546e-09	3026.2	0.37694	25.031	2979	0.16732	1004.4	0.026353	296.88	296.73
21	1.1282e-09	3021.1	0.36688	25.172	3023.4	0.16706	990.19	0.027853	297.57	297.82
22	1.1523e-09	2978.7	0.37421	24.971	2944.3	0.1678	1008.9	0.029353	298.27	298.67
23	1.1484e-09	3005.6	0.3689	25.144	3017.7	0.17122	1005.4	0.030853	298.96	298.84
24	1.1552e-09	2970.8	0.37168	25.082	3004.9	0.17252	990.59	0.032353	299.66	298.97
25	1.1222e-09	2947.6	0.36859	24.948	2983.9	0.17179	1005.1	0.033853	300.35	301.49
26	1.1409e-09	2981.7	0.36482	25.086	2971.5	0.1669	1010.2	0.035353	301.05	301.85
27	1.1547e-09	2991.6	0.37574	24.891	3032.3	0.1693	1012.3	0.036853	301.75	301.54
28	1.1575e-09	3010.6	0.36489	24.7	2988.8	0.17169	1013	0.038353	302.44	302.03
29	1.1596e-09	3023.6	0.37123	25.315	3045.5	0.17332	980.02	0.039853	303.14	301.64
30	1.1476e-09	2950	0.37186	25.161	3027.6	0.17266	1019.3	0.041353	303.83	304.35
31	1.1337e-09	2945.9	0.36985	24.693	2954.8	0.168	985.86	0.042853	304.53	304.82
32	1.1267e-09	3007.8	0.37208	24.917	2964.7	0.17305	983.28	0.044353	305.22	305.31
33	1.153e-09	3001.6	0.36523	24.899	2956.1	0.16681	1017.6	0.045853	305.92	306.4
34	1.1323e-09	3047.8	0.36435	25.488	3004.8	0.17141	1020	0.047353	306.61	307.67
35	1.148e-09	2996.2	0.3761	24.604	3029.5	0.17161	1002.5	0.048853	307.31	306.78

36	1.1312e-09	2994.7	0.3641	25.495	2979.9	0.16862	982.48	0.050353	308	308.27
37	1.1512e-09	2941.2	0.36332	25.168	3012.4	0.17018	1009.2	0.051853	308.7	309
38	1.1393e-09	3046.9	0.37442	25.234	2946.2	0.1671	983.54	0.053353	309.39	309.45
39	1.1507e-09	3056.5	0.37543	24.586	2984	0.16911	1007.4	0.054853	310.09	309.69
40	1.1218e-09	2975.3	0.36611	25.031	2951	0.16936	984.19	0.056353	310.79	311.55
41	1.1536e-09	2998.5	0.37398	24.896	2972.8	0.16685	1006.9	0.057853	311.48	311.6
42	1.1414e-09	2953.1	0.37195	24.626	2956.1	0.16727	985.68	0.059353	312.18	312.18
43	1.1426e-09	2977.6	0.36506	25.122	3058.6	0.16776	990.31	0.060853	312.87	312.6
44	1.1306e-09	3003.7	0.37492	25.097	2980.2	0.16863	998.1	0.062353	313.57	314.27
45	1.1282e-09	3031.7	0.37384	25.241	3029.2	0.16732	1007.3	0.063853	314.26	315.11
46	1.1189e-09	3037.1	0.37368	24.62	3003	0.16882	1001.9	0.065353	314.96	315.62
47	1.1515e-09	2967.4	0.36355	25.267	3020.5	0.17146	1005.7	0.066853	315.65	315.72
48	1.1334e-09	3059.6	0.36592	25.152	3012.6	0.16923	985.69	0.068353	316.35	316.14
49	1.1212e-09	3016.8	0.36527	24.545	3026.8	0.16896	1006.4	0.069853	317.04	317.39
50	1.1276e-09	3036.5	0.37719	24.53	3004.3	0.16719	1012.1	0.071353	317.74	318.42
51	1.1221e-09	3014	0.37651	24.854	2989.3	0.17329	1017.8	0.072853	318.44	319.64
52	1.1438e-09	3001.4	0.36382	25.22	3059.5	0.16901	1018.9	0.074353	319.13	319.63
53	1.1191e-09	2985.4	0.37302	25.23	2966.9	0.16843	1006.9	0.075853	319.83	321.51
54	1.1192e-09	3006.9	0.37403	24.812	2961.5	0.1689	988.41	0.077353	320.52	321.27
55	1.1595e-09	3050.1	0.37316	25.118	2981.2	0.17296	984.99	0.078853	321.22	319.87
56	1.1361e-09	2999.1	0.37288	25.473	2979.3	0.1723	1009.6	0.080353	321.91	322.93
57	1.1498e-09	3042.7	0.36677	25.231	2956.5	0.17229	985.54	0.081853	322.61	322.11
58	1.148e-09	2983.3	0.37178	25.311	2942.3	0.16717	1019	0.083353	323.3	324.4
59	1.1194e-09	2981.1	0.37349	25.295	3005.4	0.17127	1015.7	0.084853	324	325.7
60	1.1498e-09	3040.7	0.36901	24.971	3007.3	0.16843	1010	0.086353	324.69	324.7
61	1.1619e-09	2974.4	0.37445	25.396	3011.7	0.17261	1017.7	0.087853	325.39	324.97
62	1.1598e-09	3020.2	0.36566	25.154	2948.6	0.16937	1006.7	0.089353	326.09	326.06
63	1.1427e-09	3011.9	0.3648	25.4	2994	0.168	1016	0.090853	326.78	327.74
64	1.1489e-09	3040.1	0.37162	25.075	2979.1	0.1697	1008.6	0.092353	327.48	327.39
65	1.1352e-09	2987.8	0.37023	25.158	3054.1	0.17151	996	0.093853	328.17	328.29
66	1.1432e-09	3059.6	0.37079	25.015	2979.7	0.16952	999.67	0.095353	328.87	328.7
67	1.1402e-09	3013.5	0.37473	25.032	2964.2	0.16969	997.12	0.096853	329.56	329.46
68	1.1379e-09	2986.4	0.37408	25.234	2991.6	0.17132	1017.8	0.098353	330.26	330.92
69	1.1271e-09	3008.6	0.36441	25.171	3012	0.16698	982.25	0.099853	330.95	330.8
70	1.0208e-09	1962	0.366	23.448	1800.4	0.26753	1476	0	0	-7.1937
71	1.0113e-09	1939.2	0.36259	22.878	1781.2	0.27085	1522	0.0005	30.21	34.195
72	1.0018e-09	1929.2	0.35452	22.995	1814.9	0.26723	1517.1	0.001	60.42	63.816
73	1.0093e-09	1925.4	0.36034	22.784	1768.9	0.26931	1480.4	0.0024301	133.88	150.51
74	1.0258e-09	1962.6	0.3586	22.833	1807.8	0.27443	1524.5	0.0039301	174.71	170.78
75	9.9177e-10	1939.1	0.35676	22.762	1781.5	0.26626	1527.4	0.0054301	197.85	197.06
76	1.0206e-09	1955.3	0.3611	23.228	1810.5	0.26593	1500.3	0.0069301	208.4	206.41
77	9.908e-10	1948.3	0.36486	23.434	1768.1	0.26946	1504.9	0.0084301	213.27	215.24
78	1.0036e-09	1968.5	0.35843	22.791	1774.9	0.26889	1492.5	0.0099301	216.09	216.15
79	1.0236e-09	1971.5	0.36499	23.006	1784.1	0.27266	1484.2	0.01143	218.17	218.73
80	1.0297e-09	1903.3	0.35742	23.01	1768.4	0.27244	1503.4	0.01293	219.94	220.2

81	1.0016e-09	1962.1	0.36593	23.128	1782.4	0.26556	1520.3	0.01443	221.58	221.53
82	1.0169e-09	1940.5	0.35524	22.676	1798.3	0.27441	1503.1	0.01593	223.13	222.72
83	1.0135e-09	1928.3	0.35725	22.783	1818.6	0.27535	1481.2	0.01743	224.65	224.29
84	1.0201e-09	1899.3	0.36643	23.243	1804.2	0.26659	1499.9	0.01893	226.13	226.77
85	1.0287e-09	1937.7	0.36668	22.646	1767.7	0.26789	1504.8	0.02043	227.59	227.86
86	1.0011e-09	1911.6	0.35561	22.841	1827.4	0.26969	1494.2	0.02193	229.04	228.38
87	1.0262e-09	1950.6	0.35824	23.216	1832.7	0.27046	1502.4	0.02343	230.48	230.39
88	1.0192e-09	1923.7	0.36404	22.942	1795.4	0.26513	1473	0.02493	231.91	231.65
89	1.0269e-09	1908.8	0.36311	23.072	1795.2	0.27415	1493.6	0.02643	233.34	233.77
90	1.0119e-09	1924.9	0.3558	22.946	1832.8	0.26594	1498.2	0.02793	234.76	234.24
91	9.9609e-10	1959.7	0.3618	23.219	1822	0.26533	1527	0.02943	236.18	235.89
92	1.0256e-09	1927.9	0.35332	23.226	1775.1	0.26615	1506.4	0.03093	237.6	236.64
93	1.0231e-09	1960.4	0.35702	22.825	1801.7	0.26811	1519.9	0.03243	239.02	238.76
94	1.0204e-09	1942.9	0.36514	23.449	1830.9	0.26902	1470	0.03393	240.44	240.45
95	1.0119e-09	1923.1	0.36177	23.273	1817.7	0.26596	1519.3	0.03543	241.86	242.17
96	1.0137e-09	1908.9	0.36487	22.694	1800.2	0.27539	1491.3	0.03693	243.27	243.81
97	1.0275e-09	1955.4	0.3647	23.068	1821.1	0.26815	1483.4	0.03843	244.69	244.76
98	1.014e-09	1958.3	0.35431	23.296	1824.6	0.26843	1495.8	0.03993	246.1	245.3
99	1.01e-09	1936.7	0.3541	23.372	1827.7	0.26934	1516.9	0.04143	247.52	247.15
100	1.005e-09	1971.7	0.3668	23.132	1825.9	0.26894	1507.9	0.04293	248.93	249.19
101	1.0162e-09	1904.7	0.35332	23.109	1804.8	0.27499	1514.8	0.04443	250.35	250.4
102	9.9903e-10	1946.8	0.35375	22.793	1784.3	0.2741	1496.7	0.04593	251.76	250.78
103	1.0079e-09	1899	0.3602	22.915	1771.8	0.26957	1497.1	0.04743	253.17	253.1
104	9.9788e-10	1929.4	0.35523	23.232	1790.5	0.27477	1471	0.04893	254.59	253.55
105	1.0161e-09	1963.2	0.35361	23.292	1802.1	0.2721	1482.7	0.05043	256	255.09
106	9.9816e-10	1956.3	0.36596	23.26	1785.3	0.26624	1520.9	0.05193	257.41	257.35
107	1.0011e-09	1948.6	0.36581	23.376	1817.8	0.26741	1511.4	0.05343	258.83	259.04
108	1.0292e-09	1899.1	0.3575	23.435	1790.3	0.26794	1477.3	0.05493	260.24	259.94
109	9.9974e-10	1941.3	0.3663	22.584	1767.9	0.26482	1510.9	0.05643	261.65	261.56
110	1.0194e-09	1946.7	0.36023	22.84	1811.6	0.26587	1478.9	0.05793	263.07	262.79
111	1.0062e-09	1968.9	0.35648	23.031	1832.7	0.26749	1485	0.05943	264.48	264.02
112	1.0236e-09	1967.6	0.35997	22.795	1811	0.27451	1500.6	0.06093	265.89	265.99
113	1.0012e-09	1908.3	0.35281	22.801	1803.7	0.27401	1472.5	0.06243	267.3	266.79
114	1.0096e-09	1950.1	0.35872	22.572	1785.1	0.27326	1490.8	0.06393	268.72	268.45
115	1.0118e-09	1943.2	0.36375	23.327	1791.6	0.26551	1514	0.06543	270.13	270.09
116	1.0076e-09	1908.4	0.35749	22.829	1828.4	0.26727	1488.6	0.06693	271.54	271.71
117	1.0262e-09	1928.8	0.35796	22.99	1782.4	0.27464	1498	0.06843	272.96	272.9
118	1.024e-09	1948.9	0.35477	23.33	1778.4	0.27116	1502.6	0.06993	274.37	273.85
119	9.9258e-10	1910.5	0.36341	23.181	1819.9	0.27002	1495.5	0.07143	275.78	276.08
120	9.8992e-10	1903.1	0.35655	22.561	1794.5	0.26828	1502.5	0.07293	277.19	277.18
121	9.9317e-10	1918	0.35924	23.081	1827.2	0.26967	1496.2	0.07443	278.61	278.77
122	1.0277e-09	1907.1	0.35847	23.442	1810.4	0.27428	1498.9	0.07593	280.02	280.33
123	9.9124e-10	1964.9	0.35636	22.548	1822.7	0.26612	1522.8	0.07743	281.43	281.43
124	9.9107e-10	1961	0.36483	22.586	1803.3	0.27479	1489.3	0.07893	282.84	282.85
125	1.0079e-09	1959.5	0.35422	23.331	1766	0.27431	1524	0.08043	284.26	283.77

126	1.0011e-09	1941.4	0.35886	22.625	1765.7	0.2699	1486.7	0.08193	285.67	285.07
127	1.028e-09	1951.6	0.36258	23.423	1819.8	0.27116	1526.9	0.08343	287.08	287.6
128	1.0122e-09	1961.8	0.35868	22.965	1823.5	0.2753	1501.4	0.08493	288.49	288.63
129	9.9221e-10	1947.2	0.36561	22.641	1795.5	0.26763	1529.1	0.08643	289.91	290.26
130	9.9291e-10	1933	0.36482	22.972	1793.8	0.27003	1477.5	0.08793	291.32	291.07
131	1.0011e-09	1925.7	0.36525	22.926	1781.3	0.27105	1498.8	0.08943	292.73	292.78
132	1.0015e-09	1901.6	0.35402	22.603	1793.5	0.26593	1496.6	0.09093	294.14	293.94
133	1.0152e-09	1964.2	0.36234	23.345	1797.7	0.26613	1474.1	0.09243	295.56	294.89
134	1.0237e-09	1971.4	0.3559	23.24	1806.1	0.26895	1500.6	0.09393	296.97	296.54
135	9.9129e-10	1938.5	0.36717	23.01	1826.9	0.26536	1529.3	0.09543	298.38	298.81
136	1.0105e-09	1973.1	0.35936	22.932	1779.4	0.26669	1520	0.09693	299.79	299.41
137	1.0122e-09	1906.2	0.35524	22.541	1794.1	0.26988	1479.6	0.09843	301.21	301.01
138	1.0263e-09	1949	0.35826	23.121	1781.5	0.27077	1528.9	0.09993	302.62	302.66
139	1.0341e-09	1227.7	0.36823	51.784	1484.9	0.27496	1696.6	0	0	21.822
140	1.0129e-09	1251.4	0.37463	51.434	1485.2	0.28208	1712.1	5e-14	5.3419e-09	2.9695
141	1.0474e-09	1230.9	0.36621	50.751	1516	0.28135	1672.2	0.0005	53.419	33.93

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	PredNew	Diff
1	1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09	5.0581	5.0581
2	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419	36.569	-16.85
3	1.03e-09	1250	0.37	51	1500	0.28	1680	0.001	106.84	68.08	-38.76
4	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0031863	241.99	198.69	-43.297
5	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0056863	279.88	226.74	-53.14
6	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0081863	286.8	254.79	-32.014
7	1.03e-09	1250	0.37	51	1500	0.28	1680	0.010686	289.55	282.83	-6.7207
8	1.03e-09	1250	0.37	51	1500	0.28	1680	0.013186	291.88	310.88	18.996
9	1.03e-09	1250	0.37	51	1500	0.28	1680	0.015686	294.16	338.92	44.762
10	1.03e-09	1250	0.37	51	1500	0.28	1680	0.018186	296.44	366.97	70.529
11	1.03e-09	1250	0.37	51	1500	0.28	1680	0.020686	298.71	395.02	96.306
12	1.03e-09	1250	0.37	51	1500	0.28	1680	0.023186	300.98	400.1	99.124
13	1.03e-09	1250	0.37	51	1500	0.28	1680	0.025686	303.25	400.9	97.647
14	1.03e-09	1250	0.37	51	1500	0.28	1680	0.028186	305.52	401.69	96.17
15	1.03e-09	1250	0.37	51	1500	0.28	1680	0.030686	307.79	402.48	94.693
16	1.03e-09	1250	0.37	51	1500	0.28	1680	0.033186	310.06	403.28	93.216
17	1.03e-09	1250	0.37	51	1500	0.28	1680	0.035686	312.32	404.07	91.749
18	1.03e-09	1250	0.37	51	1500	0.28	1680	0.038186	314.59	404.86	90.272
19	1.03e-09	1250	0.37	51	1500	0.28	1680	0.040686	316.86	404.62	87.757
20	1.03e-09	1250	0.37	51	1500	0.28	1680	0.043186	319.13	404.36	85.227
21	1.03e-09	1250	0.37	51	1500	0.28	1680	0.045686	321.4	404.65	83.253
22	1.03e-09	1250	0.37	51	1500	0.28	1680	0.048186	323.67	405.14	81.473
23	1.03e-09	1250	0.37	51	1500	0.28	1680	0.050686	325.94	405.63	79.693
24	1.03e-09	1250	0.37	51	1500	0.28	1680	0.053186	328.21	406.12	77.913

25	1.03e-09	1250	0.37	51	1500	0.28	1680	0.055686	330.48	406.61	76.133
26	1.03e-09	1250	0.37	51	1500	0.28	1680	0.058186	332.75	407.1	74.353
27	1.03e-09	1250	0.37	51	1500	0.28	1680	0.060686	335.02	407.59	72.573
28	1.03e-09	1250	0.37	51	1500	0.28	1680	0.063186	337.29	408.08	70.793
29	1.03e-09	1250	0.37	51	1500	0.28	1680	0.065686	339.55	408.57	69.023
30	1.03e-09	1250	0.37	51	1500	0.28	1680	0.068186	341.82	409.06	67.243
31	1.03e-09	1250	0.37	51	1500	0.28	1680	0.070686	344.09	409.55	65.463
32	1.03e-09	1250	0.37	51	1500	0.28	1680	0.073186	346.36	410.04	63.682
33	1.03e-09	1250	0.37	51	1500	0.28	1680	0.075686	348.63	410.52	61.89
34	1.03e-09	1250	0.37	51	1500	0.28	1680	0.078186	350.9	411	60.097
35	1.03e-09	1250	0.37	51	1500	0.28	1680	0.080686	353.17	411.47	58.305
36	1.03e-09	1250	0.37	51	1500	0.28	1680	0.083186	355.44	411.95	56.513
37	1.03e-09	1250	0.37	51	1500	0.28	1680	0.085686	357.71	412.43	54.72
38	1.03e-09	1250	0.37	51	1500	0.28	1680	0.088186	359.98	412.91	52.928
39	1.03e-09	1250	0.37	51	1500	0.28	1680	0.090686	362.25	413.39	51.136
40	1.03e-09	1250	0.37	51	1500	0.28	1680	0.093186	364.52	413.86	49.343
41	1.03e-09	1250	0.37	51	1500	0.28	1680	0.095686	366.78	414.34	47.561
42	1.03e-09	1250	0.37	51	1500	0.28	1680	0.098186	369.05	414.82	45.769

APPENDIX D

execution listing of script S16_trainMod27.m

Nr	Density	Em	Poisson	YieldS	Hm	He	Lhm	Strain11	Stress11	StressPred
1	1.1537e-09	2957	0.36884	25.416	3035.1	0.17312	1006.2	0	0	12.999
2	1.1547e-09	3023.4	0.36729	25.45	2944.1	0.16958	995.26	0.0005	60.014	55.963
3	1.161e-09	2980.8	0.37126	24.724	3030.2	0.16833	1000.2	0.00085301	102.38	79.988
4	1.1286e-09	3013.9	0.3696	24.852	3039.7	0.17058	1002	0.002353	175.29	187.14
5	1.1177e-09	2980.5	0.365	25.294	2977.3	0.17019	986.63	0.003853	225.68	225.08
6	1.1374e-09	2952.8	0.37684	24.505	3033	0.17216	1014.7	0.005353	256.33	235.44
7	1.1561e-09	3014.6	0.36779	25.013	2988.2	0.16712	989.6	0.006853	273.07	268.8
8	1.135e-09	2969	0.36858	24.596	2955.8	0.17301	1018.2	0.008353	281.68	283.21
9	1.1512e-09	2962.7	0.37276	24.684	2984.2	0.17085	1011.2	0.009853	286.1	284.37
10	1.1415e-09	2982.1	0.3765	25.376	3006	0.17083	1003.5	0.011353	288.5	282.68
11	1.1585e-09	3057.6	0.3691	24.611	2971	0.16938	1003.8	0.012853	289.97	283.52
12	1.1505e-09	2998.6	0.37116	24.737	2995.1	0.17315	1001.9	0.014353	291.02	291.39
13	1.1325e-09	3021.6	0.36462	25.221	2952.8	0.17105	999.77	0.015853	291.88	291.26
14	1.1564e-09	3036.7	0.37114	24.683	2968.8	0.17263	981.15	0.017353	292.64	292.14
15	1.1501e-09	2958	0.37236	25.019	3056.8	0.17101	1012	0.018853	293.37	293.79
16	1.1458e-09	2975	0.36899	24.515	3058.1	0.16774	984.25	0.020353	294.08	293.08

17	1.1309e-09	3024.1	0.37246	25.039	3023.8	0.17113	987.13	0.021853	294.78	294.2
18	1.1344e-09	2962.9	0.36894	24.982	2954.5	0.17061	989.05	0.023353	295.48	295.55
19	1.1545e-09	2971.3	0.3714	24.523	2991	0.16873	986.46	0.024853	296.18	295.7
20	1.1546e-09	3026.2	0.37694	25.031	2979	0.16732	1004.4	0.026353	296.88	296.61
21	1.1282e-09	3021.1	0.36688	25.172	3023.4	0.16706	990.19	0.027853	297.57	296.39
22	1.1523e-09	2978.7	0.37421	24.971	2944.3	0.1678	1008.9	0.029353	298.27	298.71
23	1.1484e-09	3005.6	0.3689	25.144	3017.7	0.17122	1005.4	0.030853	298.96	299.14
24	1.1552e-09	2970.8	0.37168	25.082	3004.9	0.17252	990.59	0.032353	299.66	299.61
25	1.1222e-09	2947.6	0.36859	24.948	2983.9	0.17179	1005.1	0.033853	300.35	301.23
26	1.1409e-09	2981.7	0.36482	25.086	2971.5	0.1669	1010.2	0.035353	301.05	301.15
27	1.1547e-09	2991.6	0.37574	24.891	3032.3	0.1693	1012.3	0.036853	301.75	302.02
28	1.1575e-09	3010.6	0.36489	24.7	2988.8	0.17169	1013	0.038353	302.44	303.12
29	1.1596e-09	3023.6	0.37123	25.315	3045.5	0.17332	980.02	0.039853	303.14	302.22
30	1.1476e-09	2950	0.37186	25.161	3027.6	0.17266	1019.3	0.041353	303.83	305.03
31	1.1337e-09	2945.9	0.36985	24.693	2954.8	0.168	985.86	0.042853	304.53	304.41
32	1.1267e-09	3007.8	0.37208	24.917	2964.7	0.17305	983.28	0.044353	305.22	305.26
33	1.153e-09	3001.6	0.36523	24.899	2956.1	0.16681	1017.6	0.045853	305.92	306.42
34	1.1323e-09	3047.8	0.36435	25.488	3004.8	0.17141	1020	0.047353	306.61	307.16
35	1.148e-09	2996.2	0.3761	24.604	3029.5	0.17161	1002.5	0.048853	307.31	307.65
36	1.1312e-09	2994.7	0.3641	25.495	2979.9	0.16862	982.48	0.050353	308	306.85
37	1.1512e-09	2941.2	0.36332	25.168	3012.4	0.17018	1009.2	0.051853	308.7	308.96
38	1.1393e-09	3046.9	0.37442	25.234	2946.2	0.1671	983.54	0.053353	309.39	308.55
39	1.1507e-09	3056.5	0.37543	24.586	2984	0.16911	1007.4	0.054853	310.09	310.29
40	1.1218e-09	2975.3	0.36611	25.031	2951	0.16936	984.19	0.056353	310.79	310.58
41	1.1536e-09	2998.5	0.37398	24.896	2972.8	0.16685	1006.9	0.057853	311.48	311.65
42	1.1414e-09	2953.1	0.37195	24.626	2956.1	0.16727	985.68	0.059353	312.18	311.96
43	1.1426e-09	2977.6	0.36506	25.122	3058.6	0.16776	990.31	0.060853	312.87	311.91
44	1.1306e-09	3003.7	0.37492	25.097	2980.2	0.16863	998.1	0.062353	313.57	313.64
45	1.1282e-09	3031.7	0.37384	25.241	3029.2	0.16732	1007.3	0.063853	314.26	314.11
46	1.1189e-09	3037.1	0.37368	24.62	3003	0.16882	1001.9	0.065353	314.96	315.09
47	1.1515e-09	2967.4	0.36355	25.267	3020.5	0.17146	1005.7	0.066853	315.65	315.6
48	1.1334e-09	3059.6	0.36592	25.152	3012.6	0.16923	985.69	0.068353	316.35	315.23
49	1.1212e-09	3016.8	0.36527	24.545	3026.8	0.16896	1006.4	0.069853	317.04	316.94
50	1.1276e-09	3036.5	0.37719	24.53	3004.3	0.16719	1012.1	0.071353	317.74	318.14
51	1.1221e-09	3014	0.37651	24.854	2989.3	0.17329	1017.8	0.072853	318.44	319.91
52	1.1438e-09	3001.4	0.36382	25.22	3059.5	0.16901	1018.9	0.074353	319.13	318.96
53	1.1191e-09	2985.4	0.37302	25.23	2966.9	0.16843	1006.9	0.075853	319.83	320.41
54	1.1192e-09	3006.9	0.37403	24.812	2961.5	0.1689	988.41	0.077353	320.52	320.47
55	1.1595e-09	3050.1	0.37316	25.118	2981.2	0.17296	984.99	0.078853	321.22	320.86
56	1.1361e-09	2999.1	0.37288	25.473	2979.3	0.1723	1009.6	0.080353	321.91	322.77
57	1.1498e-09	3042.7	0.36677	25.231	2956.5	0.17229	985.54	0.081853	322.61	321.87
58	1.148e-09	2983.3	0.37178	25.311	2942.3	0.16717	1019	0.083353	323.3	324.08
59	1.1194e-09	2981.1	0.37349	25.295	3005.4	0.17127	1015.7	0.084853	324	325.1
60	1.1498e-09	3040.7	0.36901	24.971	3007.3	0.16843	1010	0.086353	324.69	324.44
61	1.1619e-09	2974.4	0.37445	25.396	3011.7	0.17261	1017.7	0.087853	325.39	324.77

62	1.1598e-09	3020.2	0.36566	25.154	2948.6	0.16937	1006.7	0.089353	326.09	325.73
63	1.1427e-09	3011.9	0.3648	25.4	2994	0.168	1016	0.090853	326.78	327.38
64	1.1489e-09	3040.1	0.37162	25.075	2979.1	0.1697	1008.6	0.092353	327.48	327.22
65	1.1352e-09	2987.8	0.37023	25.158	3054.1	0.17151	996	0.093853	328.17	328.18
66	1.1432e-09	3059.6	0.37079	25.015	2979.7	0.16952	999.67	0.095353	328.87	329.62
67	1.1402e-09	3013.5	0.37473	25.032	2964.2	0.16969	997.12	0.096853	329.56	329.87
68	1.1379e-09	2986.4	0.37408	25.234	2991.6	0.17132	1017.8	0.098353	330.26	330.83
69	1.1271e-09	3008.6	0.36441	25.171	3012	0.16698	982.25	0.099853	330.95	327.84
70	1.0208e-09	1962	0.366	23.448	1800.4	0.26753	1476	0	0	-4.4459
71	1.0113e-09	1939.2	0.36259	22.878	1781.2	0.27085	1522	0.0005	30.21	32.419
72	1.0018e-09	1929.2	0.35452	22.995	1814.9	0.26723	1517.1	0.001	60.42	53.323
73	1.0093e-09	1925.4	0.36034	22.784	1768.9	0.26931	1480.4	0.0024301	133.88	123.87
74	1.0258e-09	1962.6	0.3586	22.833	1807.8	0.27443	1524.5	0.0039301	174.71	183.61
75	9.9177e-10	1939.1	0.35676	22.762	1781.5	0.26626	1527.4	0.0054301	197.85	210.86
76	1.0206e-09	1955.3	0.3611	23.228	1810.5	0.26593	1500.3	0.0069301	208.4	199.38
77	9.908e-10	1948.3	0.36486	23.434	1768.1	0.26946	1504.9	0.0084301	213.27	216.06
78	1.0036e-09	1968.5	0.35843	22.791	1774.9	0.26889	1492.5	0.0099301	216.09	217.69
79	1.0236e-09	1971.5	0.36499	23.006	1784.1	0.27266	1484.2	0.01143	218.17	219.67
80	1.0297e-09	1903.3	0.35742	23.01	1768.4	0.27244	1503.4	0.01293	219.94	222.04
81	1.0016e-09	1962.1	0.36593	23.128	1782.4	0.26556	1520.3	0.01443	221.58	217.7
82	1.0169e-09	1940.5	0.35524	22.676	1798.3	0.27441	1503.1	0.01593	223.13	223.52
83	1.0135e-09	1928.3	0.35725	22.783	1818.6	0.27535	1481.2	0.01743	224.65	225.81
84	1.0201e-09	1899.3	0.36643	23.243	1804.2	0.26659	1499.9	0.01893	226.13	217.82
85	1.0287e-09	1937.7	0.36668	22.646	1767.7	0.26789	1504.8	0.02043	227.59	225.24
86	1.0011e-09	1911.6	0.35561	22.841	1827.4	0.26969	1494.2	0.02193	229.04	226.86
87	1.0262e-09	1950.6	0.35824	23.216	1832.7	0.27046	1502.4	0.02343	230.48	235.48
88	1.0192e-09	1923.7	0.36404	22.942	1795.4	0.26513	1473	0.02493	231.91	231.96
89	1.0269e-09	1908.8	0.36311	23.072	1795.2	0.27415	1493.6	0.02643	233.34	232.99
90	1.0119e-09	1924.9	0.3558	22.946	1832.8	0.26594	1498.2	0.02793	234.76	235.22
91	9.9609e-10	1959.7	0.3618	23.219	1822	0.26533	1527	0.02943	236.18	236.67
92	1.0256e-09	1927.9	0.35332	23.226	1775.1	0.26615	1506.4	0.03093	237.6	237.6
93	1.0231e-09	1960.4	0.35702	22.825	1801.7	0.26811	1519.9	0.03243	239.02	238.83
94	1.0204e-09	1942.9	0.36514	23.449	1830.9	0.26902	1470	0.03393	240.44	240.82
95	1.0119e-09	1923.1	0.36177	23.273	1817.7	0.26596	1519.3	0.03543	241.86	242.25
96	1.0137e-09	1908.9	0.36487	22.694	1800.2	0.27539	1491.3	0.03693	243.27	242.82
97	1.0275e-09	1955.4	0.3647	23.068	1821.1	0.26815	1483.4	0.03843	244.69	244.72
98	1.014e-09	1958.3	0.35431	23.296	1824.6	0.26843	1495.8	0.03993	246.1	246.52
99	1.01e-09	1936.7	0.3541	23.372	1827.7	0.26934	1516.9	0.04143	247.52	248.01
100	1.005e-09	1971.7	0.3668	23.132	1825.9	0.26894	1507.9	0.04293	248.93	249.13
101	1.0162e-09	1904.7	0.35332	23.109	1804.8	0.27499	1514.8	0.04443	250.35	250.29
102	9.9903e-10	1946.8	0.35375	22.793	1784.3	0.2741	1496.7	0.04593	251.76	251.51
103	1.0079e-09	1899	0.3602	22.915	1771.8	0.26957	1497.1	0.04743	253.17	253.01
104	9.9788e-10	1929.4	0.35523	23.232	1790.5	0.27477	1471	0.04893	254.59	254.68
105	1.0161e-09	1963.2	0.35361	23.292	1802.1	0.2721	1482.7	0.05043	256	256.46
106	9.9816e-10	1956.3	0.36596	23.26	1785.3	0.26624	1520.9	0.05193	257.41	257.57

107	1.0011e-09	1948.6	0.36581	23.376	1817.8	0.26741	1511.4	0.05343	258.83	259.28
108	1.0292e-09	1899.1	0.3575	23.435	1790.3	0.26794	1477.3	0.05493	260.24	260.48
109	9.9974e-10	1941.3	0.3663	22.584	1767.9	0.26482	1510.9	0.05643	261.65	261.41
110	1.0194e-09	1946.7	0.36023	22.84	1811.6	0.26587	1478.9	0.05793	263.07	263.23
111	1.0062e-09	1968.9	0.35648	23.031	1832.7	0.26749	1485	0.05943	264.48	265.42
112	1.0236e-09	1967.6	0.35997	22.795	1811	0.27451	1500.6	0.06093	265.89	265.55
113	1.0012e-09	1908.3	0.35281	22.801	1803.7	0.27401	1472.5	0.06243	267.3	267.59
114	1.0096e-09	1950.1	0.35872	22.572	1785.1	0.27326	1490.8	0.06393	268.72	268.31
115	1.0118e-09	1943.2	0.36375	23.327	1791.6	0.26551	1514	0.06543	270.13	270.4
116	1.0076e-09	1908.4	0.35749	22.829	1828.4	0.26727	1488.6	0.06693	271.54	272.32
117	1.0262e-09	1928.8	0.35796	22.99	1782.4	0.27464	1498	0.06843	272.96	273.36
118	1.024e-09	1948.9	0.35477	23.33	1778.4	0.27116	1502.6	0.06993	274.37	274.42
119	9.9258e-10	1910.5	0.36341	23.181	1819.9	0.27002	1495.5	0.07143	275.78	276.15
120	9.8992e-10	1903.1	0.35655	22.561	1794.5	0.26828	1502.5	0.07293	277.19	276.86
121	9.9317e-10	1918	0.35924	23.081	1827.2	0.26967	1496.2	0.07443	278.61	278.83
122	1.0277e-09	1907.1	0.35847	23.442	1810.4	0.27428	1498.9	0.07593	280.02	280.42
123	9.9124e-10	1964.9	0.35636	22.548	1822.7	0.26612	1522.8	0.07743	281.43	281.13
124	9.9107e-10	1961	0.36483	22.586	1803.3	0.27479	1489.3	0.07893	282.84	282.15
125	1.0079e-09	1959.5	0.35422	23.331	1766	0.27431	1524	0.08043	284.26	282.93
126	1.0011e-09	1941.4	0.35886	22.625	1765.7	0.2699	1486.7	0.08193	285.67	285.09
127	1.028e-09	1951.6	0.36258	23.423	1819.8	0.27116	1526.9	0.08343	287.08	287.54
128	1.0122e-09	1961.8	0.35868	22.965	1823.5	0.2753	1501.4	0.08493	288.49	288.26
129	9.9221e-10	1947.2	0.36561	22.641	1795.5	0.26763	1529.1	0.08643	289.91	290.34
130	9.9291e-10	1933	0.36482	22.972	1793.8	0.27003	1477.5	0.08793	291.32	291.76
131	1.0011e-09	1925.7	0.36525	22.926	1781.3	0.27105	1498.8	0.08943	292.73	293.07
132	1.0015e-09	1901.6	0.35402	22.603	1793.5	0.26593	1496.6	0.09093	294.14	293.85
133	1.0152e-09	1964.2	0.36234	23.345	1797.7	0.26613	1474.1	0.09243	295.56	295.61
134	1.0237e-09	1971.4	0.3559	23.24	1806.1	0.26895	1500.6	0.09393	296.97	296.7
135	9.9129e-10	1938.5	0.36717	23.01	1826.9	0.26536	1529.3	0.09543	298.38	299.66
136	1.0105e-09	1973.1	0.35936	22.932	1779.4	0.26669	1520	0.09693	299.79	299.75
137	1.0122e-09	1906.2	0.35524	22.541	1794.1	0.26988	1479.6	0.09843	301.21	301.1
138	1.0263e-09	1949	0.35826	23.121	1781.5	0.27077	1528.9	0.09993	302.62	302.32
139	1.0341e-09	1227.7	0.36823	51.784	1484.9	0.27496	1696.6	0	0	25.765
140	1.0129e-09	1251.4	0.37463	51.434	1485.2	0.28208	1712.1	5e-14	5.3419e-09	5.4236
141	1.0474e-09	1230.9	0.36621	50.751	1516	0.28135	1672.2	0.0005	53.419	30.824

Nr	**Density**	**Em**	**Poisson**	**YieldS**	**Hm**	**He**	**Lhm**	**Strain11**	**Stress11**	**PredNew**	**Diff**
1	1.03e-09	1250	0.37	51	1500	0.28	1680	5e-14	5.3419e-09	9.0245	9.0245
2	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0005	53.419	33.391	-20.028
3	1.03e-09	1250	0.37	51	1500	0.28	1680	0.001	106.84	57.76	-49.08
4	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0031863	241.99	168.27	-73.717
5	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0056863	279.88	293.24	13.36
6	1.03e-09	1250	0.37	51	1500	0.28	1680	0.0081863	286.8	389.37	102.57

7	1.03e-09	1250	0.37	51	1500	0.28	1680	0.010686	289.55	390.66	101.11
8	1.03e-09	1250	0.37	51	1500	0.28	1680	0.013186	291.88	390.83	98.952
9	1.03e-09	1250	0.37	51	1500	0.28	1680	0.015686	294.16	389.1	94.936
10	1.03e-09	1250	0.37	51	1500	0.28	1680	0.018186	296.44	387.68	91.241
11	1.03e-09	1250	0.37	51	1500	0.28	1680	0.020686	298.71	387.35	88.636
12	1.03e-09	1250	0.37	51	1500	0.28	1680	0.023186	300.98	387.23	86.25
13	1.03e-09	1250	0.37	51	1500	0.28	1680	0.025686	303.25	371.07	67.824
14	1.03e-09	1250	0.37	51	1500	0.28	1680	0.028186	305.52	352.78	47.258
15	1.03e-09	1250	0.37	51	1500	0.28	1680	0.030686	307.79	343.02	35.233
16	1.03e-09	1250	0.37	51	1500	0.28	1680	0.033186	310.06	333.27	23.208
17	1.03e-09	1250	0.37	51	1500	0.28	1680	0.035686	312.32	329.16	16.845
18	1.03e-09	1250	0.37	51	1500	0.28	1680	0.038186	314.59	324.94	10.351
19	1.03e-09	1250	0.37	51	1500	0.28	1680	0.040686	316.86	323.25	6.393
20	1.03e-09	1250	0.37	51	1500	0.28	1680	0.043186	319.13	323.38	4.2461
21	1.03e-09	1250	0.37	51	1500	0.28	1680	0.045686	321.4	323.4	1.9974
22	1.03e-09	1250	0.37	51	1500	0.28	1680	0.048186	323.67	323.48	-0.18638
23	1.03e-09	1250	0.37	51	1500	0.28	1680	0.050686	325.94	322.26	-3.6768
24	1.03e-09	1250	0.37	51	1500	0.28	1680	0.053186	328.21	322.2	-6.0088
25	1.03e-09	1250	0.37	51	1500	0.28	1680	0.055686	330.48	321.86	-8.6174
26	1.03e-09	1250	0.37	51	1500	0.28	1680	0.058186	332.75	321.52	-11.235
27	1.03e-09	1250	0.37	51	1500	0.28	1680	0.060686	335.02	320.25	-14.772
28	1.03e-09	1250	0.37	51	1500	0.28	1680	0.063186	337.29	318.87	-18.424
29	1.03e-09	1250	0.37	51	1500	0.28	1680	0.065686	339.55	317.53	-22.023
30	1.03e-09	1250	0.37	51	1500	0.28	1680	0.068186	341.82	316.7	-25.118
31	1.03e-09	1250	0.37	51	1500	0.28	1680	0.070686	344.09	315.99	-28.097
32	1.03e-09	1250	0.37	51	1500	0.28	1680	0.073186	346.36	315.63	-30.728
33	1.03e-09	1250	0.37	51	1500	0.28	1680	0.075686	348.63	315.27	-33.359
34	1.03e-09	1250	0.37	51	1500	0.28	1680	0.078186	350.9	315.38	-35.524
35	1.03e-09	1250	0.37	51	1500	0.28	1680	0.080686	353.17	318.74	-34.43
36	1.03e-09	1250	0.37	51	1500	0.28	1680	0.083186	355.44	322.1	-33.336
37	1.03e-09	1250	0.37	51	1500	0.28	1680	0.085686	357.71	325.92	-31.79
38	1.03e-09	1250	0.37	51	1500	0.28	1680	0.088186	359.98	330.12	-29.857
39	1.03e-09	1250	0.37	51	1500	0.28	1680	0.090686	362.25	334.32	-27.925
40	1.03e-09	1250	0.37	51	1500	0.28	1680	0.093186	364.52	338.6	-25.915
41	1.03e-09	1250	0.37	51	1500	0.28	1680	0.095686	366.78	343.2	-23.581
42	1.03e-09	1250	0.37	51	1500	0.28	1680	0.098186	369.05	347.37	-21.678