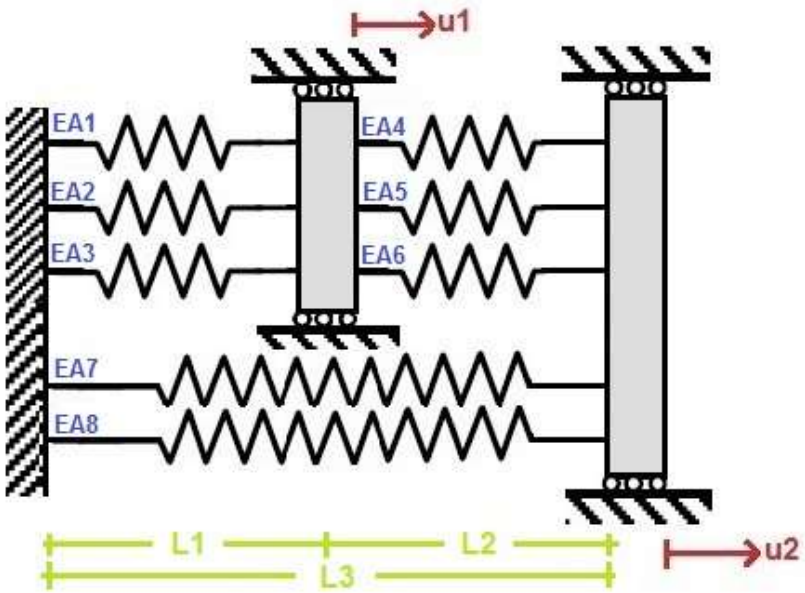
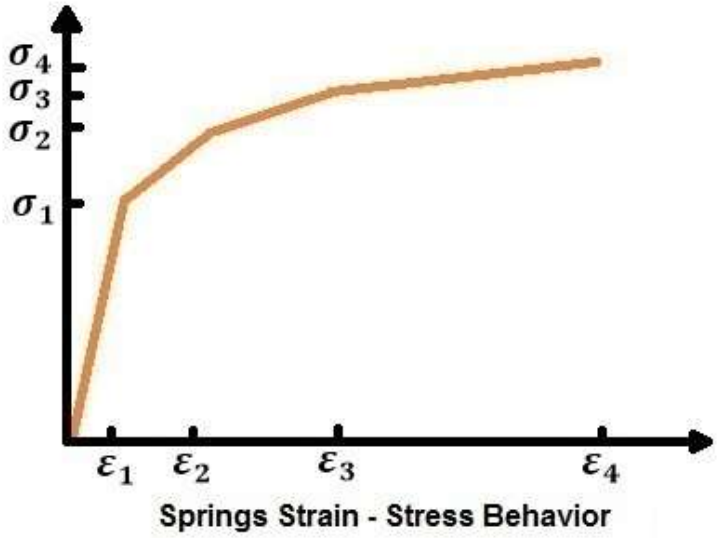
>> IN THE NAME OF GOD <<

Analysis of Linear and Nonlinear Springs with Displacement Control in MATLAB and C++





MATLAB and C++ program is written by Salar Delavar Ghashghaei – Publication Date: 14/June/2017
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Define Parameters:

```
% Define Parameters in Free Unit
P1 = 0; % External force [DOF(1)]
P2 = 0; % External force [DOF(2)]
D2 = 0.1;  % Initial Incremental Displacement [DOF(2)]
itermax = 500;% maximum number of iterations
tolerance = 1e-12; % specified tolerance for convergence
u = 0;% initial guess value
```

Spring Properties:

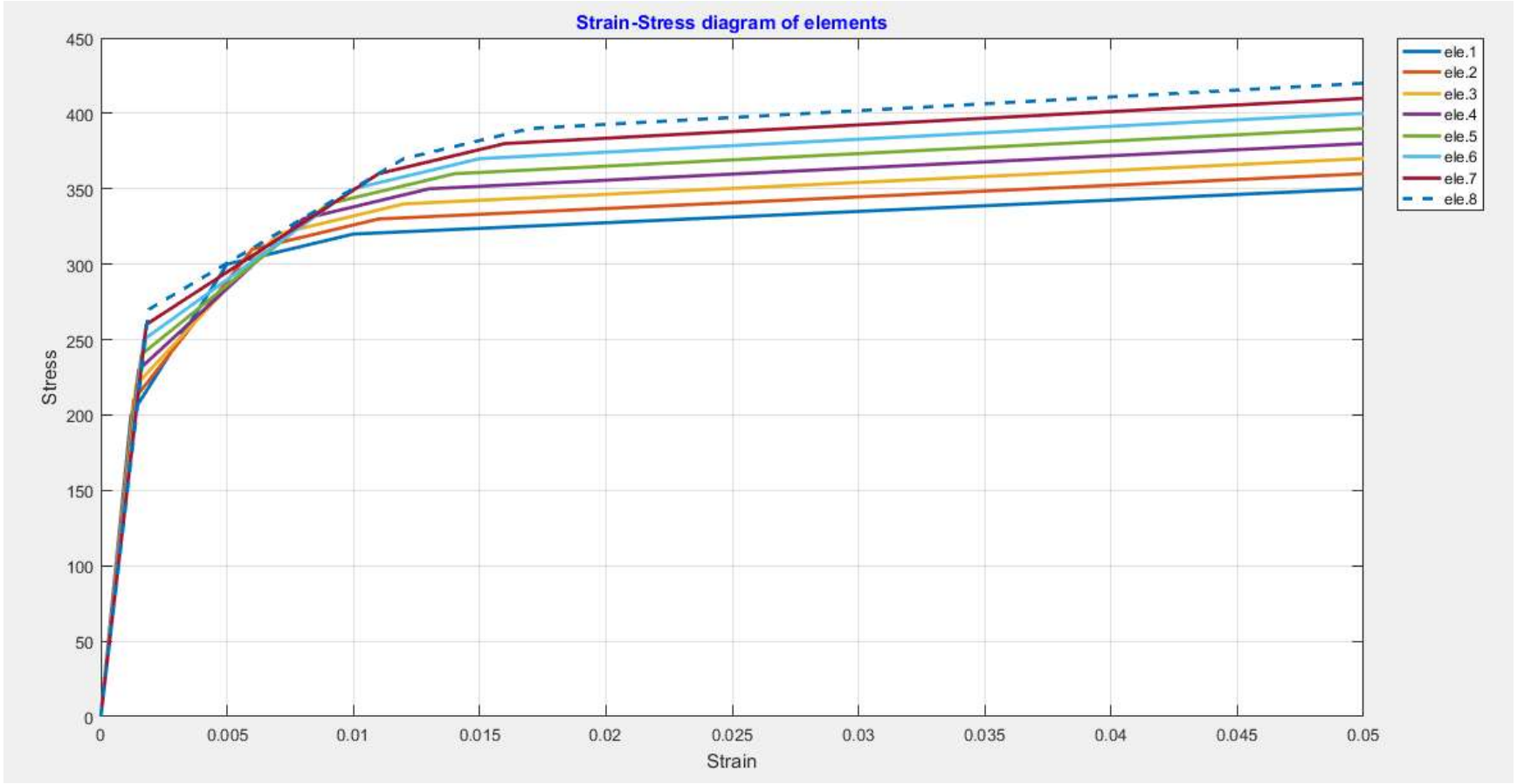
```
%       Strain Stress
DATA = [.0012 200 .005 300 .01 320 .05 350 10;
        .0013 210 .006 310 .011 330 .05 360 10;
        .0014 220 .007 320 .012 340 .05 370 10;
        .0015 230 .008 330 .013 350 .05 380 10;
        .0016 240 .009 340 .014 360 .05 390 10;
```

```
        .0017 250 .01 350 .015 370 .05 400 10;
        .0018 260 .011 360 .016 380 .05 410 20;
        .0019 270 .012 370 .017 390 .05 420 20];
L1 = 1000; % Length of spring 1
L2 = 1000; % Length of spring 2
L3 = 2000; % Length of spring 3
D2max=L1*max(DATA(:,7)); % Maximum displacement [DOF(2)]
for i=1:8
A(i)= DATA(i,9);
E1(i)=(DATA(i,2)-0)/(DATA(i,1)-0);
E2(i)=(DATA(i,4)-DATA(i,2))/(DATA(i,3)-DATA(i,1));
E3(i)=(DATA(i,6)-DATA(i,4))/(DATA(i,5)-DATA(i,3));
E4(i)=(DATA(i,8)-DATA(i,6))/(DATA(i,7)-DATA(i,5));
end
m = D2max/D2 +1; % Number of steps increment
```

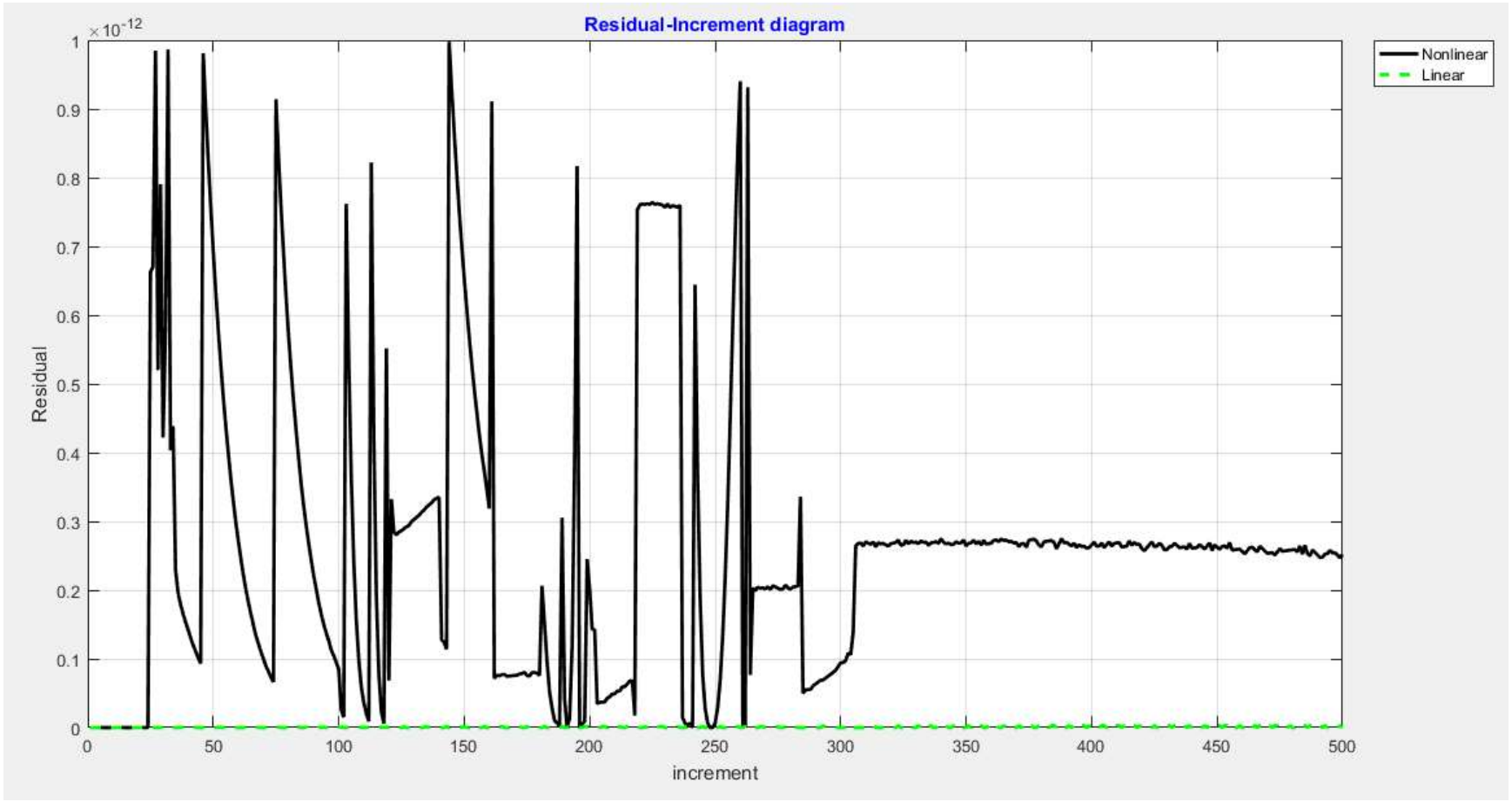
```
########################################
#   Pushover Analysis of Nonlinear Springs    #
########################################
(+)Increment 1 : It is converged in 2 iterations
(+)Increment 2 : It is converged in 2 iterations
(+)Increment 3 : It is converged in 2 iterations
(+)Increment 4 : It is converged in 2 iterations
(+)Increment 5 : It is converged in 2 iterations
(+)Increment 6 : It is converged in 2 iterations
(+)Increment 7 : It is converged in 2 iterations
(+)Increment 8 : It is converged in 2 iterations
(+)Increment 9 : It is converged in 2 iterations
(+)Increment 10 : It is converged in 2 iterations
.
.
.
(+)Increment 490 : It is converged in 11 iterations
(+)Increment 491 : It is converged in 11 iterations
(+)Increment 492 : It is converged in 11 iterations
(+)Increment 493 : It is converged in 11 iterations
(+)Increment 494 : It is converged in 11 iterations
(+)Increment 495 : It is converged in 11 iterations
(+)Increment 496 : It is converged in 11 iterations
(+)Increment 497 : It is converged in 11 iterations
(+)Increment 498 : It is converged in 11 iterations
(+)Increment 499 : It is converged in 11 iterations
(+)Increment 500 : It is converged in 11 iterations
 ## Displacement reached to ultimate displacement ##
```

```
####################################
#     Pushover Analysis of Linear Springs     #
####################################
(+)Increment 1 : It is converged in 2 iterations
(+)Increment 2 : It is converged in 2 iterations
(+)Increment 3 : It is converged in 2 iterations
(+)Increment 4 : It is converged in 2 iterations
(+)Increment 5 : It is converged in 2 iterations
(+)Increment 6 : It is converged in 2 iterations
(+)Increment 7 : It is converged in 2 iterations
(+)Increment 8 : It is converged in 2 iterations
(+)Increment 9 : It is converged in 2 iterations
.
.
.
(+)Increment 490 : It is converged in 2 iterations
(+)Increment 491 : It is converged in 2 iterations
(+)Increment 492 : It is converged in 2 iterations
(+)Increment 493 : It is converged in 2 iterations
(+)Increment 494 : It is converged in 2 iterations
(+)Increment 495 : It is converged in 2 iterations
(+)Increment 496 : It is converged in 2 iterations
(+)Increment 497 : It is converged in 2 iterations
(+)Increment 498 : It is converged in 2 iterations
(+)Increment 499 : It is converged in 2 iterations
(+)Increment 500 : It is converged in 2 iterations
```

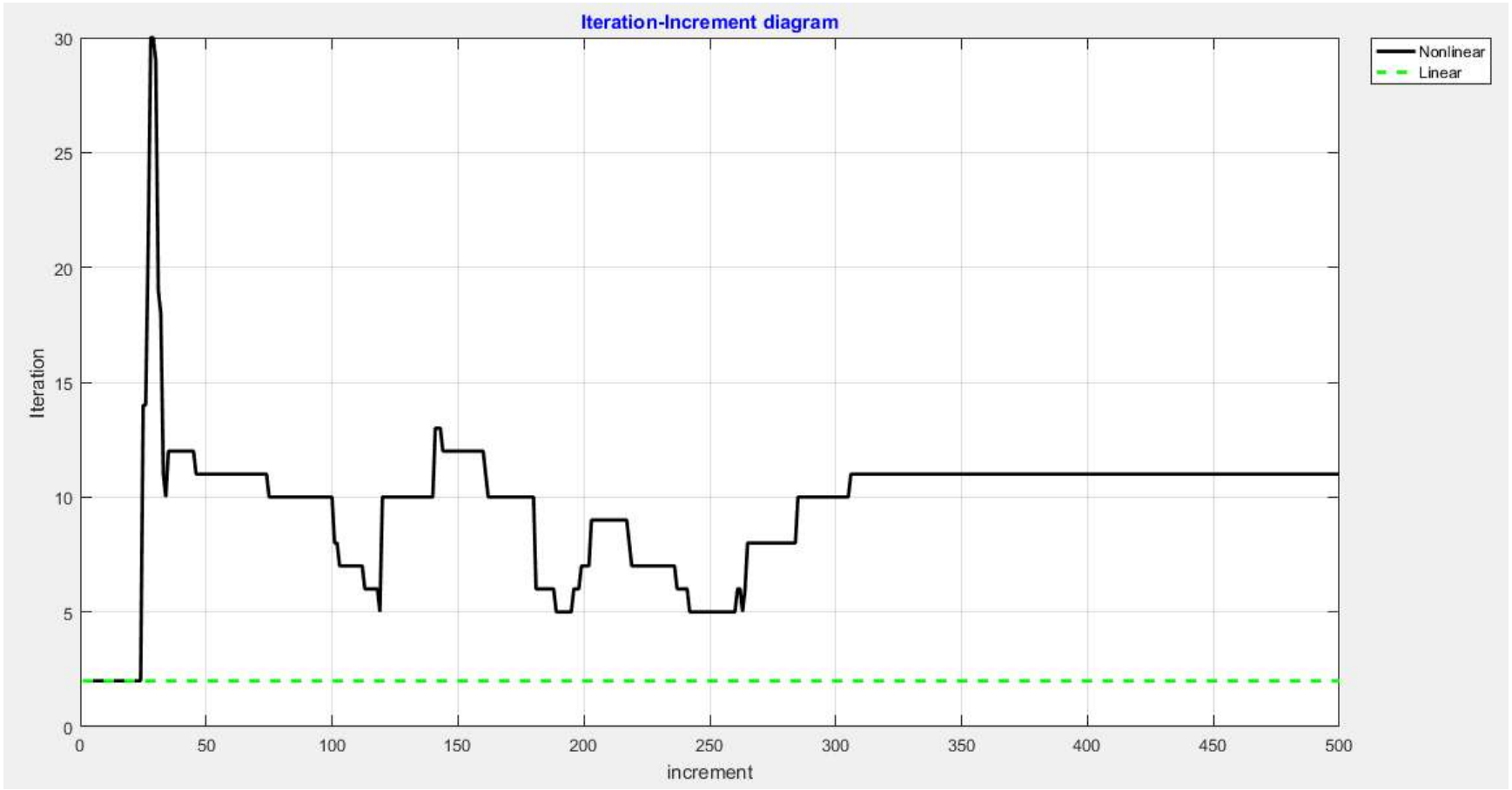
Plot :



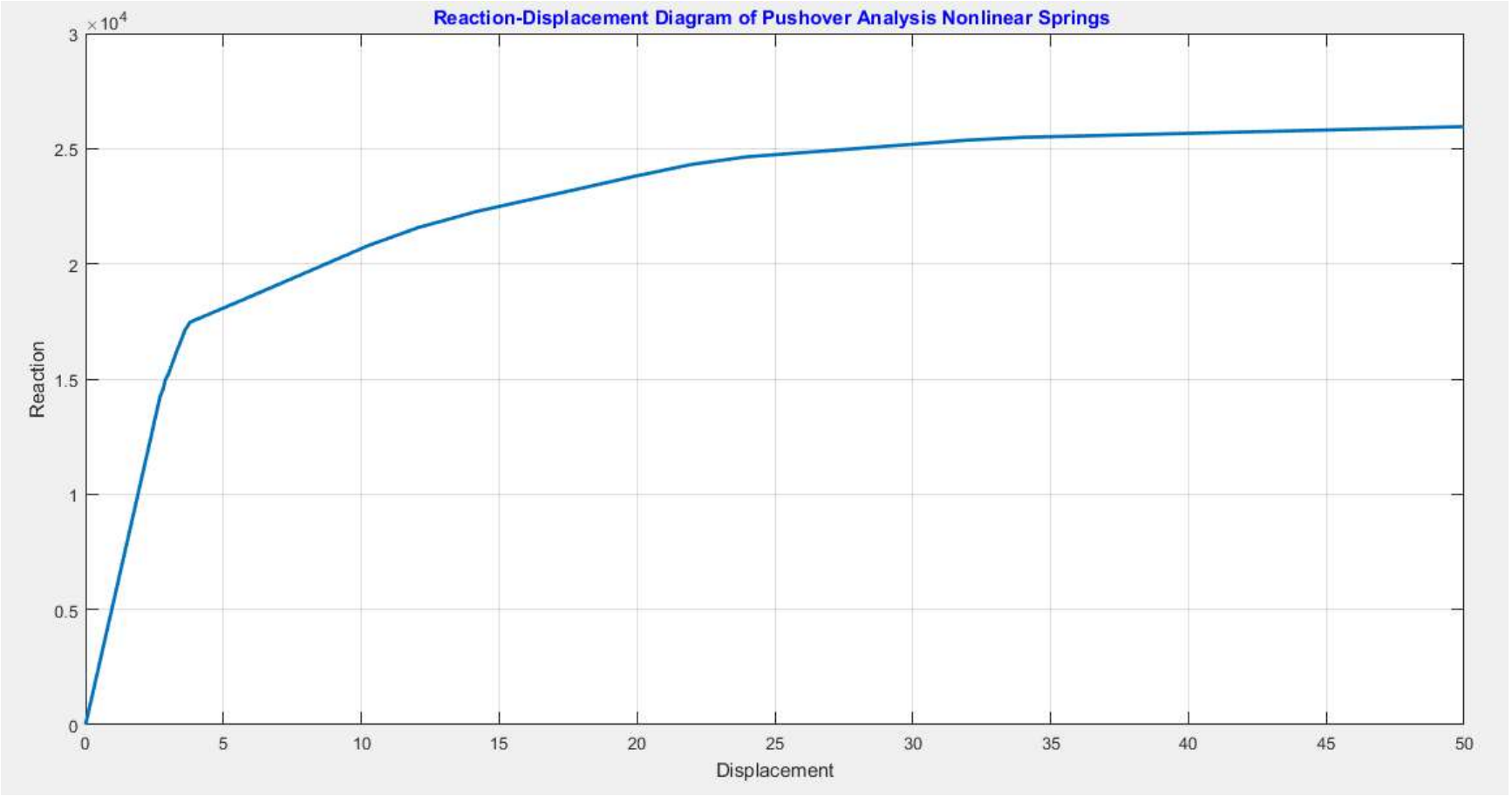
Figure(1) Strain-Stress diagram of elements in MATLAB



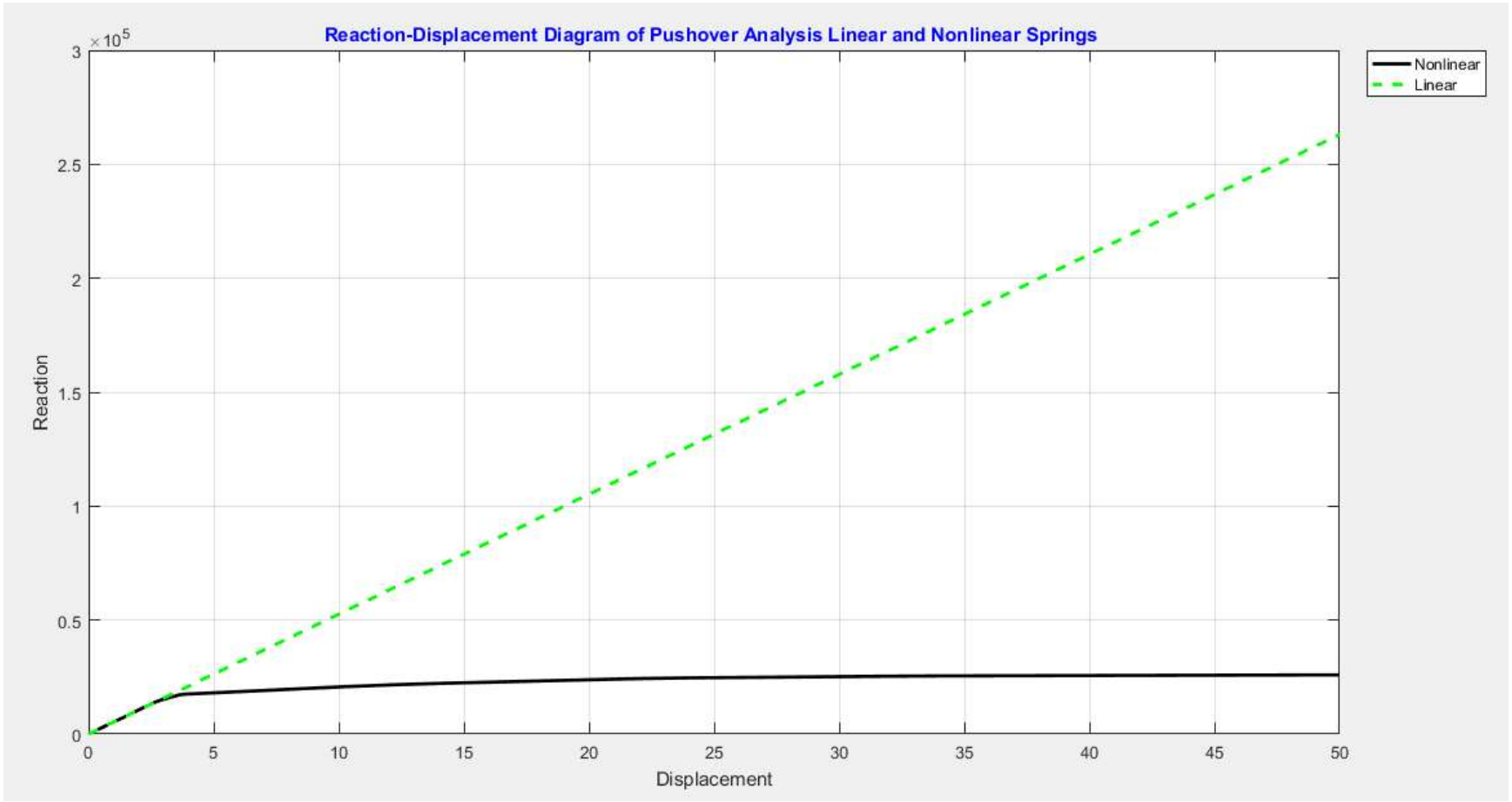
Figure(2) Residual-Increment diagram in MATLAB



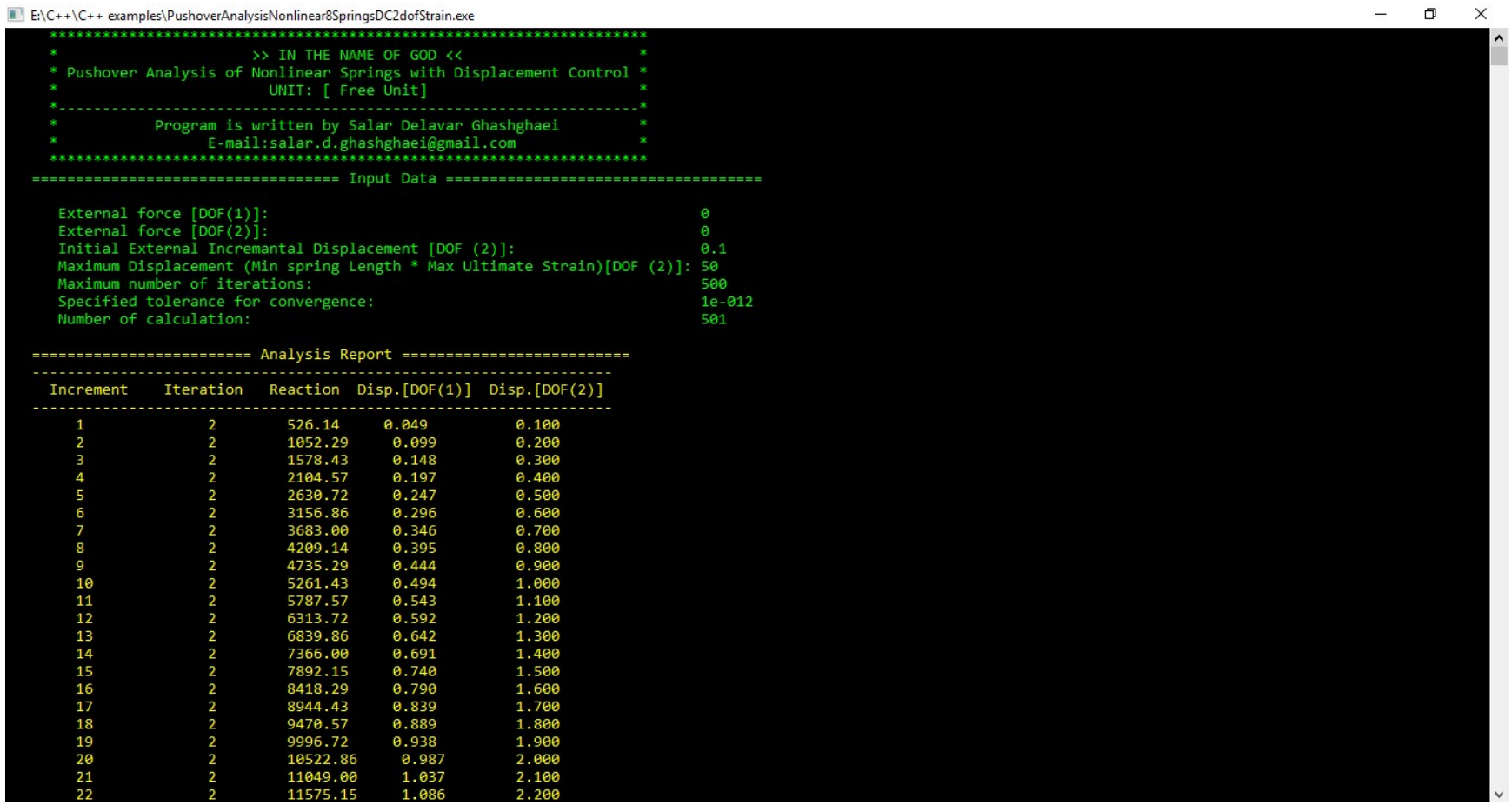
Figure(3) Iteration-Increment diagram in MATLAB



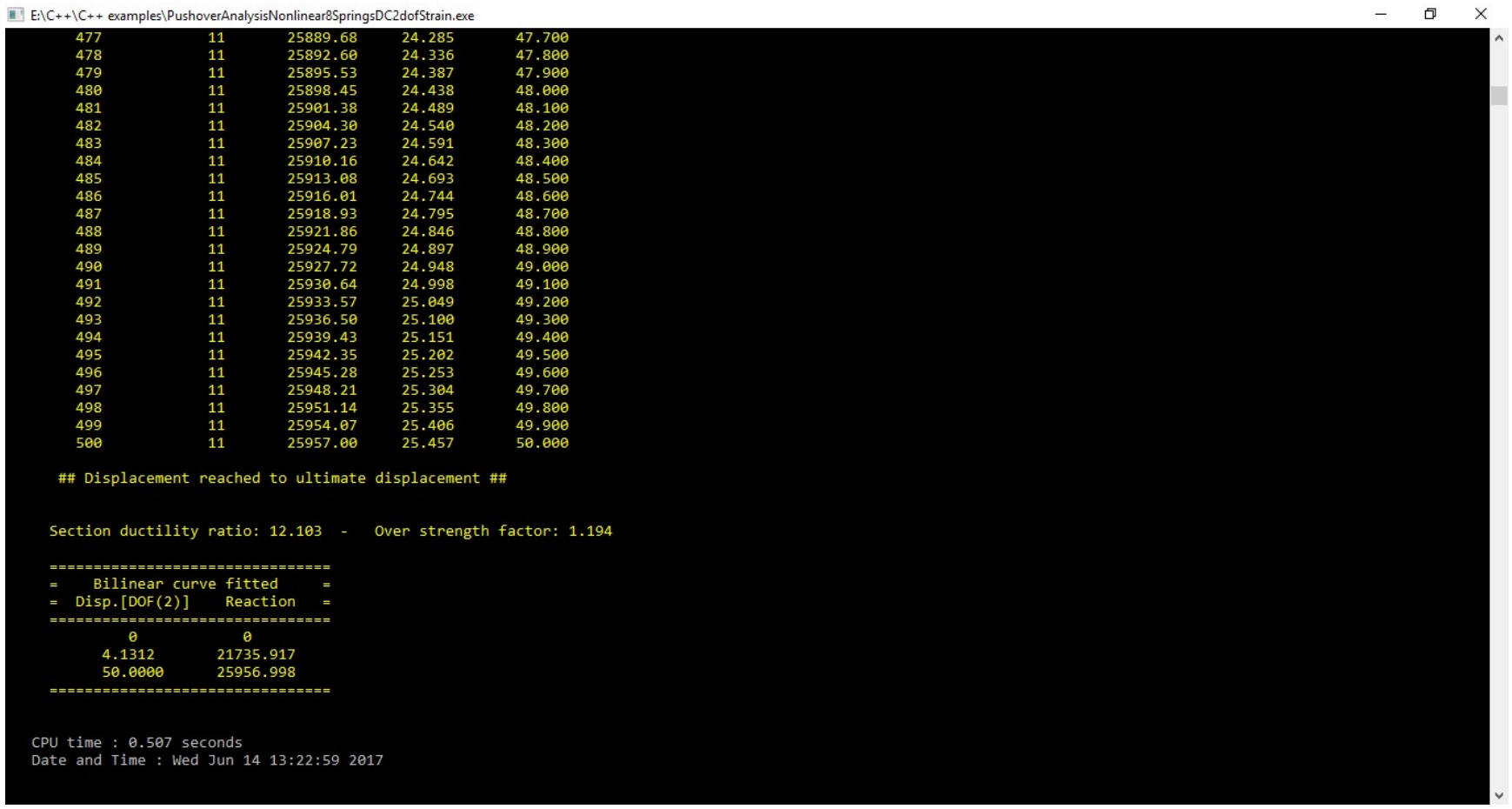
Figure(4) Reaction-Displacement diagram of Nonlinear Springs in MATLAB



Figure(4) Reaction-Displacement diagram of Linear and Nonlinear Springs in MATLAB



Figure(5) Pushover analysis of Nonlinear springs with Displacement control in C++



Figure(6) Pushover analysis of Nonlinear springs with Displacement control in C++