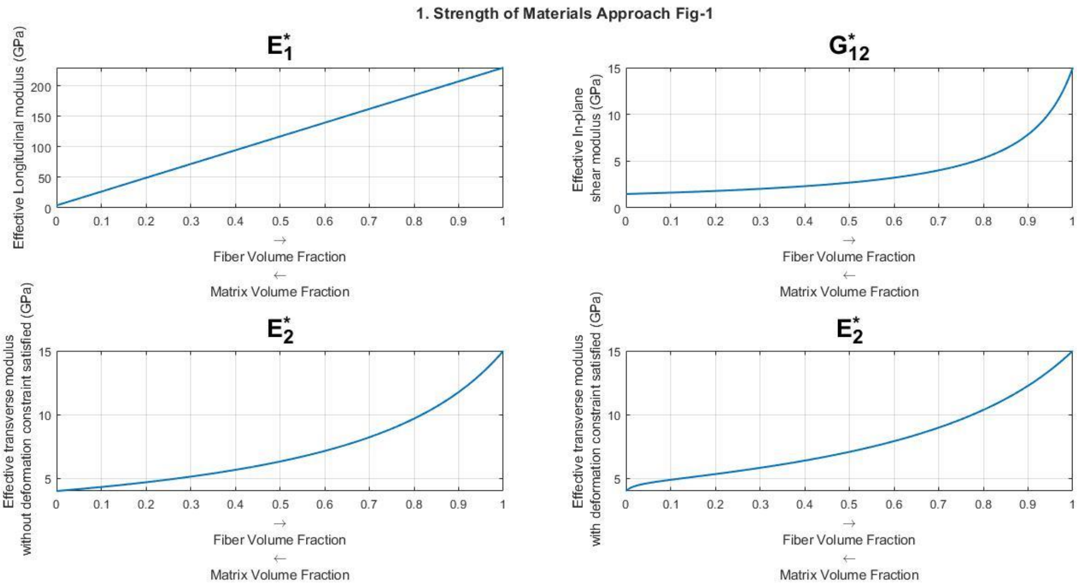
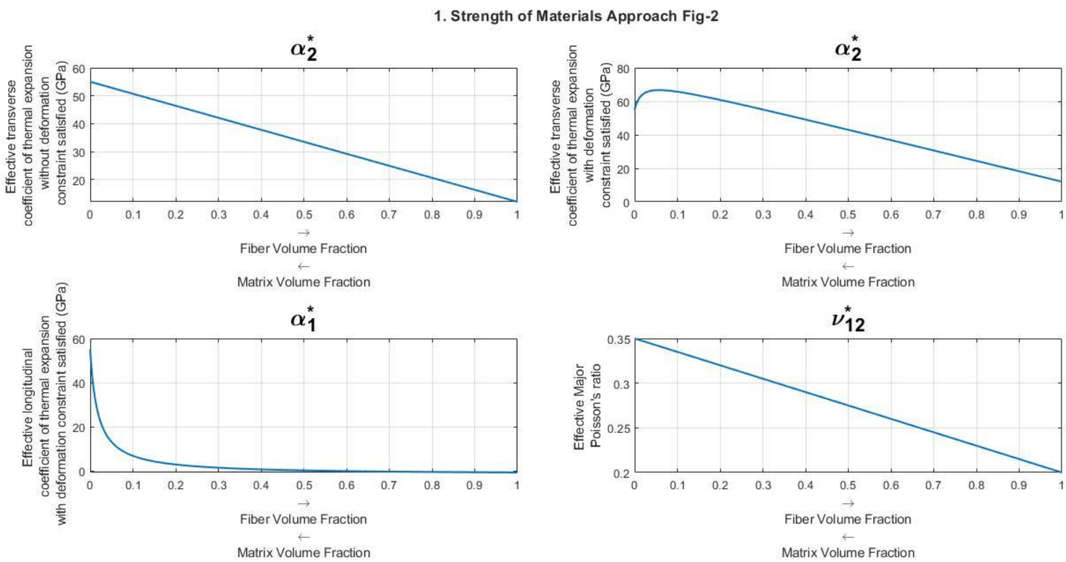
1. Strength of Materials Approach

Plots for different properties versus fiber volume fraction or matrix volume fraction using Strength of materials approach are as below.

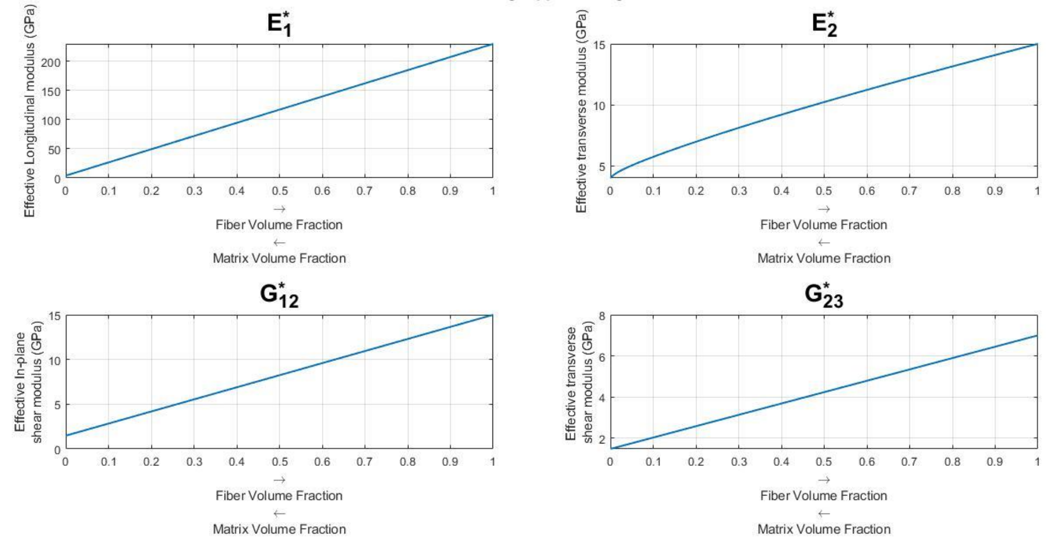




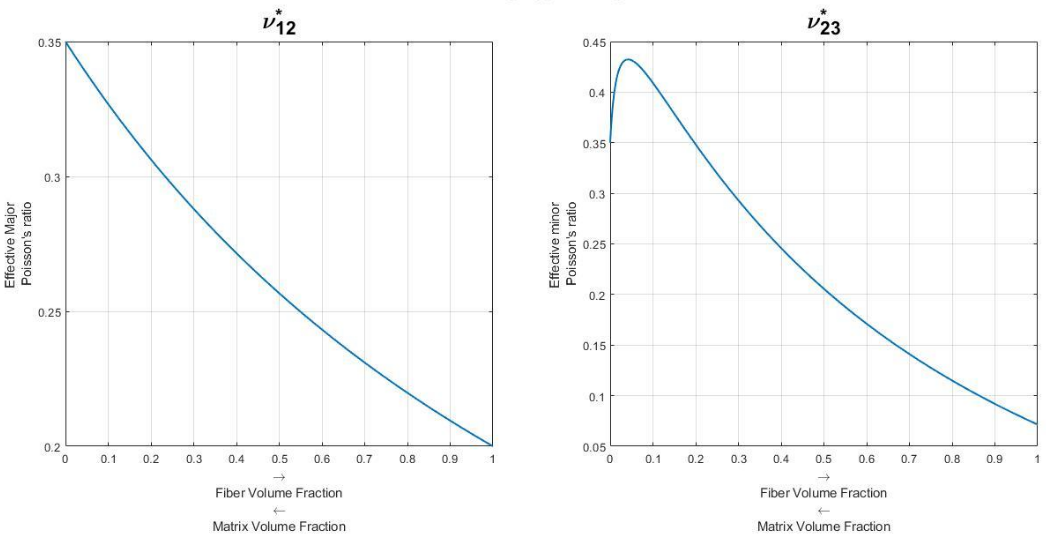
2. Voigt Approximation Method

Plots for different properties versus fiber volume fraction or matrix volume fraction using Voigt Approximation Method are as below.

2. Voigt Approach Fig-1

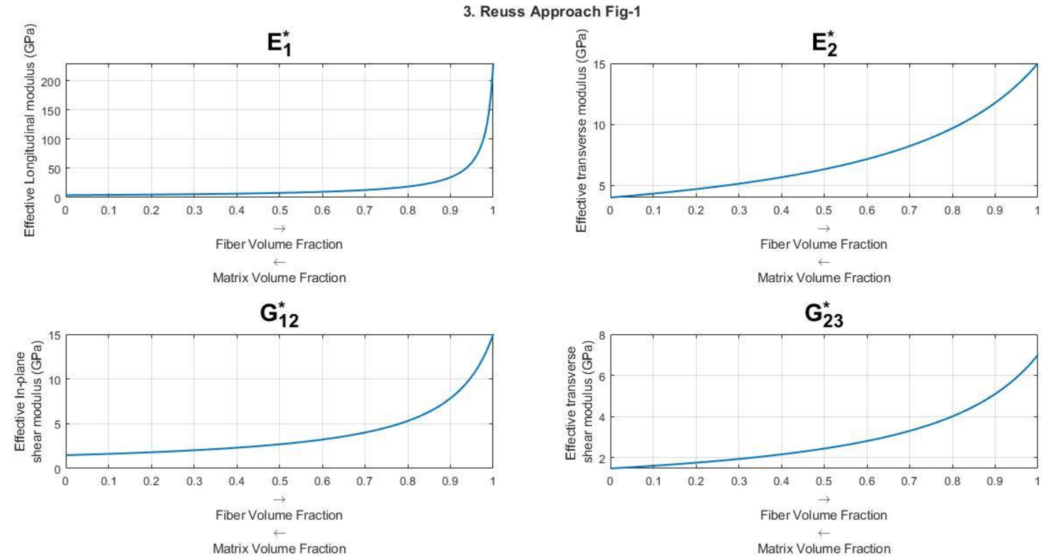


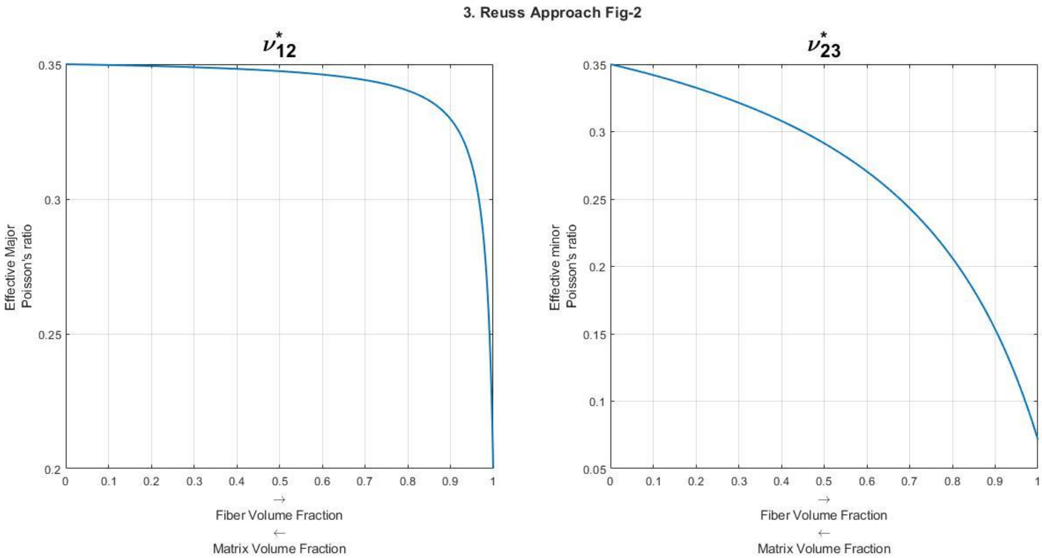
2. Voigt Approach Fig-2



3. Reuss Approximation Method

Plots for different properties versus fiber volume fraction or matrix volume fraction using Reuss Approximation Method are as below.

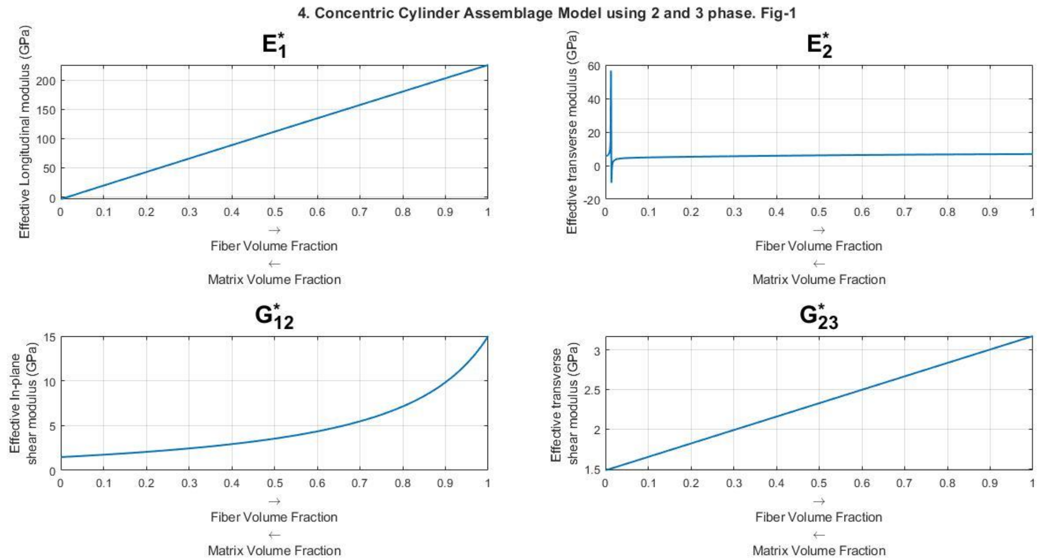


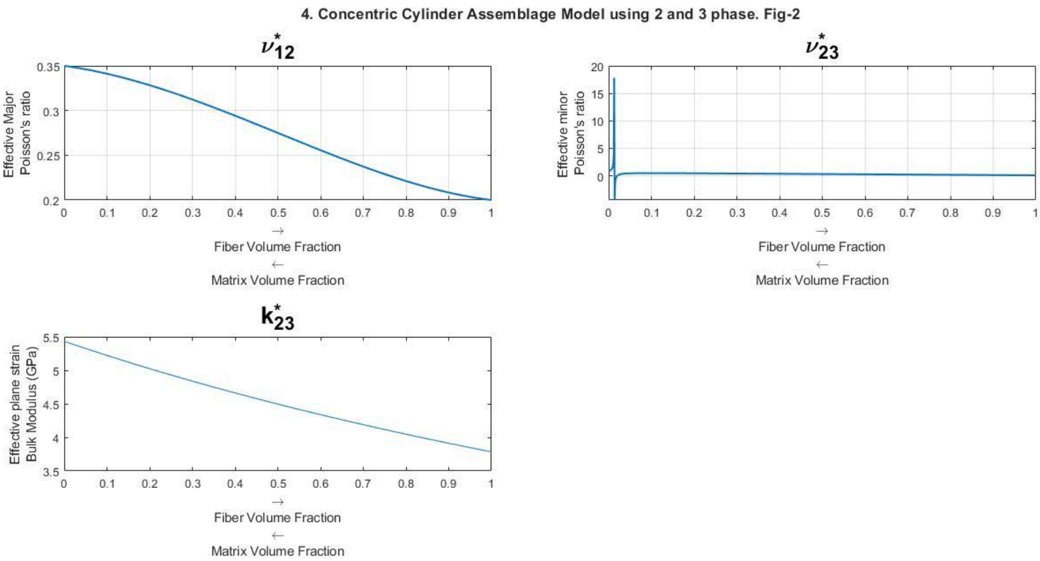


4. Concentric Cylinder Assemblage Model Method

Plots for different properties versus fiber volume fraction or matrix volume fraction using Reuss Approximation Method are as below.

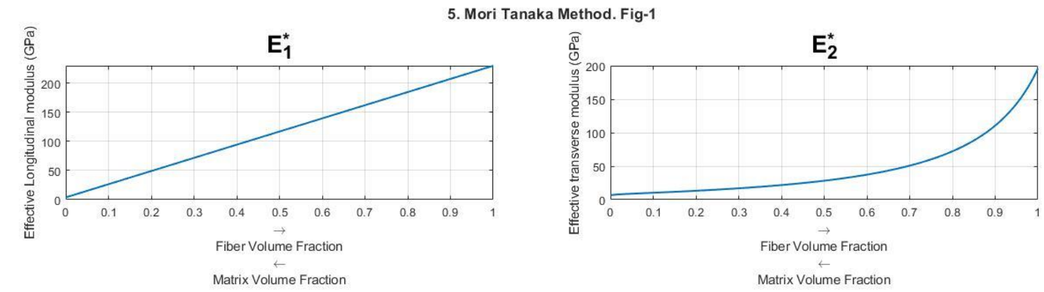
From figure one can conclude that plot for Effective transverse modulus and Effective minor Poisson’s ratio is having some error.

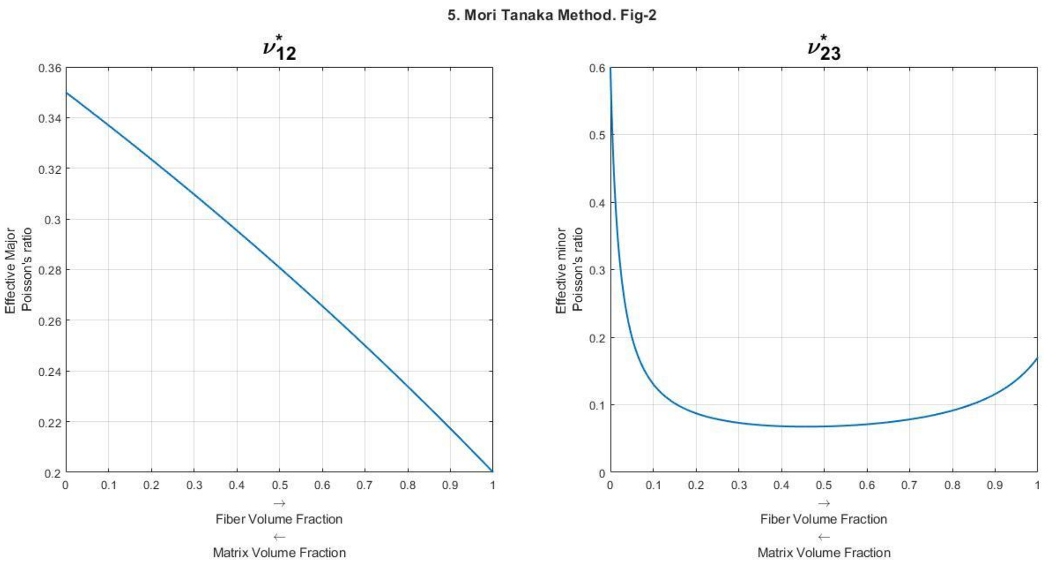




5. Mori Tanaka Method

Plots for different properties versus fiber volume fraction or matrix volume fraction using Strength of materials approach are as below.





6. Self Consistent Method.

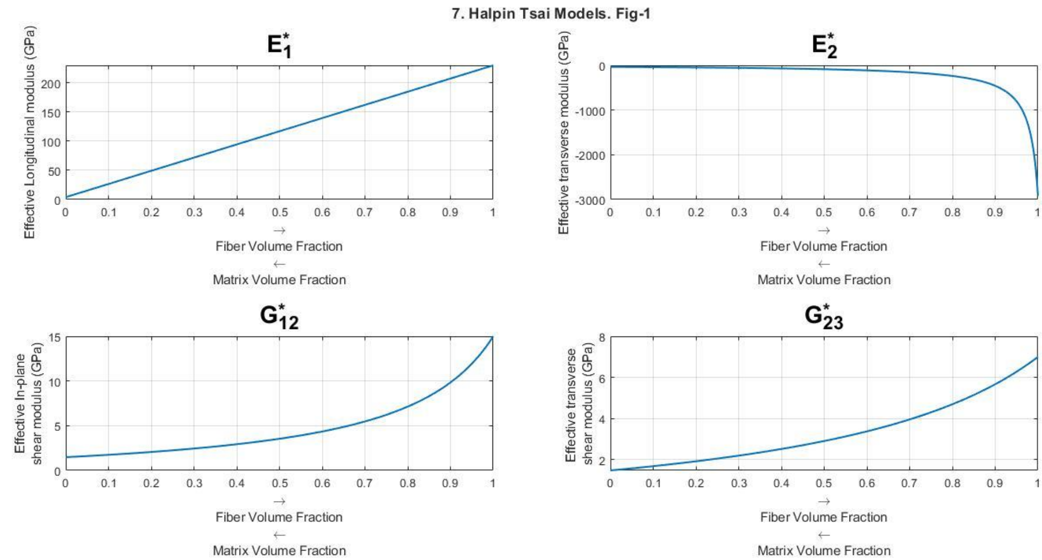
I have tried solving using below program but it gives all complex roots except very few, so I left it.

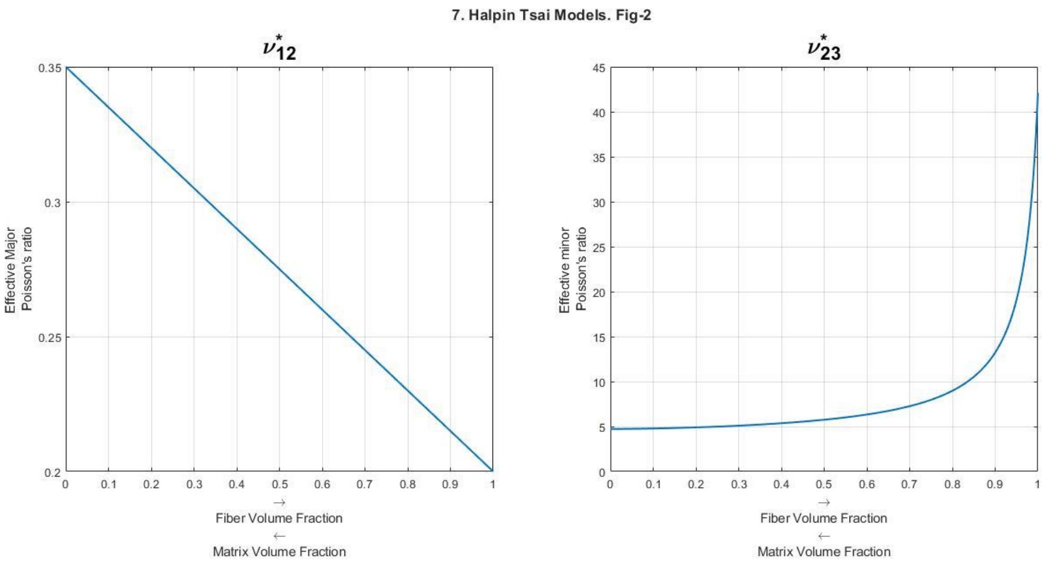
```
clc;    clear all;  close all;  format compact
my_data_composite
%%6. Self Consistent Approach
fprintf('6. Self Consistent Approach')
n=1;
kf = (1/G23 - 4/E2 + 4*mu12^2/E1)^(-1); lf = 2*kf*mu12;
nf = E1 + 4*kf*mu12^2;
mf = G23;    pf = G12; kf = 1/E2-mf; lf = mu12/E1;  nf = 1/E1;
km = (1/Gm - 4/Em + 4*mum^2/Em)^(-1); lm = 2*km*mum;
nm = Em + 4*kf*mum^2;  mm = Gm;    pm = Gm;
km = 1/Em-mm; lm = mum/Em;  nm = 1/Em;
syms m_st positive

for i = 0:0.01:1
    Vf(n) = i; %Fiber Volume Fraction
    Vm(n) = 1-Vf(n);    %Matrix Volume Fraction
    eqn1 = Vf(n)*kf/(kf+m_st) + Vm(n)*km/(km+m_st) == 2*Vf(n)*mm/(mm-m_st) + 2*Vm(n)*mf/(mf-m_st);
    solv =(solve(eqn1,m_st,'Real',true))

    n=n+1;
end
```

7. Halpin Tsai Models.

Plots for different properties versus fiber volume fraction or matrix volume fraction using Halpin Tsai models are as below.

Observing plot it can be concluded that plots of Effective transverse modulus and Effective minor poisson’s ratio seems to have some error.



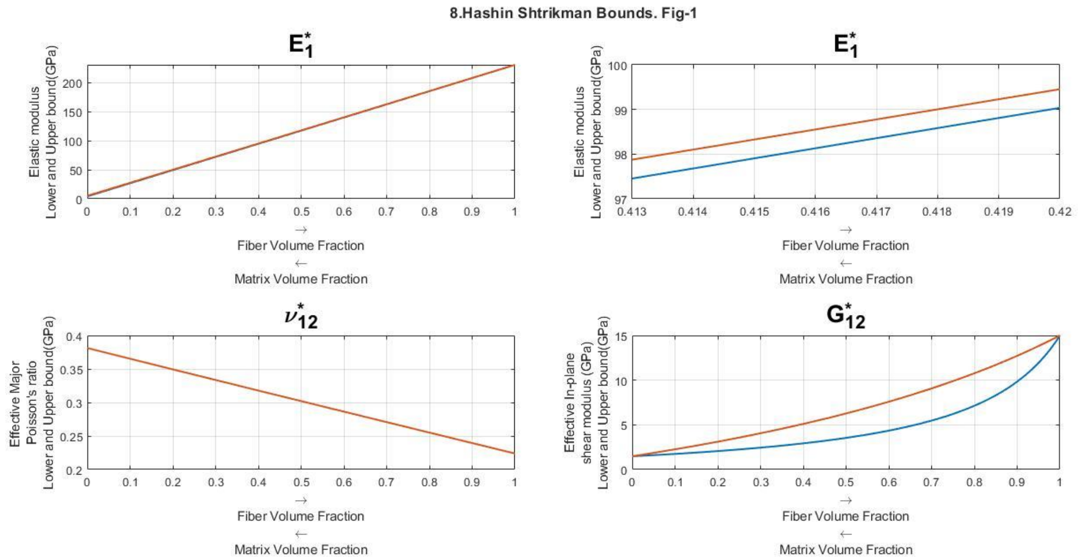


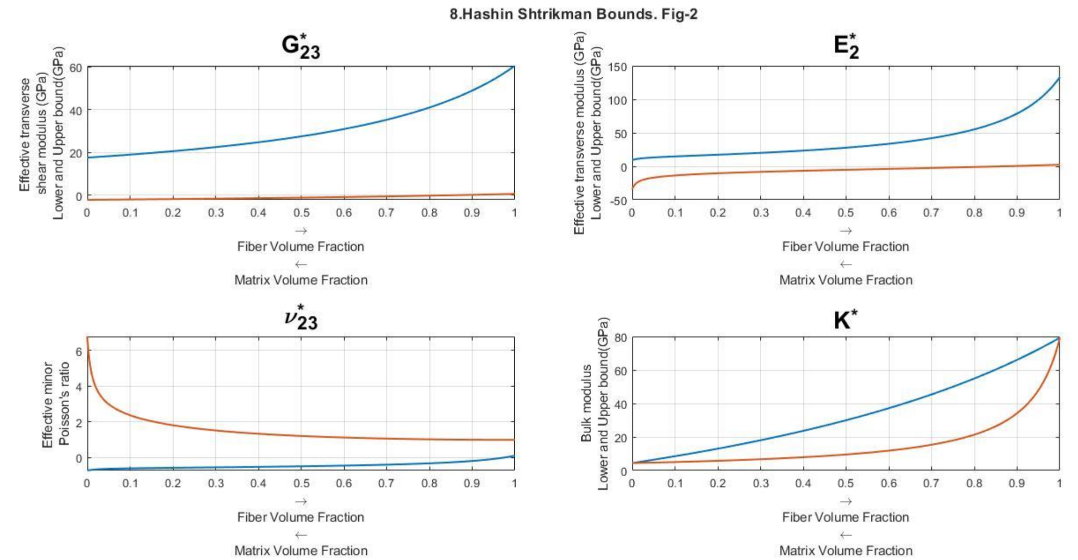
8. Hashin-Strikman Bounds.

Plots for different properties versus fiber volume fraction or matrix volume fraction using Hashin-Strikman bounds are as below.

In second figure plot of Effective modulus is zoomed to see there is fine difference between upper and lower bounds.

Observing plot it can be concluded that plots of Effective modulus, Effective major poisson's ratio don't show much difference on upper and lower bounds and Effective transverse shear modulus seems to have some error.



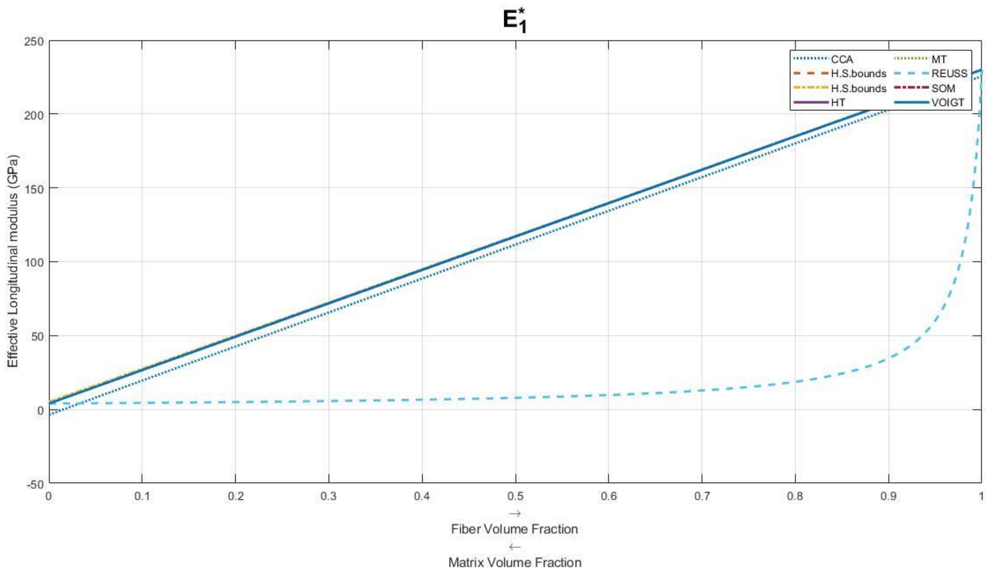


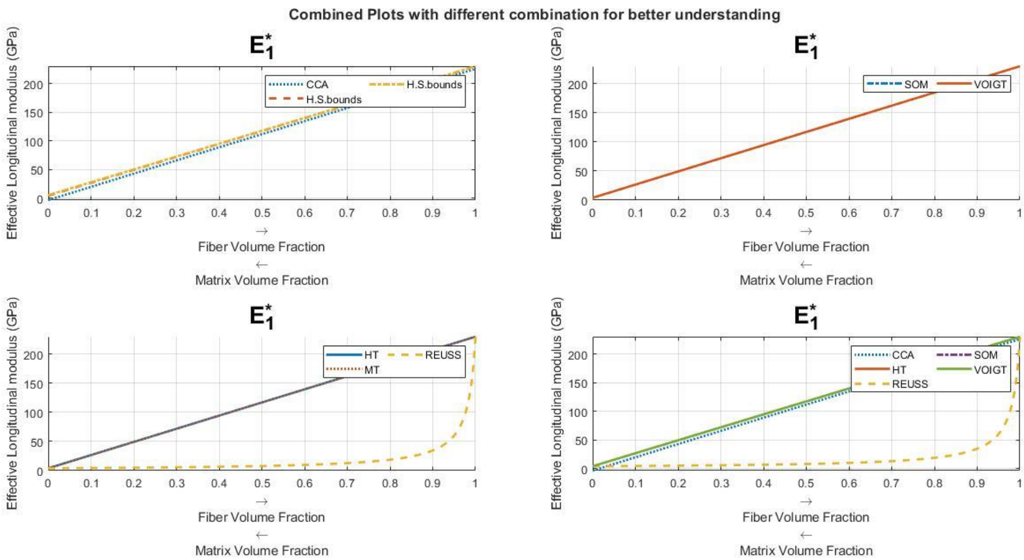
• Combined Plots for each elastic constants.

Now when we have calculated all possible elastic constants with different method, we will plot it on same plot to observe it more, to get clear picture of it. Also due to many methods available separate plots with different combination os method is plotted to get clear idea. Here SOM is the abbreviated form of Strength of materials approach, CCA is the abbreviated form of Concentric Cylinder Assemblage Model, MT is the abbreviated form of Mori Tanaka Method, HT is the abbreviated form of Halpin Tsai Equations and HS is the abbreviated form of Hashin Shtrikman Bounds.

1. Effective Longitudinal Modulus (E_1^*).

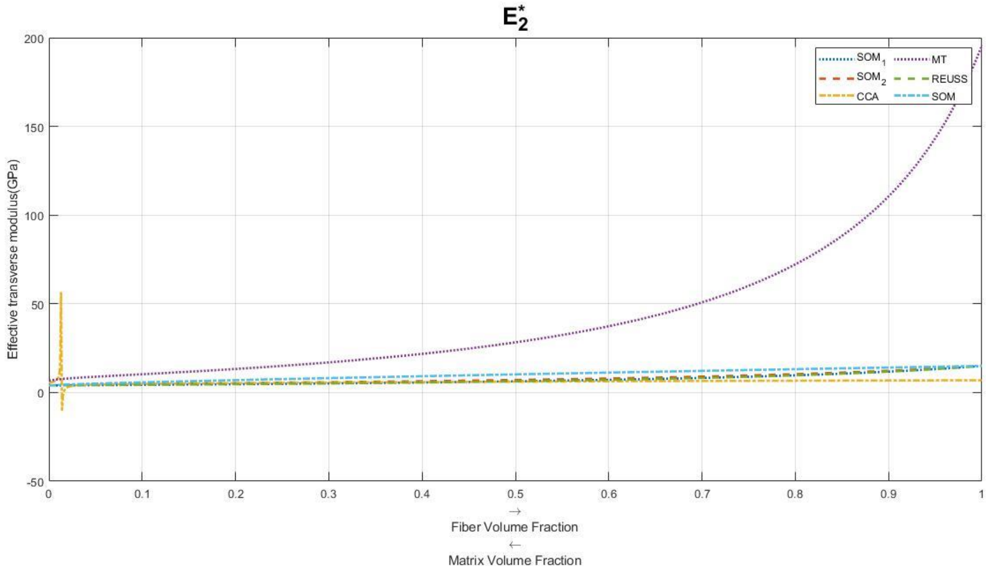
As we can observe all methods give almost similar results, But approximation given by Reuss method deviates large, It may due to some instability of model so clearly we will discard results by Reuss method.

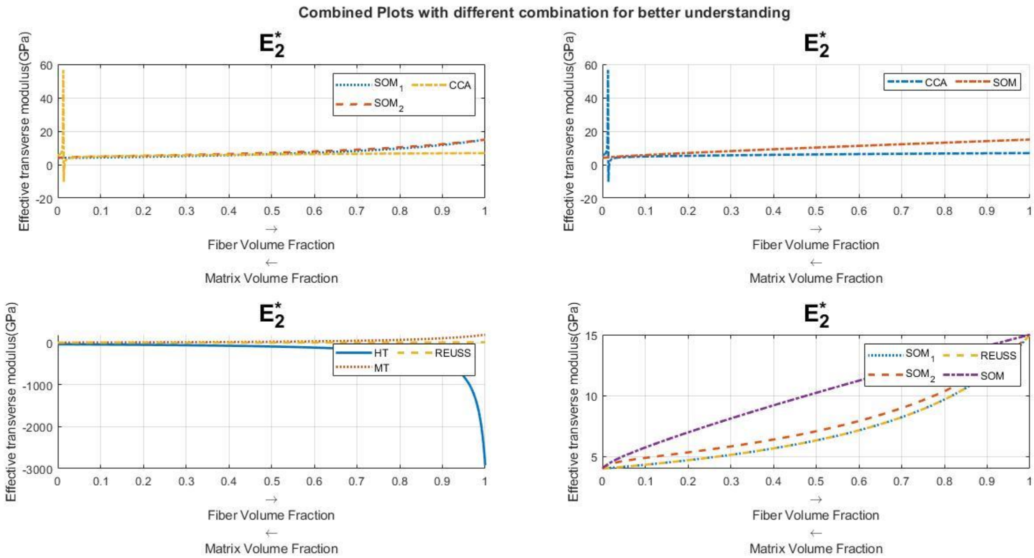




2. Effective Longitudinal Modulus ($\boldsymbol{E}_2^*$).

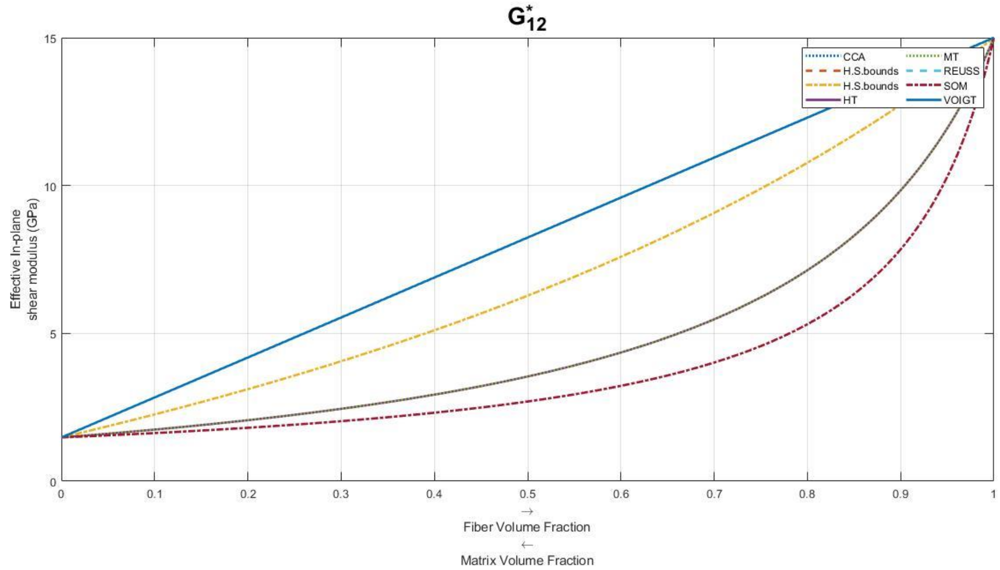
As we can observe all methods give almost similar and correct results, for some range of values. By use of Mori Tanaka it deviates very high and we can discard that result.



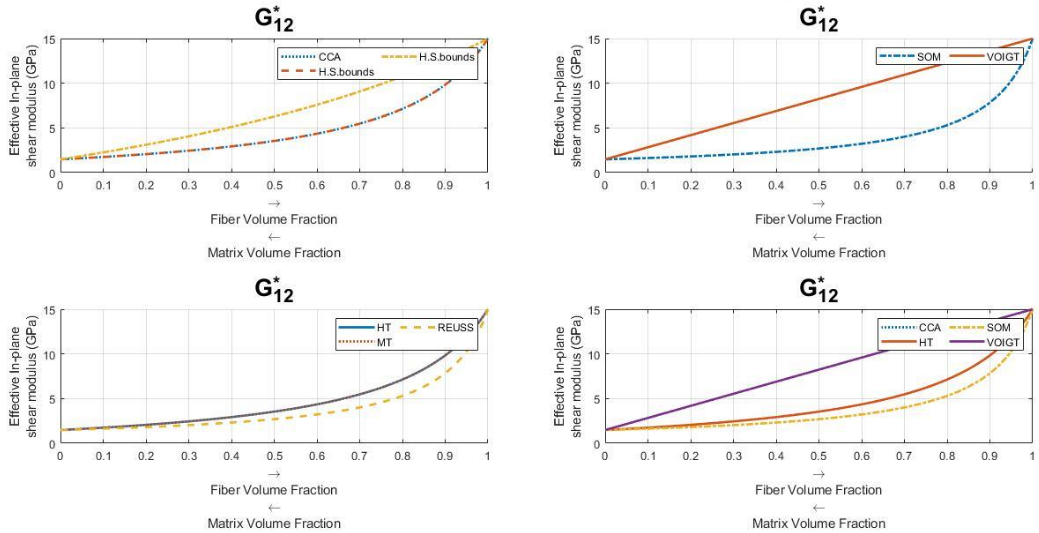


3. Effective in-plane shear Modulus (G_{12}^{*}).

As we can observe all methods give similar results every method deviates with another.

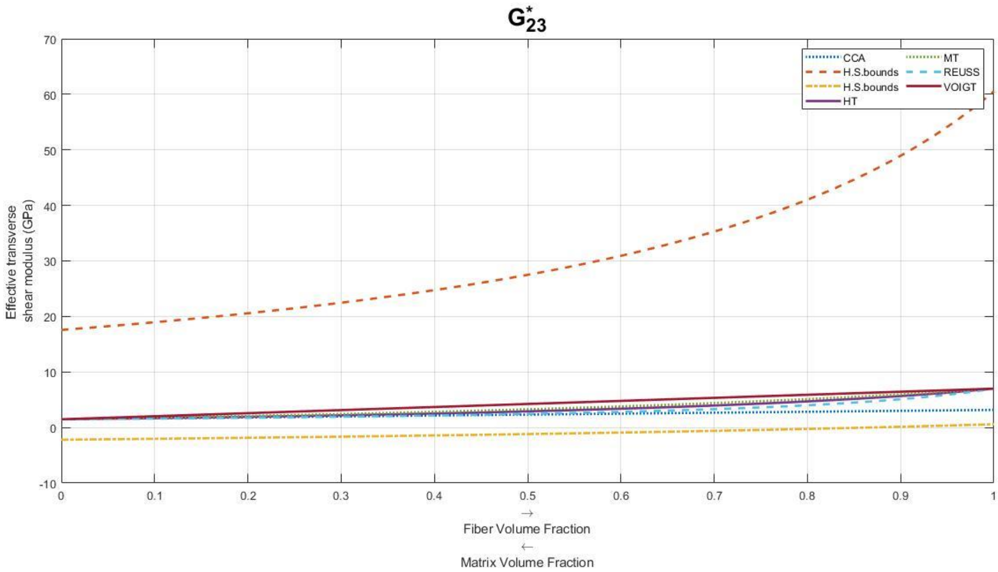


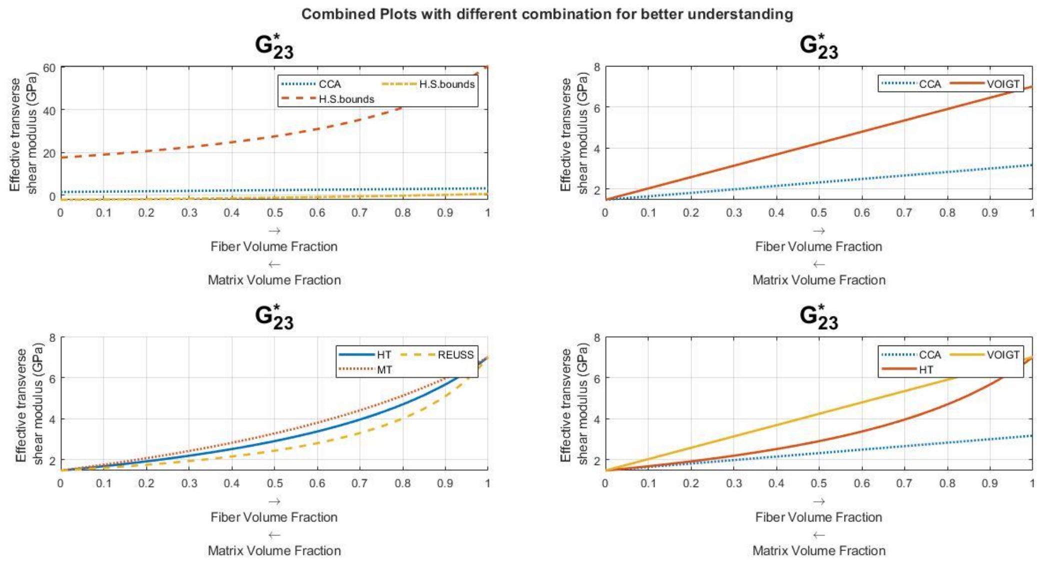
Combined Plots with different combination for better understanding



4. Effective in-plane shear Modulus (G_{23}^{*}).

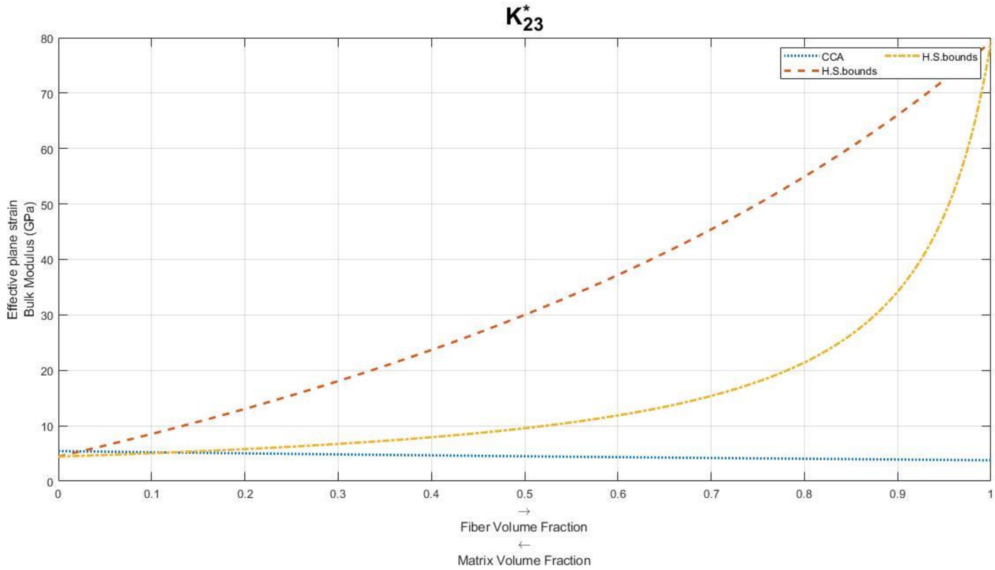
As we can observe all methods give similar results every method with some deviation with another. While Hashin Strikman bounds deviates very much definitely seems absurd.





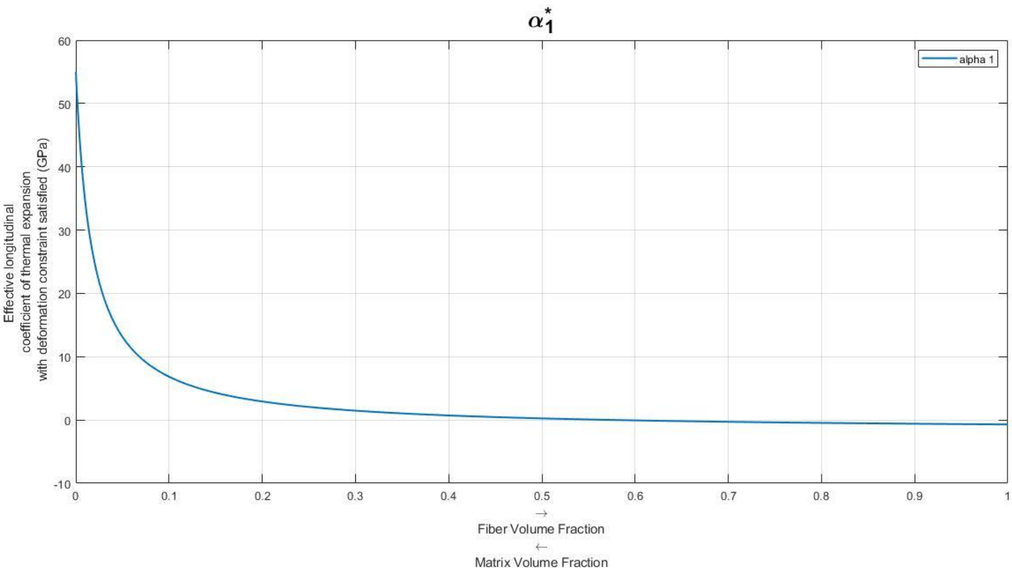
5. Effective plane strain Bulk Modulus (K_{23}^*).

Very few methods are available to calculate this modulus. Results are as follows.



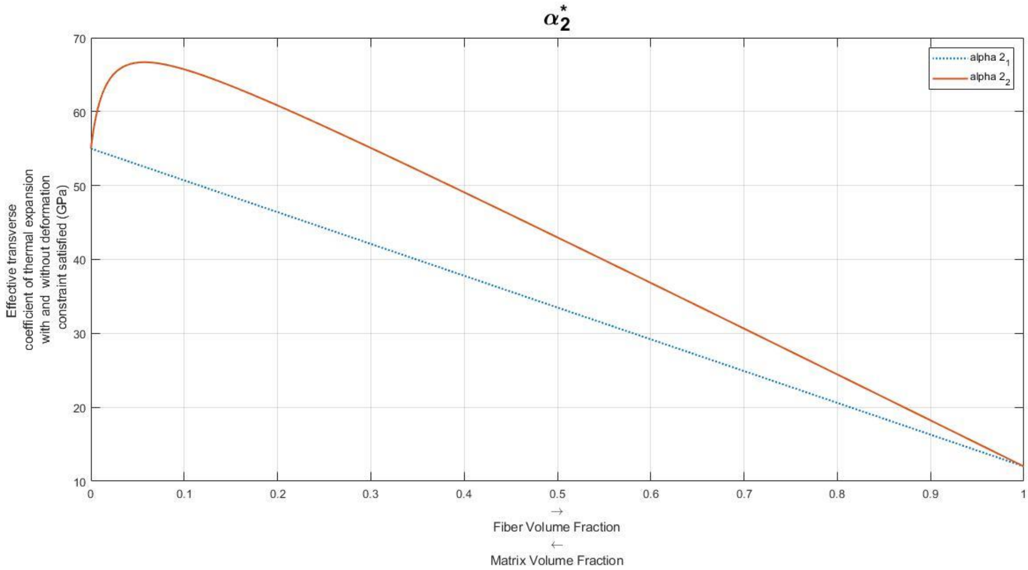
6. Effective longitudinal coefficient of thermal expansion. (α_1^*).

We have only one method to calculate this coefficient i.e Strength of materials approach. Result are as below.



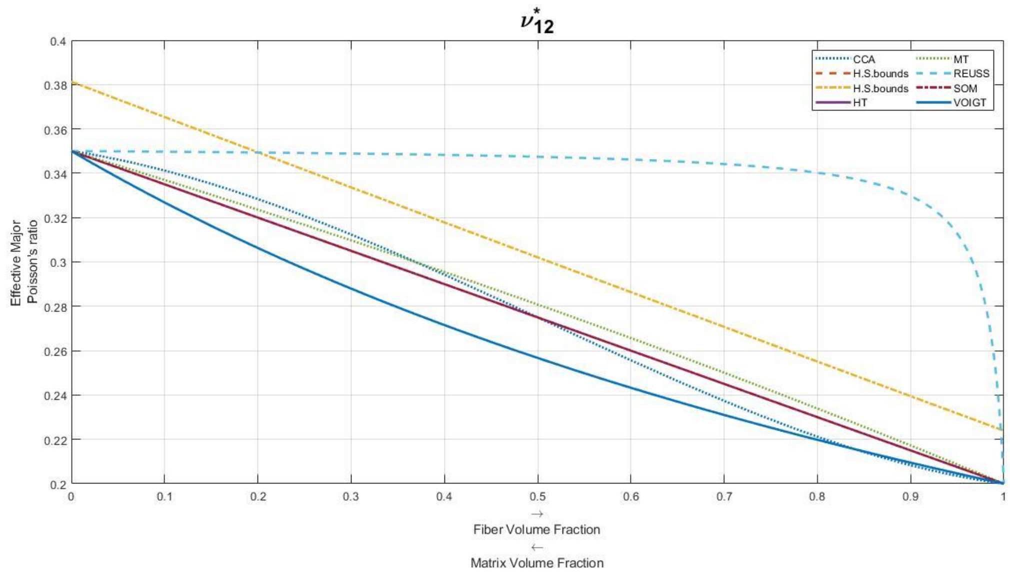
7. Effective transverse coefficient of thermal expansion. (α_2^*).

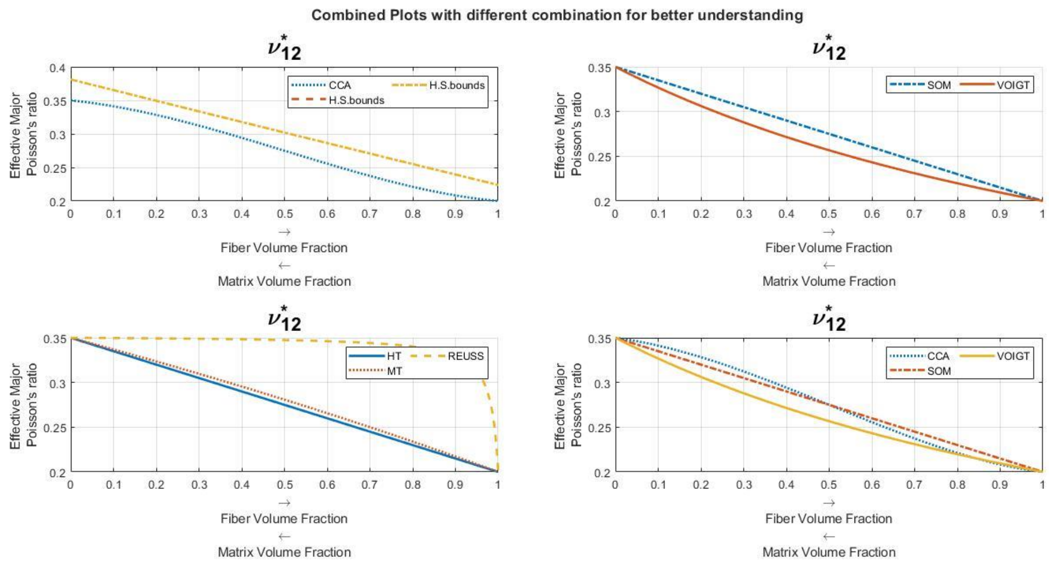
We have only one method to calculate this coefficient i.e Strength of materials approach. Result are as below using with and without deformation consideration.



8. Effective major poisson's ratio (ν_{12}^{*}).

We have calculated major poisson's ratio using different available approach. All methods give similar results except Reuss with this method results are very stiffer in the beginning then it drops suddenly which seems to be absurd and we can discard this result.





9. Effective minor poisson's ratio (ν_{23}^{*}).

We have calculated major poisson's ratio using different available approach. Halpin Tsai model gives absurd impossible value so we can discard that result. For all other method it gives similar results except for some value of volume fractions.