Project Report

AE681A

COMPOSITE MATERIALS

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CONTENTS

QUESTION

Given Material Properties of Fiber and Matrix

Material ID – 7

Fibre type	E-glass 21xK43 Gevetex
Longitudinal modulus, E_1 (GPa)	80
Transverse modulus, E_2 (GPa)	80
In-plane shear modulus, G_{12} (GPa)	33.33
Major Poisson's ratio, ν_{12}	0.2
Transverse shear modulus, G_{23} (GPa)	33.33
Longitudinal thermal coefficient, α_1 (10^{-6} /°C)	4.9
Transverse thermal coefficient, α_2 (10^{-6} /°C)	4.9

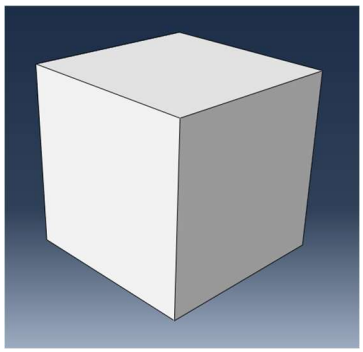
Matrix type	MY750/HY917/ DY063 epoxy
Modulus, E_m (GPa)	3.35
Poisson's ratio, ν_m	0.35
Thermal coefficient, α_m (10^{-6} /°C)	58

Volume Fraction – 0.5

Load – Displacement

ABAQUS MODELING

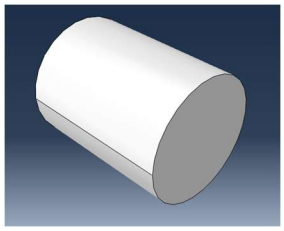
Matrix:



Dimensions:

Length = breadth = Height = 2 mm

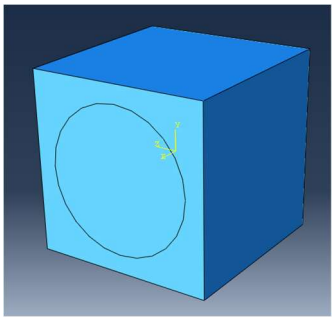
Fibre:



Dimensions:

Length – 2 mm
Volume fraction = 0.5
Thus, Radius = $\frac{2}{\sqrt{2\pi}}$ = 0.79788456 mm

Assembly:



Merge the two objects in the assembly such that the intersecting boundaries are retained

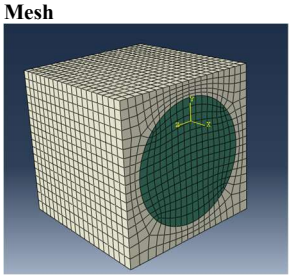
Assigning properties:
Fibre:
E1 = 80000
E2 = 80000
E3 = 80000
Nu12 = 0.2
Nu13 = 0.2
Nu23 = 0.2

G12 = 33330
G13 = 33330
G23 = 33330
Alpha1 = 4.9*10^-6
Alpha2 = 4.9*10^-6

Matrix:

E = 3350
Nu = 0.35
Alpha = 58*10^-6

Mesh



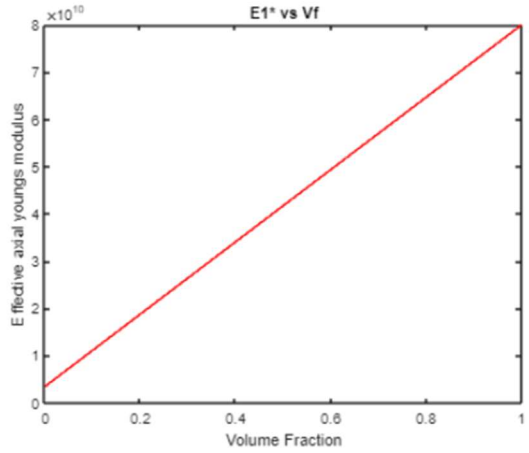
Apply loads to obtain the following outputs (Ref: attached files)

E_fibre11.csv	17-04-2023 21:45	Microsoft Excel C...	292 KB
E_fibre12.csv	20-04-2023 00:30	Microsoft Excel C...	290 KB
E_fibre13.csv	17-04-2023 23:39	Microsoft Excel C...	292 KB
E_fibre22.csv	17-04-2023 21:57	Microsoft Excel C...	292 KB
E_fibre23.csv	19-04-2023 23:40	Microsoft Excel C...	290 KB
E_fibre33.csv	17-04-2023 22:03	Microsoft Excel C...	292 KB
E_matrix11.csv	17-04-2023 21:47	Microsoft Excel C...	271 KB
E_matrix12.csv	20-04-2023 00:31	Microsoft Excel C...	267 KB
E_matrix13.csv	17-04-2023 23:40	Microsoft Excel C...	271 KB
E_matrix22.csv	17-04-2023 21:58	Microsoft Excel C...	271 KB
E_matrix23.csv	19-04-2023 23:54	Microsoft Excel C...	269 KB
E_matrix33.csv	17-04-2023 22:04	Microsoft Excel C...	271 KB
EVOL.csv	16-04-2023 02:35	Microsoft Excel C...	302 KB
EVol_fibre.csv	16-04-2023 18:14	Microsoft Excel C...	69 KB
EVol_matrix.csv	16-04-2023 18:15	Microsoft Excel C...	64 KB

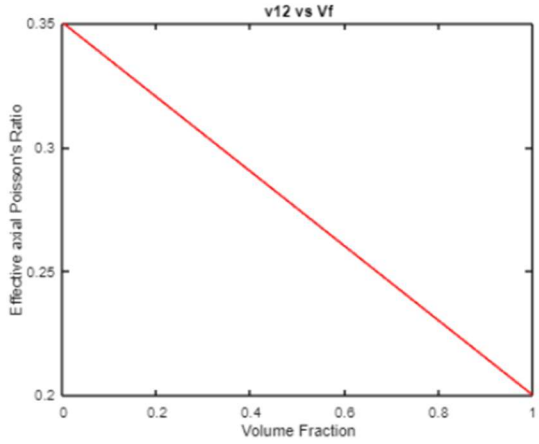
OBSERVATIONS

1. **Strength of Materials Approach:**

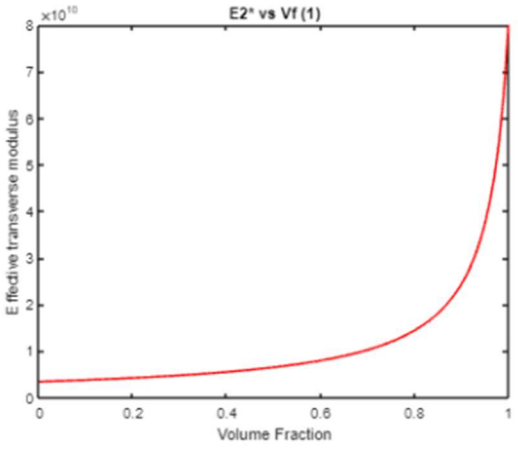
E_1 vs V_f

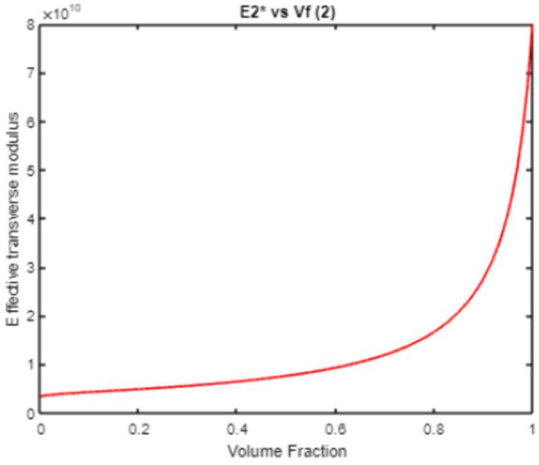


V_{21} vs V_f

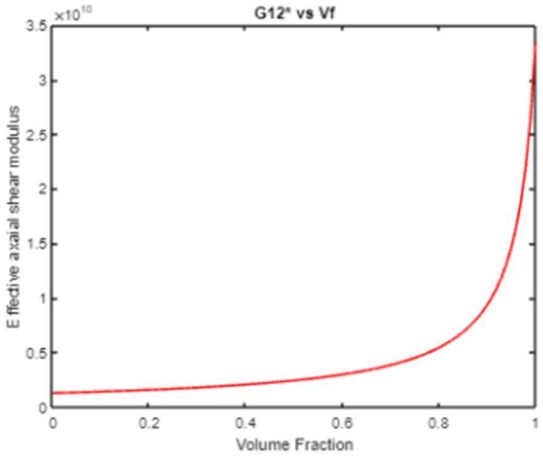


E_2 vs V_f (1. when deformation in direction 1 is not considered and 2. when deformation in direction 1 is also considered)

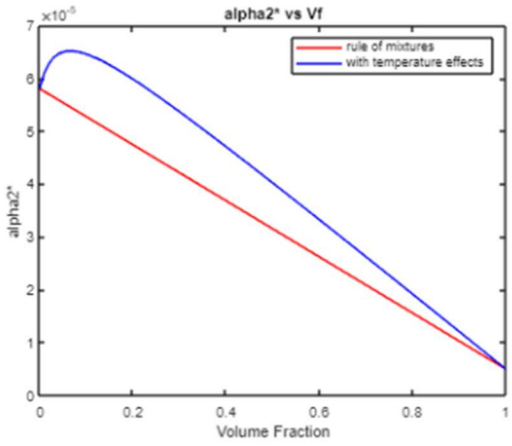


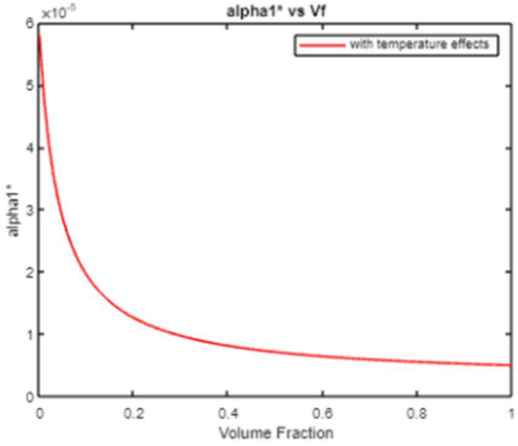


G_{12} vs V_f



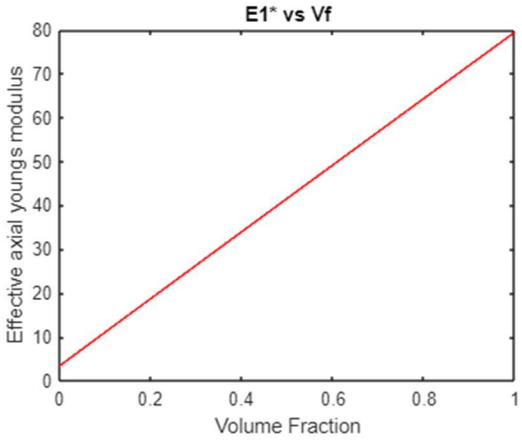
Alpha vs V_f



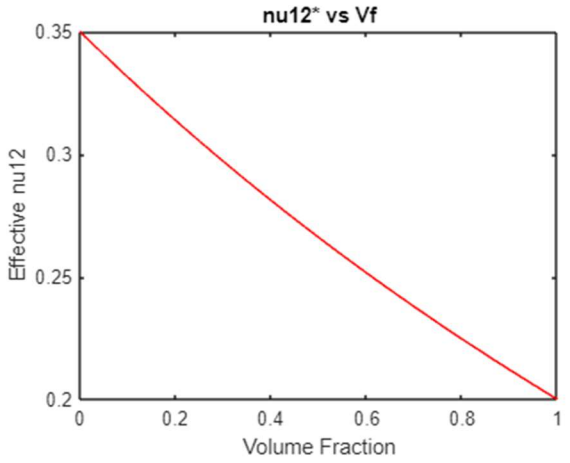


2. <u>CCA:</u>

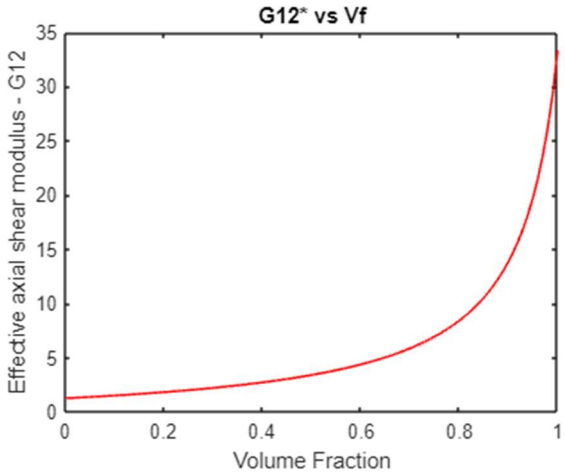
E_1 vs V_f



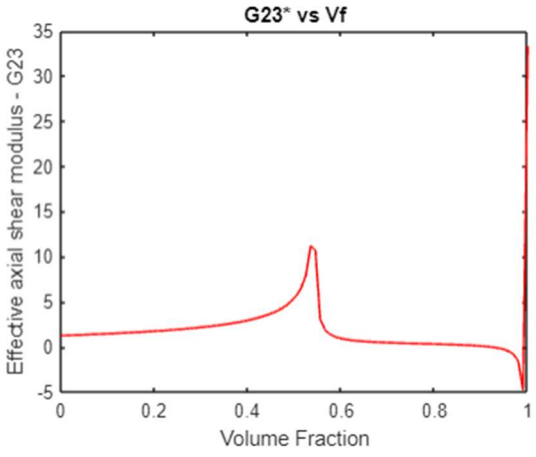
V_{21} vs V_f



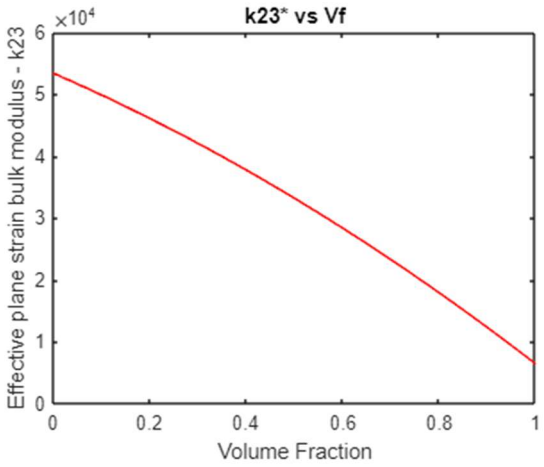
G_{12} vs V_f



G_{23} vs V_f (3 phase model)

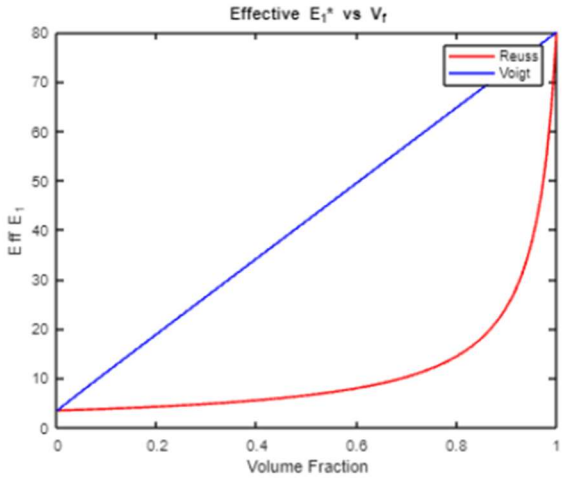


K_{23} vs V_f

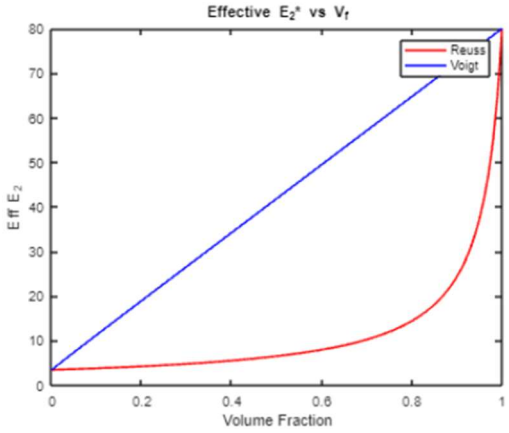


3. Voigt and Reuss Approximation

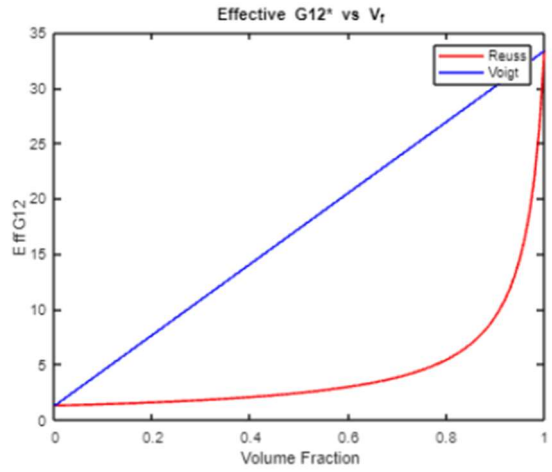
E_1 vs V_f



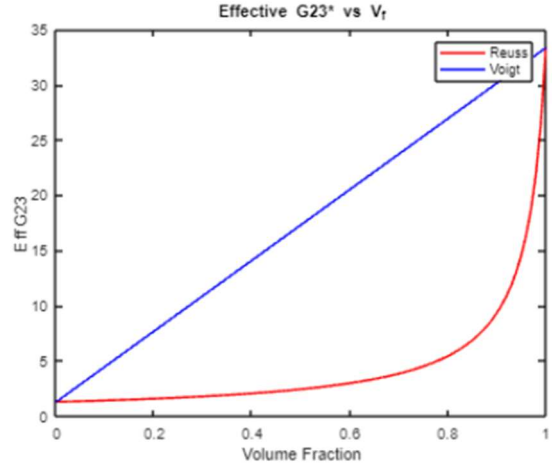
E_2 vs V_f



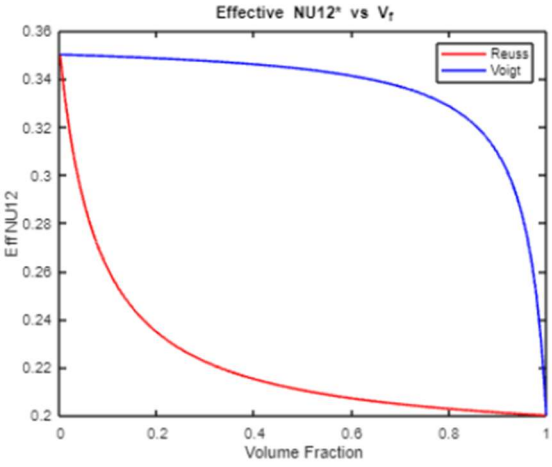
G_{12} vs V_f



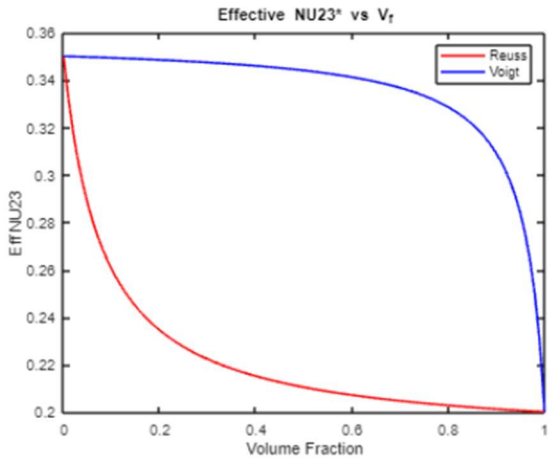
G_{23} vs V_f



v_{12} vs V_f

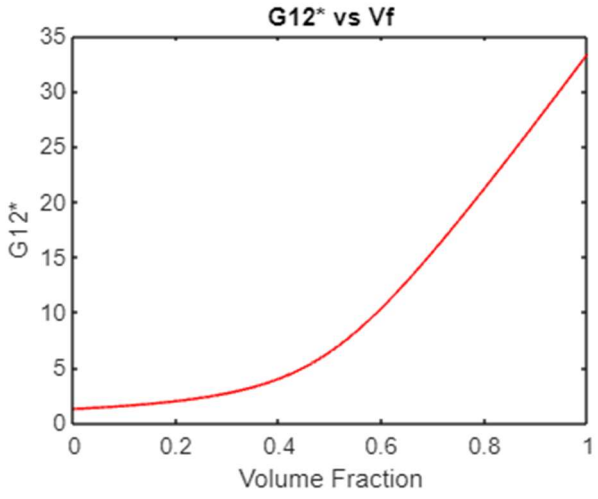


v_{23} vs V_f

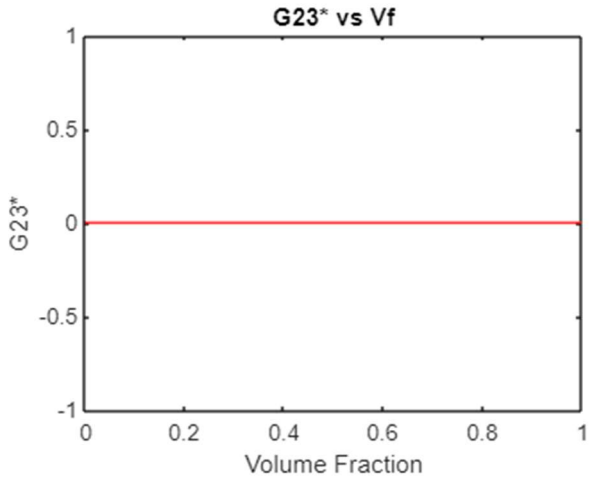


4. SELF CONSISTENT METHOD

G_{12} vs V_f



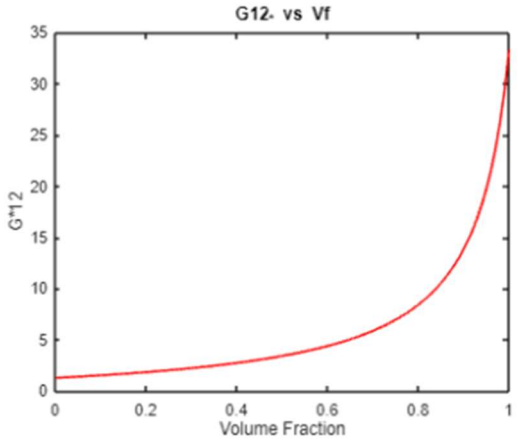
G_{23} vs V_f



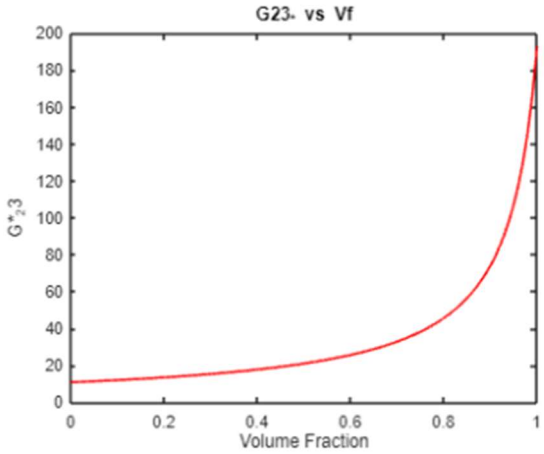
Since, G_{23} = 0 throughout in this method, other properties which are dependent on G_{23} through the implicit relations will also be inaccurate. Hence not included here.

5. MORI TANAKA METHOD

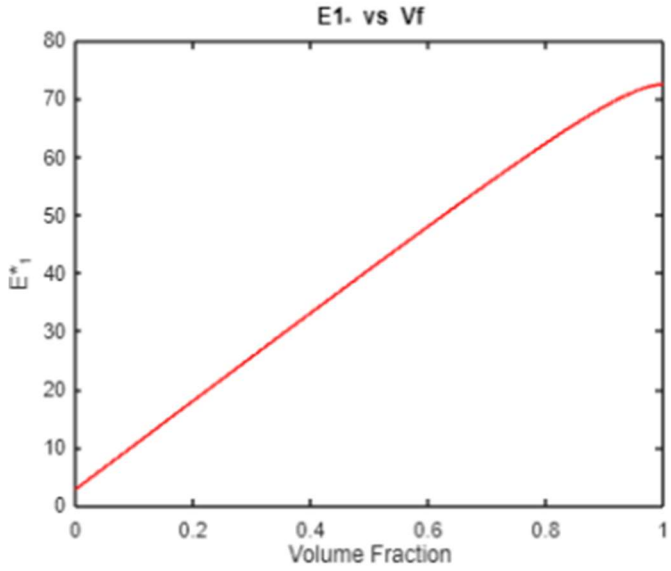
G_{12} vs V_f



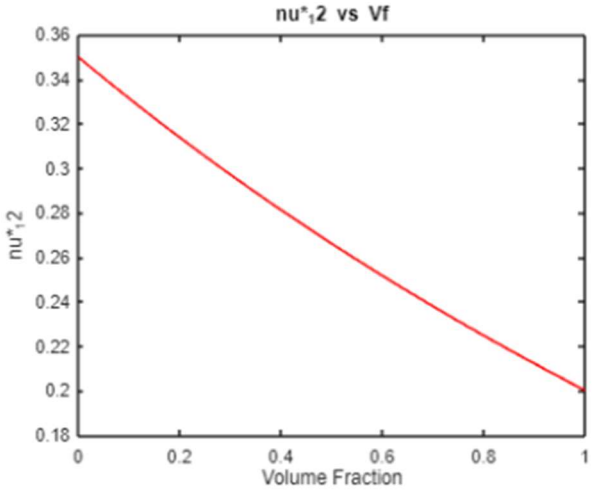
G_{23} vs V_f



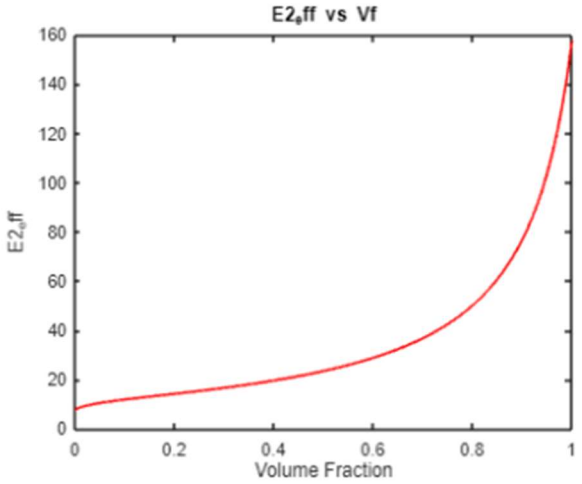
E_1 vs V_f



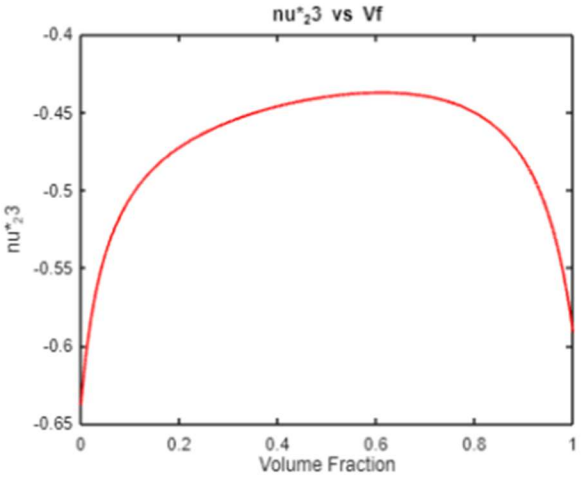
v_{12} vs V_f



E_2 vs V_f

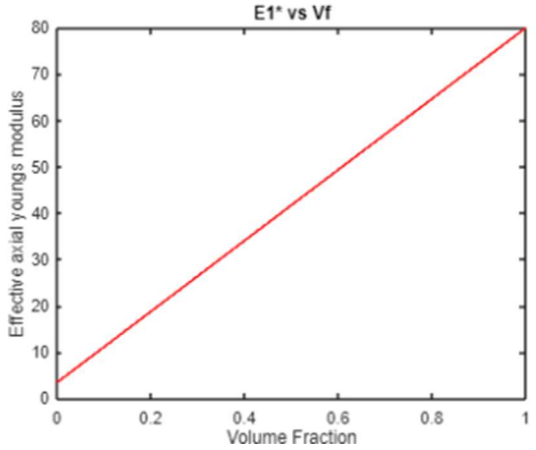


v_{23} vs V_f

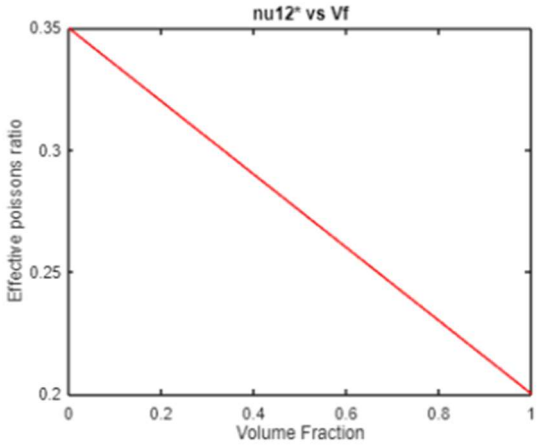


6. Halpin Tsai Method

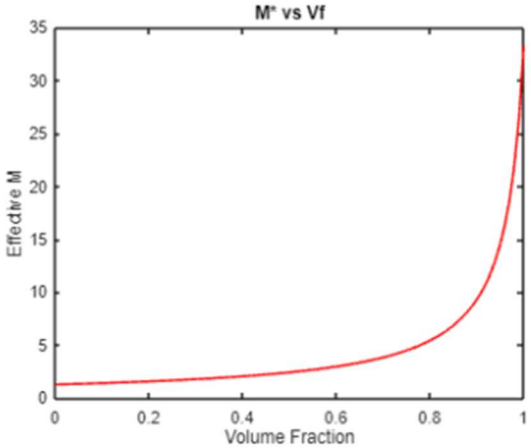
E_1 vs V_f



v_{12} vs V_f

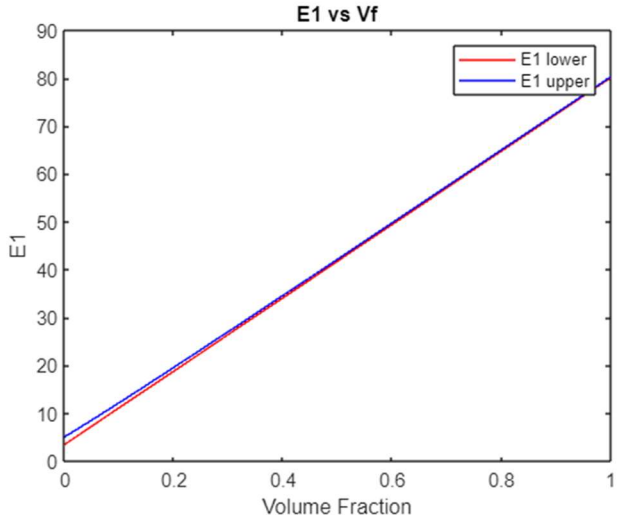


M vs V_f

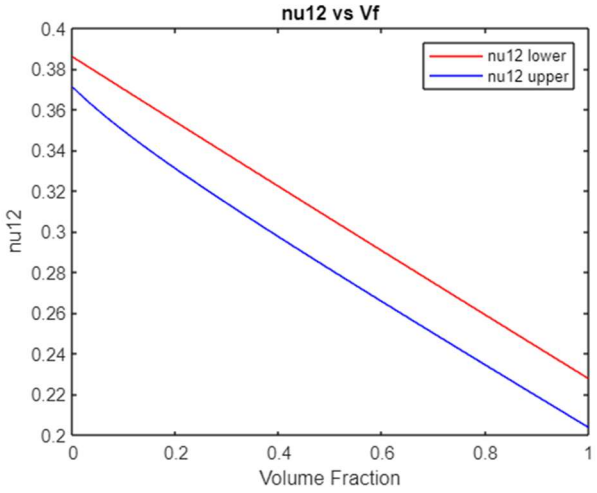


7. Hashin Strickman Bounds

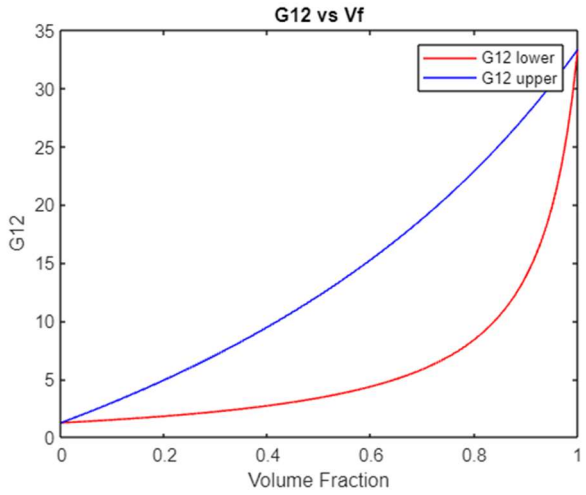
E_1 vs V_f



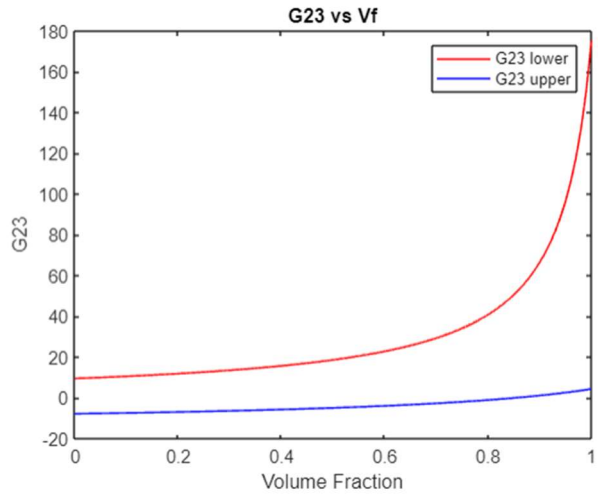
v_{12} vs V_f



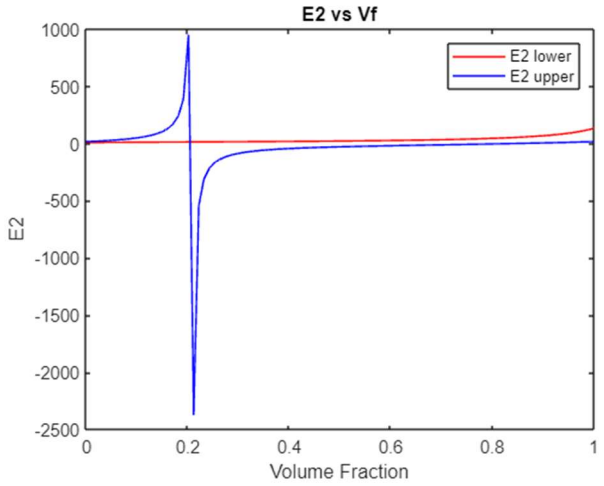
G_{12} vs V_f



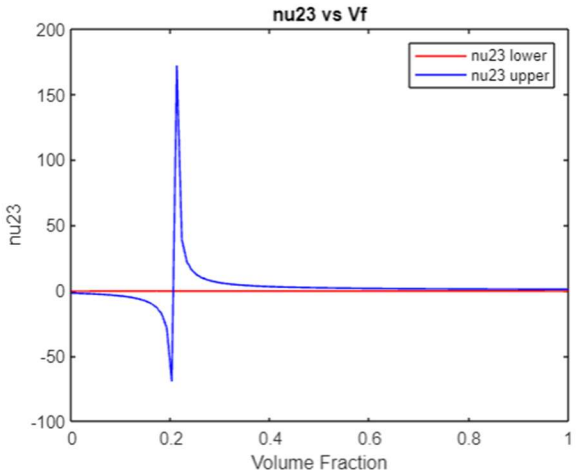
G_{23} vs V_f



E_2 vs V_f



v_{23} vs V_f


nu23 vs Vf
nu23 lower
nu23 upper
nu23
Volume Fraction
200
150
100
50
0
-50
-100
0
0.2
0.4
0.6
0.8
1

8. **Hills Concentration Factor Approach**

```
HSS_E1 =
     4.160112628995121e+01
HSS_E2 =
     1.107430476266366e+01
HSS_E3 =
     1.131757192547568e+01
HSS_G12 =
     1.857225654253460e+01
HSS_G13 =
     1.857702192916757e+01
HSS_G23 =
     5.383263309385313e+00
HSS_NU12 =
     2.689422597421439e-01
HSS_NU21 =
     7.072594240996219e-02
HSS_NU31 =
     7.152436839861509e-02
HSS_NU13 =
     2.614357634301269e-01
HSS_NU23 =
     3.199971715300808e-01
HSS_NU32 =
     3.290645470320256e-01
```

CONCLUSION / INFERENCE

- **Self consistent method could not be successfully employed to calculate the effective properties as the Solution of the implicit equation for G_{23} was giving complex roots. Since some of the other quantities were dependent on the value of G_{23}, more than one quantity was unable to be found out.**
- **G_{23} for 3 phase model could be calculated for volume fractions of fibre upto around 0.5. After which it showed complex values.**

50	5.09859524830647 + 0.000000000000000i
51	5.69242132291322 + 0.000000000000000i
52	6.54780178137192 + 0.000000000000000i
53	7.96165441370215 + 0.000000000000000i
54	11.2048993734378 + 0.000000000000000i
55	10.6888123708112 - 18.16845097401341i
56	3.10089246522342 - 10.71021801291211i
57	1.90116777004521 - 8.382534002015331i
58	1.41112533396407 - 7.169567908374251i
59	1.14405810951455 - 6.404378786125471i
60	0.975456037515753 - 5.871056819437541i
61	0.858928337982191 - 5.476043173874771i
62	0.773240537798083 - 5.171438929247161i

- **The upper and lower bounds of Hashin Strickman method to find out E_1 almost coincides and is linear.**
- **E_2 and v_{23} in Hashin strickman method shoots up at around a volume fraction of fibre: 0.2.**
- **The bounds in Effective properties can be clearly visualised in case of Hashin Strickman and Voigt-Reuss Approximation.**