Formulation of Hygrothermal Expansion Coefficients of the Angle-ply Laminates

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#include<bits/stdc++.h>
using namespace std;


int main(){
int a;
cout<<" Enter angle of lamina ; "<<endl;
cin>>a;
//  mateial proerties:

double a1 ,a2, b1,b2,T , E1,E2, V12, G66 , y1, y2, y3 ,q11, q12, q22, q16, q26, q66, m;
cout<<"Longitudinal coefficient of thermal expansion: "<<endl;
cin>>a1;

cout<<"Transverse coefficient of thermal expansion: "<<endl;
cin>>a2;

cout<<"Longitudinal coefficient of moisture expansion in m/m/kg/kg: "<<endl;
cin>>b1;

cout<<"Transverse coefficient of moisture expansion in m/m/kg/kg: "<<endl;
cin>>b2;

cout<<"Enter the temperature of composite  in degree centigrade: "<<endl;
cin>>T;

cout<<"Longitudinal elastic modulus in Pa: "<<endl;
cin>>E1;
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cout<<" Transverse elastic modulus in Pa: "<<endl;
cin>>E2;

cout<<"Major Poisson’s ratio:  "<<endl;
cin>>V12;

cout<<" Shear modulus in Pa: "<<endl;
cin>>G66;

 cout<<" Enter Longitudinal Stress in Pa: "<<endl;
 cin>>y1;

 cout<<" Enter transverse stress in Pa: "<<endl;
 cin>>y2;

 cout<<" Enter shear stress in Pa: "<<endl;
 cin>>y3;

cout<<"Enter the weight of moisture absorption per unit weight of the lamina in kg/kg: "<<endl;
cin>>m;


// define a variable for compliance matrix
double S11, S12, S22,S66;

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S11= 1/E1;
S12= -V12/E1;
S22= 1/E2;
S66= 1/G66;


  double c=cos(a*3.14159/180);
   double s=sin(a*3.14159/180);

// define a T-inverse matrix

 double x[3][3] = {{c*c,s*s,-2*s*c},{s*s,c*c,2*s*c},{s*c,-s*c,c*c-s*s}};

// Now define a compliance matrix for angle lamina

//double q11, q12, q22, q16, q26, q66 ;

 q11= (S11*c*c*c*c) + (((2*S12) +S66)*s*s*c*c) + (S22*s*s*s*s) ;
  q12= (S12)*((s*s*s*s) + (c*c*c*c)) +(s*s*c*c)*(S11+S22-S66);
  q22= (S11*s*s*s*s) + ((2*S12)+S66)*(s*s*c*c) +(S22*c*c*c*c);
  q16= ((2*S11)-(2*S12)-S66)*(s*c*c*c) - ((2*S22)-(2*S12)-S66)*(s*s*s*c) ;
  q26= ((2*S11)-(2*S12)-S66)*(s*s*s*c) - ((2*S22)-(2*S12)-S66)*(s*c*c*c);
  q66= ((2*S11)+(2*S22)-(4*S12) - S66)*(s*s*c*c) + (S66)*((c*c*c*c)+(s*s*s*s));


  // Now here we make a compliance matrix

  double comp[3][3]= {{q11,q12,q16}, {q12, q22, q26}, {q16, q26, q66}};
```

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   // stress matrix for strain calculation
   double st[3][1] = {y1, y2, y3};

   //here we are calculating strain due to stress;

   double f1[3][1];

   // multiplication logic
   for(int i=0; i<3; i++){
     for(int j=0; j<1; j++){
         f1[i][j]=0;

         for(int k=0; k<3; k++){

             f1[i][j]+=comp[i][k]*st[k][j];
           }
       }
   }
   cout<<" Strain due stress"<<endl;
   for(int i=0; i<3; i++){
     for( int j=0; j<1; j++){
         cout<<f1[i][j]<<" ";
       }
       cout<<endl;
   }
```

```
    // now we calculate strain due to thermal elongation
    // matrix of thermal expansion
    double Th[3][1]={a1,a2,0};

    //calculation of principle thermal coefficient
    double Pt[3][1];
    for(int i=0; i<3; i++){
      for(int j=0; j<1; j++){
          Pt[i][j]=0;

          for(int k=0; k<3; k++){

              Pt[i][j]+=x[i][k]*Th[k][j];
            }
        }
    }
    double Pt1[3][1]= {Pt[0][0]*T, Pt[1][0]*T, (Pt[2][0]/2)*T};

  // Now strain due to thermal elongation
  cout<<"Strain due to Thermal Elongation : "<<endl;
  for(int i=0; i<3; i++){
      for( int j=0; j<1; j++){
          cout<<Pt1[i][j]<<" ";
        }
        cout<<endl;
    }

```

```
    // let's calculate strain due to moisture content
    double Mc[3][1]= {b1, b2, 0};
    double Mc1[3][1];

    for(int i=0; i<3; i++){
      for(int j=0; j<1; j++){
          Mc1[i][j]=0;

          for(int k=0; k<3; k++){

              Mc1[i][j]+=x[i][k]*Mc[k][j];
            }
        }
    }

    double Mc2[3][1]= {Mc1[0][0]*T, Mc1[1][0]*T, (Mc1[2][0]/2)*T};

    cout<<"Strain due to Moisture content: "<<endl;

    for(int i=0; i<3; i++){
      for( int j=0; j<1; j++){
          cout<<Mc2[i][j]<<" ";
        }
        cout<<endl;
    }

```

```
    cout<<" Total strain in Lamina "<<endl;
    cout<<endl<<endl;
    cout<<"Strain in Longitudenal direction :- "<<Mc2[0][0]+Pt1[0][0]+f1[0][0]<<endl;
    cout<<"Strain in Transverse direction :- "<<Mc2[1][0]+Pt1[1][0]+f1[1][0]<<endl;
    cout<<"Shear strain  :- "<<Mc2[2][0]+Pt1[2][0]+f1[2][0]<<endl;


  return 0;
  }
```

Input Data:

```
 Enter angle of lamina ;
60
Longitudinal coefficient of thermal expansion:
0.0000086
Transverse coefficient of thermal expansion:
0.0000221
Longitudinal coefficient of moisture expansion in m/m/kg/kg:
0
Transverse coefficient of moisture expansion in m/m/kg/kg:
0.6
Enter the temperature of composite  in degree centigrade:
-100
Longitudinal elastic modulus in Pa:
38600000000
 Transverse elastic modulus in Pa:
8270000000
Major Poisson's ratio:
0.26
 Shear modulus in Pa:
4400000000
 Enter Longitudinal Stress in Pa:
5000000000
 Enter transverse stress in Pa:
3000000000
 Enter shear stress in Pa:
0
Enter the weight of moisture absorption per unit weight of the lamina in kg/kg:
0.02
```

Output Data:

```
 Strain due stress
0.490738
0.090185
-0.300131
Strain due to Thermal Elongation :
-0.0018725
-0.0011975
0.000292284
Strain due to Moisture content:
-45
-15
12.9904
 Total strain in Lamina


Strain in Longitudenal direction :   -44.5111
Strain in Transverse direction :   -14.9111
Shear strain  :  12.6906
```