C priedas. Atitvaros aktyvios šiluminės talpos vertinimo Matlab kodas pagal ISO 13786:2007

Ši programa parašyta programiniam paketui Matlab, skirta aktyvaus atitvaros šilumos sluoksnio skaičiavimui.

```
% 1 sluoksnis (betonas) (nuo vidinės pusės)
q1=1;
l1 = 0.36; % šilumos laidumo koeficientas, [W/(mK)]
ro1=700; % tankis, [kg/m3]
c1=1050; % medžiagos šiluminė talpa, [J/(kg K)]
d1=240; % sluoksnio storis, [mm]

% 2 sluoksnis (šilumos izoliacija)
q2=0;
l2 = 0.025; % šilumos laidumo koeficientas, [W/(mK)]
ro2=60; % tankis, [kg/m3]
c2=1400; % medžiagos šiluminė talpa, [J/(kg K)]
d2=246; % sluoksnio storis, [mm]

% 3 sluoksnis (tinkas)
q3=0;
l3 = 2.3; % šilumos laidumo koeficientas, [W/(mK)]
ro3=2300; % tankis, [kg/m3]
c3=1000; % medžiagos šiluminė talpa, [J/(kg K)]
d3=100; % sluoksnio storis, [mm]

% 4 sluoksnis (betonas)
q4=0;
l4 =0.8; % šilumos laidumo koeficientas, [W/(mK)]
ro4=5; % tankis, [kg/m3]
c4=1600; % medžiagos šiluminė talpa, [J/(kg K)]
d4=1; % sluoksnio storis, [mm]

% 5 sluoksnis (betonas)
q5=0;
l5 =1; % šilumos laidumo koeficientas, [W/(mK)]
ro5=1; % tankis, [kg/m3]
c5=1; % medžiagos šiluminė talpa, [J/(kg K)]
d5=1; % sluoksnio storis, [mm]

% 6 sluoksnis (betonas)
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```
q6=0;
l6 =1; % šilumos laidumo koeficientas, [W/(mK)]
ro6=1; % tankis, [kg/m3]
c6=1; % medžiagos šiluminė talpa, [J/(kg K)]
d6=1; % sluoksnio storis, [mm]

% 7 sluoksnis (betonas)
q7=0;
l7 =1; % šilumos laidumo koeficientas, [W/(mK)]
ro7=1; % tankis, [kg/m3]
c7=1; % medžiagos šiluminė talpa, [J/(kg K)]
d7=1; % sluoksnio storis, [mm]

t=24; % periodas,[h]
Rsi = 0.1149; % Rsi
Rse=0.05376; % Rse

% periodic penetration depth

if q7 == 1
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));
de2 =sqrt(l2*(t*3600)/(pi*ro2*c2));
de3 =sqrt(l3*(t*3600)/(pi*ro3*c3));
de4 =sqrt(l4*(t*3600)/(pi*ro4*c4));
de5 =sqrt(l5*(t*3600)/(pi*ro5*c5));
de6 =sqrt(l6*(t*3600)/(pi*ro6*c6));
de7 =sqrt(l7*(t*3600)/(pi*ro7*c7));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;
Xi2=(d2/1000)/de2;
Xi3=(d3/1000)/de3;
Xi4=(d4/1000)/de4;
Xi5=(d5/1000)/de5;
Xi6=(d6/1000)/de6;
Xi7=(d7/1000)/de7;

%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
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b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2
a2=cosh(Xi2)*cos(Xi2)+sqrt(-1)*sinh(Xi2)*sin(Xi2); % z11
b2=a2; % z22
n2=-de2/(2*l2)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(cosh(Xi2)*sin(Xi2)-sinh(Xi2)*cos(Xi2))); %z12
m2=-l2/de2*(sinh(Xi2)*cos(Xi2)-cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2))); %z21
z2 =[a2 n2; m2 b2];

% layer no 3
a3=cosh(Xi3)*cos(Xi3)+sqrt(-1)*sinh(Xi3)*sin(Xi3); % z11
b3=a3; % z22
n3=-de3/(2*l3)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(cosh(Xi3)*sin(Xi3)-sinh(Xi3)*cos(Xi3))); %z12
m3=-l3/de3*(sinh(Xi3)*cos(Xi3)-cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3))); %z21
z3 =[a3 n3; m3 b3];

% layer no 4
a4=cosh(Xi4)*cos(Xi4)+sqrt(-1)*sinh(Xi4)*sin(Xi4); % z11
b4=a4; % z22
n4=-de4/(2*l4)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(cosh(Xi4)*sin(Xi4)-sinh(Xi4)*cos(Xi4))); %z12
m4=-l4/de4*(sinh(Xi4)*cos(Xi4)-cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4))); %z21
z4 =[a4 n4; m4 b4];

% layer no 5
a5=cosh(Xi5)*cos(Xi5)+sqrt(-1)*sinh(Xi5)*sin(Xi5); % z11
b5=a5; % z22
n5=-de5/(2*l5)*(sinh(Xi5)*cos(Xi5)+cosh(Xi5)*sin(Xi5)+sqrt(-
1)*(cosh(Xi5)*sin(Xi5)-sinh(Xi5)*cos(Xi5))); %z12
m5=-l5/de5*(sinh(Xi5)*cos(Xi5)-cosh(Xi5)*sin(Xi5)+sqrt(-
1)*(sinh(Xi5)*cos(Xi5)+cosh(Xi5)*sin(Xi5))); %z21
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z5 =[a5 n5; m5 b5];

% layer no 6
a6=cosh(Xi6)*cos(Xi6)+sqrt(-1)*sinh(Xi6)*sin(Xi6); % z11
b6=a6; % z22
n6=-de6/(2*l6)*(sinh(Xi6)*cos(Xi6)+cosh(Xi6)*sin(Xi6)+sqrt(-
1)*(cosh(Xi6)*sin(Xi6)-sinh(Xi6)*cos(Xi6))); %z12
m6=-l6/de6*(sinh(Xi6)*cos(Xi6)-cosh(Xi6)*sin(Xi6)+sqrt(-
1)*(sinh(Xi6)*cos(Xi6)+cosh(Xi6)*sin(Xi6))); %z21
z6 =[a6 n6; m6 b6];

% layer no 7
a7=cosh(Xi7)*cos(Xi7)+sqrt(-1)*sinh(Xi7)*sin(Xi7); % z11
b7=a7; % z22
n7=-de7/(2*l7)*(sinh(Xi7)*cos(Xi7)+cosh(Xi7)*sin(Xi7)+sqrt(-
1)*(cosh(Xi7)*sin(Xi7)-sinh(Xi7)*cos(Xi7))); %z12
m7=-l7/de7*(sinh(Xi7)*cos(Xi7)-cosh(Xi7)*sin(Xi7)+sqrt(-
1)*(sinh(Xi7)*cos(Xi7)+cosh(Xi7)*sin(Xi7))); %z21
z7 =[a7 n7; m7 b7];

Z1=z7*z6*z5*z4*z3*z2*z1;

U=1/((d1/1000)/l1+(d2/1000)/l2+(d3/1000)/l3+(d4/1000)/l4+(d5/1000)/l5+(d6/1
000)/l6+(d7/1000)/l7+Rsi+Rse); % thermal transmittance

elseif  q7 == 0 && q6 == 1
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));
de2 =sqrt(l2*(t*3600)/(pi*ro2*c2));
de3 =sqrt(l3*(t*3600)/(pi*ro3*c3));
de4 =sqrt(l4*(t*3600)/(pi*ro4*c4));
de5 =sqrt(l5*(t*3600)/(pi*ro5*c5));
de6 =sqrt(l6*(t*3600)/(pi*ro6*c6));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;
Xi2=(d2/1000)/de2;
Xi3=(d3/1000)/de3;
Xi4=(d4/1000)/de4;
Xi5=(d5/1000)/de5;
Xi6=(d6/1000)/de6;
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```
%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2
a2=cosh(Xi2)*cos(Xi2)+sqrt(-1)*sinh(Xi2)*sin(Xi2); % z11
b2=a2; % z22
n2=-de2/(2*l2)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(cosh(Xi2)*sin(Xi2)-sinh(Xi2)*cos(Xi2))); %z12
m2=-l2/de2*(sinh(Xi2)*cos(Xi2)-cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2))); %z21
z2 =[a2 n2; m2 b2];

% layer no 3
a3=cosh(Xi3)*cos(Xi3)+sqrt(-1)*sinh(Xi3)*sin(Xi3); % z11
b3=a3; % z22
n3=-de3/(2*l3)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(cosh(Xi3)*sin(Xi3)-sinh(Xi3)*cos(Xi3))); %z12
m3=-l3/de3*(sinh(Xi3)*cos(Xi3)-cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3))); %z21
z3 =[a3 n3; m3 b3];

% layer no 4
a4=cosh(Xi4)*cos(Xi4)+sqrt(-1)*sinh(Xi4)*sin(Xi4); % z11
b4=a4; % z22
n4=-de4/(2*l4)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(cosh(Xi4)*sin(Xi4)-sinh(Xi4)*cos(Xi4))); %z12
m4=-l4/de4*(sinh(Xi4)*cos(Xi4)-cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4))); %z21
z4 =[a4 n4; m4 b4];

% layer no 5
a5=cosh(Xi5)*cos(Xi5)+sqrt(-1)*sinh(Xi5)*sin(Xi5); % z11
b5=a5; % z22
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```
n5=-de5/(2*l5)*(sinh(Xi5)*cos(Xi5)+cosh(Xi5)*sin(Xi5)+sqrt(-
1)*(cosh(Xi5)*sin(Xi5)-sinh(Xi5)*cos(Xi5))); %z12
m5=-l5/de5*(sinh(Xi5)*cos(Xi5)-cosh(Xi5)*sin(Xi5)+sqrt(-
1)*(sinh(Xi5)*cos(Xi5)+cosh(Xi5)*sin(Xi5))); %z21
z5 =[a5 n5; m5 b5];

% layer no 6
a6=cosh(Xi6)*cos(Xi6)+sqrt(-1)*sinh(Xi6)*sin(Xi6); % z11
b6=a6; % z22
n6=-de6/(2*l6)*(sinh(Xi6)*cos(Xi6)+cosh(Xi6)*sin(Xi6)+sqrt(-
1)*(cosh(Xi6)*sin(Xi6)-sinh(Xi6)*cos(Xi6))); %z12
m6=-l6/de6*(sinh(Xi6)*cos(Xi6)-cosh(Xi6)*sin(Xi6)+sqrt(-
1)*(sinh(Xi6)*cos(Xi6)+cosh(Xi6)*sin(Xi6))); %z21
z6 =[a6 n6; m6 b6];

Z1=z6*z5*z4*z3*z2*z1;
U=1/((d1/1000)/l1+(d2/1000)/l2+(d3/1000)/l3+(d4/1000)/l4+(d5/1000)/l5+(d6/1
000)/l6+Rsi+Rse); % thermal transmittance

elseif  q7 == 0 && q6 == 0 && q5 == 1
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));
de2 =sqrt(l2*(t*3600)/(pi*ro2*c2));
de3 =sqrt(l3*(t*3600)/(pi*ro3*c3));
de4 =sqrt(l4*(t*3600)/(pi*ro4*c4));
de5 =sqrt(l5*(t*3600)/(pi*ro5*c5));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;
Xi2=(d2/1000)/de2;
Xi3=(d3/1000)/de3;
Xi4=(d4/1000)/de4;
Xi5=(d5/1000)/de5;

%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
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m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2
a2=cosh(Xi2)*cos(Xi2)+sqrt(-1)*sinh(Xi2)*sin(Xi2); % z11
b2=a2; % z22
n2=-de2/(2*l2)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(cosh(Xi2)*sin(Xi2)-sinh(Xi2)*cos(Xi2))); %z12
m2=-l2/de2*(sinh(Xi2)*cos(Xi2)-cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2))); %z21
z2 =[a2 n2; m2 b2];

% layer no 3
a3=cosh(Xi3)*cos(Xi3)+sqrt(-1)*sinh(Xi3)*sin(Xi3); % z11
b3=a3; % z22
n3=-de3/(2*l3)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(cosh(Xi3)*sin(Xi3)-sinh(Xi3)*cos(Xi3))); %z12
m3=-l3/de3*(sinh(Xi3)*cos(Xi3)-cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3))); %z21
z3 =[a3 n3; m3 b3];

% layer no 4
a4=cosh(Xi4)*cos(Xi4)+sqrt(-1)*sinh(Xi4)*sin(Xi4); % z11
b4=a4; % z22
n4=-de4/(2*l4)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(cosh(Xi4)*sin(Xi4)-sinh(Xi4)*cos(Xi4))); %z12
m4=-l4/de4*(sinh(Xi4)*cos(Xi4)-cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4))); %z21
z4 =[a4 n4; m4 b4];

% layer no 5
a5=cosh(Xi5)*cos(Xi5)+sqrt(-1)*sinh(Xi5)*sin(Xi5); % z11
b5=a5; % z22
n5=-de5/(2*l5)*(sinh(Xi5)*cos(Xi5)+cosh(Xi5)*sin(Xi5)+sqrt(-
1)*(cosh(Xi5)*sin(Xi5)-sinh(Xi5)*cos(Xi5))); %z12
m5=-l5/de5*(sinh(Xi5)*cos(Xi5)-cosh(Xi5)*sin(Xi5)+sqrt(-
1)*(sinh(Xi5)*cos(Xi5)+cosh(Xi5)*sin(Xi5))); %z21
z5 =[a5 n5; m5 b5];

Z1=z5*z4*z3*z2*z1;
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U=1/((d1/1000)/l1+(d2/1000)/l2+(d3/1000)/l3+(d4/1000)/l4+(d5/1000)/l5+Rsi+
Rse); % thermal transmittance

elseif  q7 == 0 && q6 == 0 && q5 == 0 && q4 == 1
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));
de2 =sqrt(l2*(t*3600)/(pi*ro2*c2));
de3 =sqrt(l3*(t*3600)/(pi*ro3*c3));
de4 =sqrt(l4*(t*3600)/(pi*ro4*c4));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;
Xi2=(d2/1000)/de2;
Xi3=(d3/1000)/de3;
Xi4=(d4/1000)/de4;

%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2
a2=cosh(Xi2)*cos(Xi2)+sqrt(-1)*sinh(Xi2)*sin(Xi2); % z11
b2=a2; % z22
n2=-de2/(2*l2)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(cosh(Xi2)*sin(Xi2)-sinh(Xi2)*cos(Xi2))); %z12
m2=-l2/de2*(sinh(Xi2)*cos(Xi2)-cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2))); %z21
z2 =[a2 n2; m2 b2];

% layer no 3
a3=cosh(Xi3)*cos(Xi3)+sqrt(-1)*sinh(Xi3)*sin(Xi3); % z11
b3=a3; % z22
n3=-de3/(2*l3)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(cosh(Xi3)*sin(Xi3)-sinh(Xi3)*cos(Xi3))); %z12
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m3=-l3/de3*(sinh(Xi3)*cos(Xi3)-cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3))); %z21
z3 =[a3 n3; m3 b3];

% layer no 4
a4=cosh(Xi4)*cos(Xi4)+sqrt(-1)*sinh(Xi4)*sin(Xi4); % z11
b4=a4; % z22
n4=-de4/(2*l4)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(cosh(Xi4)*sin(Xi4)-sinh(Xi4)*cos(Xi4))); %z12
m4=-l4/de4*(sinh(Xi4)*cos(Xi4)-cosh(Xi4)*sin(Xi4)+sqrt(-
1)*(sinh(Xi4)*cos(Xi4)+cosh(Xi4)*sin(Xi4))); %z21
z4 =[a4 n4; m4 b4];

Z1=z4*z3*z2*z1;
U=1/((d1/1000)/l1+(d2/1000)/l2+(d3/1000)/l3+(d4/1000)/l4+Rsi+Rse);  %  ther-
mal transmittance

elseif  q7 == 0 && q6 == 0 && q5 == 0 && q4 == 0 && q3 == 1
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));
de2 =sqrt(l2*(t*3600)/(pi*ro2*c2));
de3 =sqrt(l3*(t*3600)/(pi*ro3*c3));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;
Xi2=(d2/1000)/de2;
Xi3=(d3/1000)/de3;

%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2
a2=cosh(Xi2)*cos(Xi2)+sqrt(-1)*sinh(Xi2)*sin(Xi2); % z11
b2=a2; % z22
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n2=-de2/(2*l2)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(cosh(Xi2)*sin(Xi2)-sinh(Xi2)*cos(Xi2))); %z12
m2=-l2/de2*(sinh(Xi2)*cos(Xi2)-cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2))); %z21
z2 =[a2 n2; m2 b2];

% layer no 3
a3=cosh(Xi3)*cos(Xi3)+sqrt(-1)*sinh(Xi3)*sin(Xi3); % z11
b3=a3; % z22
n3=-de3/(2*l3)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(cosh(Xi3)*sin(Xi3)-sinh(Xi3)*cos(Xi3))); %z12
m3=-l3/de3*(sinh(Xi3)*cos(Xi3)-cosh(Xi3)*sin(Xi3)+sqrt(-
1)*(sinh(Xi3)*cos(Xi3)+cosh(Xi3)*sin(Xi3))); %z21
z3 =[a3 n3; m3 b3];

Z1=z3*z2*z1;
U=1/((d1/1000)/l1+(d2/1000)/l2+(d3/1000)/l3+Rsi+Rse); % thermal transmit-
tance

elseif  q7 == 0 && q6 == 0 && q5 == 0 && q4 == 0 && q3 == 0 && q2 == 1
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));
de2 =sqrt(l2*(t*3600)/(pi*ro2*c2));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;
Xi2=(d2/1000)/de2;

%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2
a2=cosh(Xi2)*cos(Xi2)+sqrt(-1)*sinh(Xi2)*sin(Xi2); % z11
b2=a2; % z22
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n2=-de2/(2*l2)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(cosh(Xi2)*sin(Xi2)-sinh(Xi2)*cos(Xi2))); %z12
m2=-l2/de2*(sinh(Xi2)*cos(Xi2)-cosh(Xi2)*sin(Xi2)+sqrt(-
1)*(sinh(Xi2)*cos(Xi2)+cosh(Xi2)*sin(Xi2))); %z21
z2 =[a2 n2; m2 b2];

Z1=z2*z1;
U=1/((d1/1000)/l1+(d2/1000)/l2+Rsi+Rse); % thermal transmittance

else
de1 =sqrt(l1*(t*3600)/(pi*ro1*c1));

% ratio of the thickness of the layer to the penetration defth is the

Xi1=(d1/1000)/de1;

%The elements of the heat transfer matrix of the concrete layer are then
% layer no 1
a1=cosh(Xi1)*cos(Xi1)+sqrt(-1)*sinh(Xi1)*sin(Xi1); % z11
b1=a1; % z22
n1=-de1/(2*l1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(cosh(Xi1)*sin(Xi1)-sinh(Xi1)*cos(Xi1))); %z12
m1=-l1/de1*(sinh(Xi1)*cos(Xi1)-cosh(Xi1)*sin(Xi1)+sqrt(-
1)*(sinh(Xi1)*cos(Xi1)+cosh(Xi1)*sin(Xi1))); %z21
z1 =[a1 n1; m1 b1];

% layer no 2

Z1=z1;
U=1/((d1/1000)/l1+Rsi+Rse); % thermal transmittance

end

v=[1 -Rsi; 0 1];
u=[1 -Rse; 0 1];

Z=u*Z1*v; % taking account of surface resistances of 0,13 m2K/W inside and
0.04 m2K/W outside, the transfer matrix of rhe wall is:

ax=Z(1,1); % Z11
bx=Z(2,2); % Z22
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```
nx=Z(1,2); % Z12
mx=Z(2,1); % Z21
ax1=abs(Z(1,1)); % Z11
bx1=abs(Z(2,2)); % Z22
nx1=abs(Z(1,2)); % Z12
mx1=abs(Z(2,1)); % Z21

 Y11=abs(-(ax/nx));
 Y111=-(ax/nx);
% internal thermal admittance
Y22=abs(-(bx/nx)); % external thermal admittance
Y222=(-(bx/nx));
Y12=abs(-(1/nx)); % periodic thermal transmittance
Y122=-(1/nx);
k1=(t*3600)/(2*pi)*abs((ax-1)/nx) % Internal areal heat capacity
k2=(t*3600)/(2*pi)*abs((bx-1)/nx);  % external areal heat capacity
% f % Decrement factor
f=abs(Y12)/U

% the time shift of the periodic thermal transmittance is
t1=(t)/(2*pi)*angle(ax) % Z11
t2=(t)/(2*pi)*angle(bx) % Z22
t3=(t)/(2*pi)*angle(nx) % Z12
t4=(t)/(2*pi)*angle(mx) % Z21

% Time shift
t5=(t)/(2*pi)*angle(Y111) % Y11
t6=(t)/(2*pi)*angle(Y222) % Y22
t7=(t)/(2*pi)*angle(Y122) % Y12
```