Geotechnical Aspects of Energy Piles

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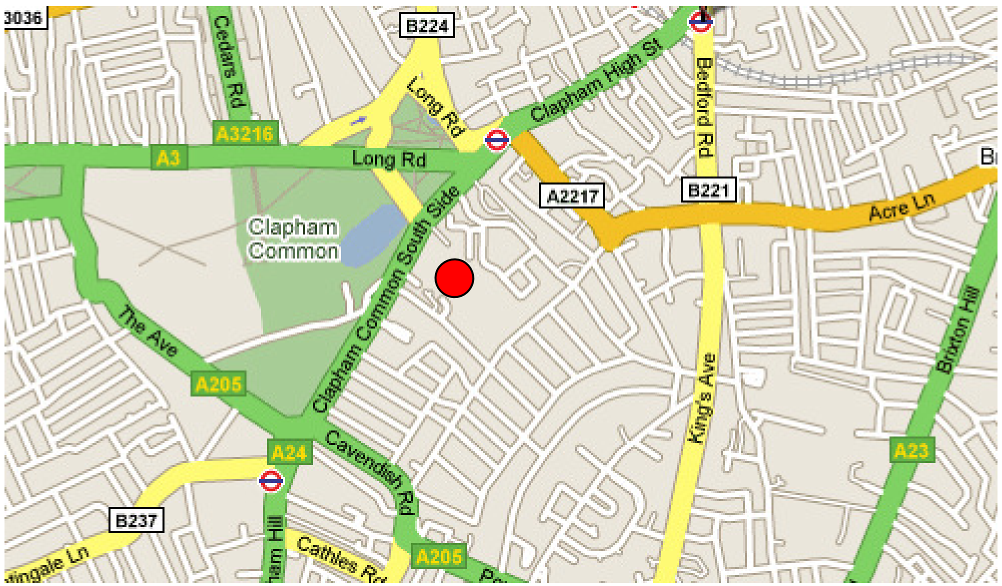
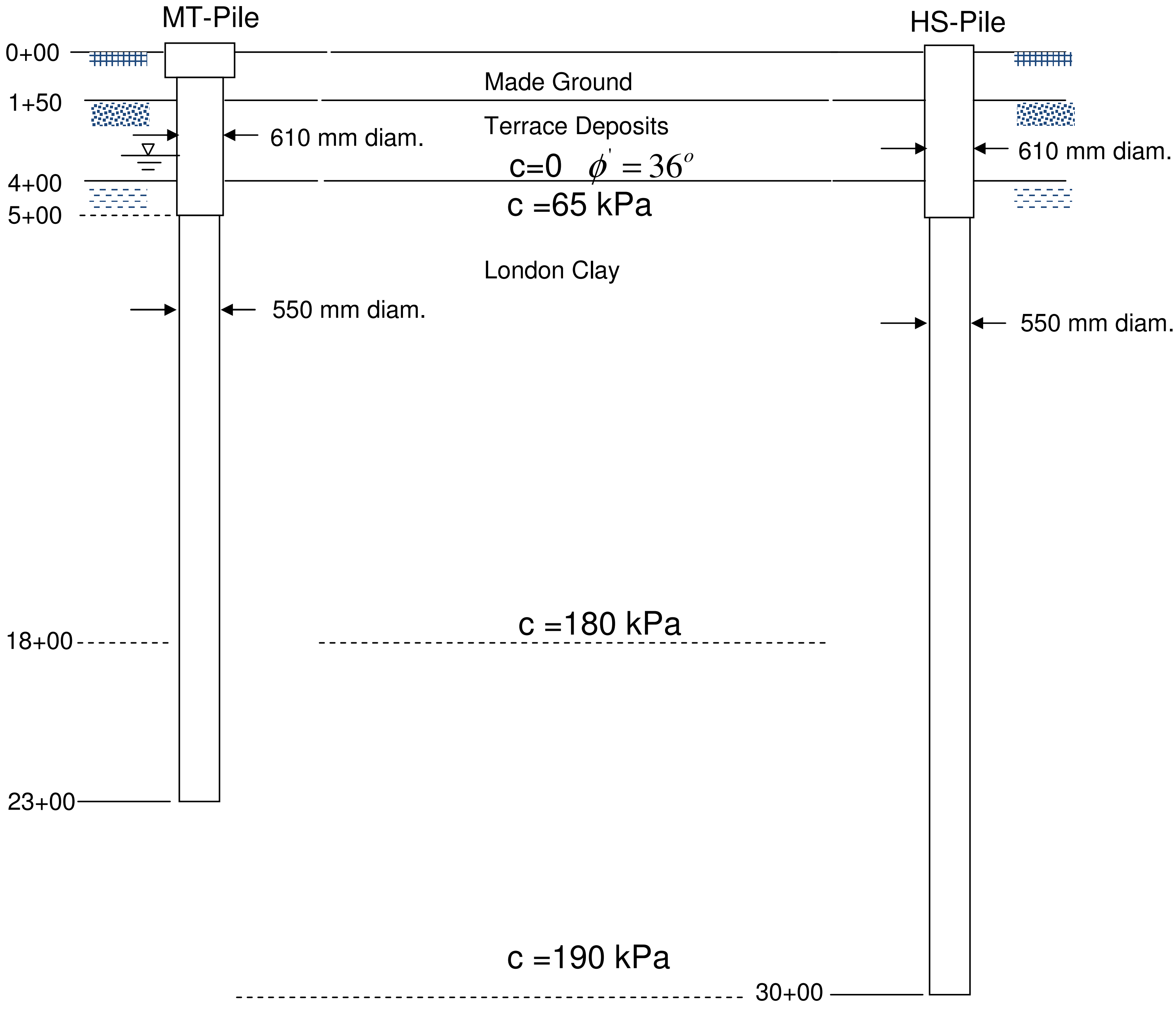
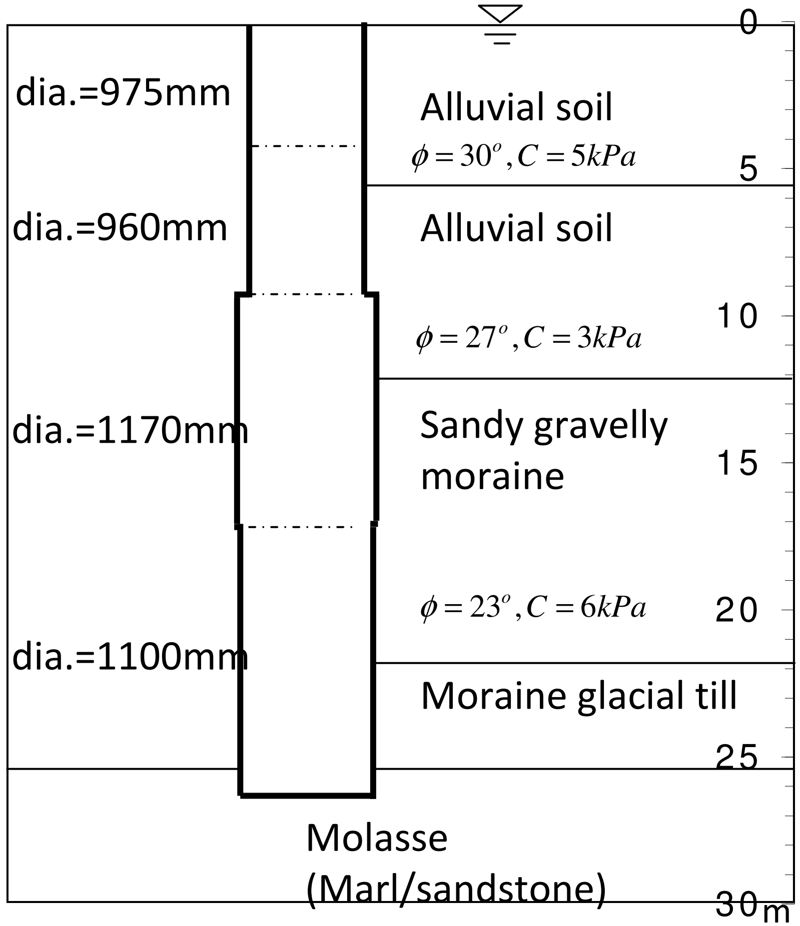
Field Test @ Lambeth College, London





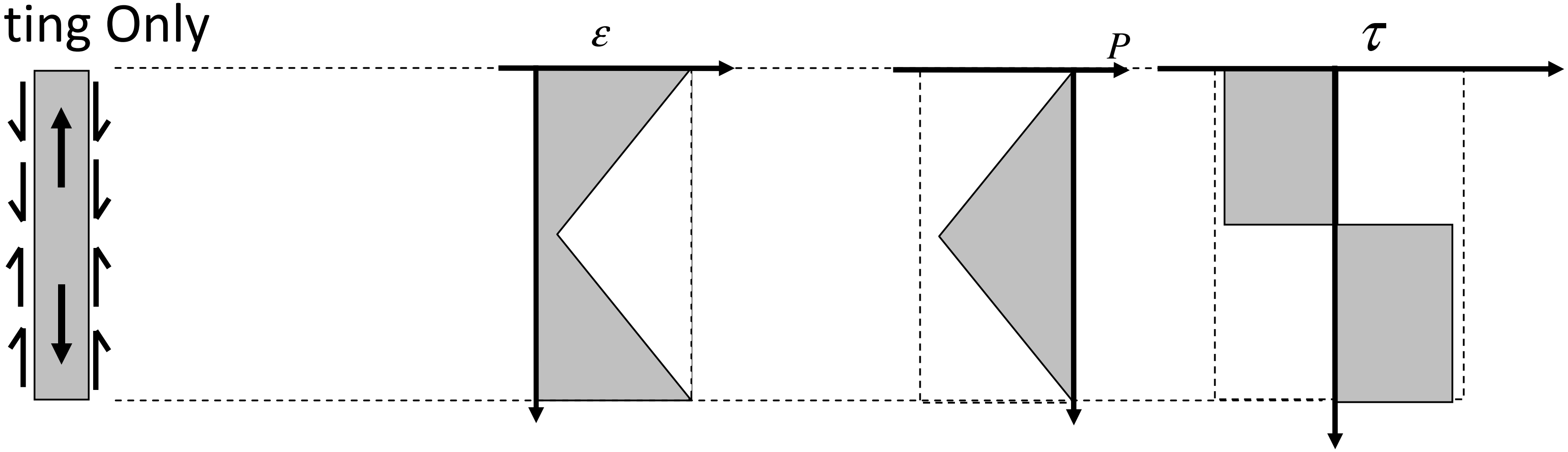
MT-Pile
HS-Pile
0+00
1+50
4+00
5+00
18+00
23+00
30+00
Made Ground
Terrace Deposits
c=0 $\phi' = 36^o$
c =65 kPa
London Clay
610 mm diam.
610 mm diam.
550 mm diam.
550 mm diam.
c =180 kPa
c =190 kPa



0
dia.=975mm
Alluvial soil
$\phi = 30^o, C = 5kPa$
5
dia.=960mm
Alluvial soil
10
$\phi = 27^o, C = 3kPa$
dia.=1170mm
Sandy gravelly
moraine
15
$\phi = 23^o, C = 6kPa$
20
dia.=1100mm
Moraine glacial till
25
Molasse
(Marl/sandstone)
30m

No pile load, no end restraint

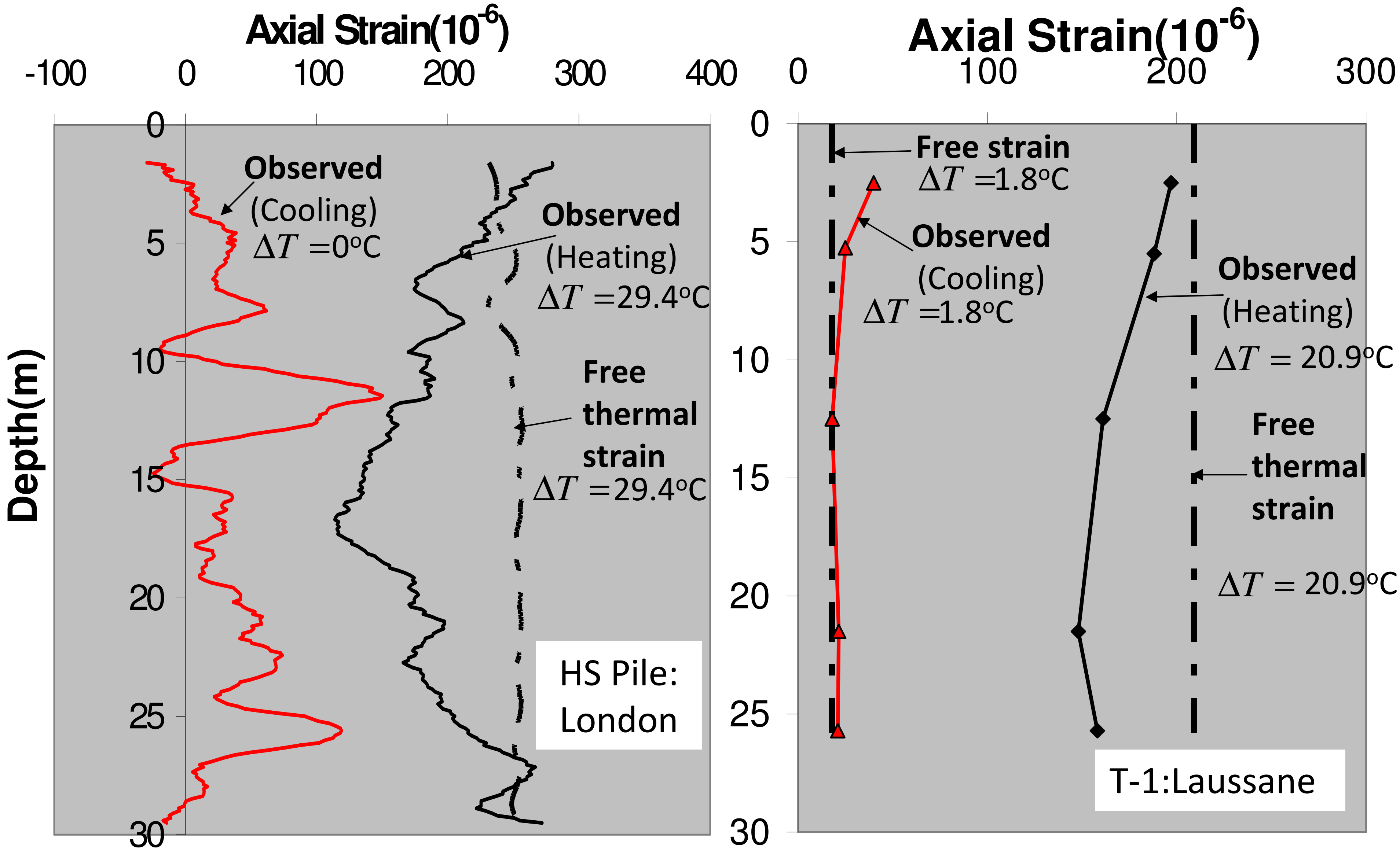
Heating Only



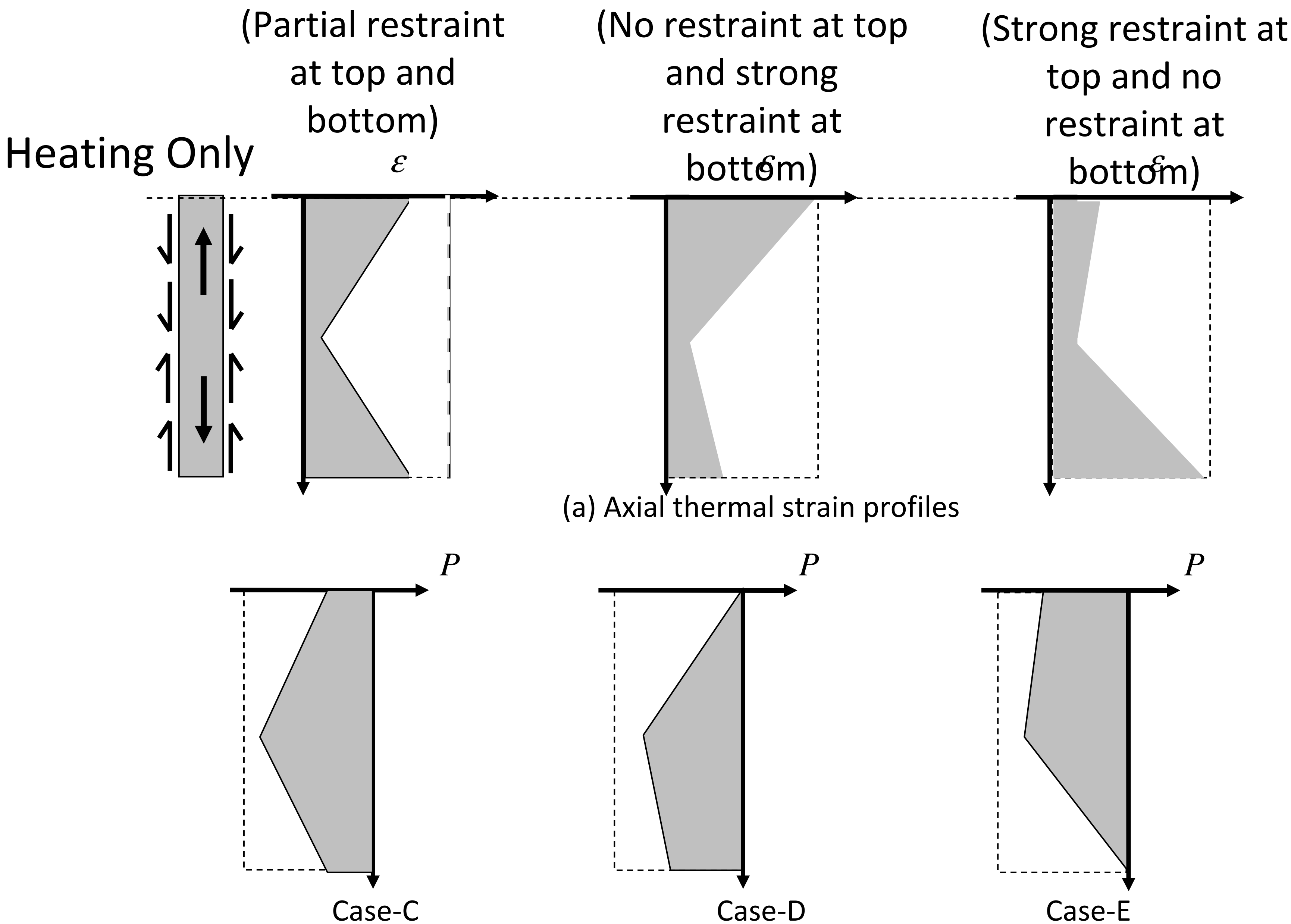
(a) Axial thermal strain profiles

(b)Axial thermal load profiles

(c) Thermal shaft resistance profiles

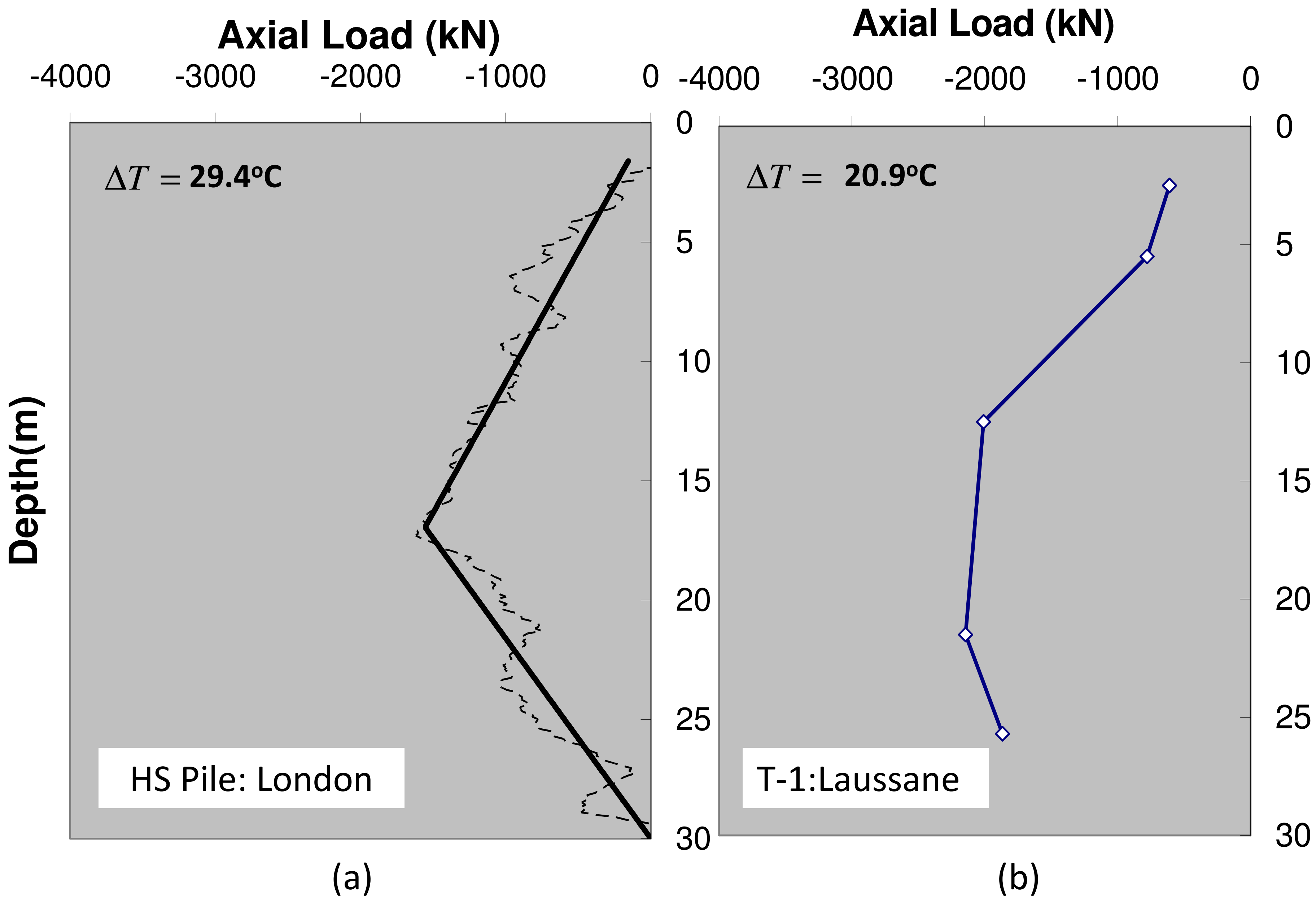


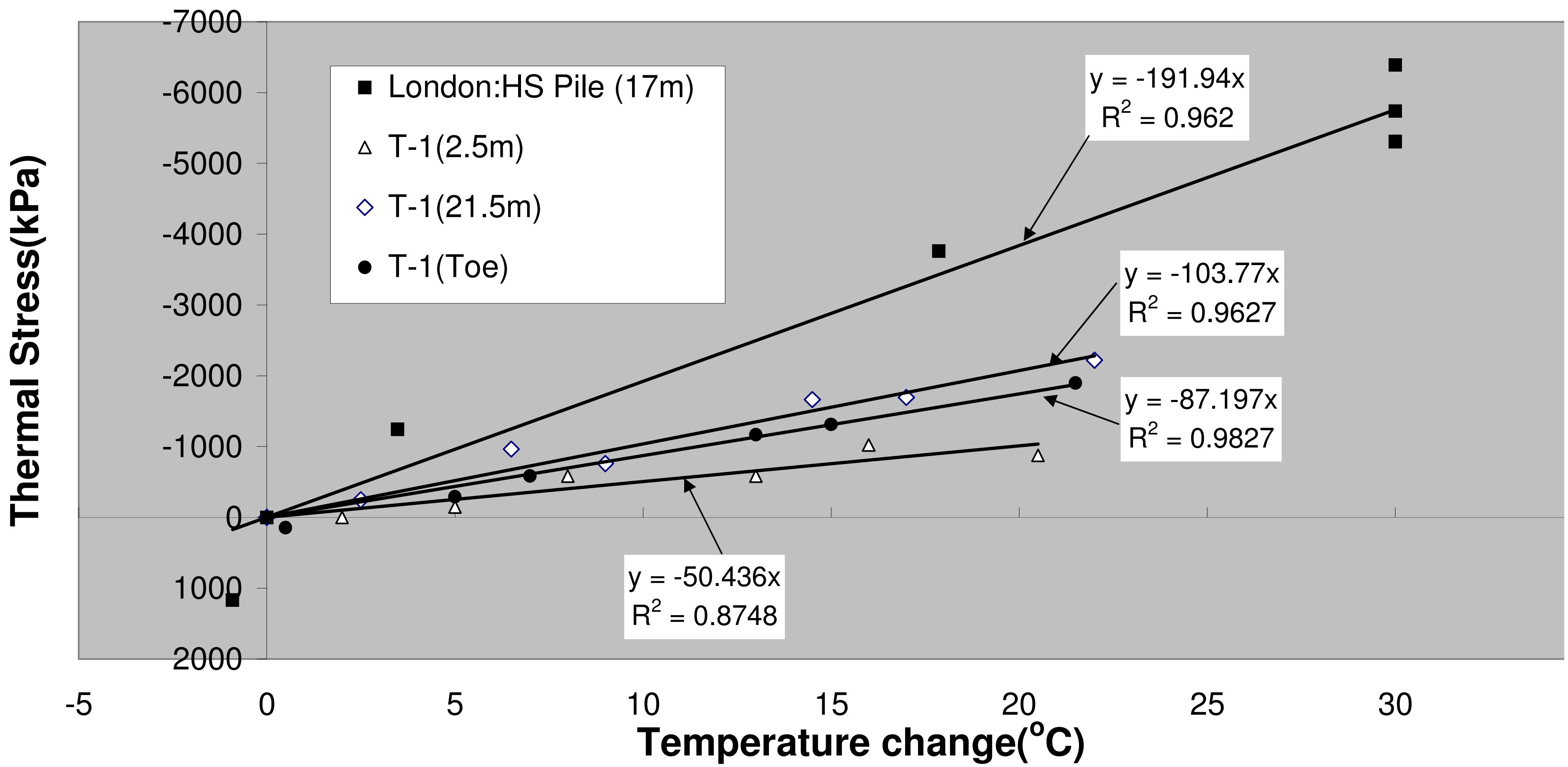
Axial Strain(10^-6)
-100
0
100
200
300
400
Depth(m)
0
5
10
15
20
25
30
Observed
(Cooling)
ΔT =0°C
Observed
(Heating)
ΔT =29.4°C
Free
thermal
strain
ΔT =29.4°C
HS Pile:
London
Axial Strain(10^-6)
0
100
200
300
Free strain
ΔT =1.8°C
Observed
(Cooling)
ΔT =1.8°C
Observed
(Heating)
ΔT = 20.9°C
Free
thermal
strain
ΔT = 20.9°C
T-1:Laussane



(a) Axial thermal strain profiles

(b) Axial thermal load profiles


Axial Load (kN)
-4000
-3000
-2000
-1000
0
Depth(m)
0
5
10
15
20
25
30
ΔT = 29.4°C
HS Pile: London
(a)
Axial Load (kN)
-4000
-3000
-2000
-1000
0
ΔT = 20.9°C
T-1:Laussane
(b)



London case

190kPa/°C at middle

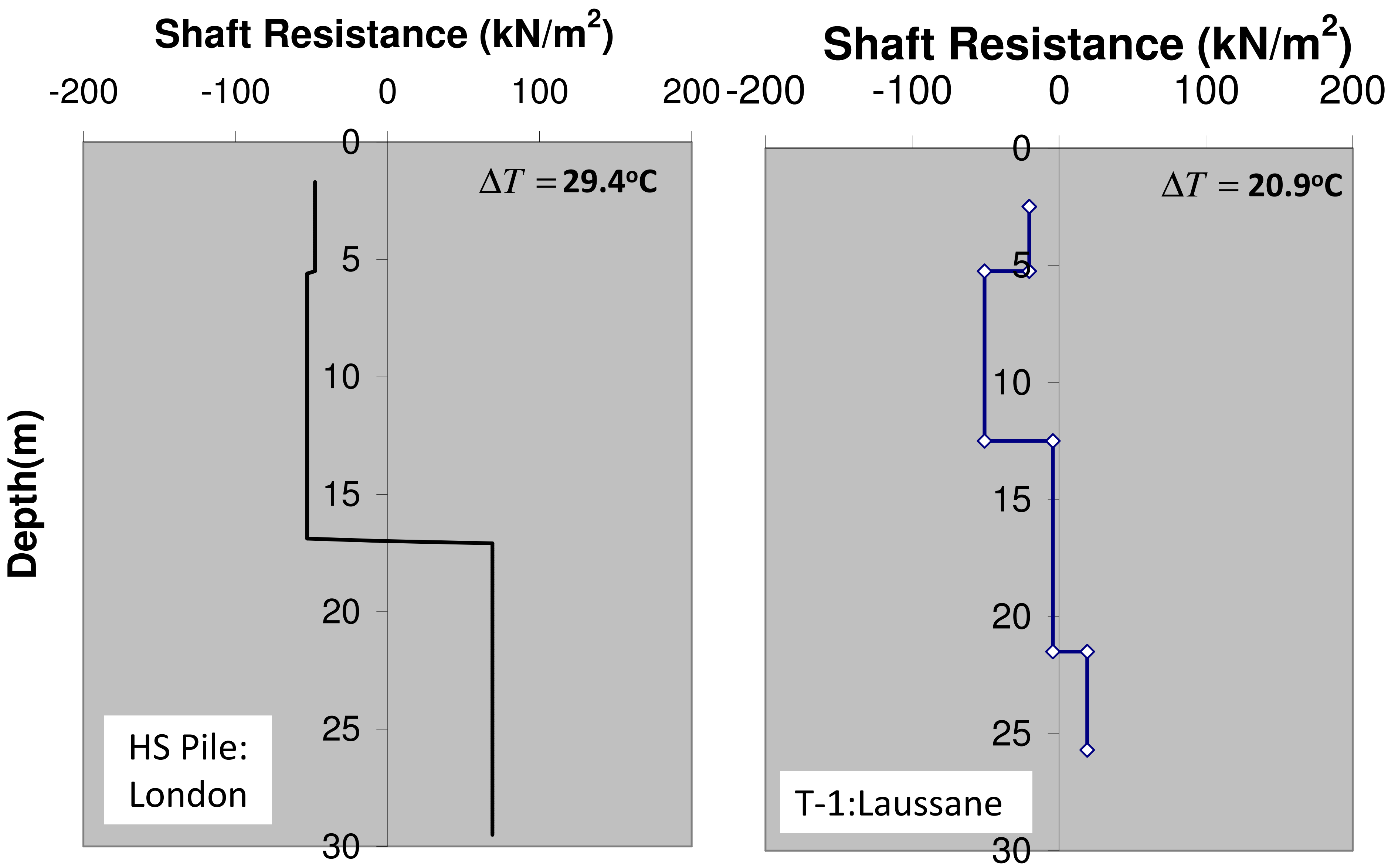
0 kPa/°C at two ends

Lausanne case

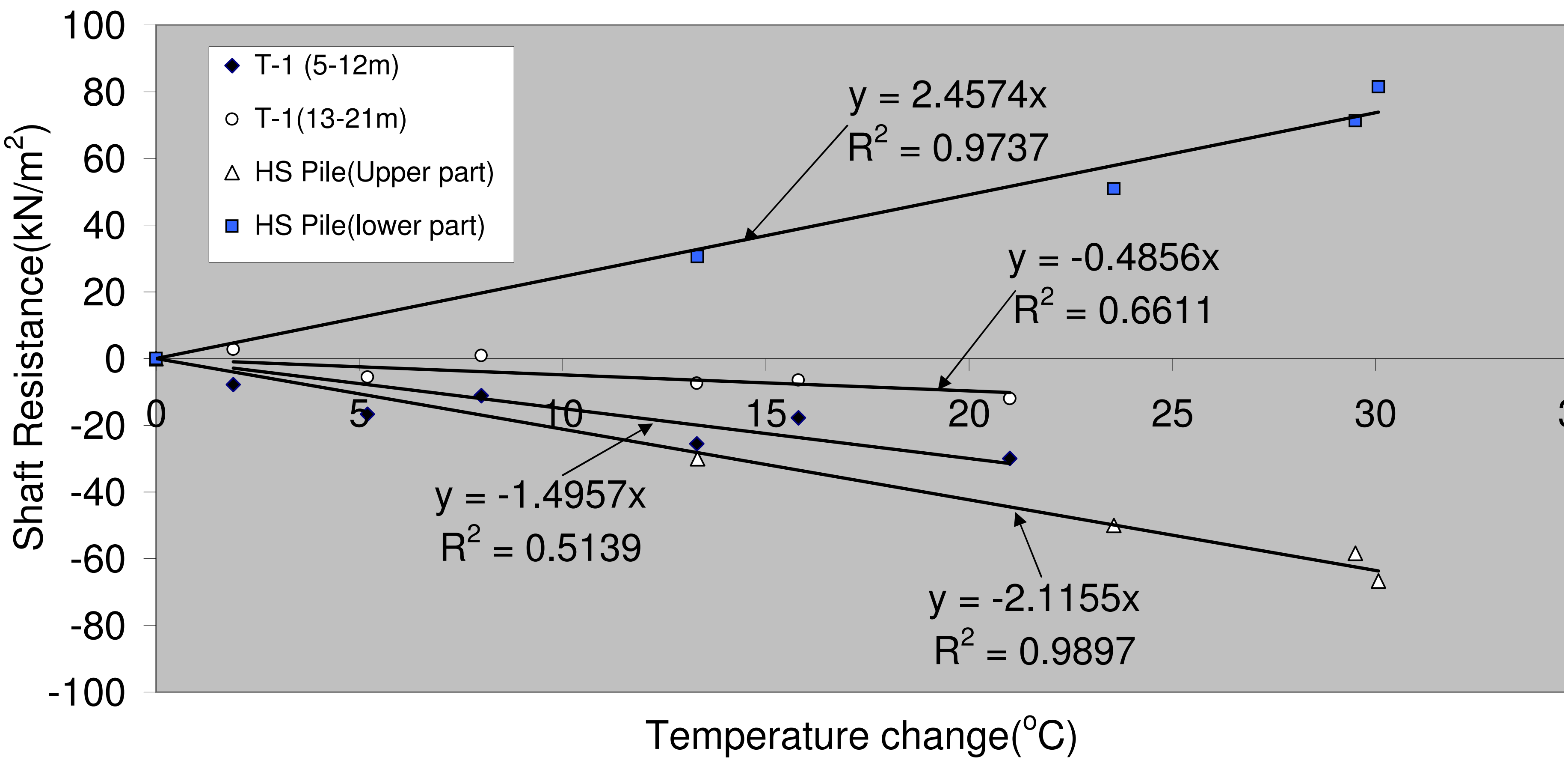
103 kPa/°C at middle

50kPa/°C at the top

87kPa/°C at the toe



Shaft Resistance (kN/m²)
-200
-100
0
100
200
Depth(m)
0
5
10
15
20
25
30
ΔT = 29.4°C
HS Pile:
London
Shaft Resistance (kN/m²)
-200
-100
0
100
200
0
5
10
15
20
25
30
ΔT = 20.9°C
T-1:Laussane



London clay : 2.1-2.5 kPa/ºC for the London clay

Lausanne : 1.5kPa/ºC for the alluvial clay deposit

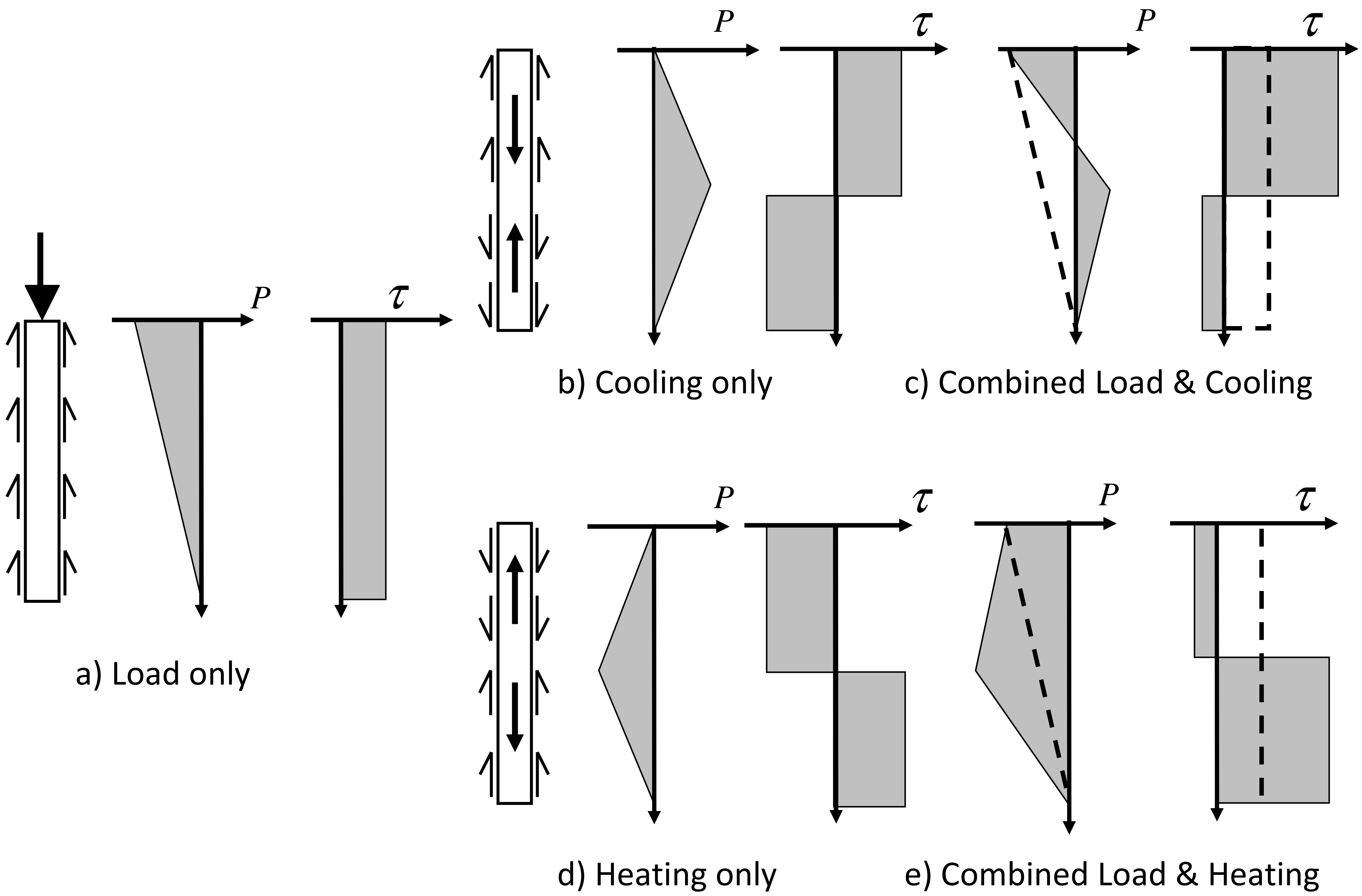
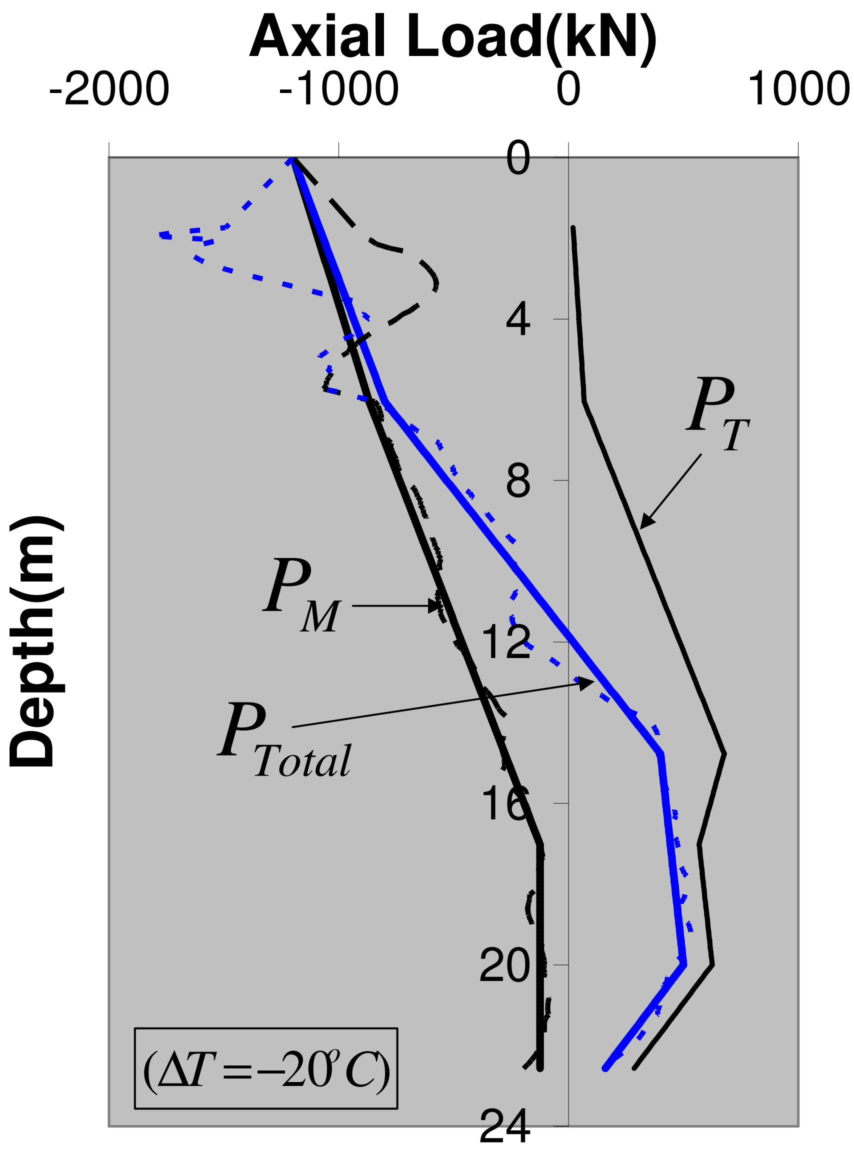
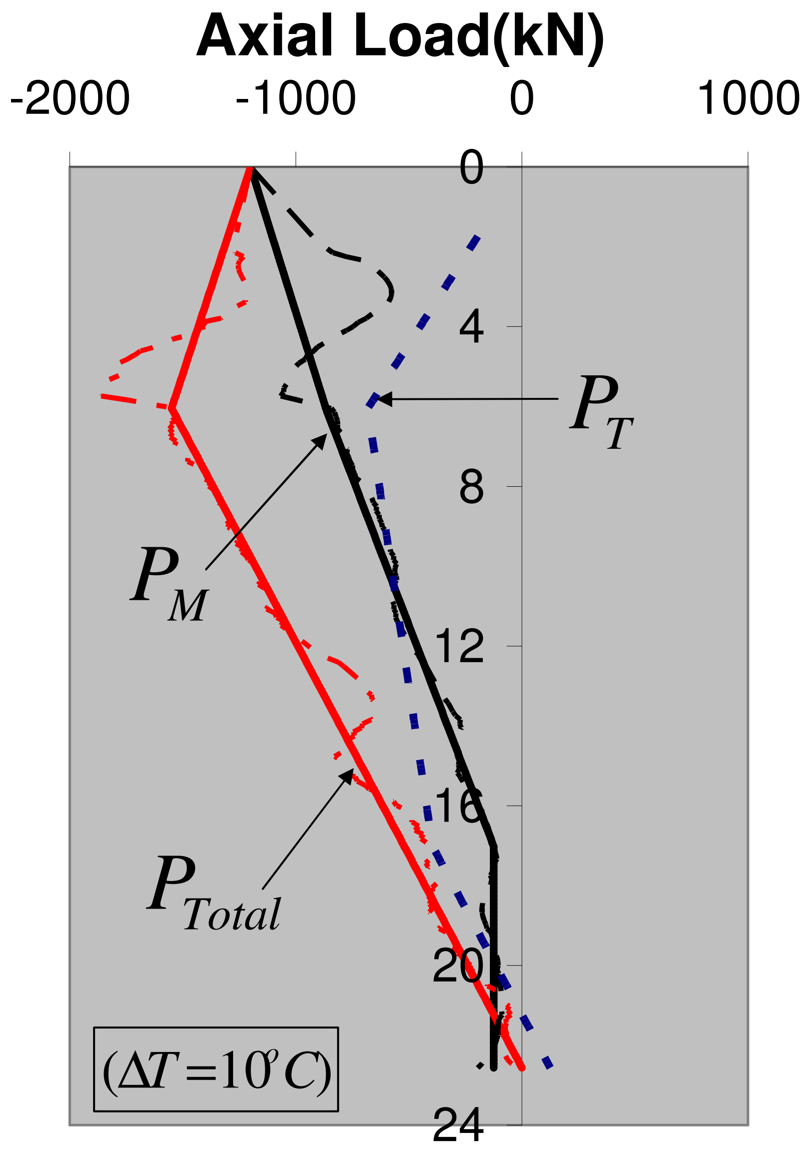


Fig.10 Mechanisms for response of pile to thermo-mechanical loading (No end restraint case)



(a-1) Cooling phase



(a-2) Heating phase

Fig. 15(a) MT-Pile: London

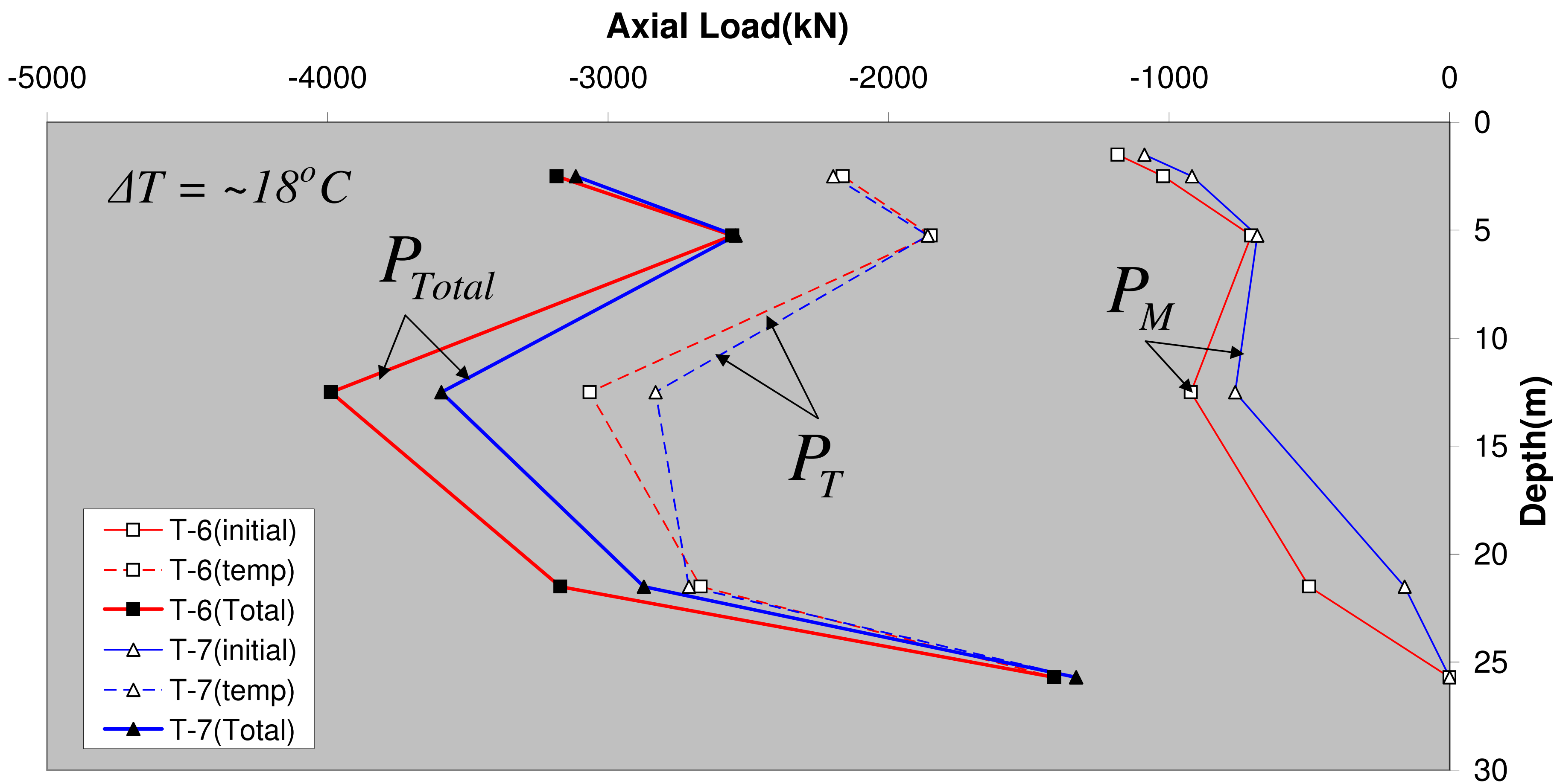
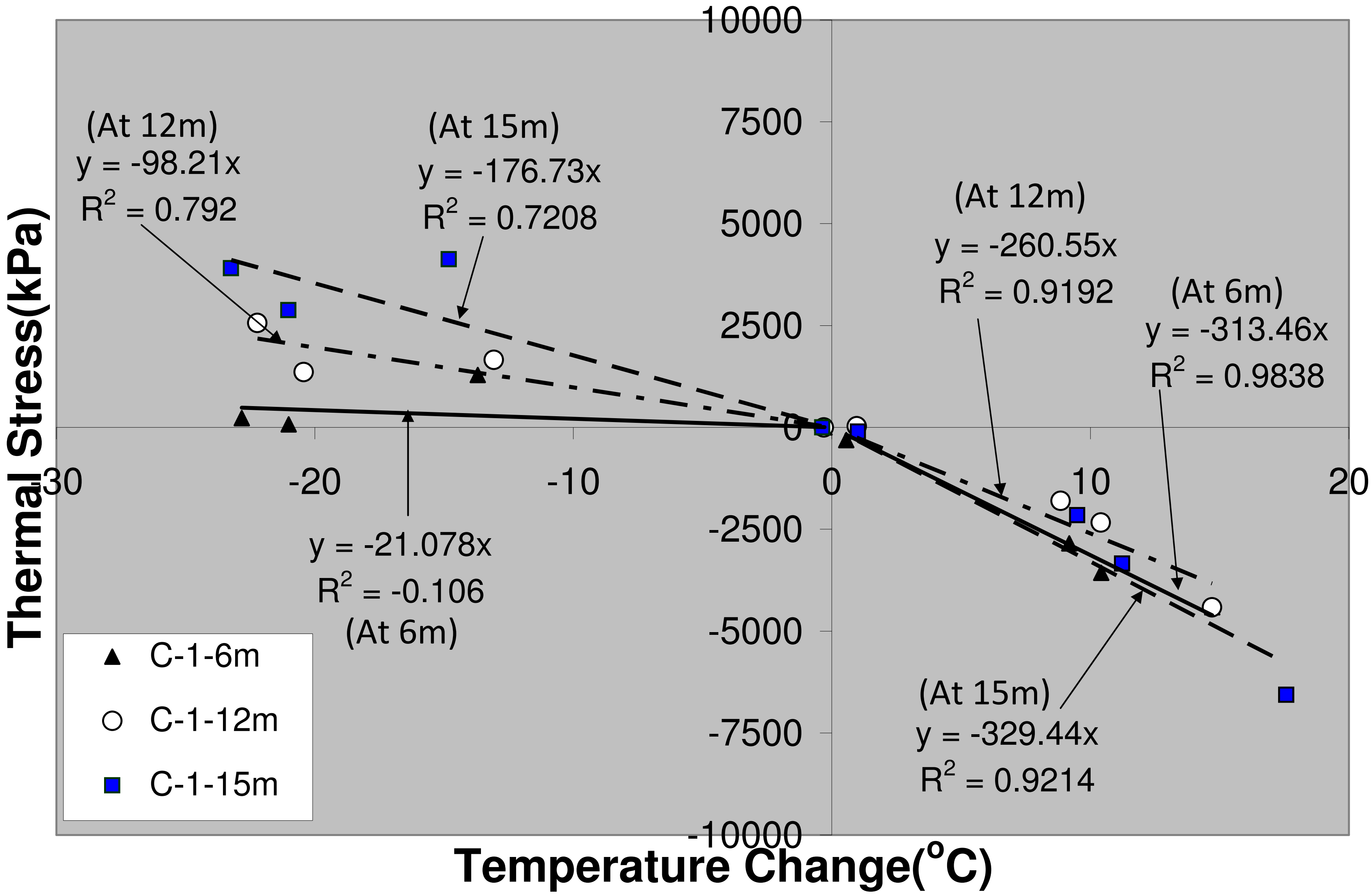


Fig. 15(b) Lausanne



Middle section (max)
London - 330kPa/°C
Lausanne - 150kPa/°C

Ends
London - Small
Lausanne - 150kPa/°C (top), 80 kPa/°C (bottom)
Bad Schallerbach - 30kPa/°C (top), small (bottom)

Summary

- Thermally induced pile stress and shaft resistance.

- London - a limited time, extreme temperature cycles
- Lausanne - heating pulses only, sat in amongst a foundation system that was otherwise not used in a GSHP system.
- Bad Schallerbach - very limited data set, complex temperature profile.

- Data of changes in axial stress and pile settlement for long-term operational conditions needed.

- Cyclic thermal loads can deteriorate the inherent soil resistance capability at soil-pile interface. Further work needed.