Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Cite this as: Xiang-dong HU, Wang GUO, Luo-yu ZHANG, Jin-tai WANG, Xue DONG, 2016. Mathematical models of steady-state temperature fields produced by multi-piped freezing. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 17(9):702-723. http://dx.doi.org/10.1631/jzus.A1600211

Mathematical models of steady-state temperature fields produced by multi-piped freezing

Key words:

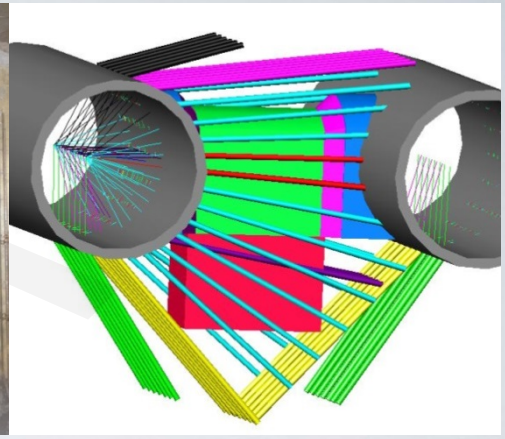
Artificial ground freezing (AGF), Multi-piped freezing, Steady state, Temperature field, Analytical solution, Potential function

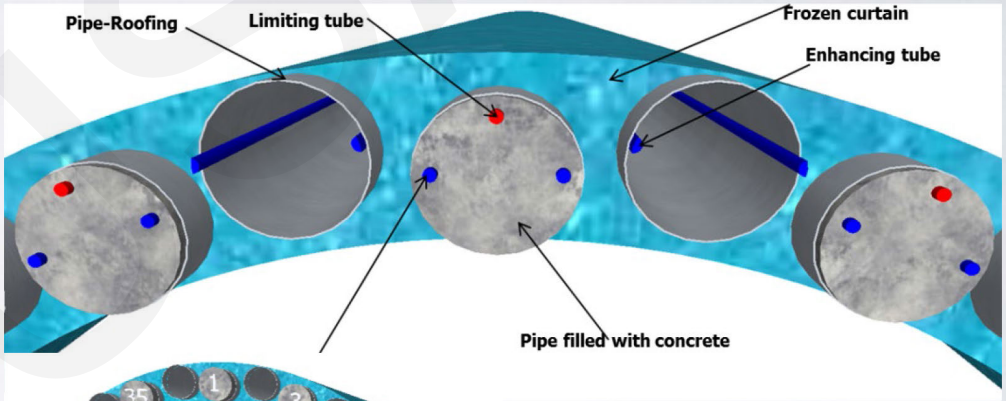
What is Artificial Ground Freezing?

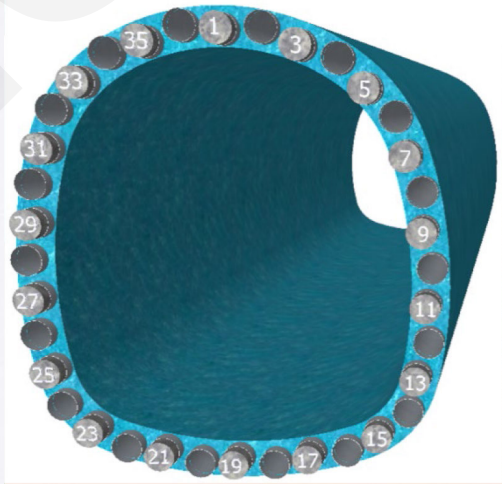
- A construction method that converts the water in the ground into ice by means of artificial refrigeration technology.

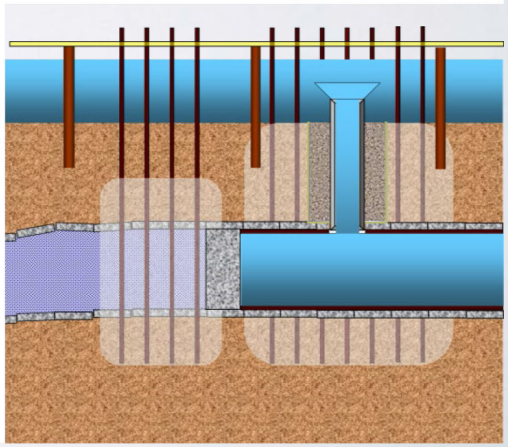
- Widely applied in various construction projects.











Theoretical Foundation

1. Heat potential applied

- Soil → assumed to be isotropic
- Temperature field of frozen soil →approximated to be steady state.
- Freezing pipe → regarded as a point source(cold source or heat sink)

2. Based on potential superposition

- Multiple freezing pipes →multiple point sources exist in the plane
- Heat potential at an arbitrary point in the plane equals the superposition of the heat potentials

Highlights of the Paper



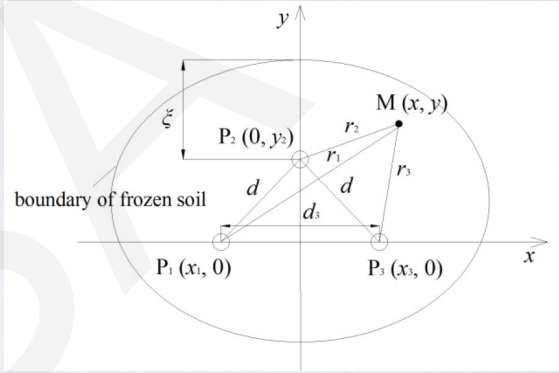
We adopted potential superposition theory in research, and concluded 4 steady-state temperature fields.

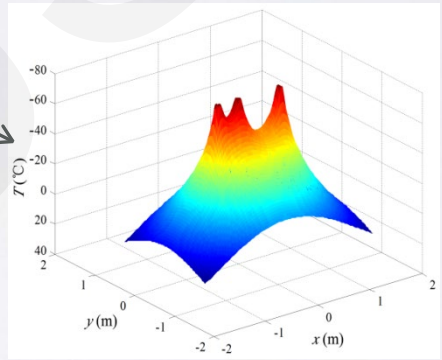
- Temperature field of a single freezing pipe
- Temperature field of two freezing pipes
- **Temperature field of three freezing pipes**
- **Temperature field of four freezing pipes**

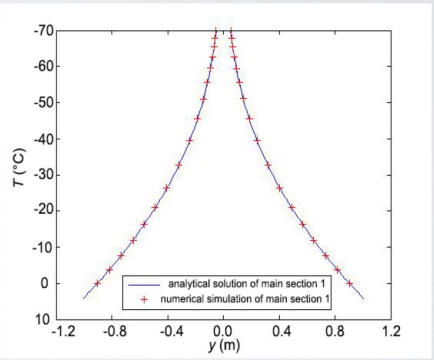
Temperature Field of Three Freezing Pipes

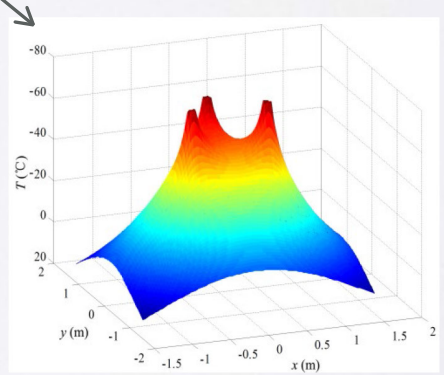
Steady-state temperature fields produced by three freezing:

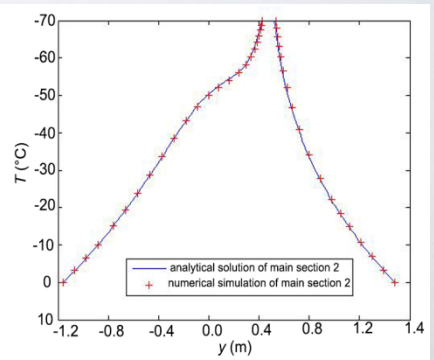
- Temperature field of three freezing pipes in an arbitrary arrangement
- Temperature field of three freezing pipes in a linear arrangement with equal spacing
- Temperature field of three freezing pipes in a linear arrangement with unequal spacing
- Temperature field of three freezing pipes in a right triangle arrangement
- Temperature field of three freezing pipes in an isosceles triangle arrangement







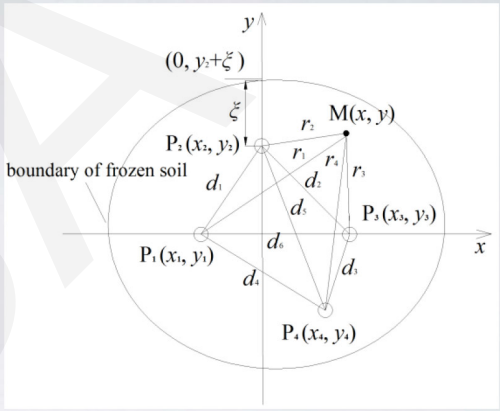


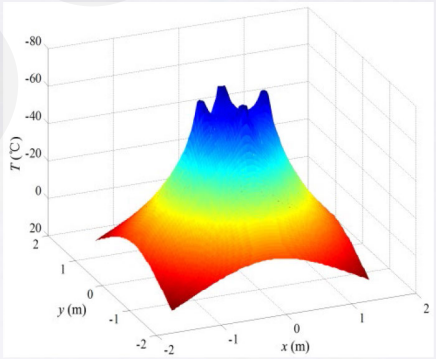


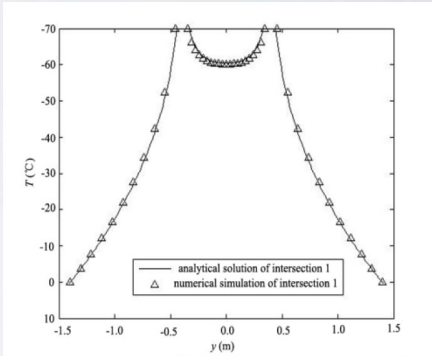
Temperature Field of Four Freezing Pipes

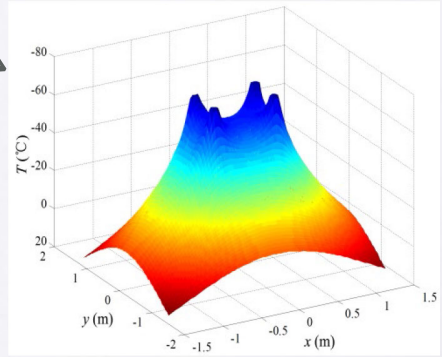
Steady-state temperature fields produced by four freezing:

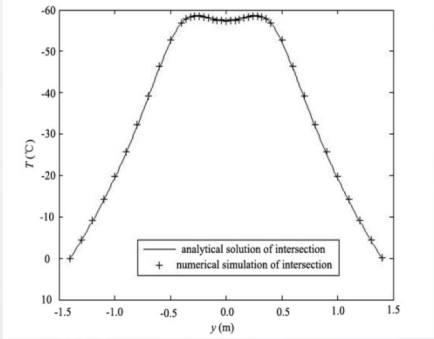
- Temperature field of four freezing pipes in an arbitrary arrangement
- Temperature field of four freezing pipes in a linear arrangement with equal spacing
- Temperature field of four freezing pipes in a rhombus arrangement
- Temperature field of four freezing pipes in a rectangle arrangement











Conclusion

By adopting potential superposition theory, we found a deriving method to the steady-state temperature field frozen by multiple freezing pipes. The conclusion derived from this method fits precisely with the result obtained in numerical simulation.

