Ground freezing technique using CO_2 in construction works

Company profile

Establish	29th Jan. 1963
President	Yuichi Tachiwada
Headquarters	2-2-5, Toranomon, minato-ku Tokyo 105-0001, Japan
Capital	300 million yen
Employee	316
Proceeds & Profit	Proceeds：38,522 million yen　Profit：3,660 million yen
Business contents	1. Research, design, execution and consulting of below works (1) Soil improvement and soil stabilization (2) Building foundation (3) Reinforcement of a structure durability (4) Soil remediation (5) Civil engineering 2. Selling the technique and the machine, technical guidance relate to above works
Business area	Japan, Taiwan, Brazil

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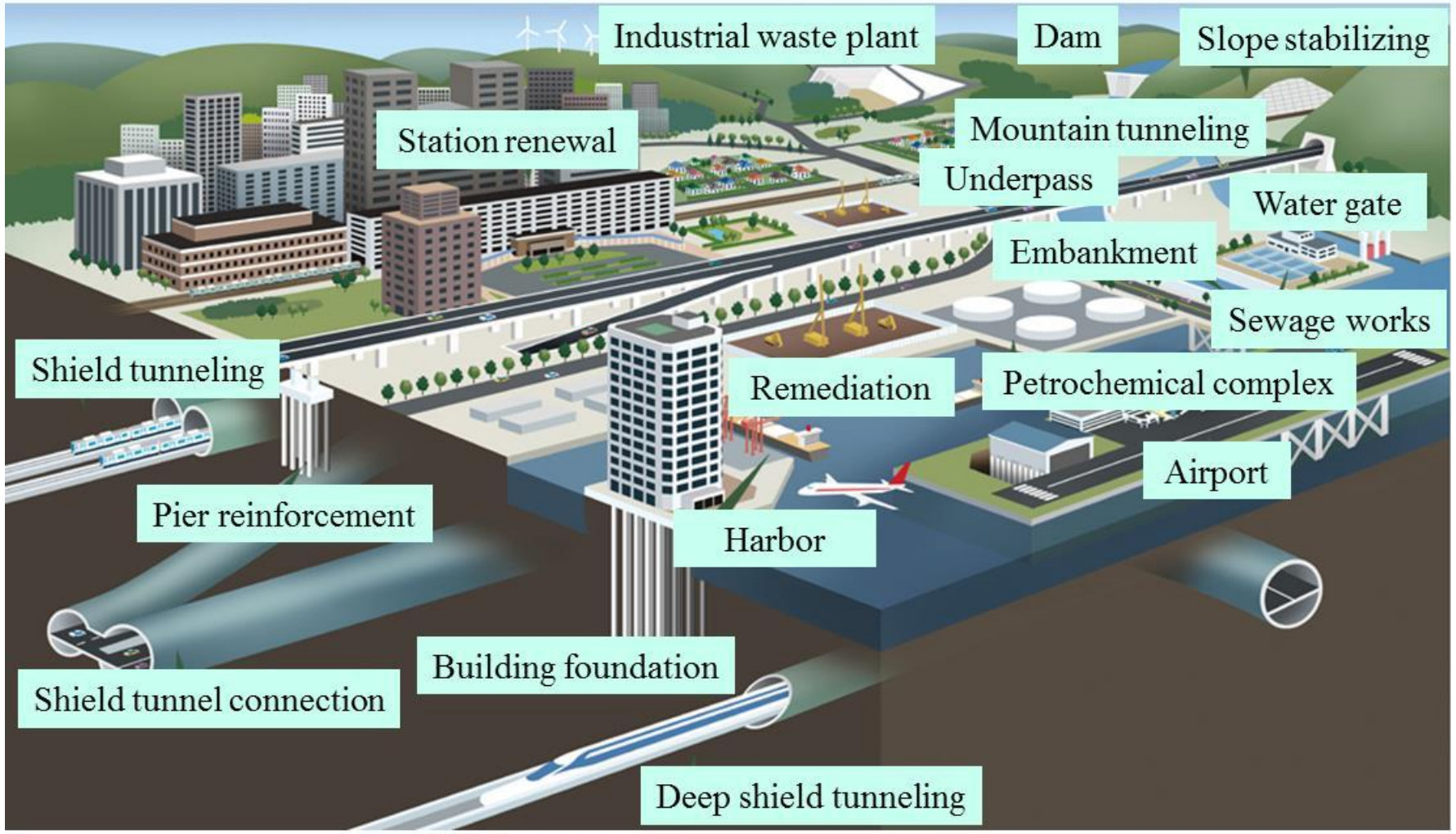
Business contents



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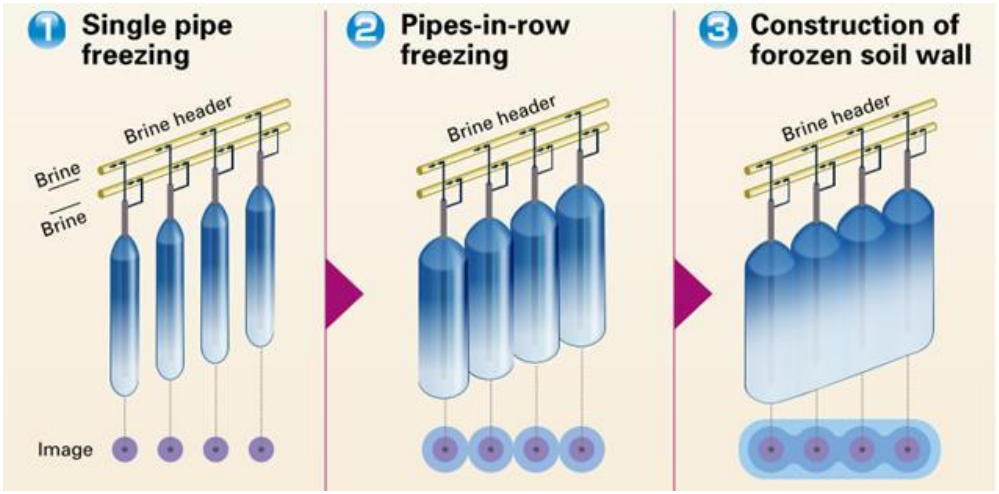
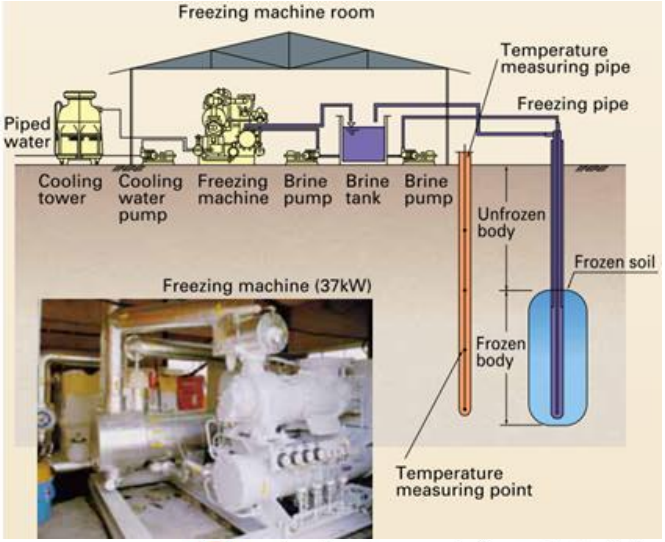
Ground freezing is

A sort of a soil improvement method that installing a freezing pipe in the ground, and circulating a cold brine through the freezing pipe, and then a hard solid frozen soil is gradually growing around a freezing pipe.

1. Available to all kind of soil.
2. Available to deep and large scale works under the high pressure ground water.
3. Ensure perfect water sealing as a result that frozen soil can be attached to steel or concrete.
4. Measuring the soil temperature during operation.
5. Eco-friendly soil improvement method.





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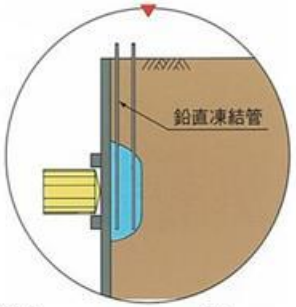
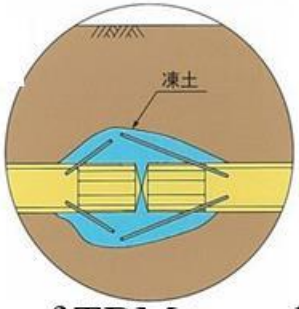
Application of ground freezing

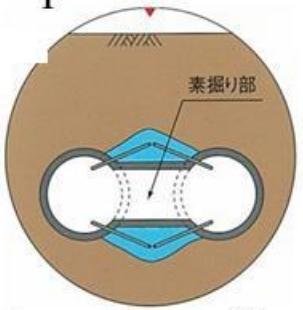
Launch of TBM



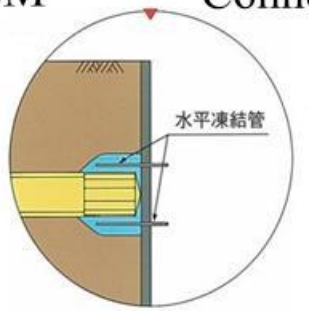
Connection of TBM tunnel



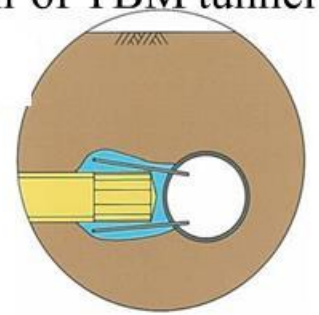
Expansion of TBM tunnel



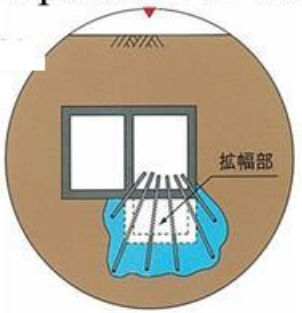
Arrival of TBM



Connection of TBM tunnel



Expansion of box type tunnel



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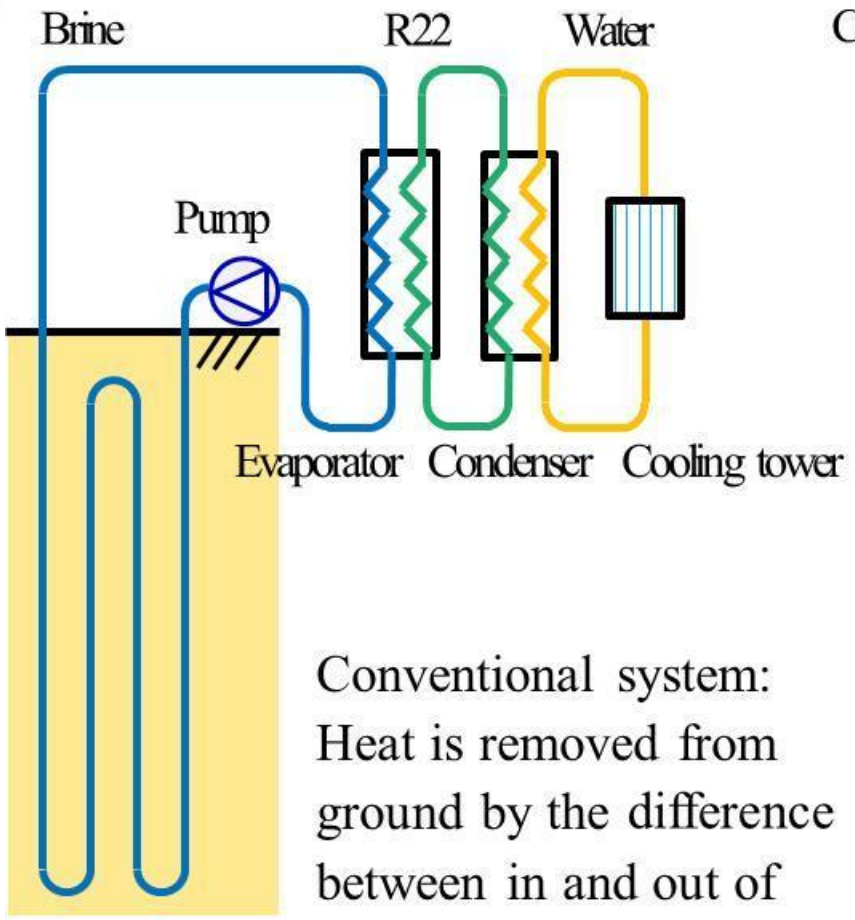
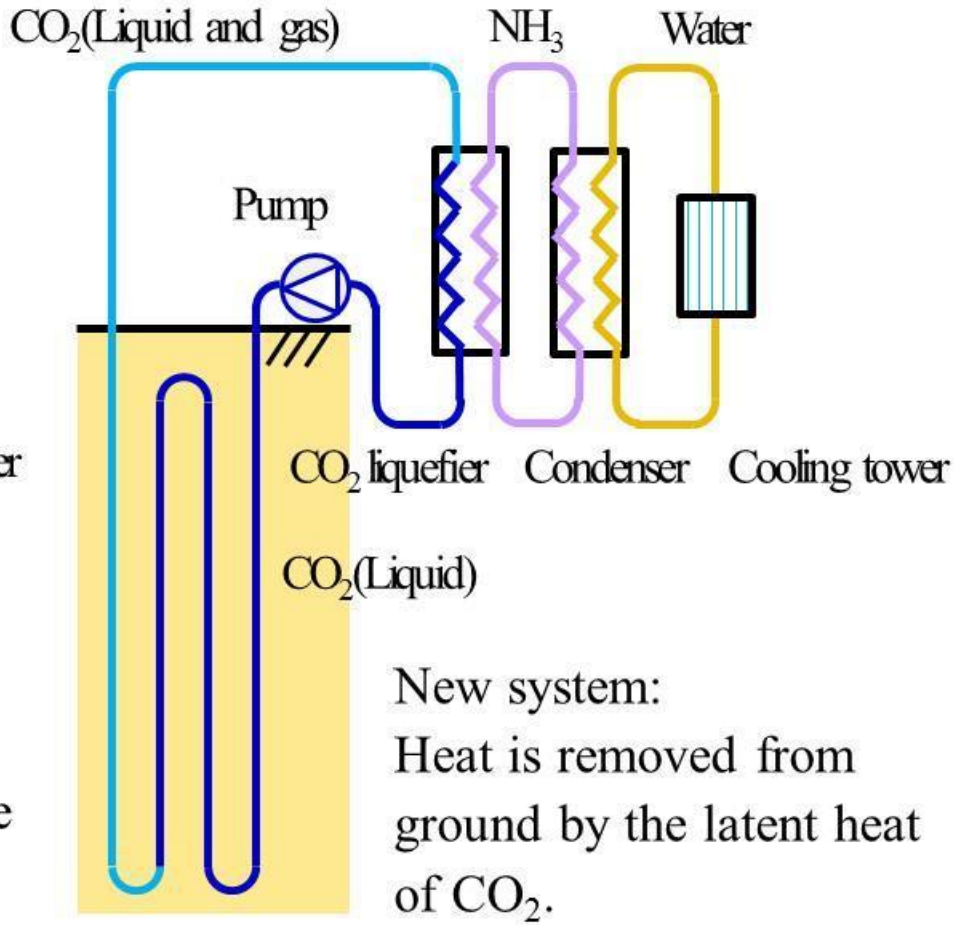
Adoption of NH_3/CO_2 system



Conventional system:
Heat is removed from ground by the difference between in and out of brine temperature.



New system:
Heat is removed from ground by the latent heat of CO_2.

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Background

- 2020
  HCFC manufacturing will be banned
- After 2025
  HFC will be regulated
- Global warming gas increasing +10.8%
  (Compared with in 1990)

In recent project

- Narrow and short head working space
- Long distance and large frozen area
- Necessary contribution for ecofriendly

Type	Number	GWP
HCFC	R22	1,810
HFC	R404A	3,920
Natural refrigerant	R717 (NH_3)	＜1
	R744 (CO_2)	1

Global warming point

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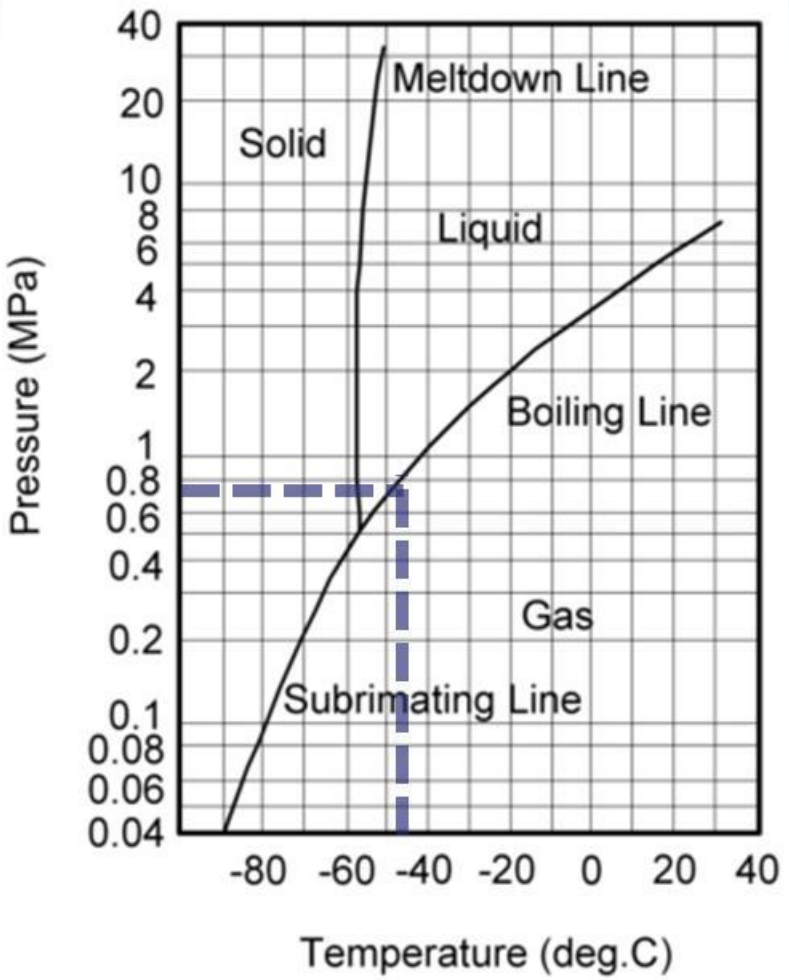
Features of new system

- CO_2 liquid and gas 2 phase flow as a second refrigerant
- Phase change between liquid and gas at 0.7MPa, -45℃
- Utilizing sensible and latent heat

- Lower amount (1/50 of conventional system)
- Lower viscosity (1/90 of conventional system)

- Size down of pipe and pump
- Long distance of pipeline
- Reduction of electric power



CO_2 Phase diagram

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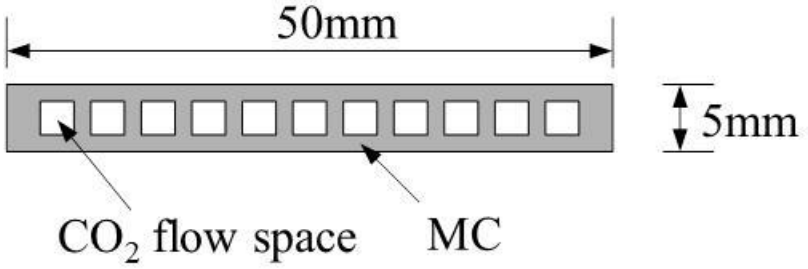
Comparison with conventional system

	New system	Conventional system
Photo		
Cooling ability	103.4 kW	110 kW
First refrigerant	NH_3 (25kg)	R22 (250kg)
Second refrigerant	CO_2	$CaCl_2$, Cold brine
Flow rate at 1freezing pipe	1 ～ 2 L/min	20 ～ 30 L/min
Minimum temperature	-45 ℃	-45 ℃
COP	2.55	1.63
Pump electric power	1 ～ 2 kW	5 ～ 11 kW
Main pipe diameter	25 ～ 50 mm	80 ～ 100 mm

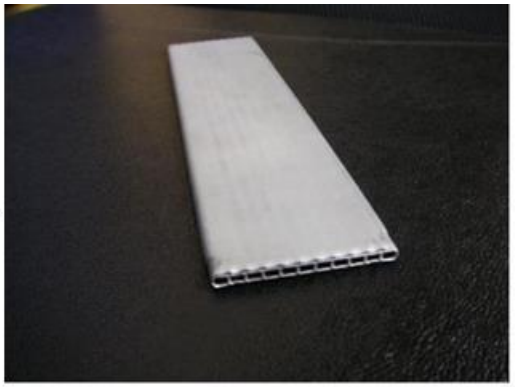
Utilizing aluminum micro channel (MC)

Features of the MC

- High heat conductivity(fourth of steel's)
- High pressure-resist and seamless(16MPa, 100m)
- Light weight(300g/m) and easy bending
- Unnecessary welding



Cross section of aluminum micro channel



Transport style in site

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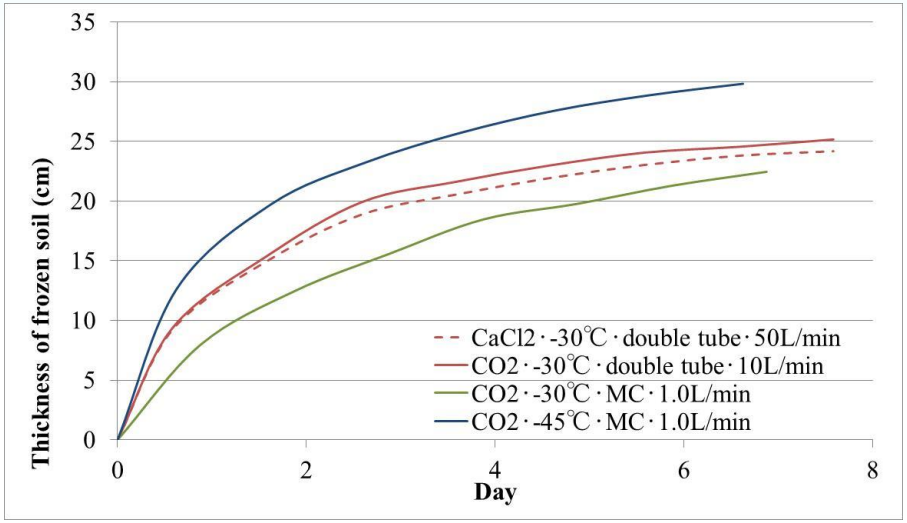
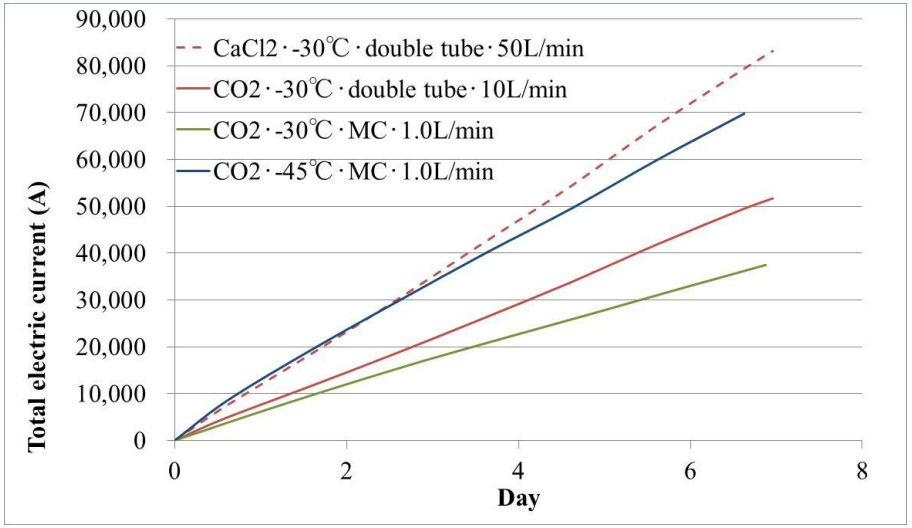
Fundamental test result (Frozen speed & Electric power)





Excavation of frozen soil

Measurement of frozen soil

Experimental equipment

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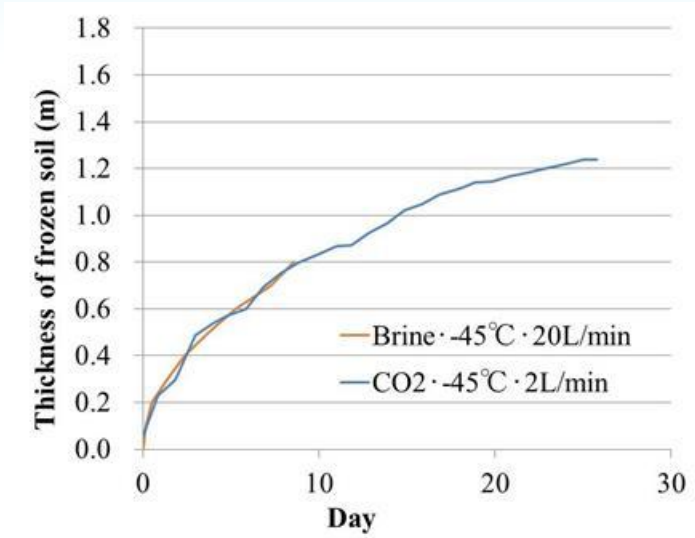
Field test result



Frozen soil

Freezing pipe

Freezing pipe attached at wall

Piping works

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Conclusion

- Adoption of natural refrigerant
  for soil freezing in construction works

- Reduction of electric power
  become 60% compared with conventional system
  In case of the frozen volume 1,200m^3
  600,000kWh → 360,000kWh

- Ecofriendly for the ground and the atmosphere

Schedule

Planed to apply for actual works in this Autumn

Marketing efforts for the big project related to
- Expand Metropolitan Expressway
- The linear Shinkansen (Bullet train)

HCFC or HFC was used in All 90 projects for the last 25 years
→Change the all system to natural refrigerant in near future
Contribute to reduction of environmental impact
in construction works

Thank you for your attention.