Precast concrete geothermal energy piles, an innovative solution for heating and cooling buildings

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Introduction

What are Energy Geostructures?

They are structures in contact with the ground that can have both a structural role and be used as a heat source/sink.

- Energy Piles
- Energy Walls
- Energy Tunnels

Energy wall

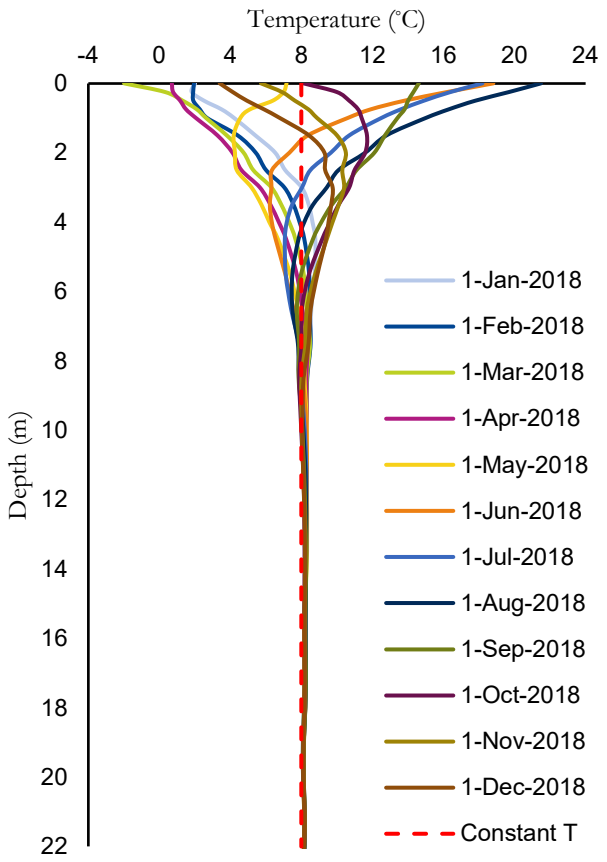
Energy pile

Energy Tunnel

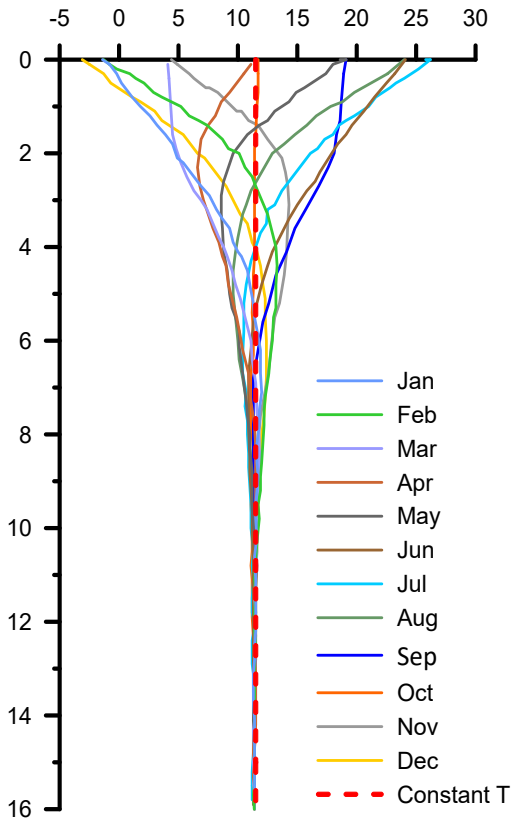
GI Energy (Tony Amis 2020)

Ground Temperature

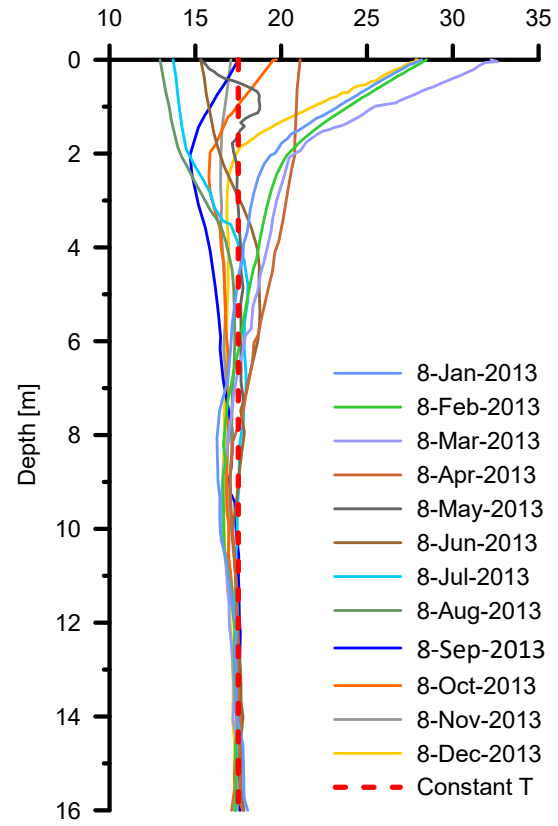
Oslo



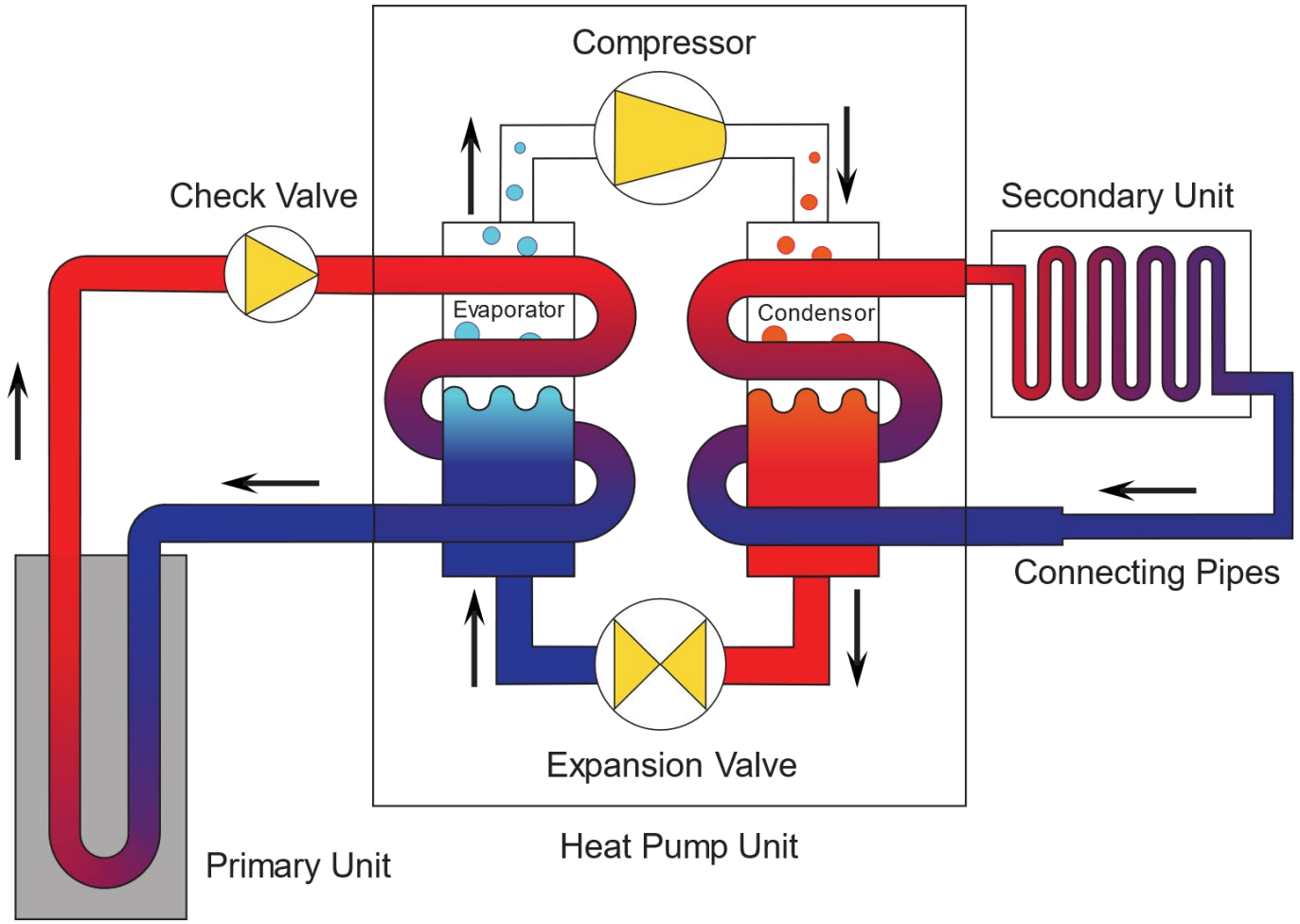
London



Melbourne

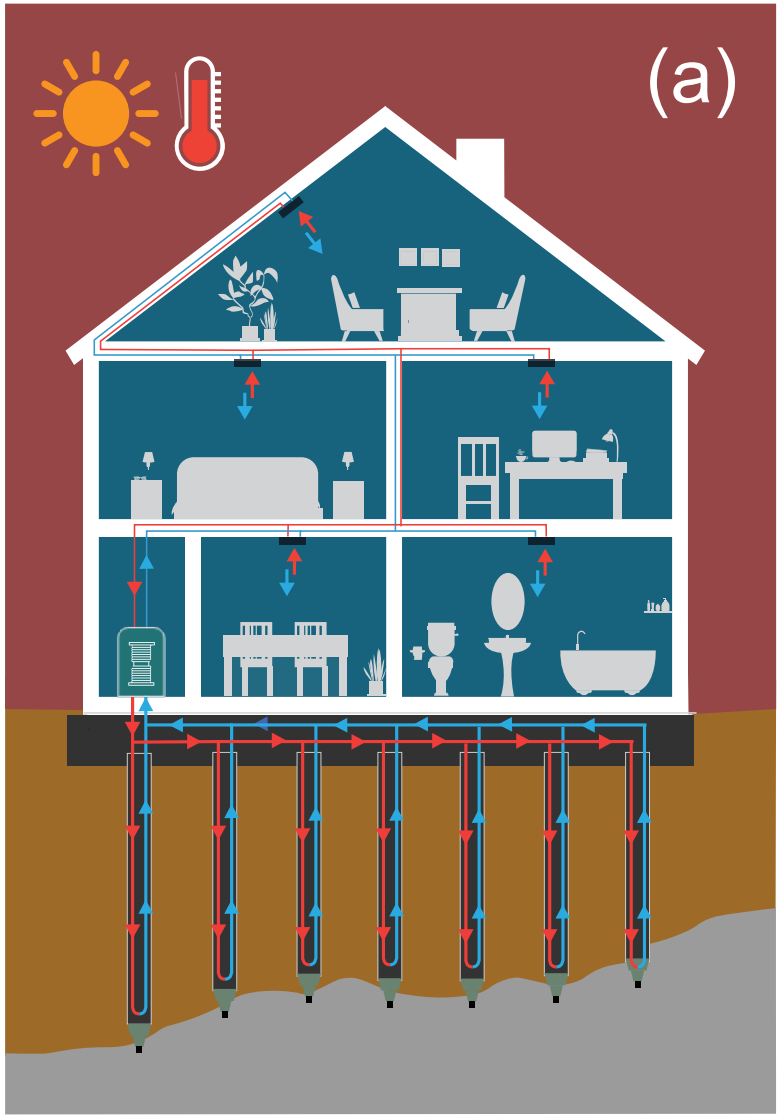


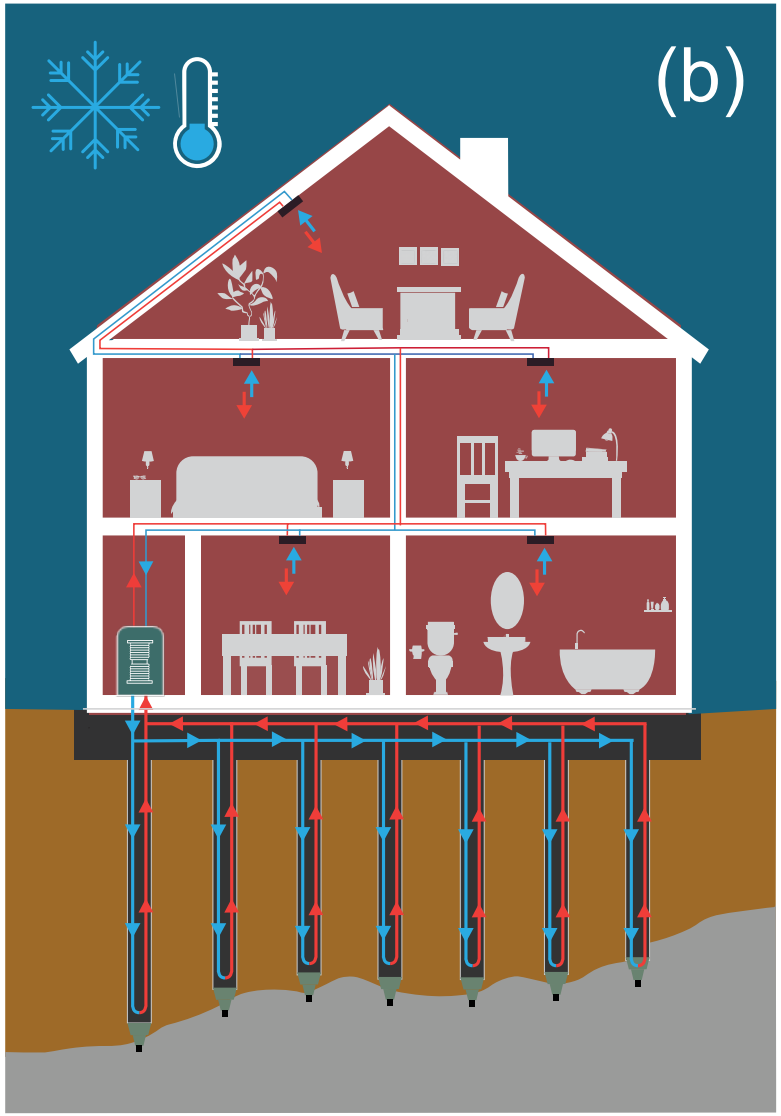
Ground source heat pump system



Sadeghi, Singh (2022)

Cooling/Heating



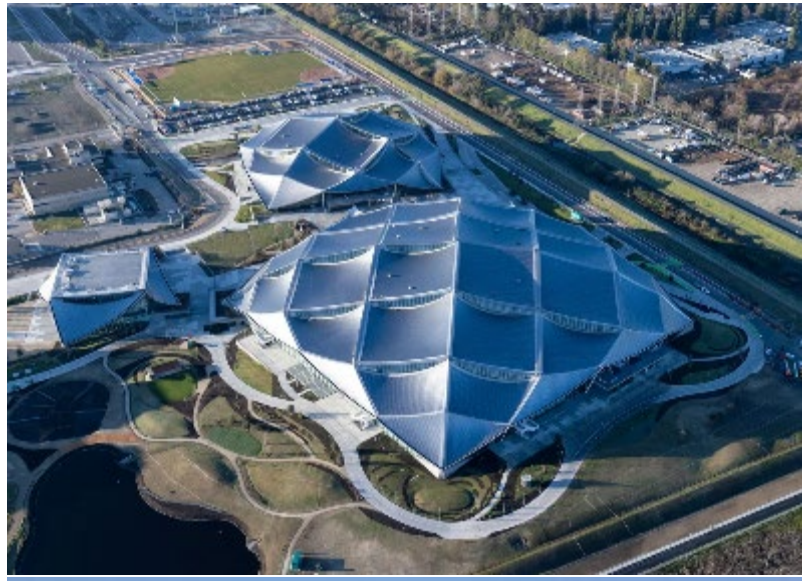


Sadeghi, Singh (2022)

Example

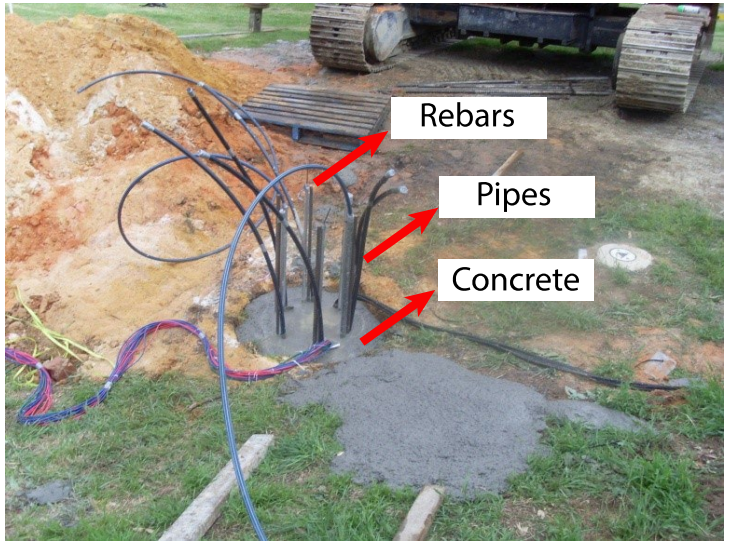
Google's new headquarter in San Francisco, California.

- Potentially the Largest Energy Pile Installation in the USA.
- 4000 piles installed under the structure
  - 26 m x 45 cm
- 2500 energy piles were used to cover 90% of cooling and all the heating loads (that's equal to five million gallons of water annually).



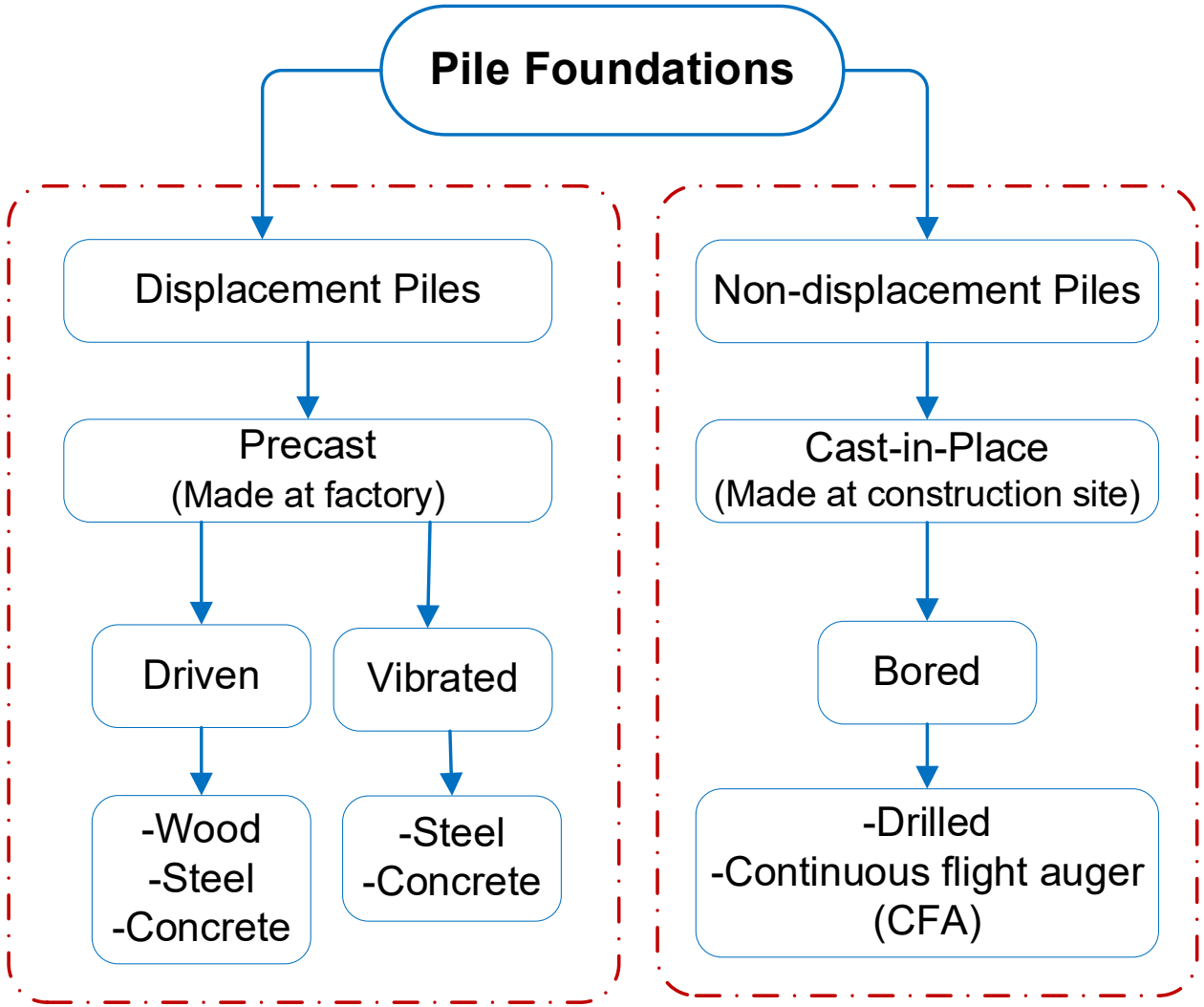
Sources:
https://www.fastcompany.com/40484709/googles-new-office-will-be-heated-and-cooled-by-the-ground-underneath
https://blog.google/inside-google/life-at-google/bay-view-campus-grand-opening/
https://www.malcolmdrilling.com/projects/google-bayview-campus/

Types of energy piles



Source: Sadeghi, Singh 2023

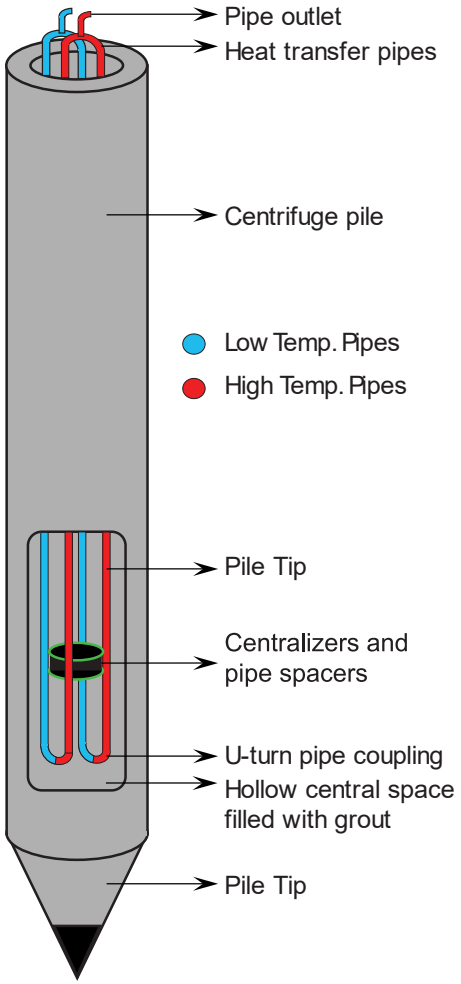
Source: Centrum Pæle AS, Denmark



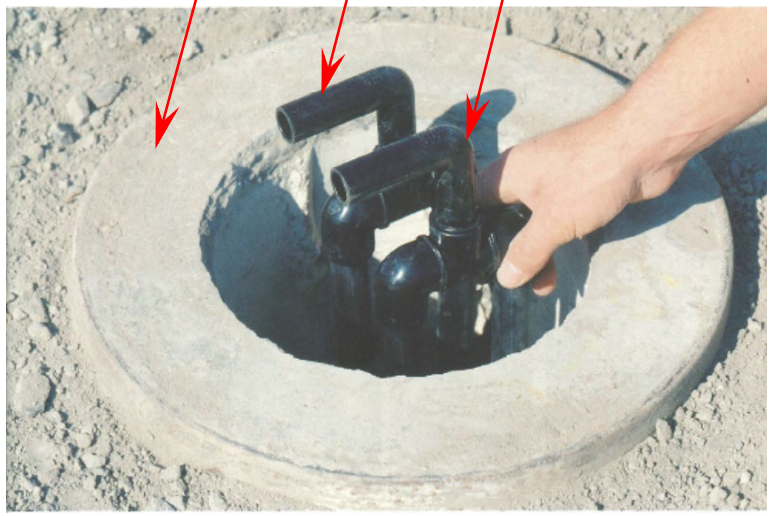
The majority of energy piles until now are cast-in-place!

Types of precast energy piles

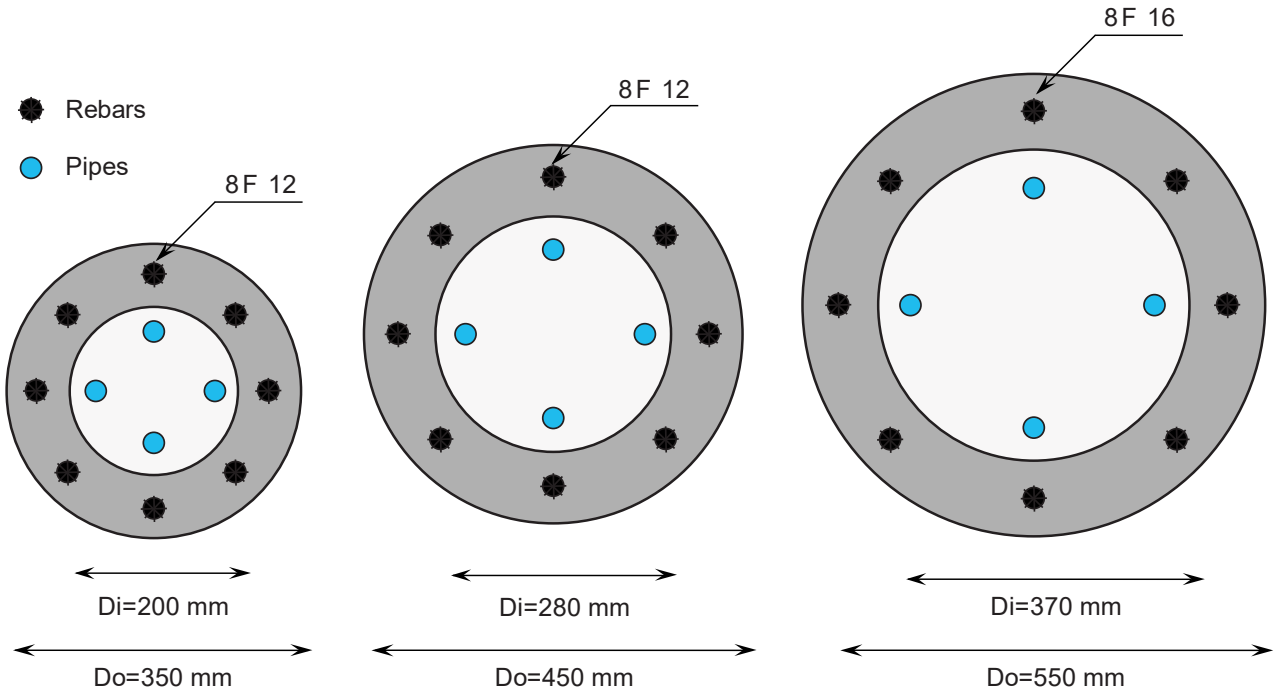
- Hollow cylindrical energy piles (concrete pipe piles)



Source: Sadeghi, Singh 2023

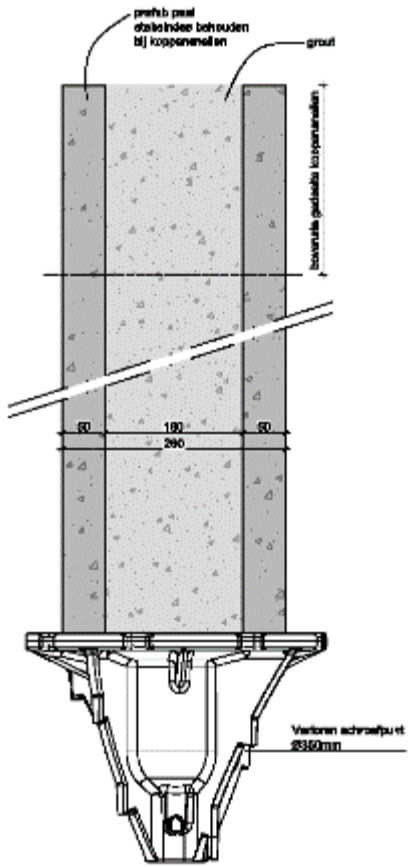


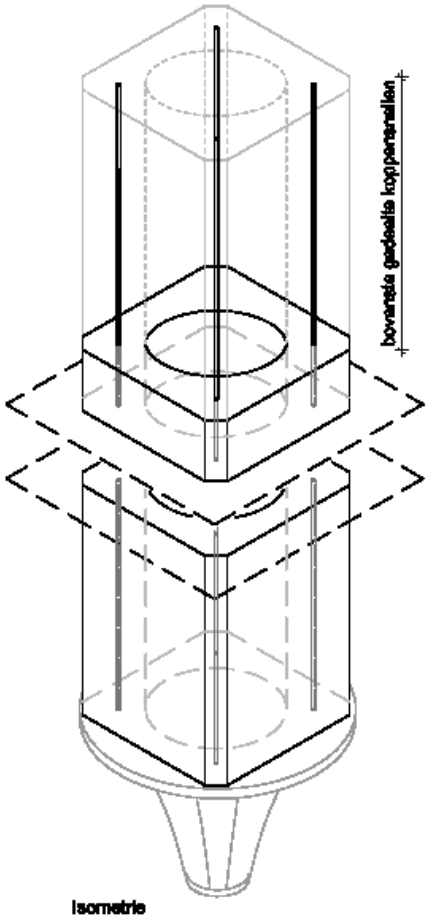
SACAC Company

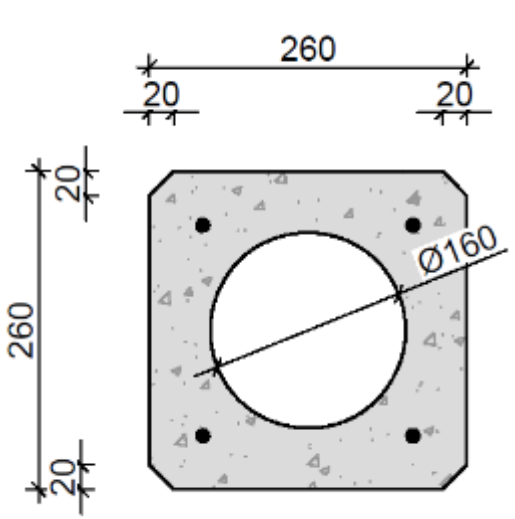


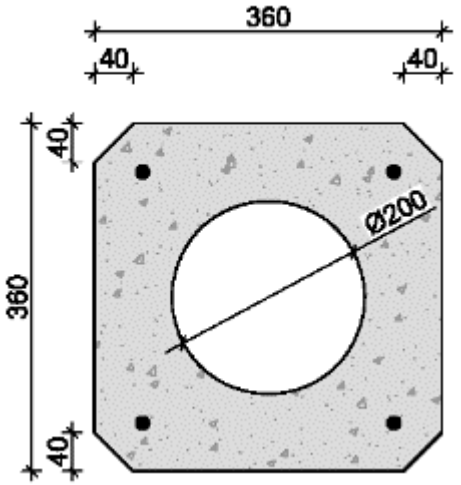
Types of precast energy piles

- Quadratic energy piles (Hollow square shaped)







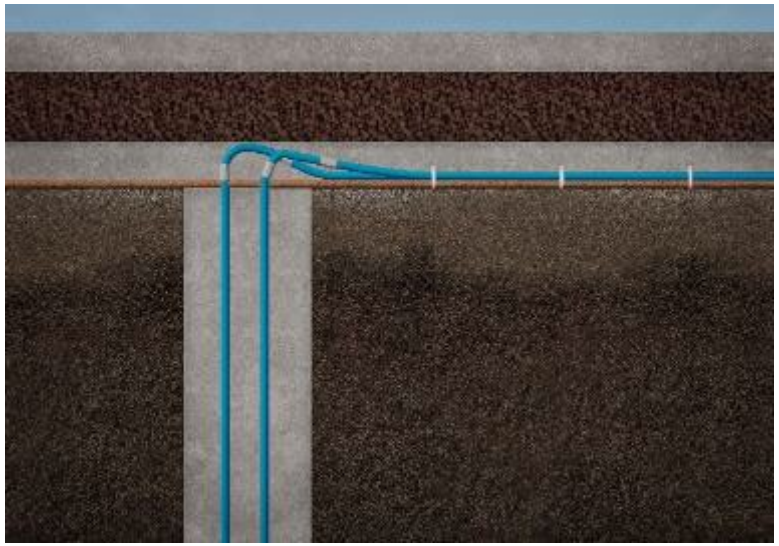


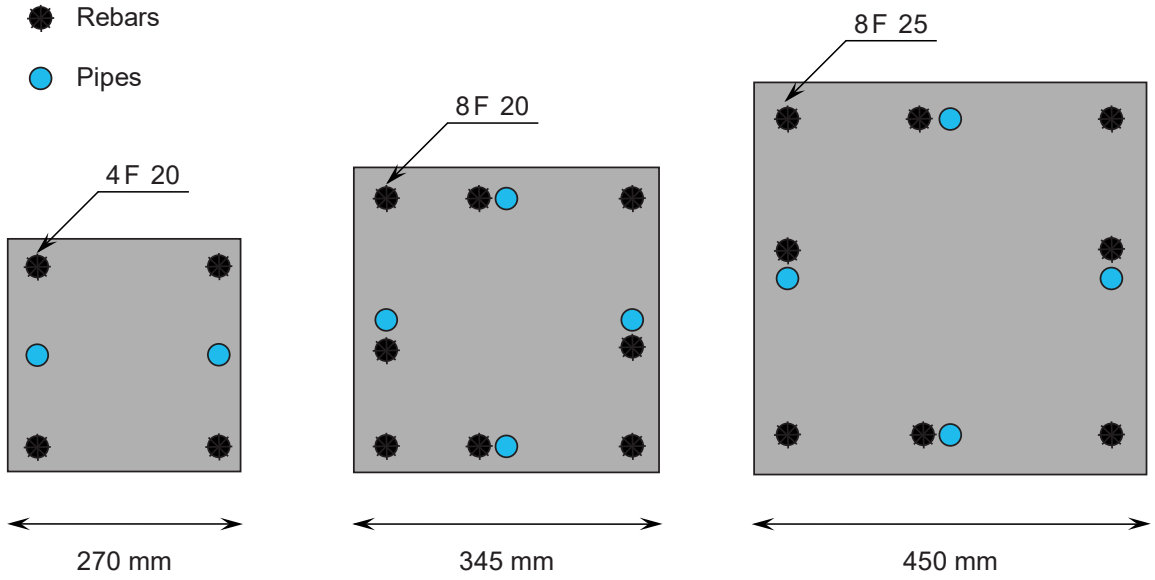
Source: HPSchroefpaal Systems B.V.

Types of precast energy piles

- Quadratic energy piles (Square shaped)

Source: Centrum Pæle A/S





Types of precast energy piles

- Quadratic energy piles (Square shaped)

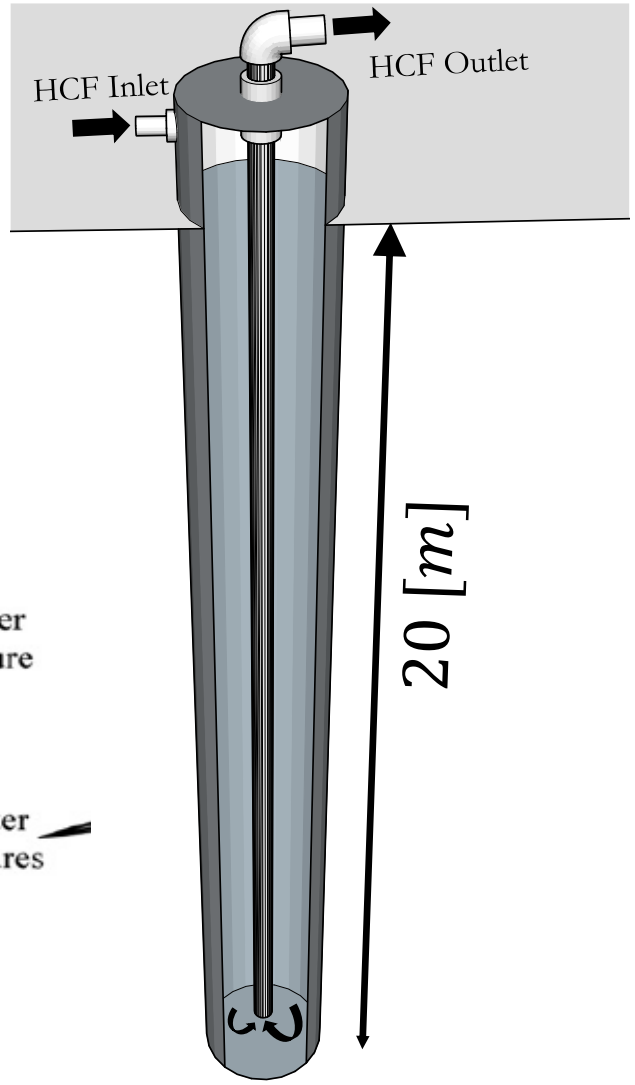
Source: Balfour Beatty, Geothermal Driven Energy Piles, Technique Sheet, 2014

Types of precast energy piles

- Steel energy piles

BEAR Project (2022)
NGI-NTNU
Malvik Kommune, Trøndelag

Jalaluddin et. al. (2010)
Saga University, Japan

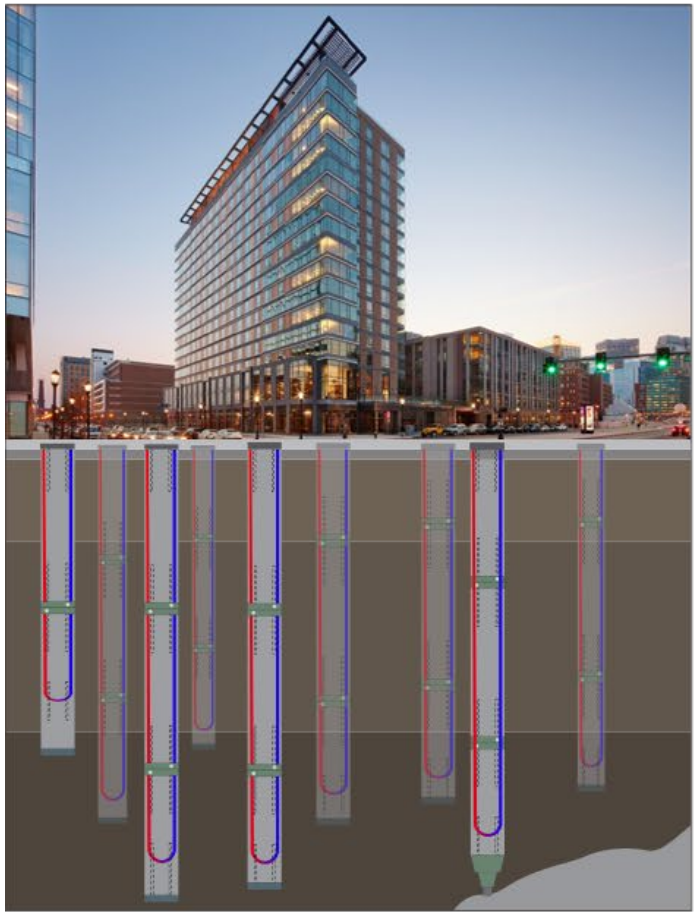


Saga University (2010)

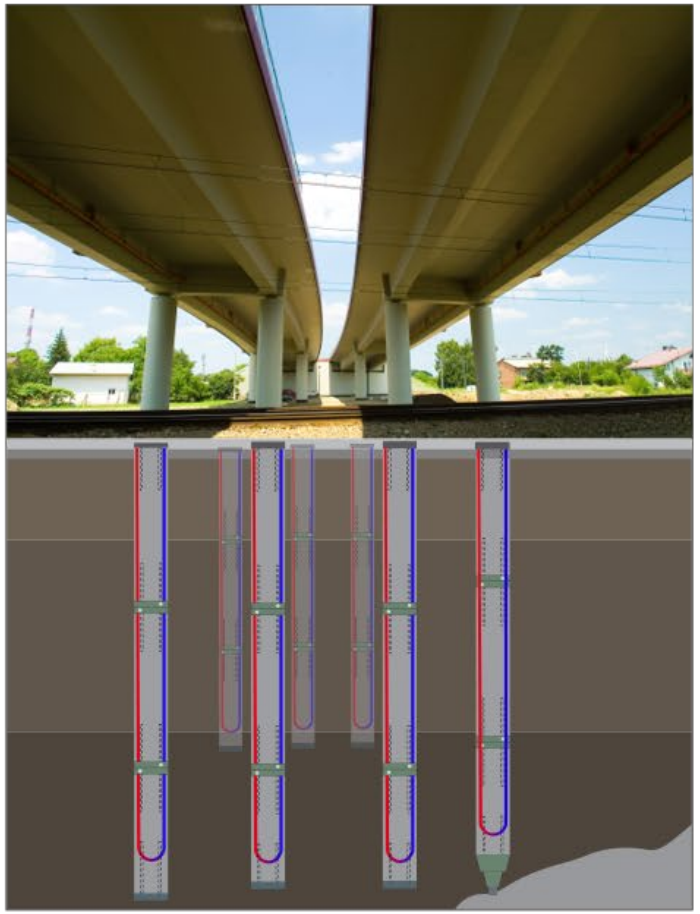
Advantages of Precast Concrete Energy piles

- Better quality control and quality assurance.
- Easier, faster, and more reliable construction process.
- No drilling is required.
- No casings are required.
- No leakage of cement and drilling fluids into the ground.
- Create no soil waste.
- Can be used below the groundwater table.
- Cheaper and labor-efficient.

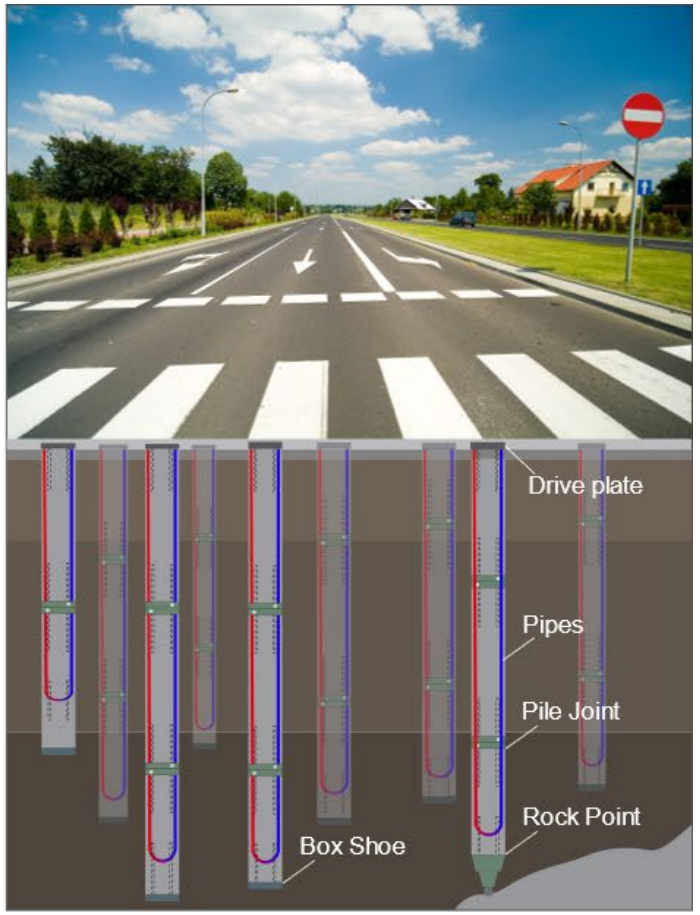
Applications



Under Buildings



Under Bridges

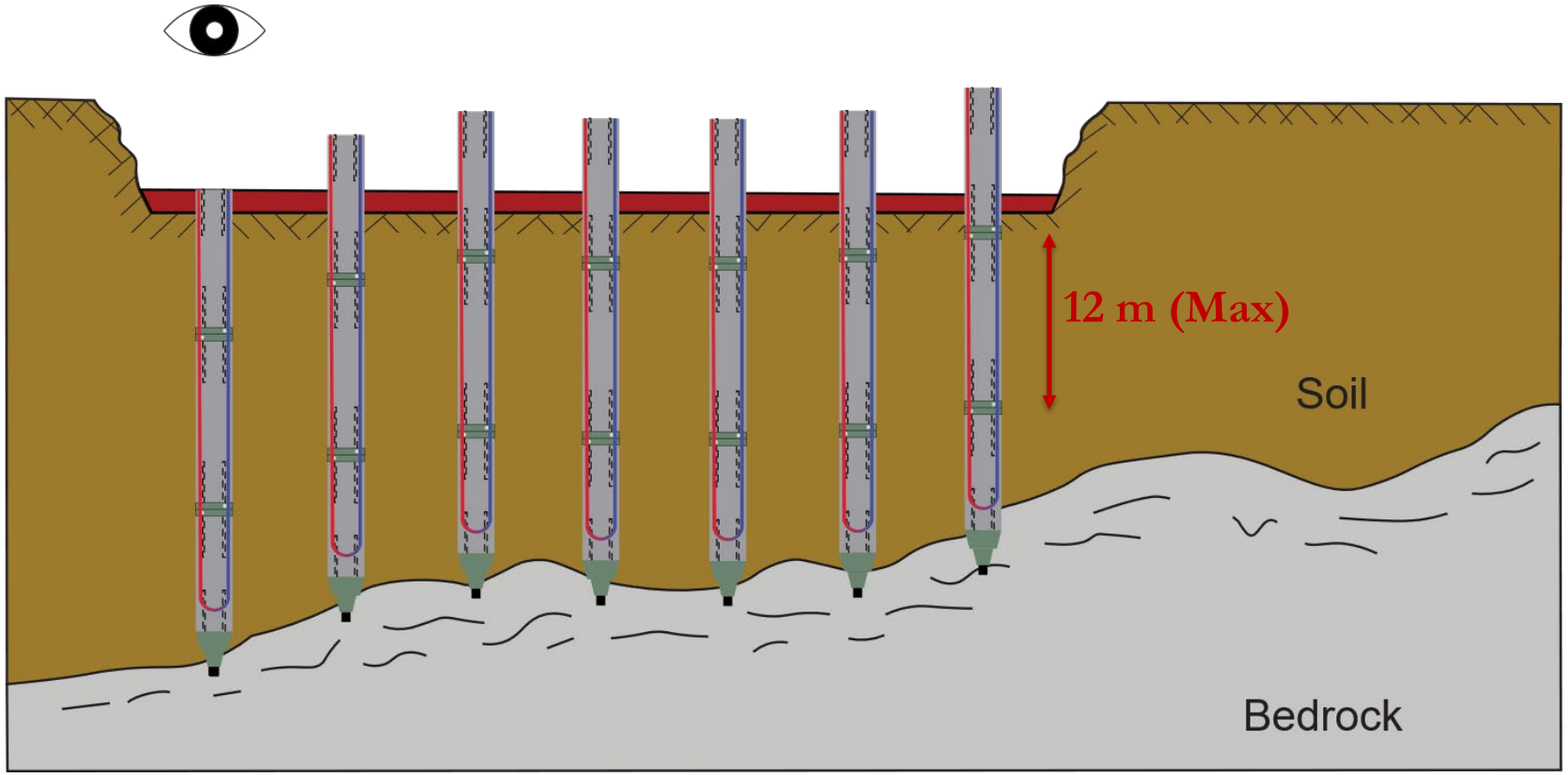


Under Roads

Sadeghi, Singh (2022)

Segmental installation using steel joints

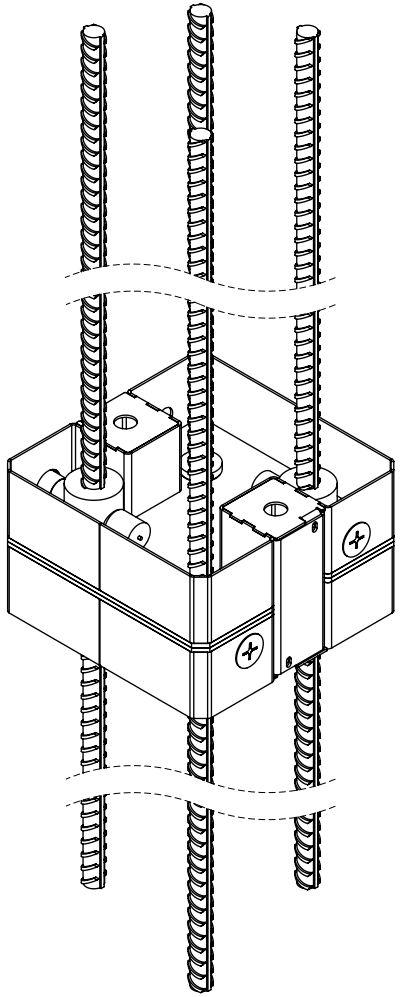
- The max length of each segment is 12-15 m → **No** suitable joint for connecting energy pile segments that allow pipe coupling.



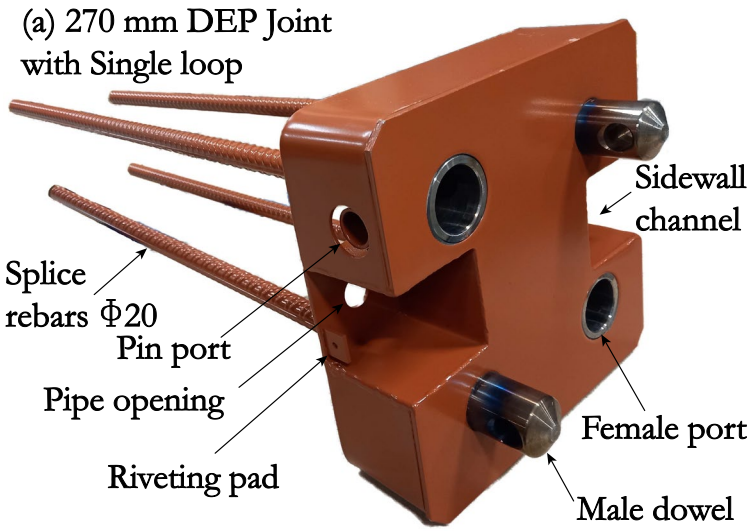
Norwegian Piling Guidelines (Peleveiledningen) 2019

DEP Joint– New generation of joints

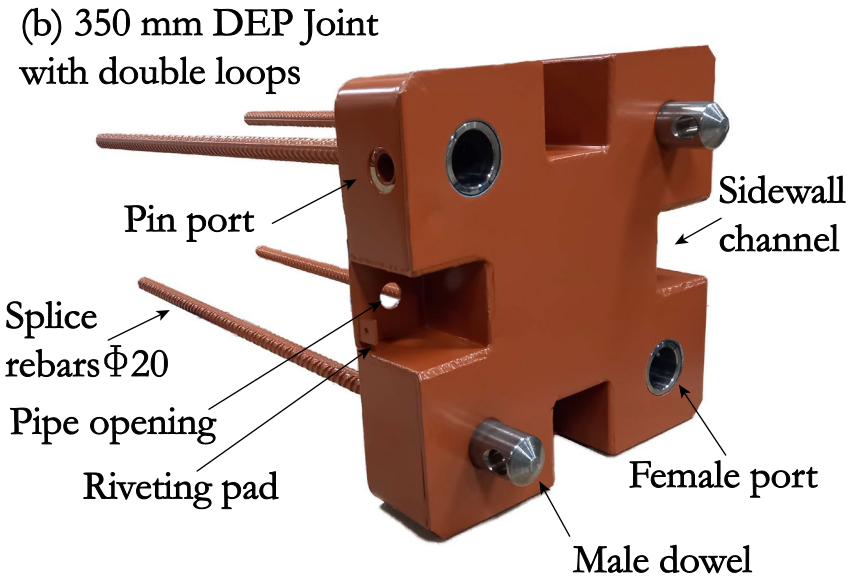
PATENTED



Shielding Plate



267-mm joint with 2 pipes

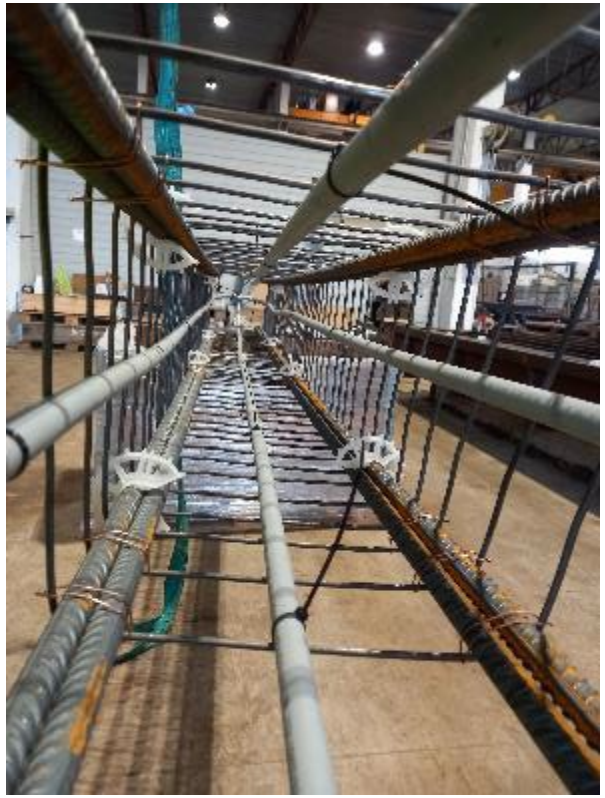


350-mm joint with 4 pipes

Sadeghi, Singh, JOINTS FOR PRE-CAST DRIVEN PILES, 2023, WO2023084125
https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2023084125&_cid=P11-LI02CC-95824-1

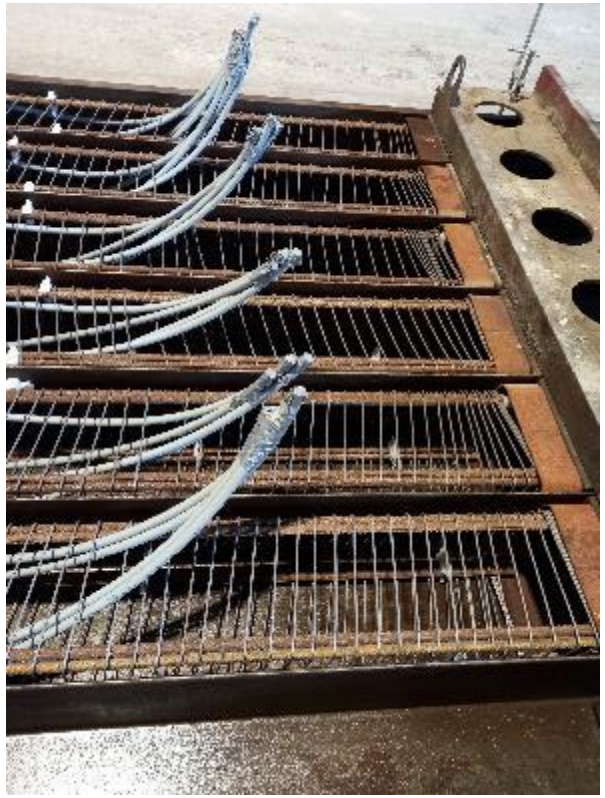
Casting

- Casting was done at SJB Factory in Stavanger, Norway.



Installation of Pipes in the cage

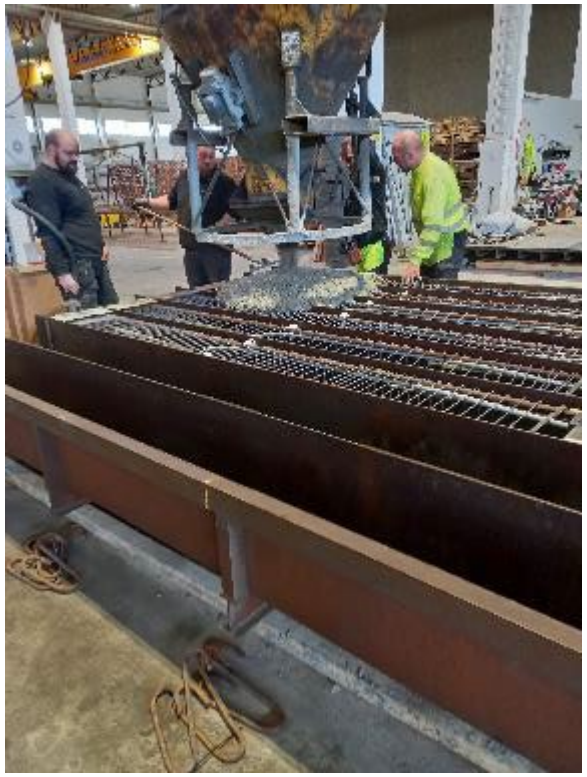
Joints and Casting guides are installed



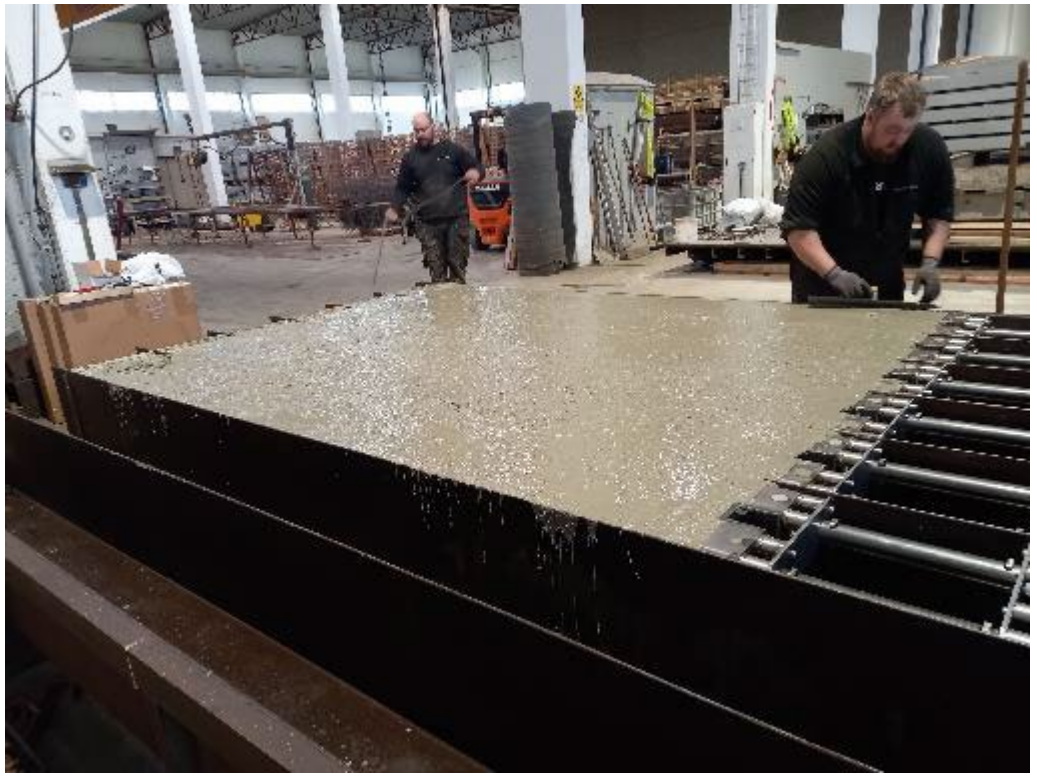
Pipes coming out of pile head

Casting

- Casting was done at Sandnes & Jærbetong factory in Stavanger, Norway.



Pouring the concrete in the formwork



Finishing the surface

Final product after 2 weeks of Curing

Preparations before the Impact tests

The Joints **shall** be tested for impact and bending, according to **BS EN 12794.**

Before the impact tests, two segments are connected, and pipes are coupled.

Before connection

Preparing the pipes

Pins installed, and pipe fittings connect the pipes

Coupling the pipes by Fusion welding

25 second welding + 5 min cooling time

Fusion welding device

20

Impact tests

- The impact test were done according to the **BS EN 12794** standard.

Moving the piles to the test box

1000 Impacts Imposing Min. 28 MPa

PDA Measurements

Hydraulic Pressure tests

- After the impact test hydraulic pressure tests were done according to the **ASTM F2164−21.**

Hydraulic pressure setup

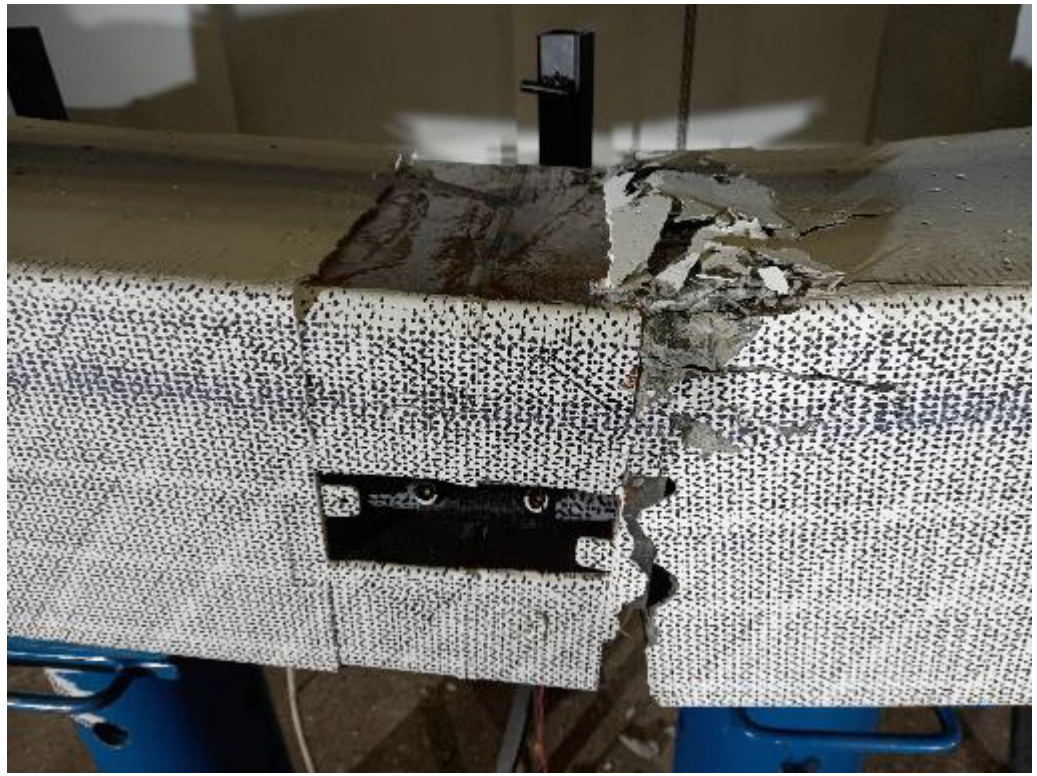
Pressure maintained for 90 Minutes

No leakage observed and pressure drop is less than 5%

Bending tests

- The bending tests were done according to **BS EN 12794** at Tampere University.

Bending test setup
Min 10 Loading steps, each 3-5 minutes



End of Bending tests

DEP Joint is ready to be used in the industry!

267 mm joint
with 2 pipes

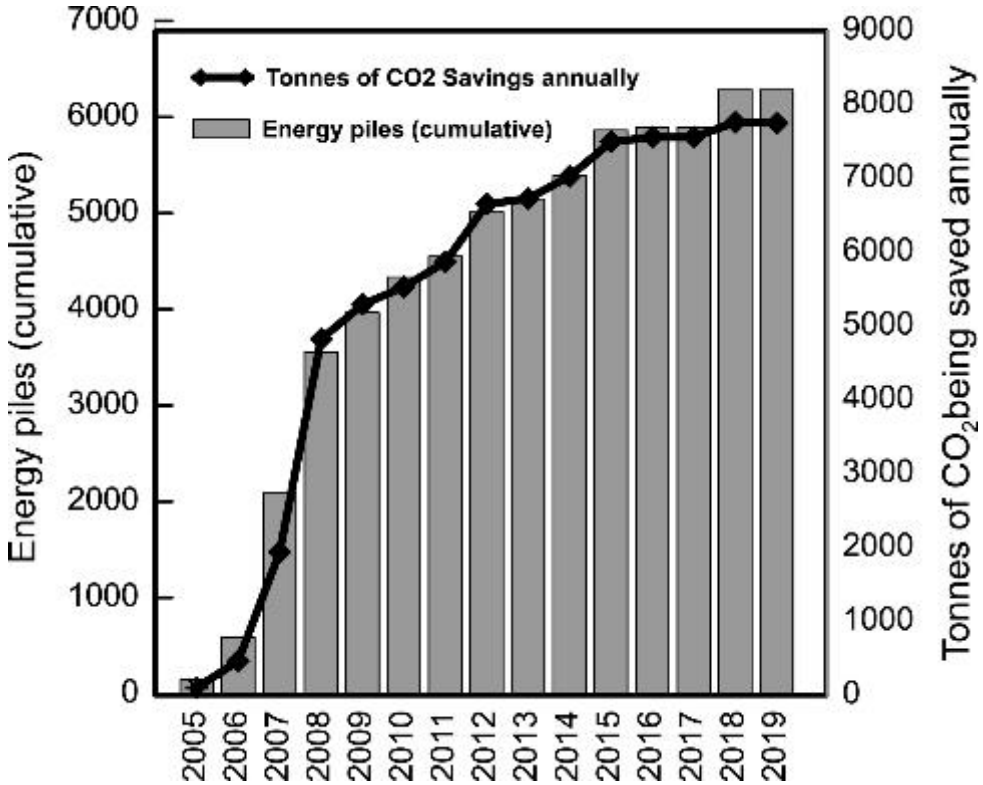
CE Mark

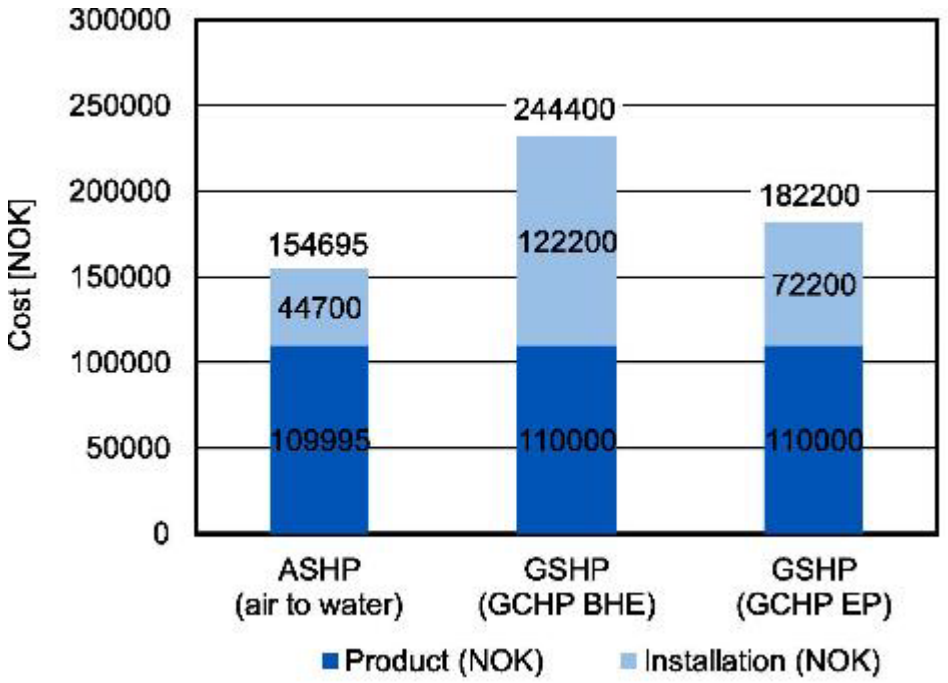
350 mm joint
with 4 pipes

Installation

Two Driven Energy piles were successfully installed on 16th and 17th October 2023

Market size and payback period





Sadeghi, Singh (2023), Driven precast concrete geothermal energy piles: Current state of knowledge, Building and Environment, Volume 228, 2023, 109790, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2022.109790 .

Sadeghi, Ijaz, Singh (2022), Current status of heat pumps in Norway and analysis of their performance and payback time, Sustainable Energy Technologies and Assessments, Volume 54, 2022, 102829, ISSN 2213-1388, https://doi.org/10.1016/j.seta.2022.102829 .

Growing market demand

Acknowledgement

Research Council of Norway

NTNU | Technology Transfer as

Sandnes & Jærbetong

LEIMET
Piling Quality™

We are actively seeking industry partners to produce DEP joints.

Contact

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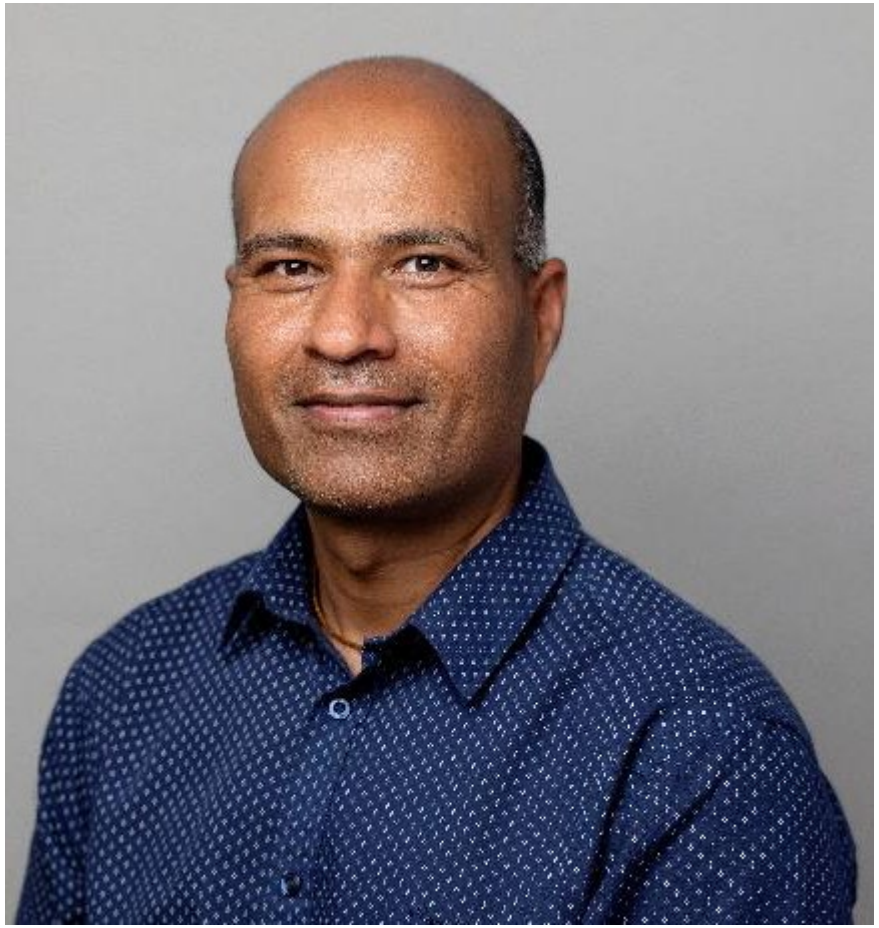

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Thank you!