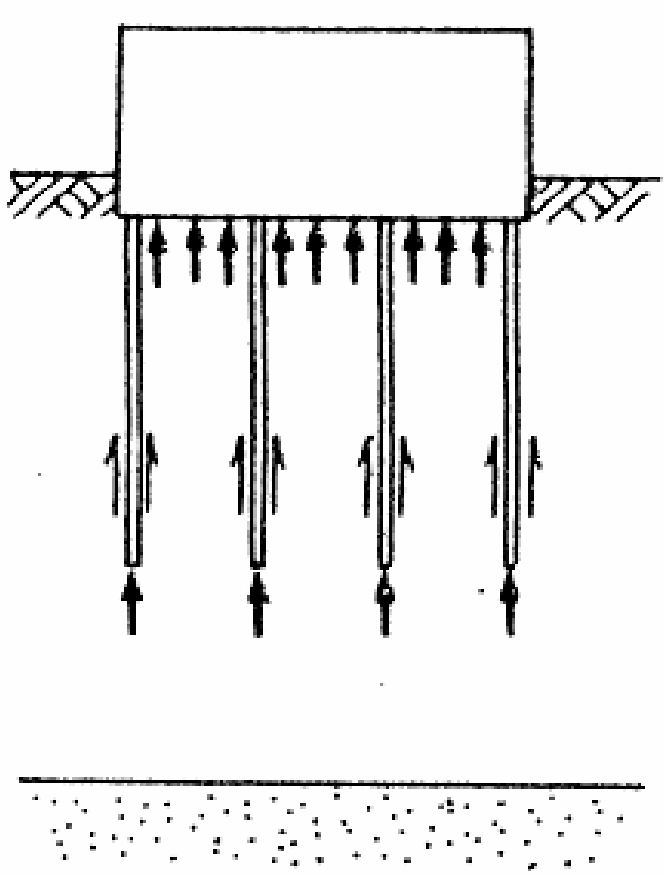
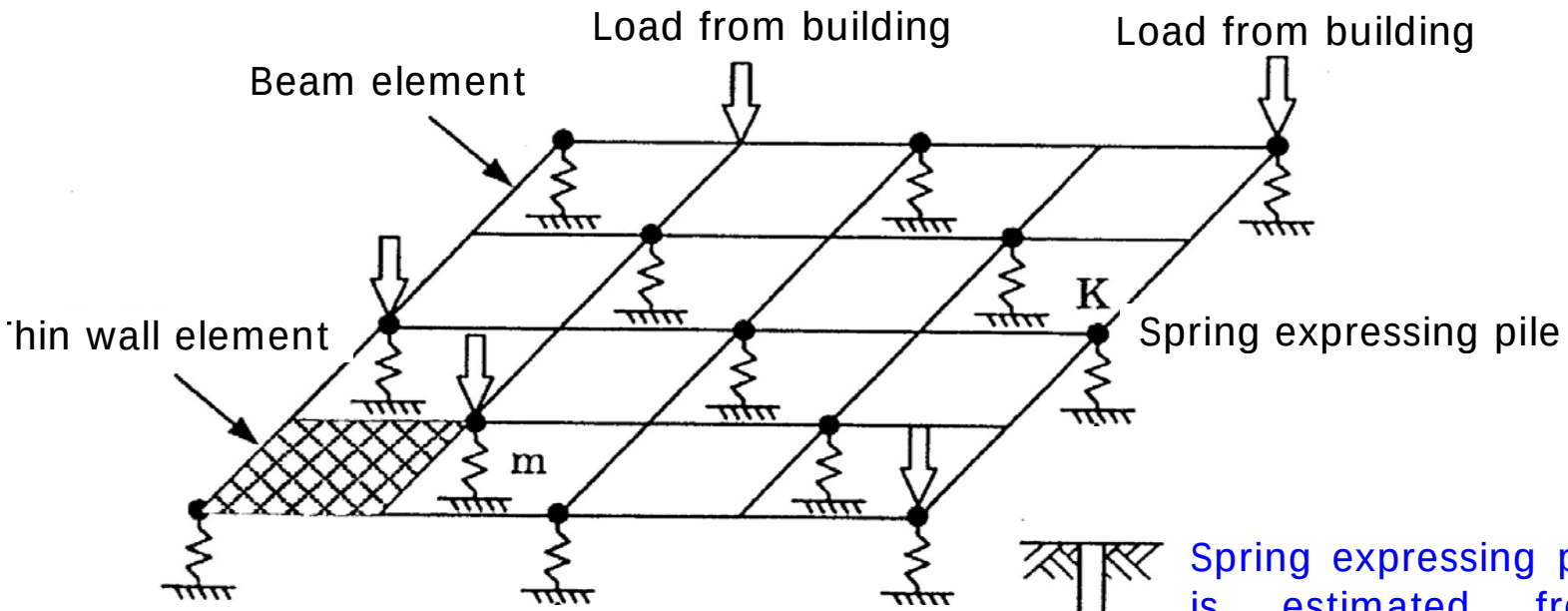
Piled raft foundations in Alluvial and Diluvial grounds

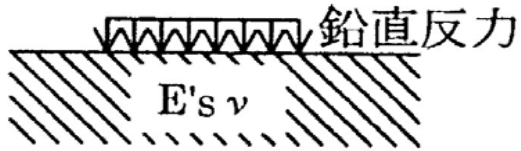
- 3 cases in Alluvial ground
  (Coal silo, Building #1, Building #2)
- 2 cases in Diluvial ground
  (Building #3, Building #4)



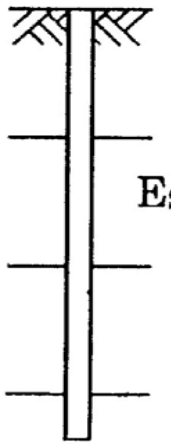
Foundations were designed as piled raft foundations.

Analytical model used in the design of piled raft foundations in the case studies by Takenaka Corporation





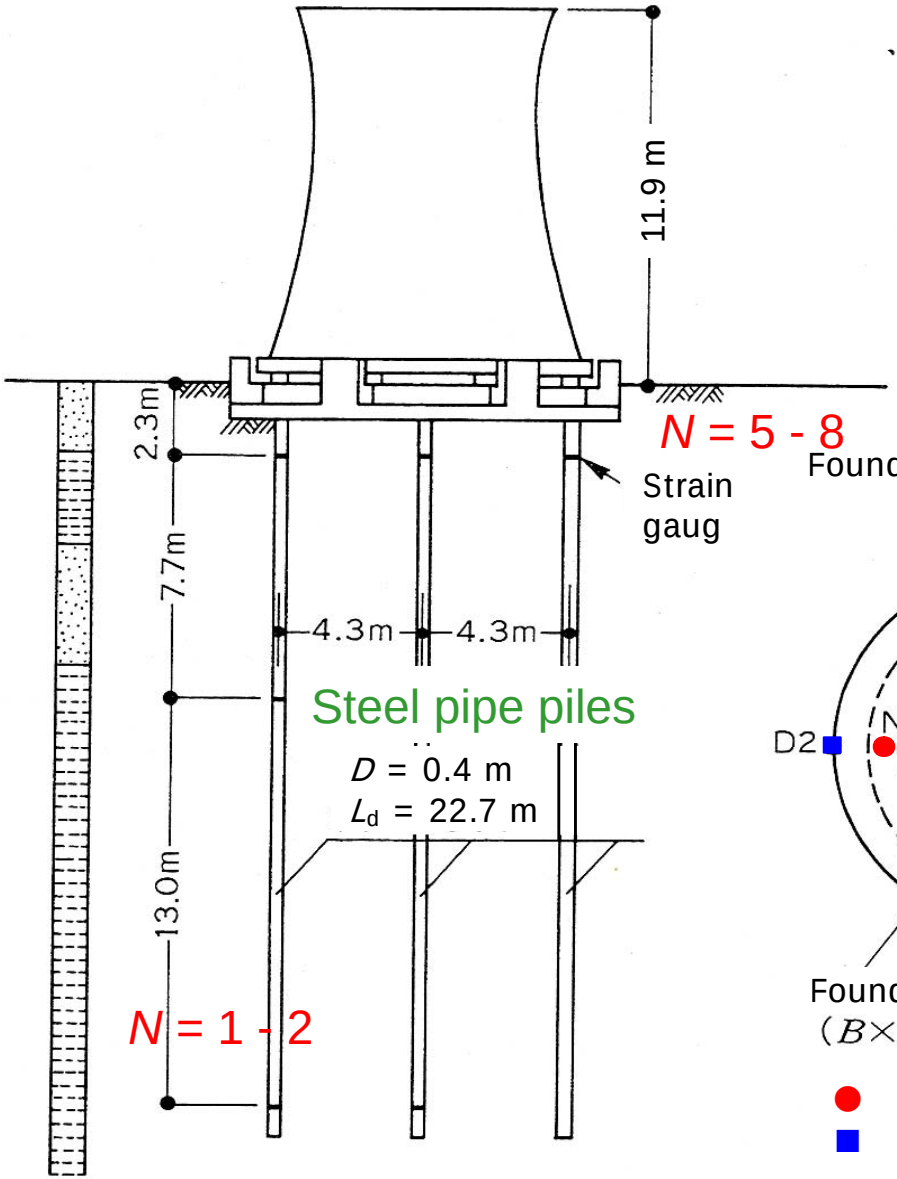
Spring at node without pile is estimated from analysis of plate on the ground

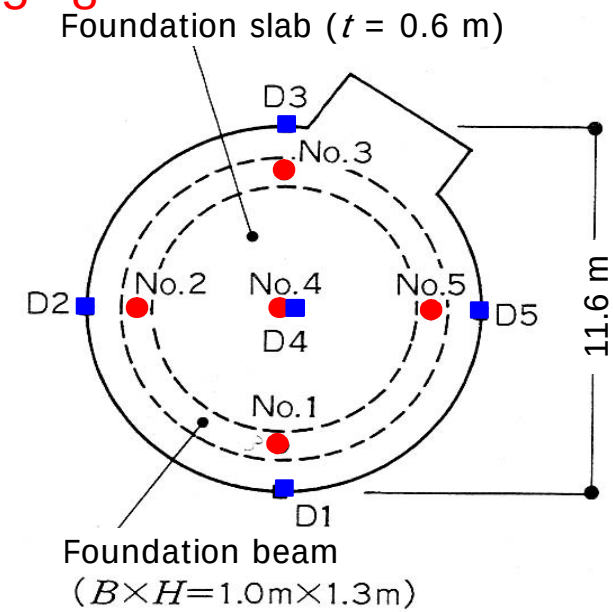


Spring expressing pile is estimated from single pile analysis

Plate on Springs Approach

Coal silo in Alluvial ground





Average contact pressure as the raft foundation = 73.6 kPa

Design as pile foundation:

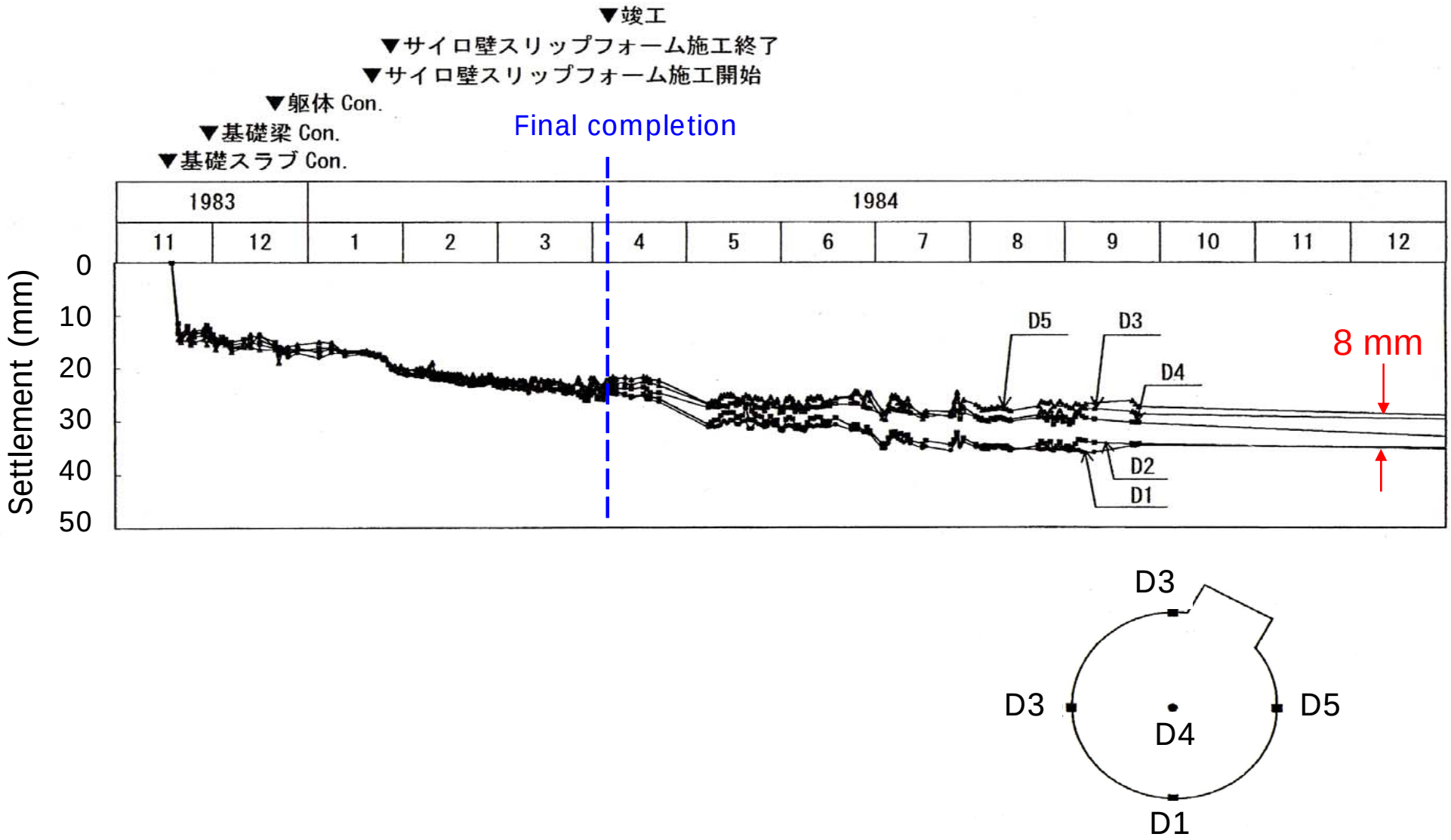
10 piles, L = 40 m

Design as piled raft foundation:

5 piles, L = 22.7 m

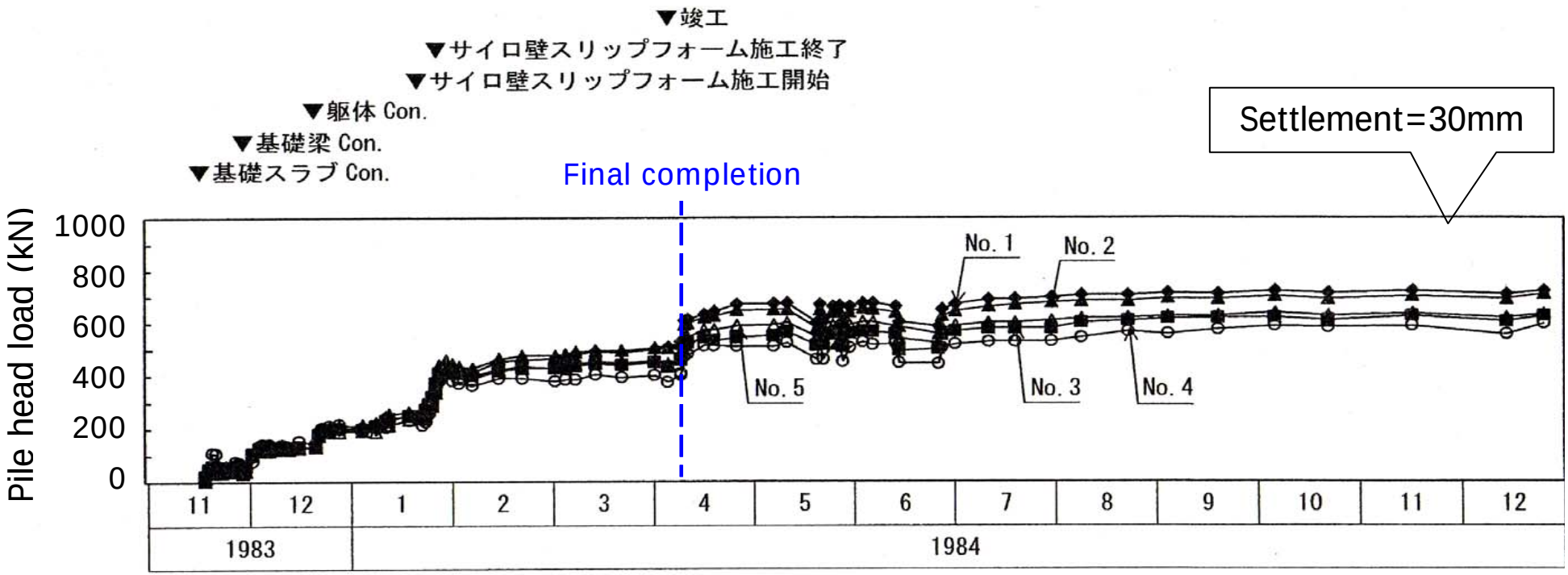
Coal silo in Alluvial ground

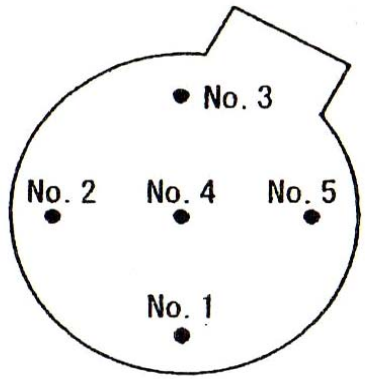
Time histories of settlements



Coal silo in Alluvial ground

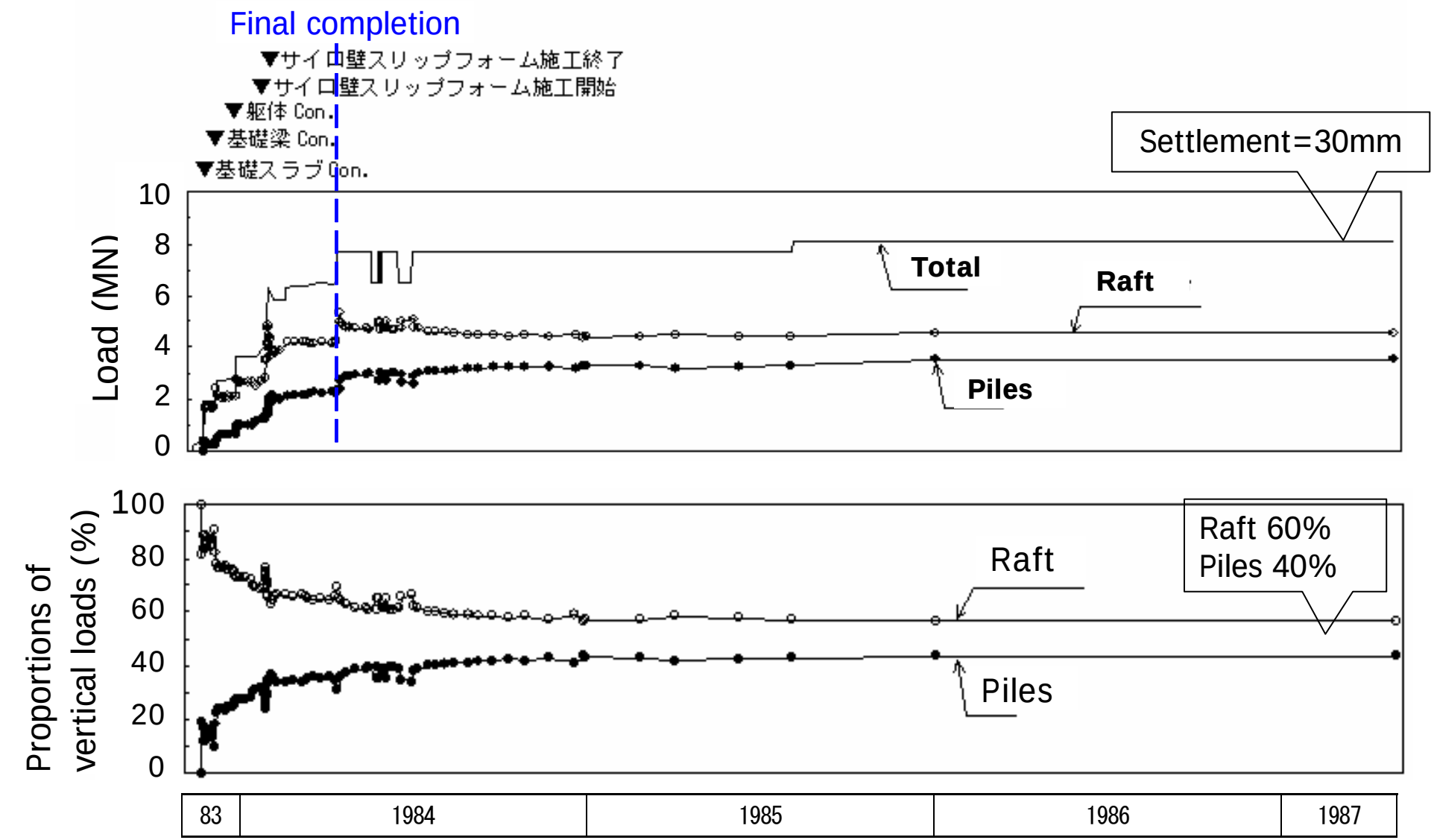
Time histories of pile head loads



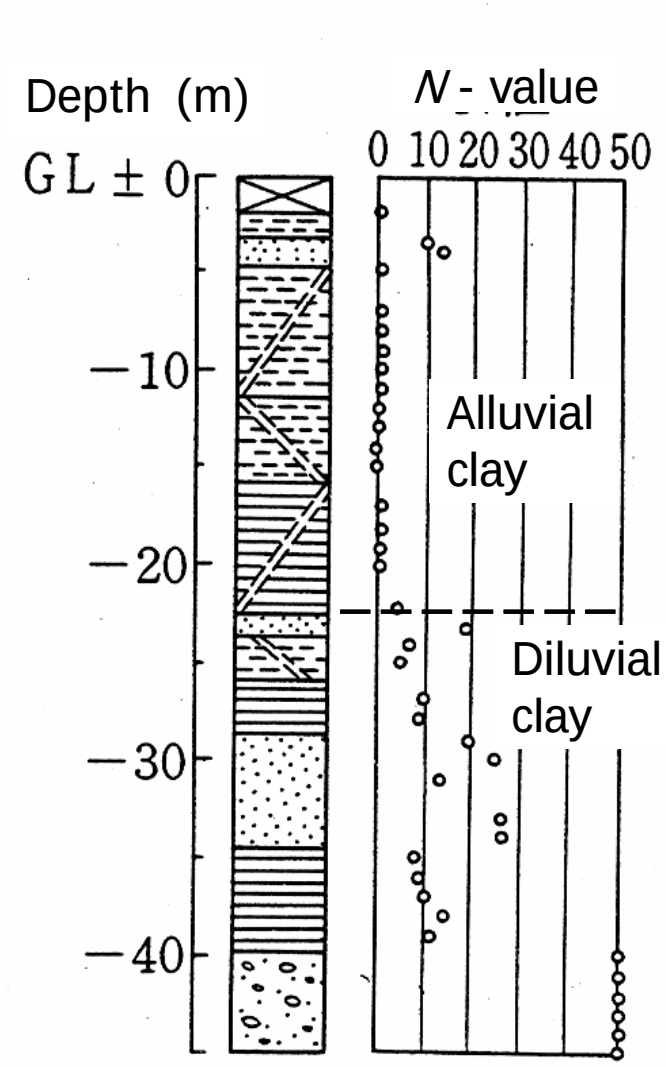


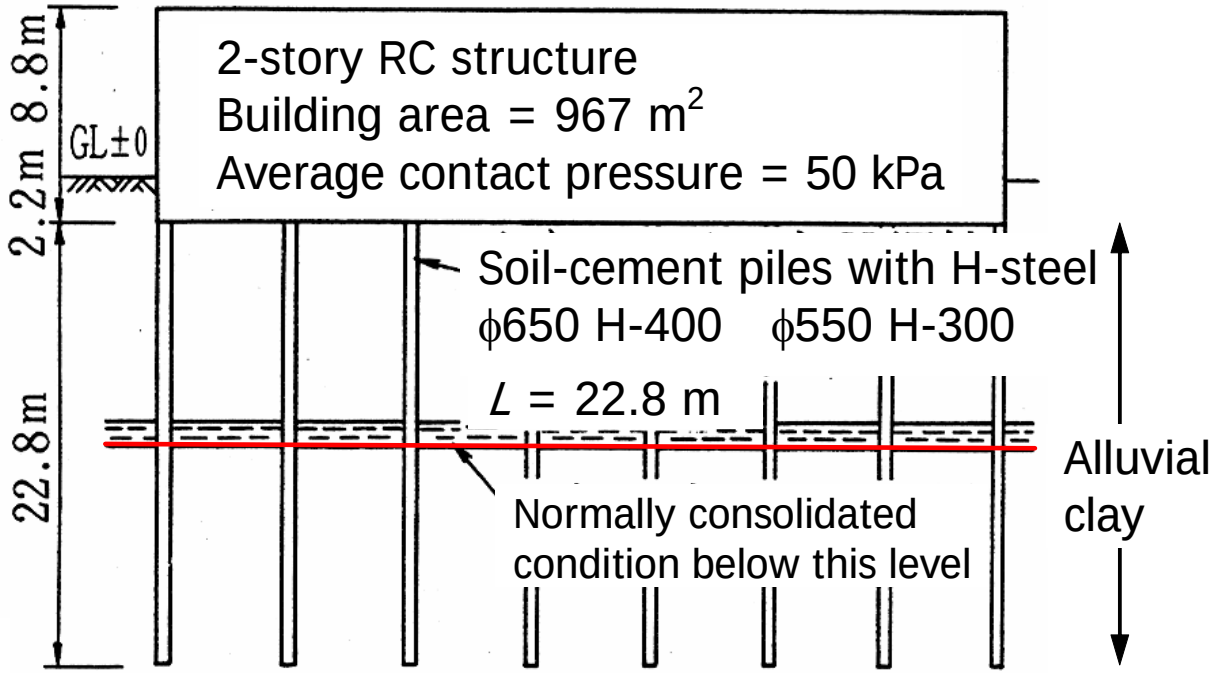
Coal silo

Time histories of loads carried by piles and raft



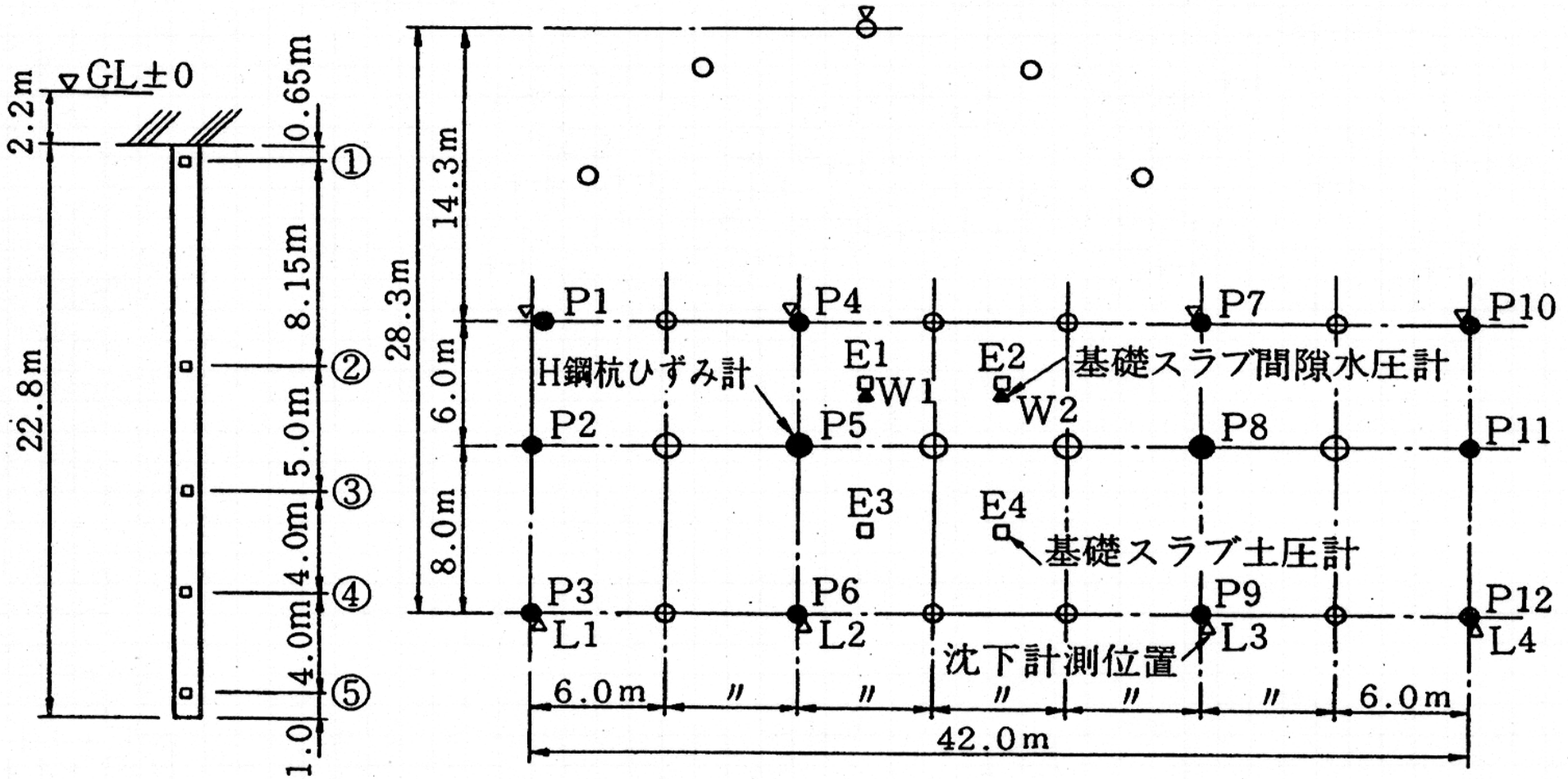
RC building #1 in Alluvial ground





RC building #1 in Alluvial ground

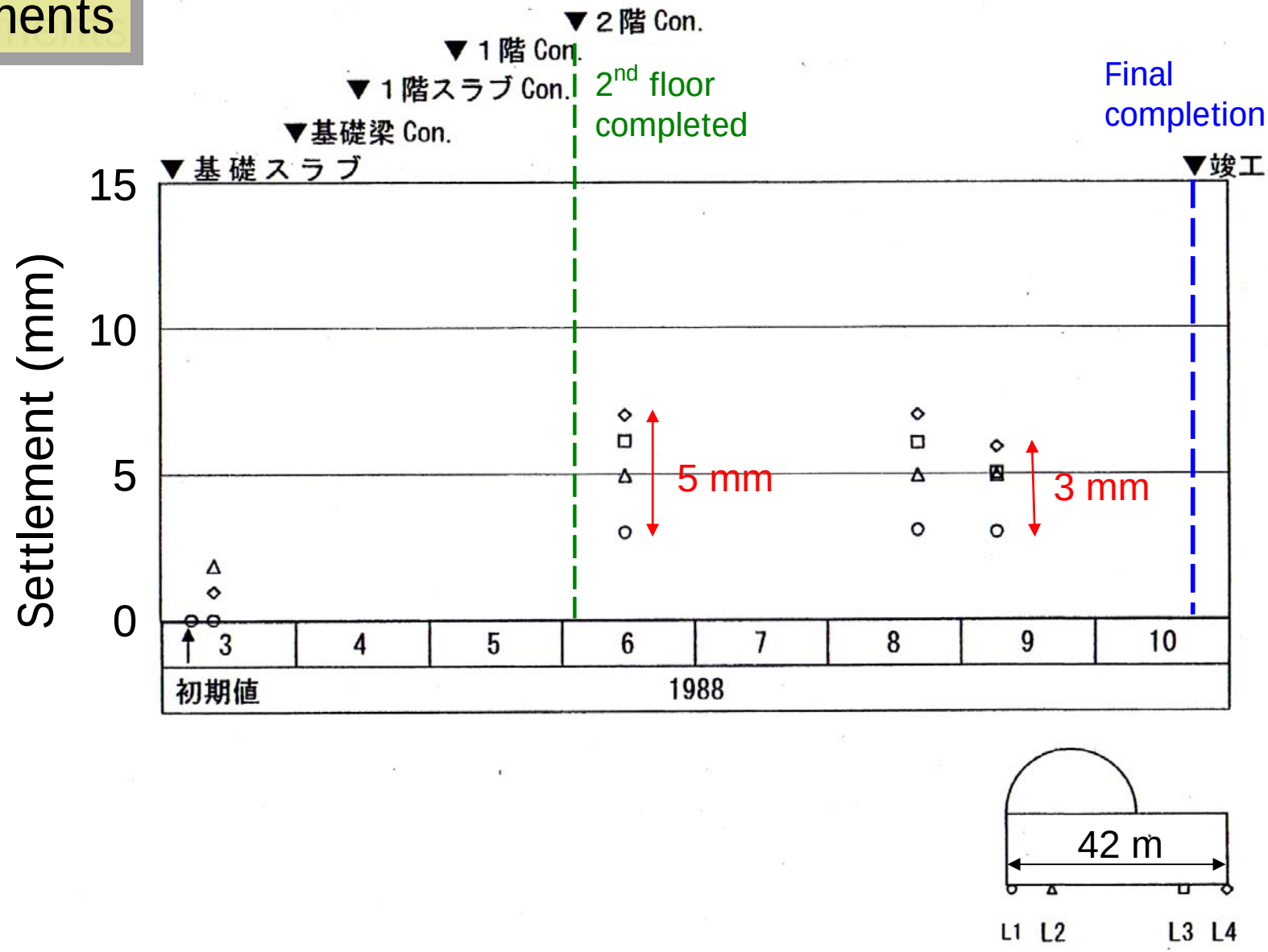
Field measurements



- ● P1 - P 12: pile head force
- □ E1 - E4: earth pressure
- ▲ W1 & W2: water pressure
- △ L1- L4: settlement

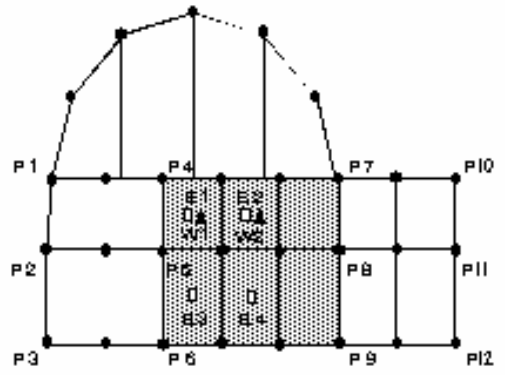
RC building #1 in Alluvial ground

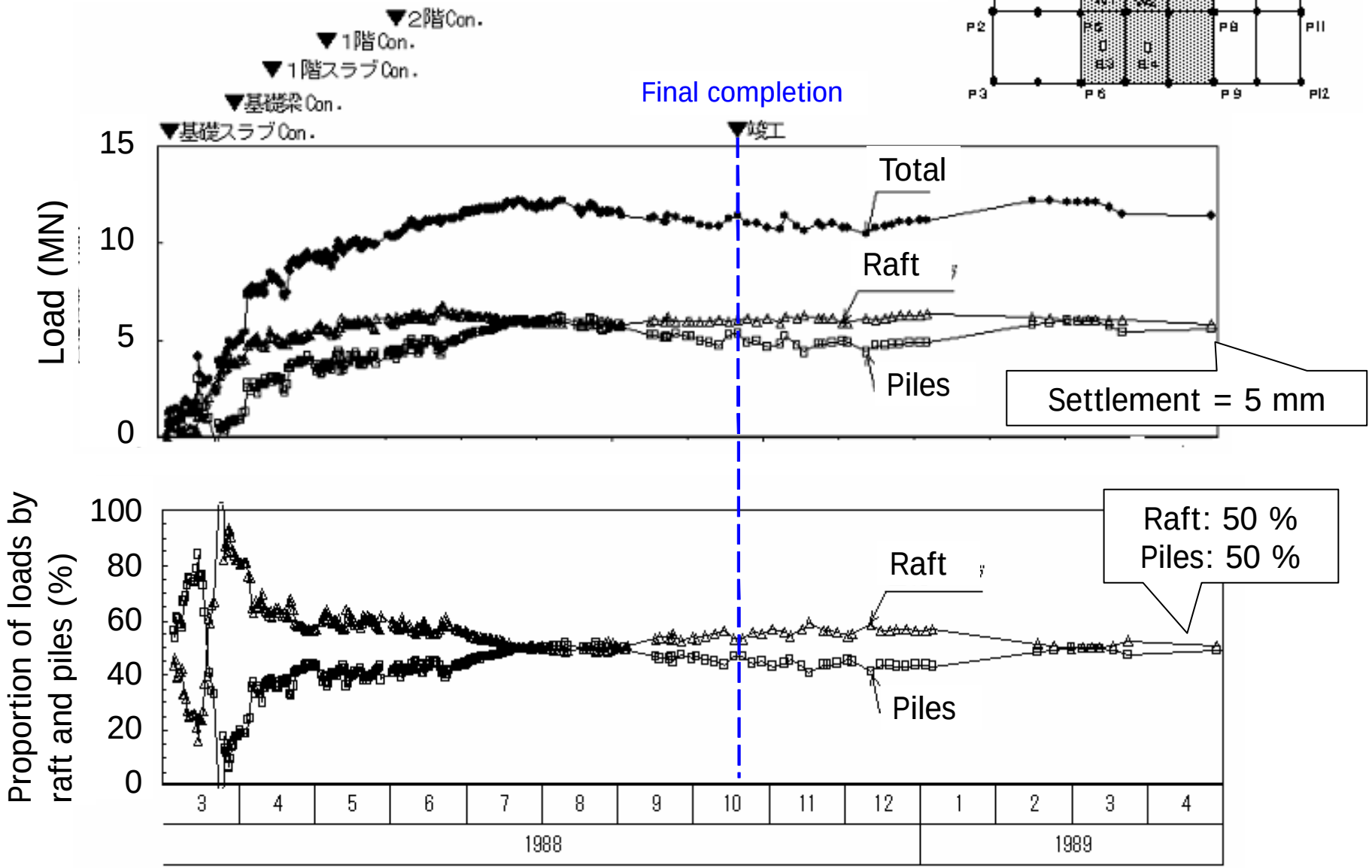
Settlements



RC building #1 in Alluvial ground

Time histories of loads carried by piles and raft





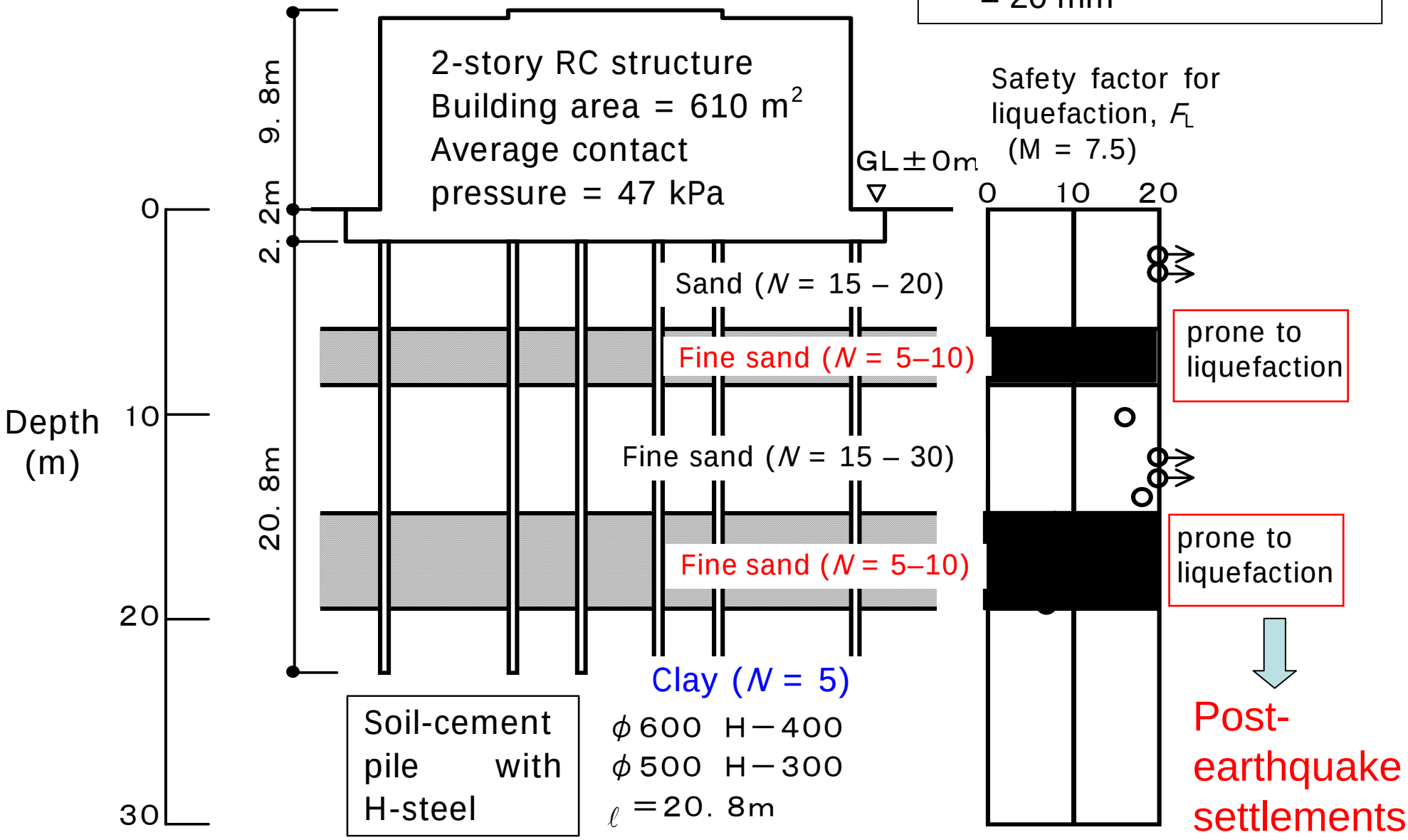
RC building #2 in Alluvial ground

Design objective:

Prevention of differential settlements when liquefaction of the foundation ground occurs.

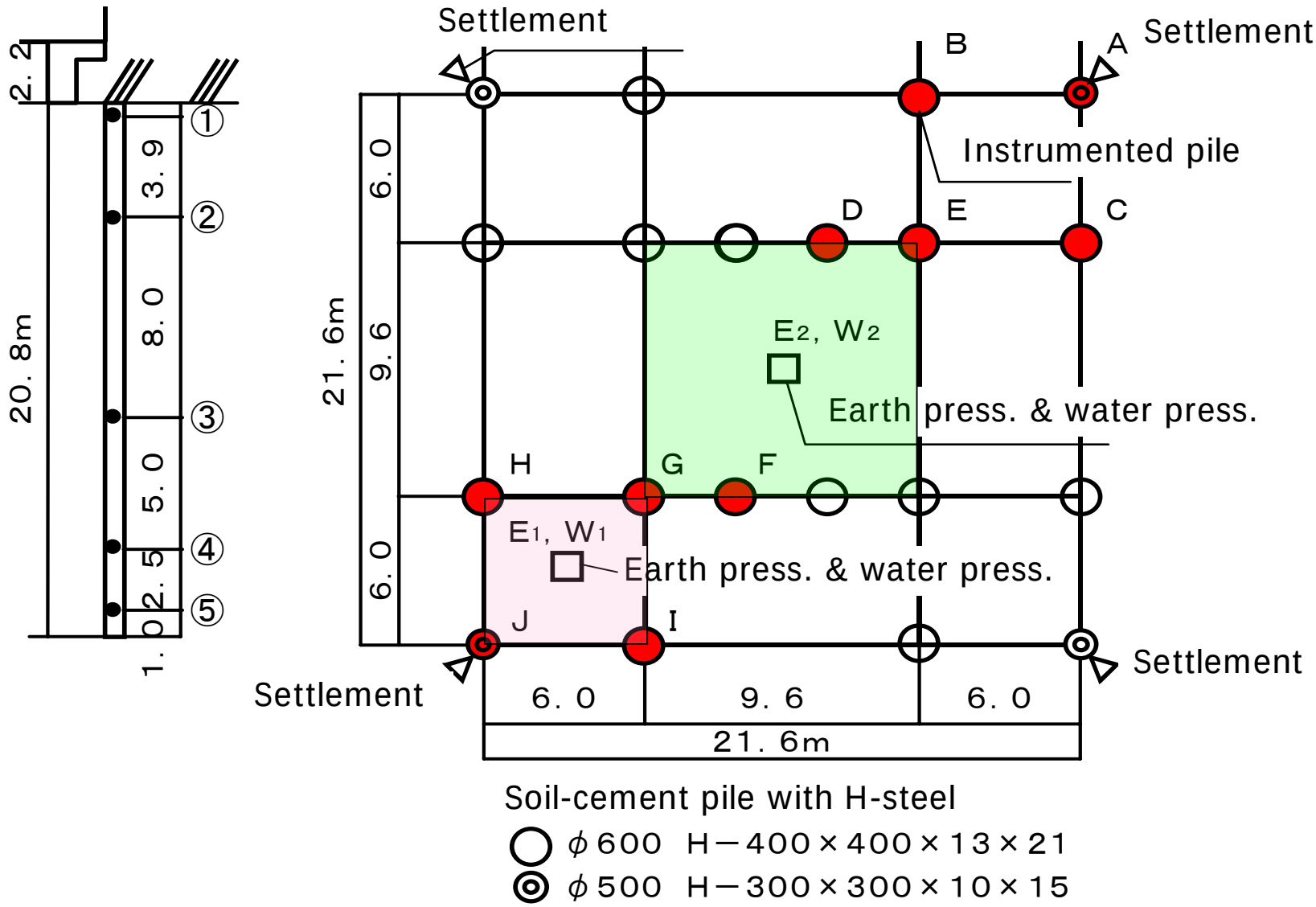
RC building #2 in Alluvial ground

Settlement of raft foundation
= 20 mm



RC building #2 in Alluvial ground

Field measurements



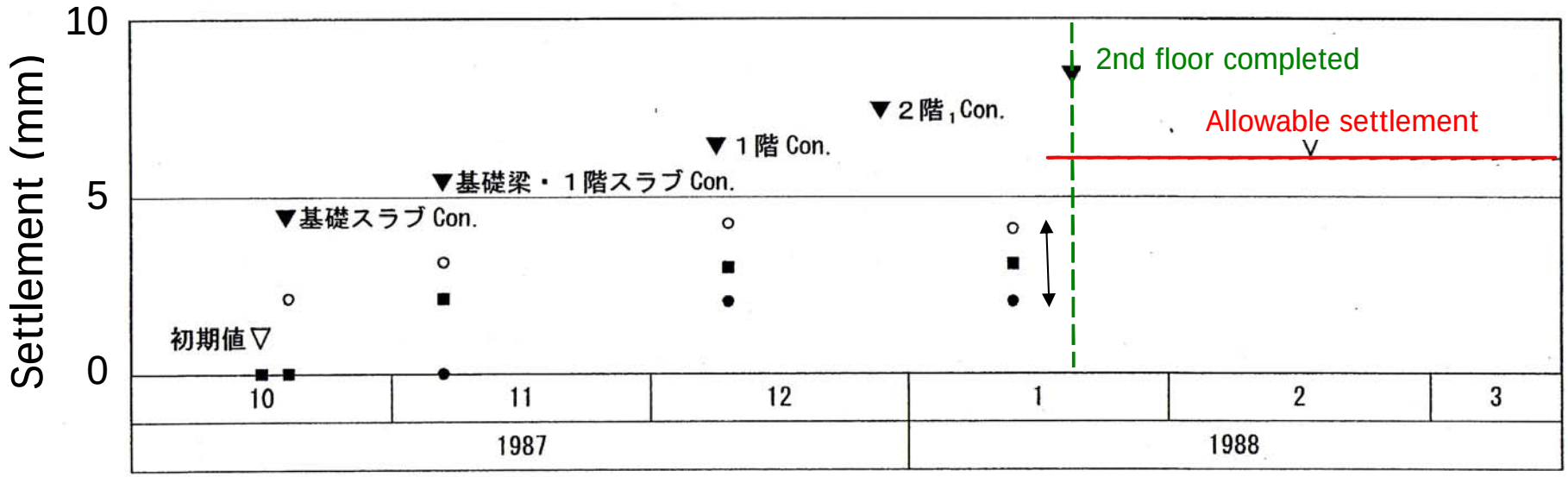
Soil-cement pile with H-steel

○ φ600 H−400×400×13×21

◎ φ500 H−300×300×10×15

RC building #2 in Alluvial ground

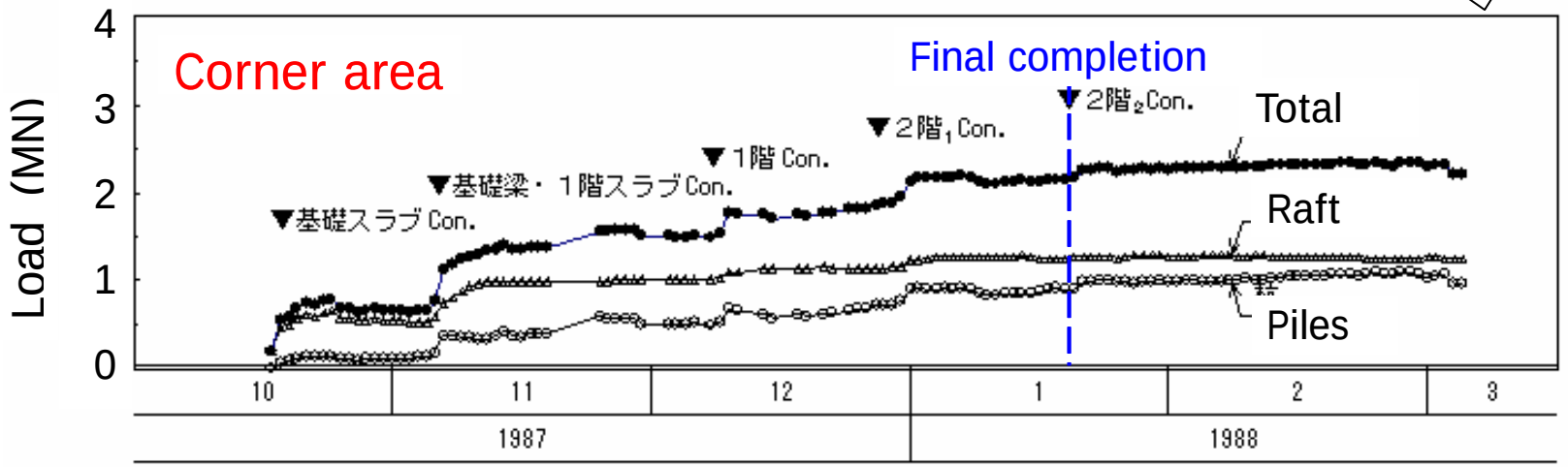
Time histories of settlements

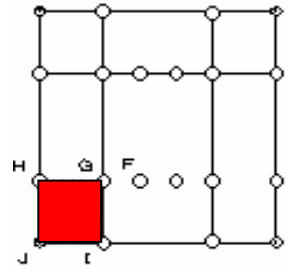


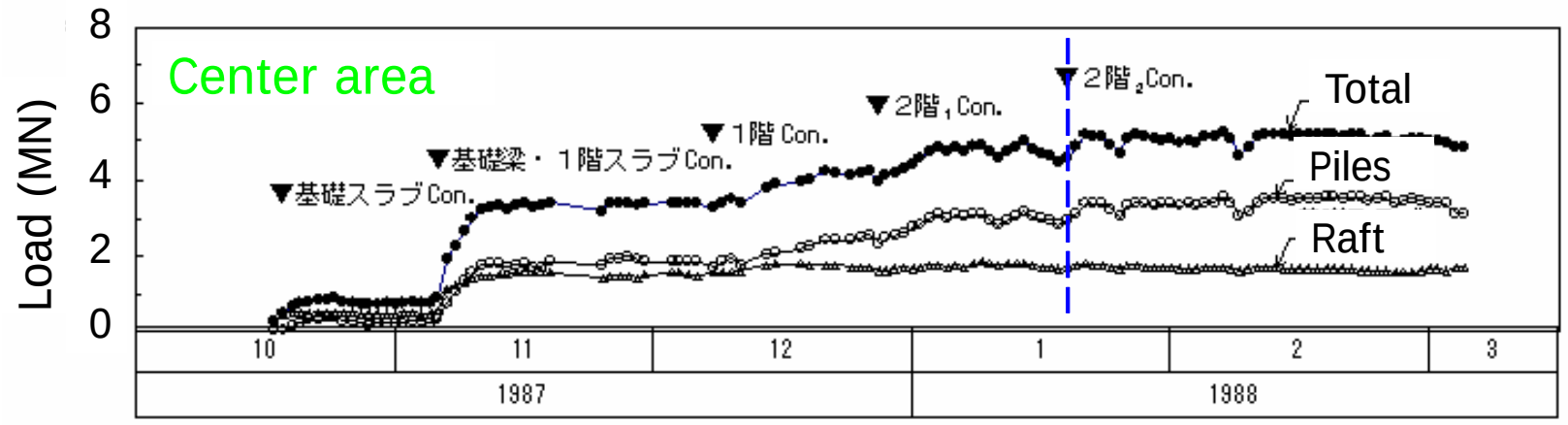
RC building #2 in Alluvial ground

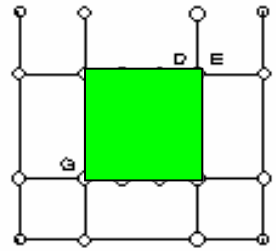
Time histories of loads carried by raft and piles

Settlement = 3 mm



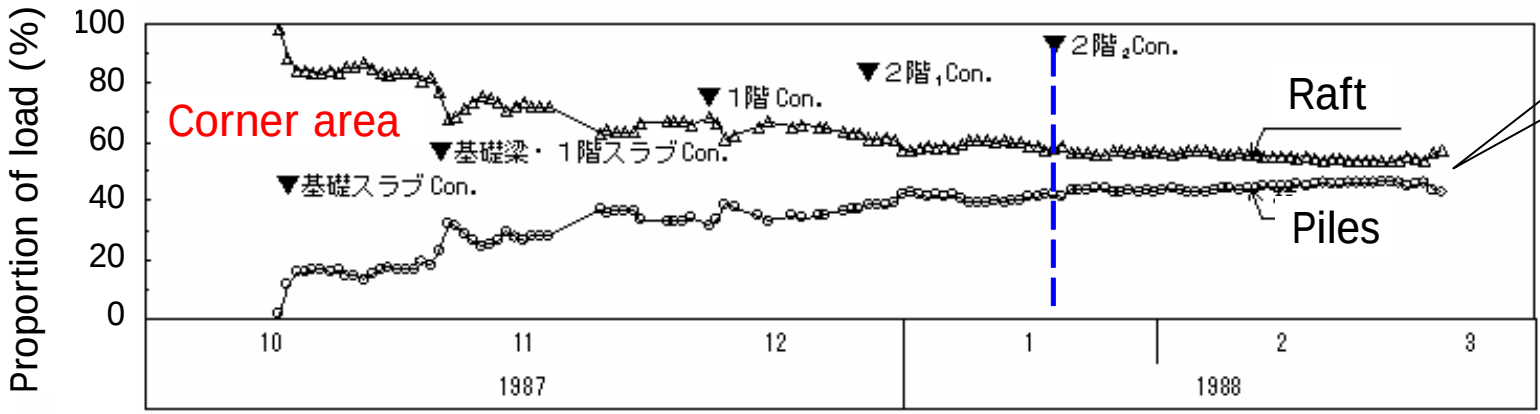




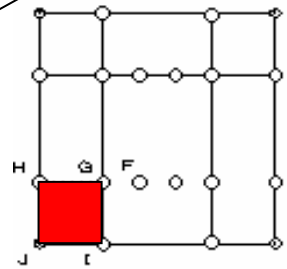


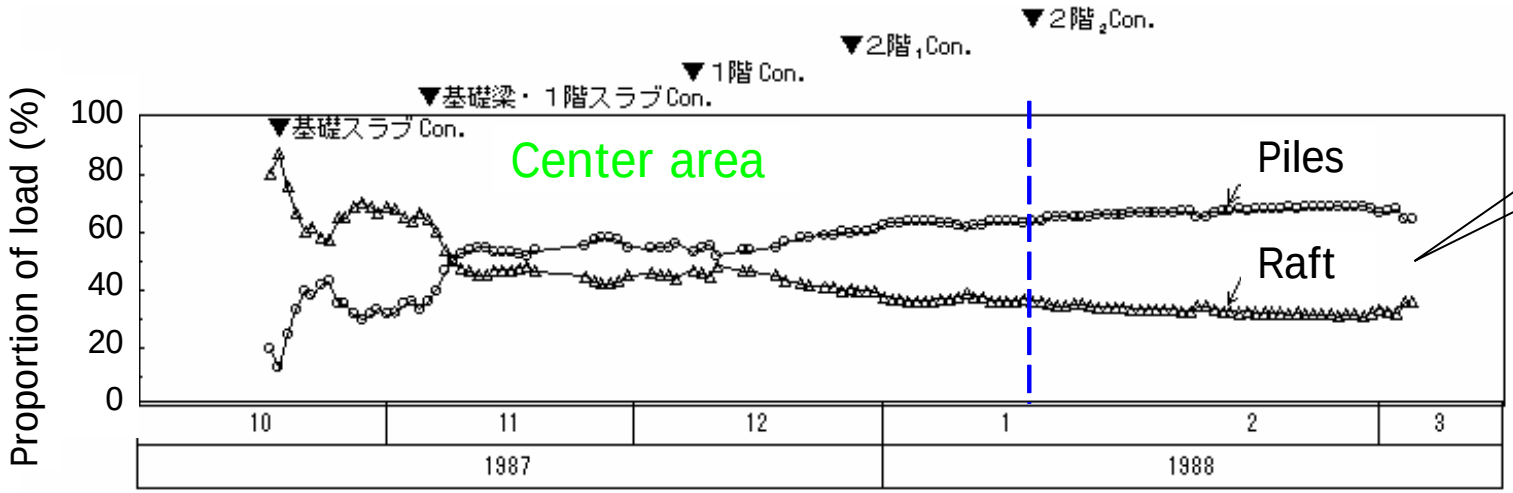
RC building #2 in Alluvial ground

Time histories of load proportions carried by piles and raft

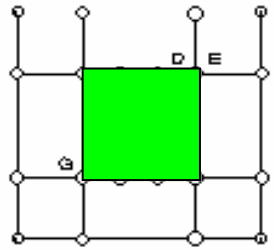


Raft 52%
Piles 48%

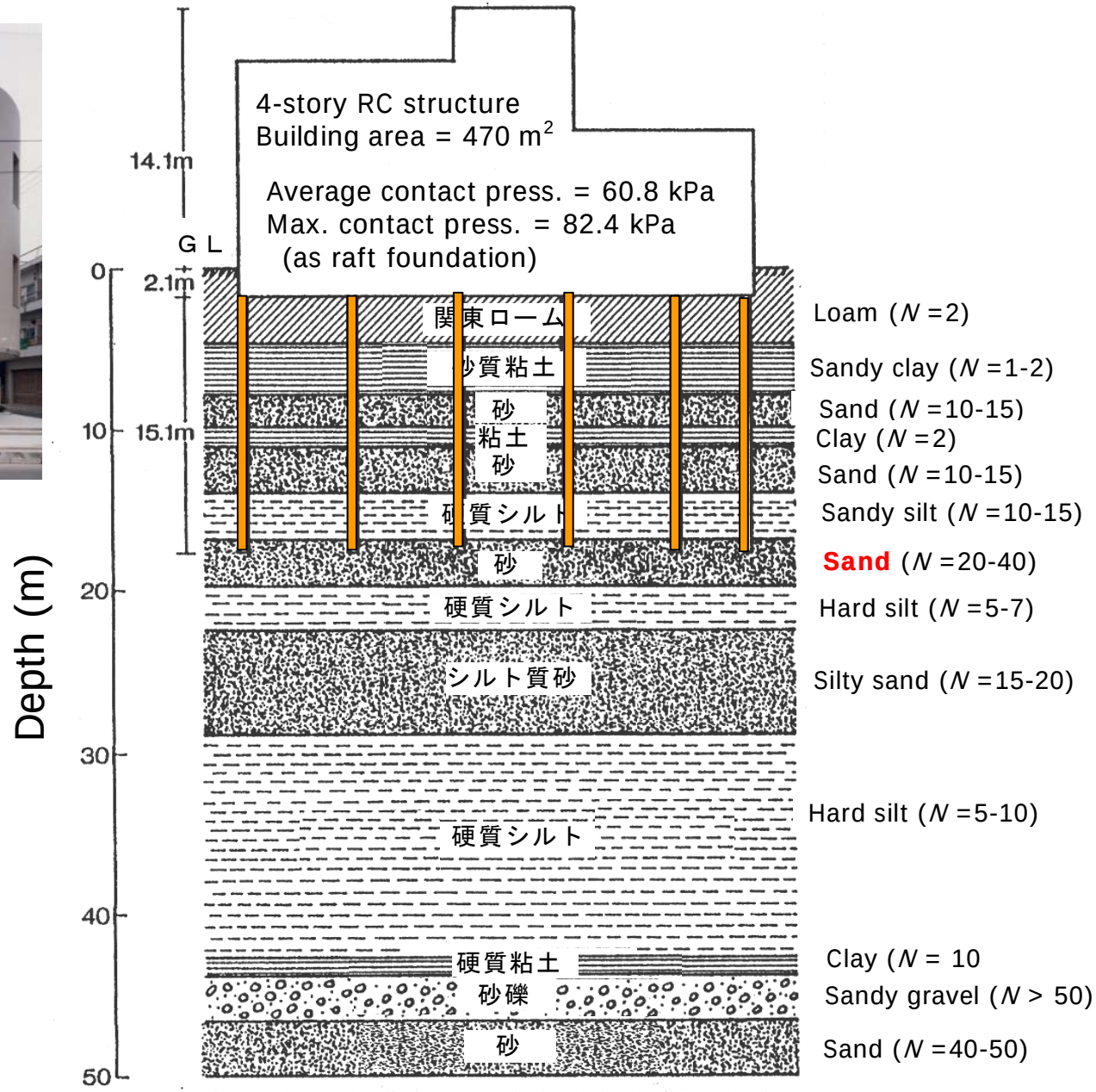




Raft 40%
Piles 60%



RC building #3 in Diluvial ground



RC building #3 in Diluvial ground

DESIGN PROCESS

Bearing capacity of the raft on the loam layer was estimated as 124 kPa.

Raft foundation was acceptable from the aspect of the bearing capacity.

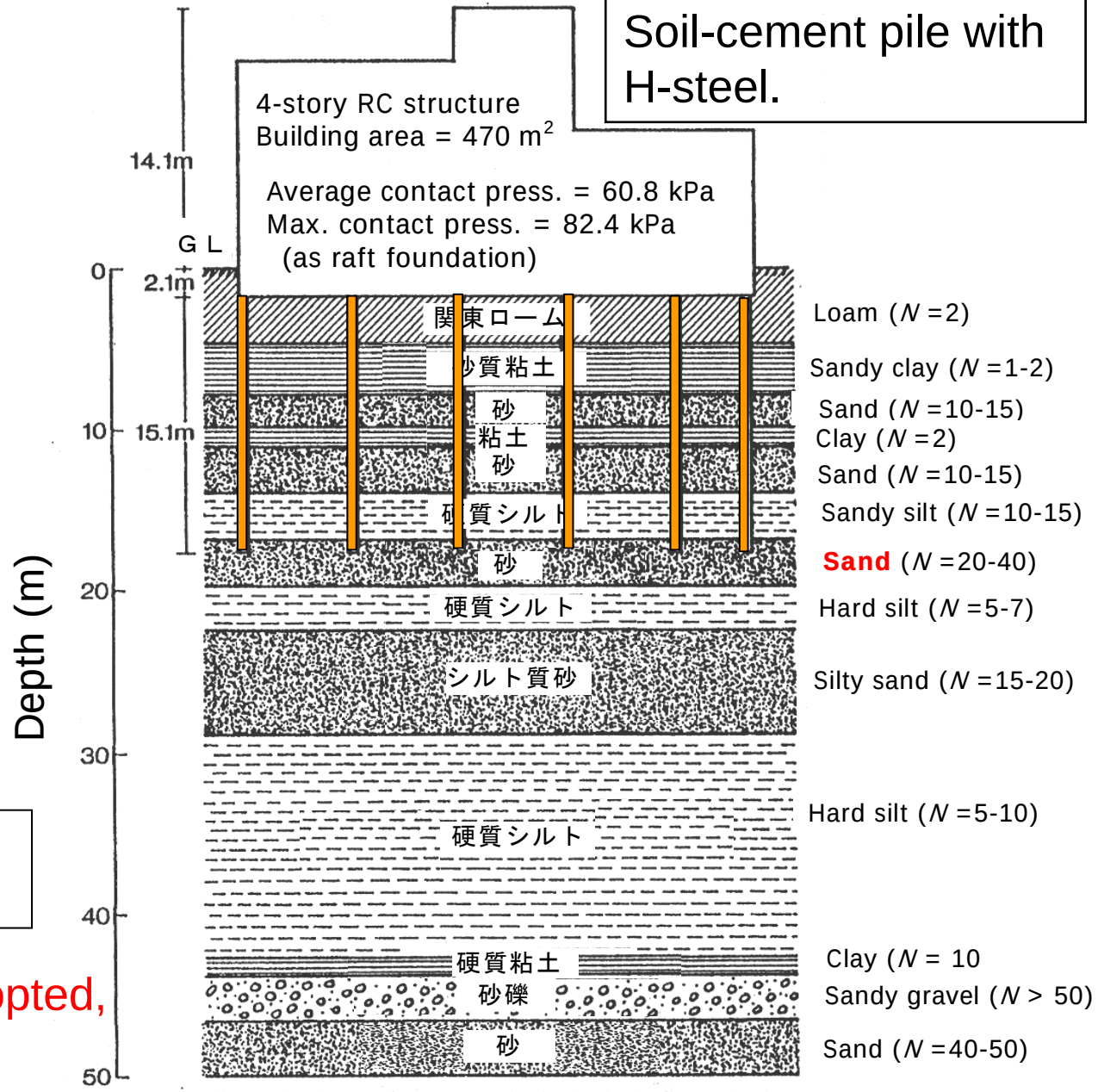
Instant average settlement of 60 mm and differential settlements were predicted for the raft foundation.

Piled raft foundation with pile tip depth of 17.2 m was adopted.

If pile group foundation was adopted, pile tip depth became 43 m.

Piles:

Soil-cement pile with H-steel.



RC building #3 in Diluvial ground

Piles:

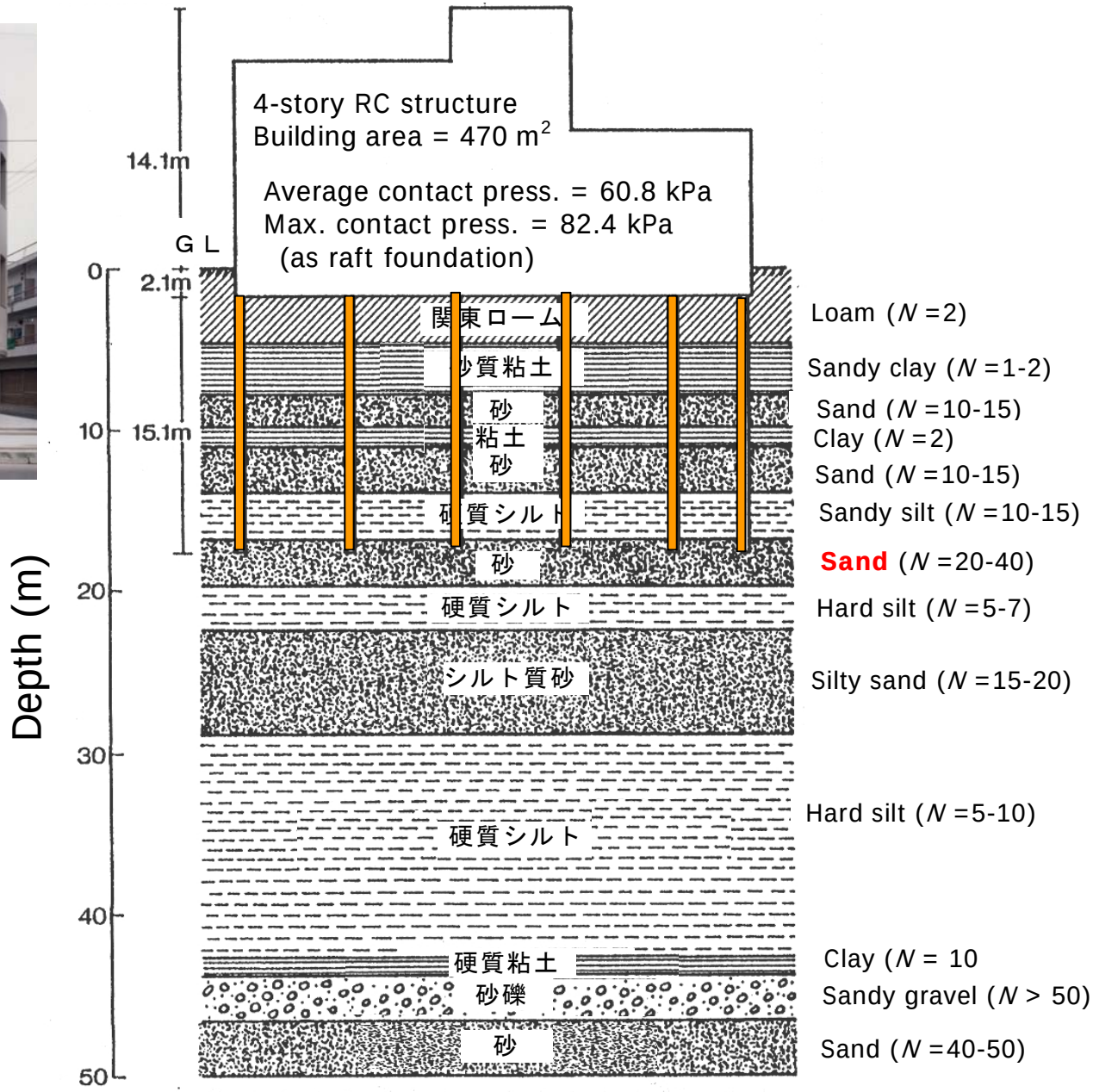
Soil-cement pile with H-steel

D = 500 mm & 600 mm

H-250: P_{ult} = 730 kN

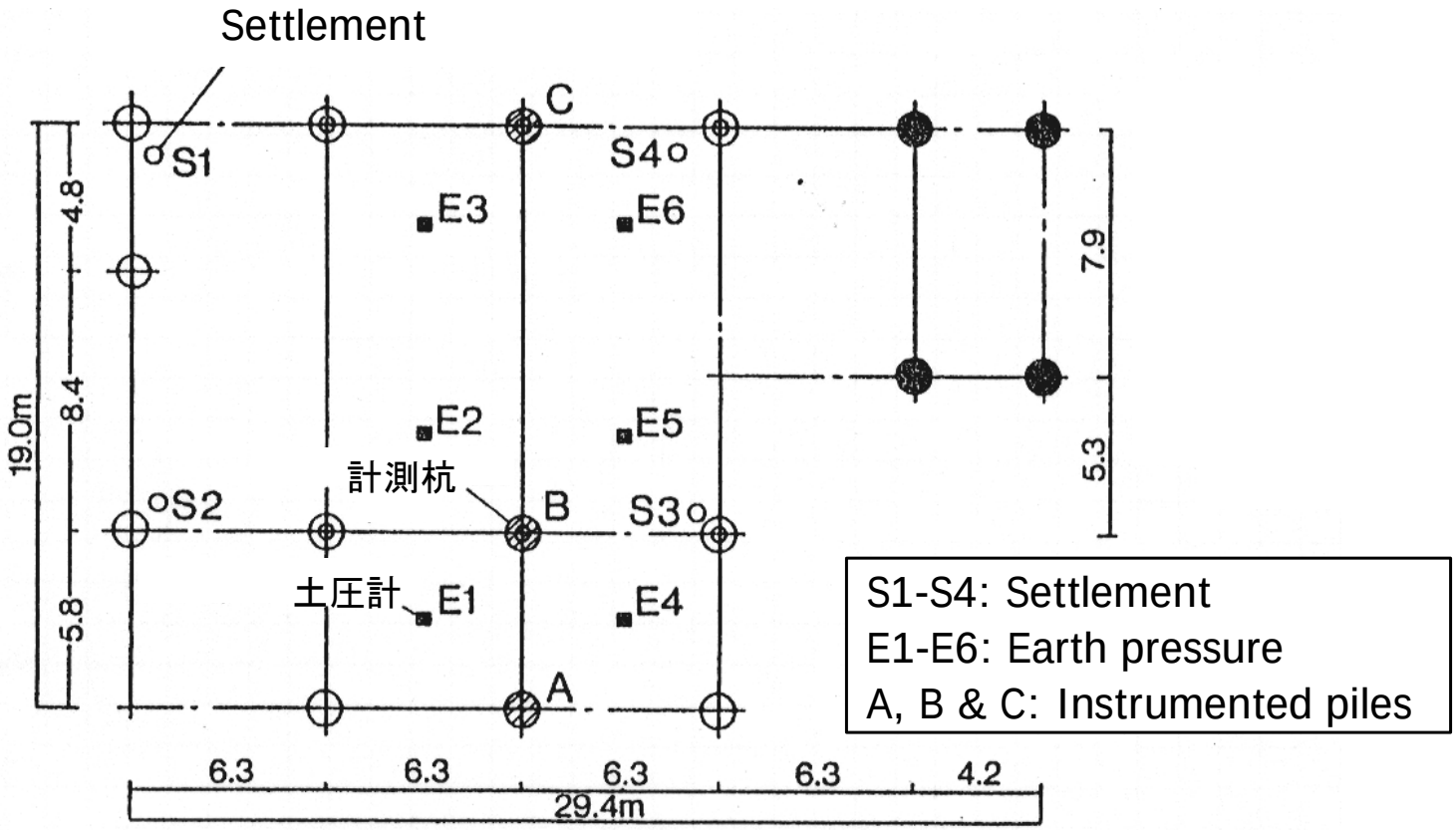
H-300: *P*ult = 1170 kN

H-400: *P*ult = 1430 kN



RC building #3 in Diluvial ground

Field measurements

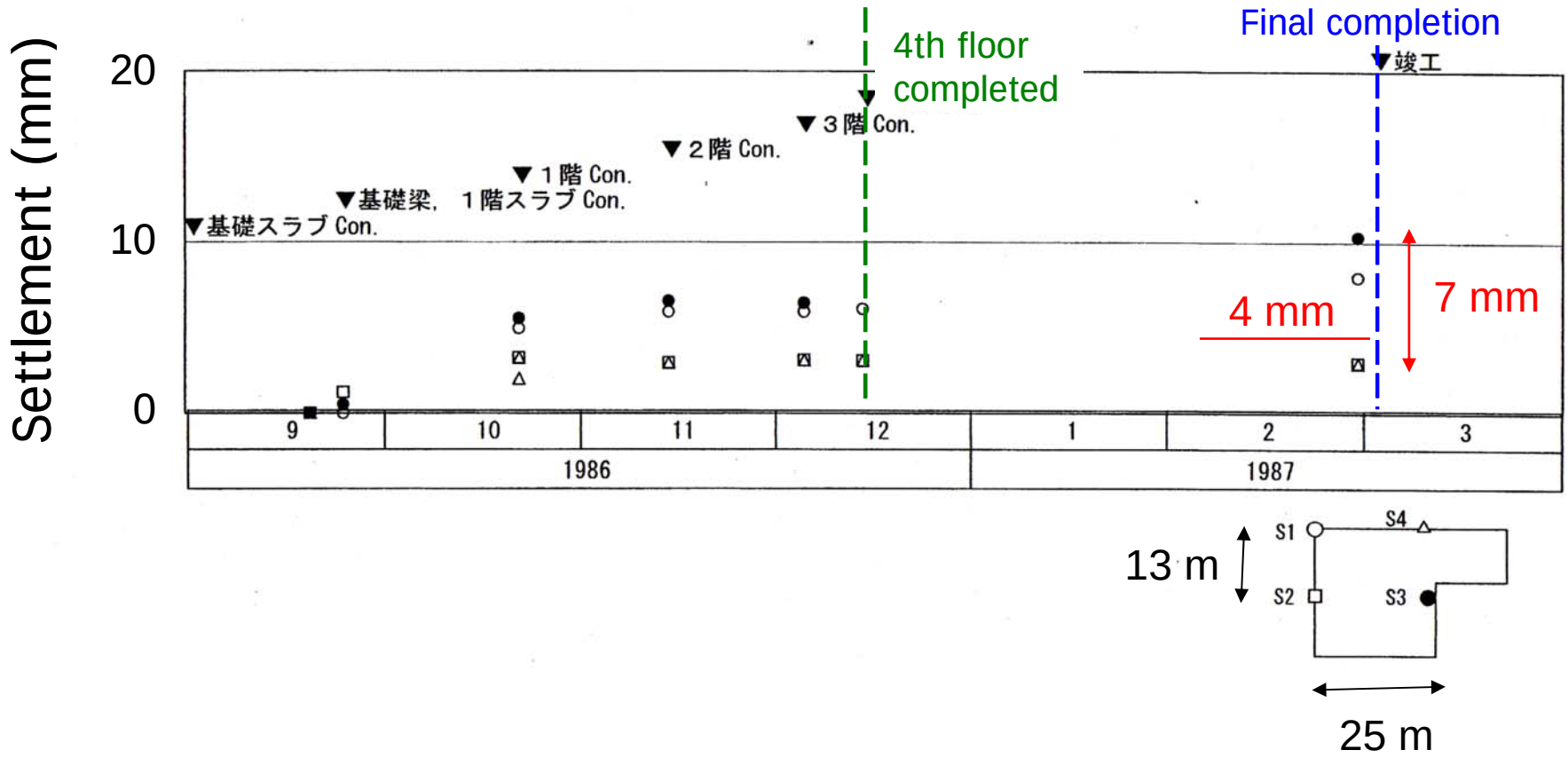


S1-S4: Settlement
E1-E6: Earth pressure
A, B & C: Instrumented piles

	Diameter (m)	Size of H-steel (m)
◎	0.6	0.4
○	0.5	0.3
●	0.5	0.25

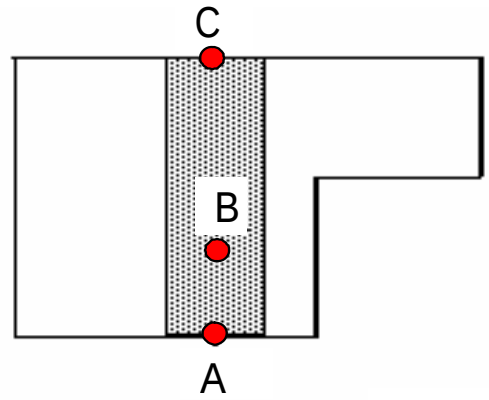
RC building #3 in Diluvial ground

Time histories of settlements



RC building #3 in Diluvial ground

Time histories of loads (for whole monitored area)



Final completion

Settlement = 4 - 11 mm

Load (MN)

10
8
6
4
2
0

Total

Piles

Raft

1986 1987 1988 1989 1990 1991

Proportion of load (%)

100
80
60
40
20
0

Piles

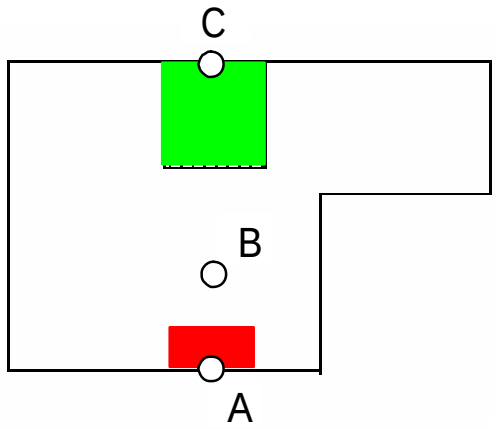
Raft

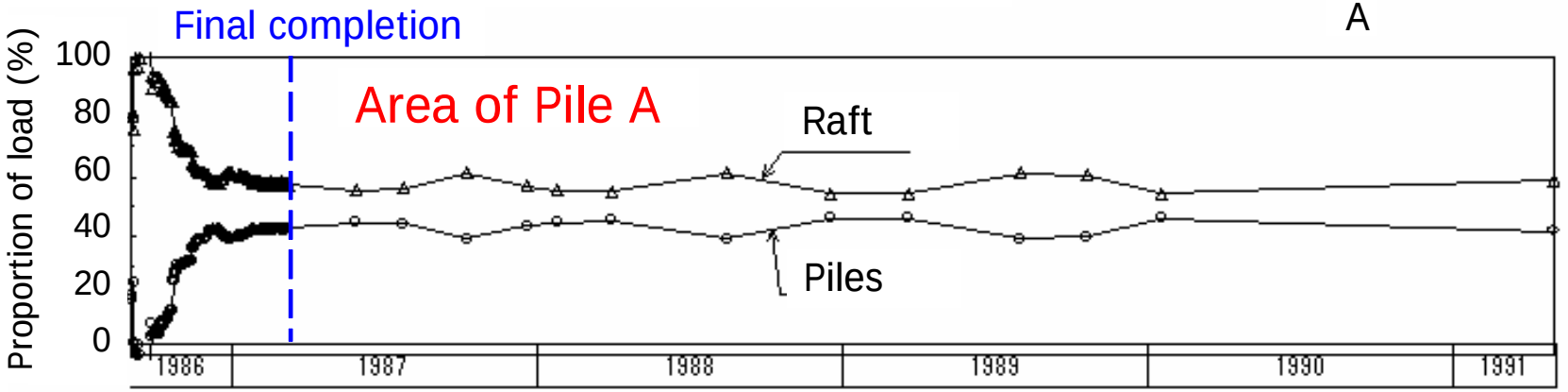
1986 1987 1988 1989 1990

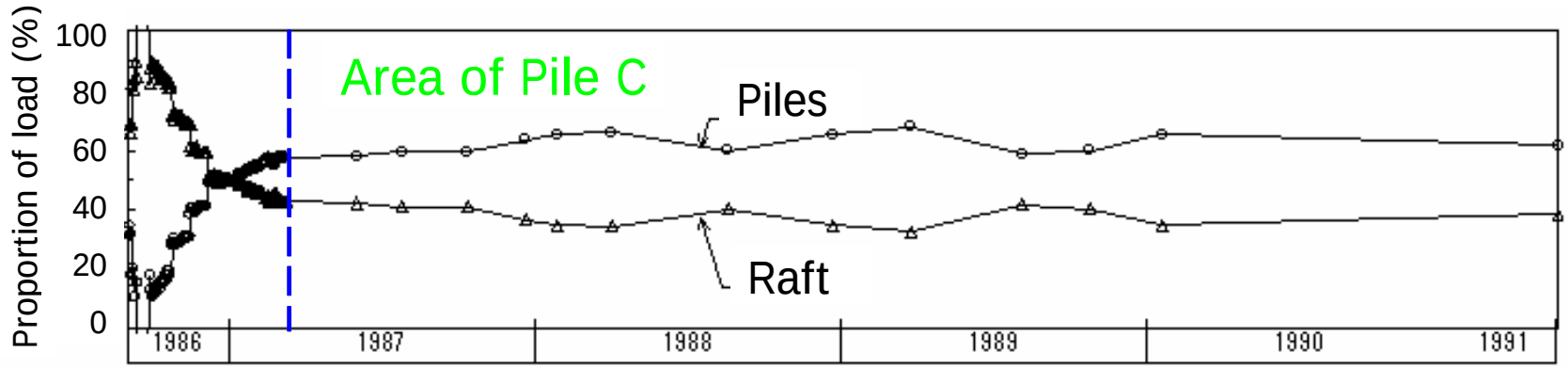
4 years after the final completion
Raft: 45 % Piles: 55 %

RC building #3 in Diluvial ground

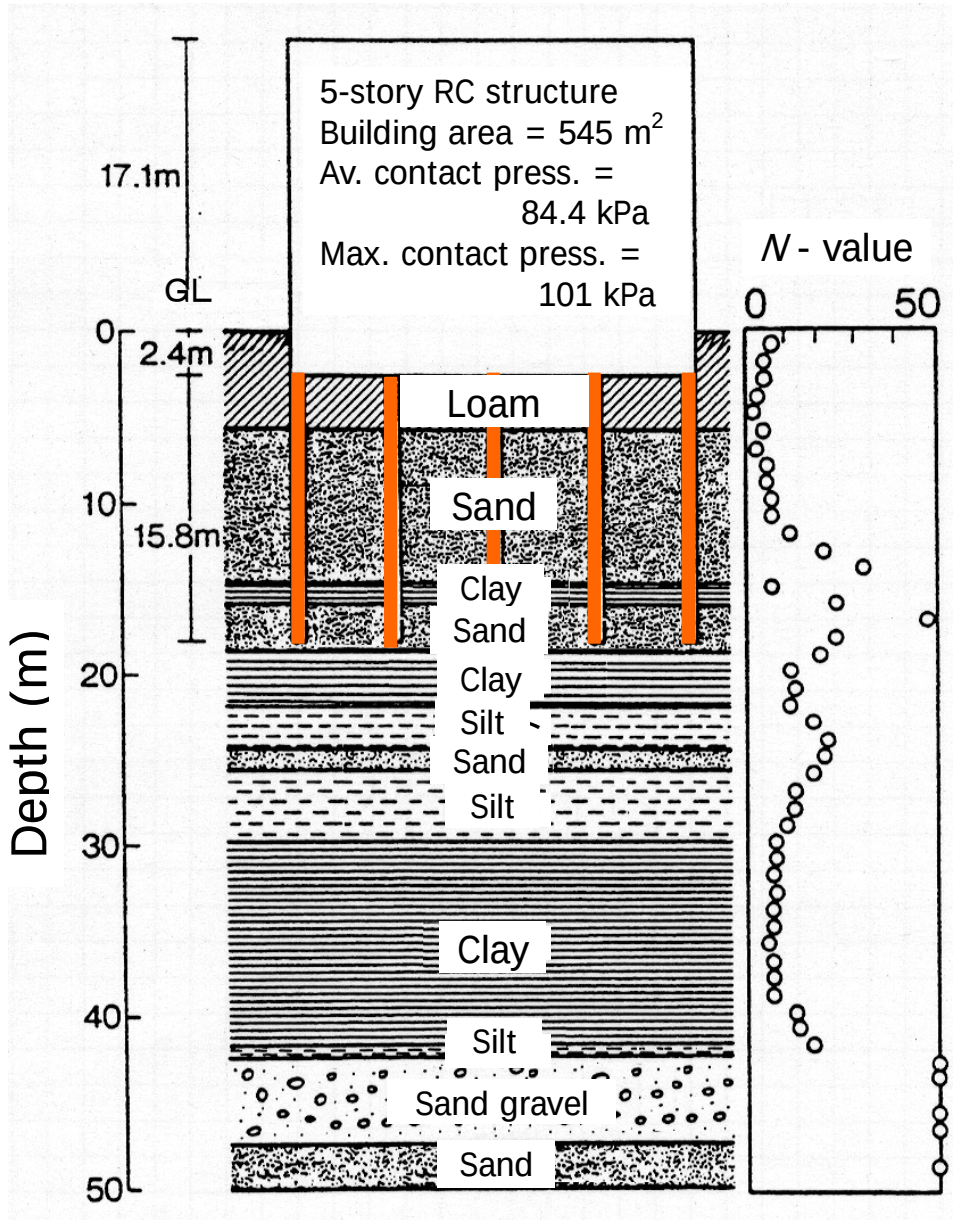
Time histories of loads for areas of pile A and Pile C







RC building #4 in Diluvial ground



RC building #4 in Diluvial ground

DESIGN PROCESS

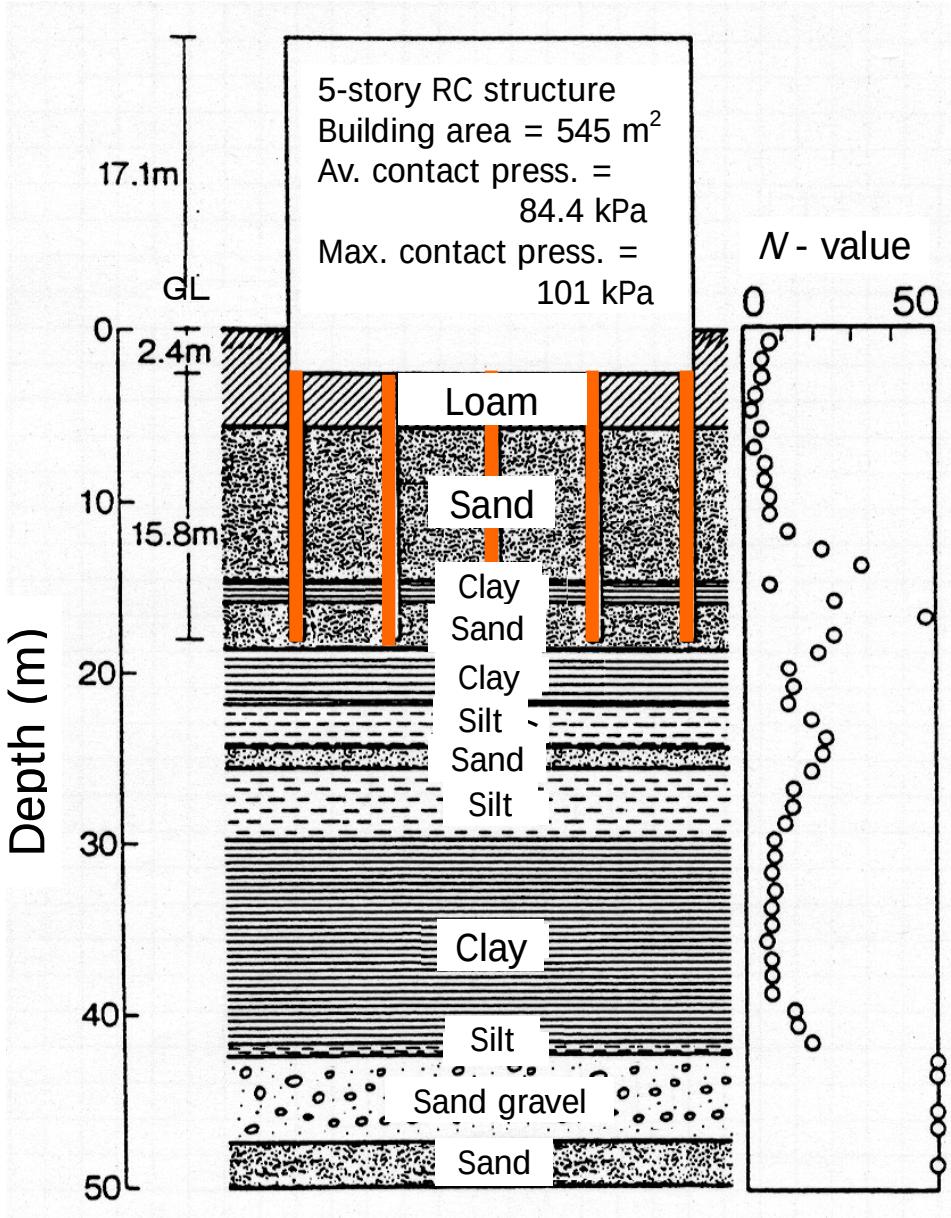
Bearing capacity of the raft on the loam layer was estimated as 163 kPa.

Raft foundation was acceptable from the aspect of the bearing capacity.

Settlements of 60 mm at the center and 20 mm at the corners were predicted for the raft foundation.

Piled raft foundation with pile tip depth of 17.2 m was employed.

(If pile group foundation was adopted, pile tip depth was 43 m.)

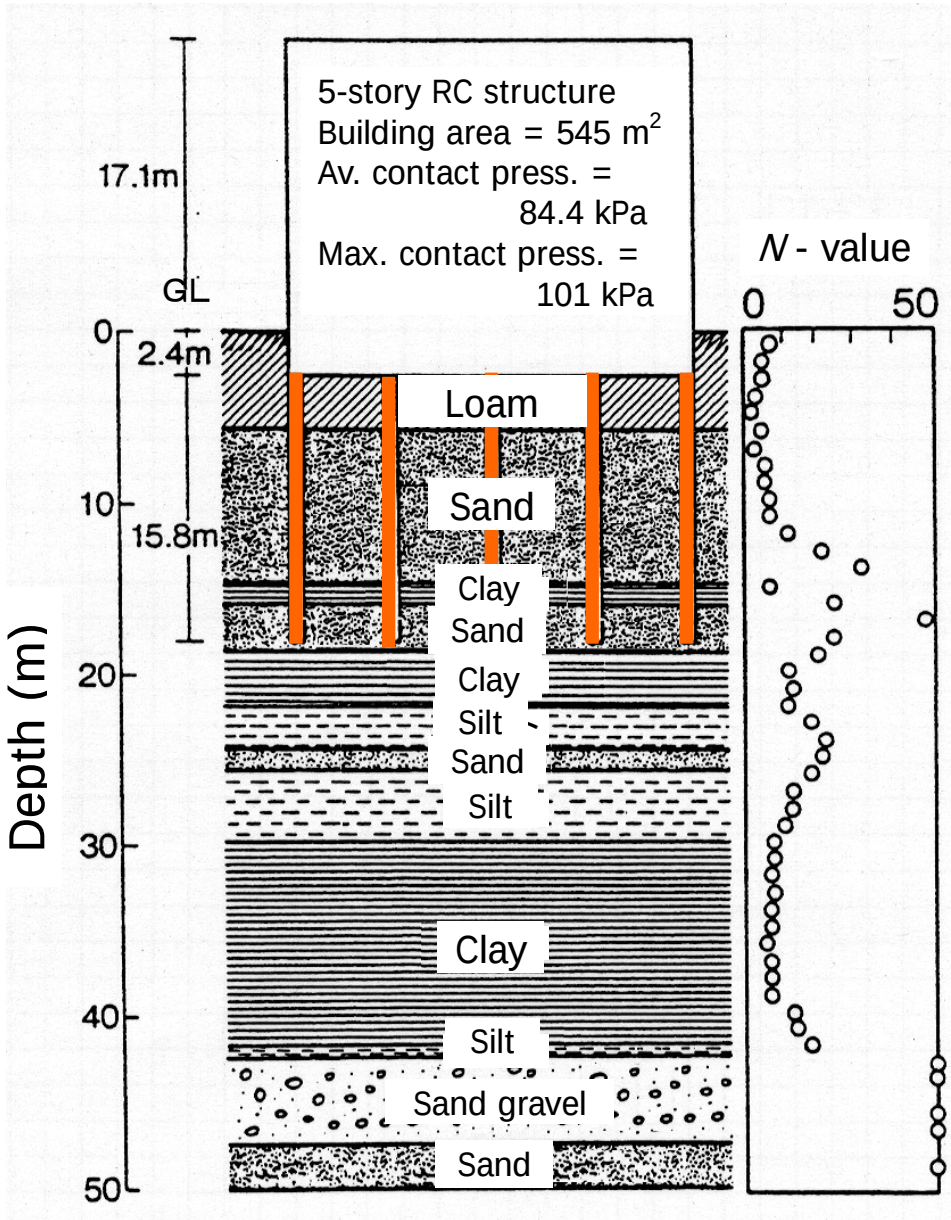


RC building #4 in Diluvial ground

20 piles:

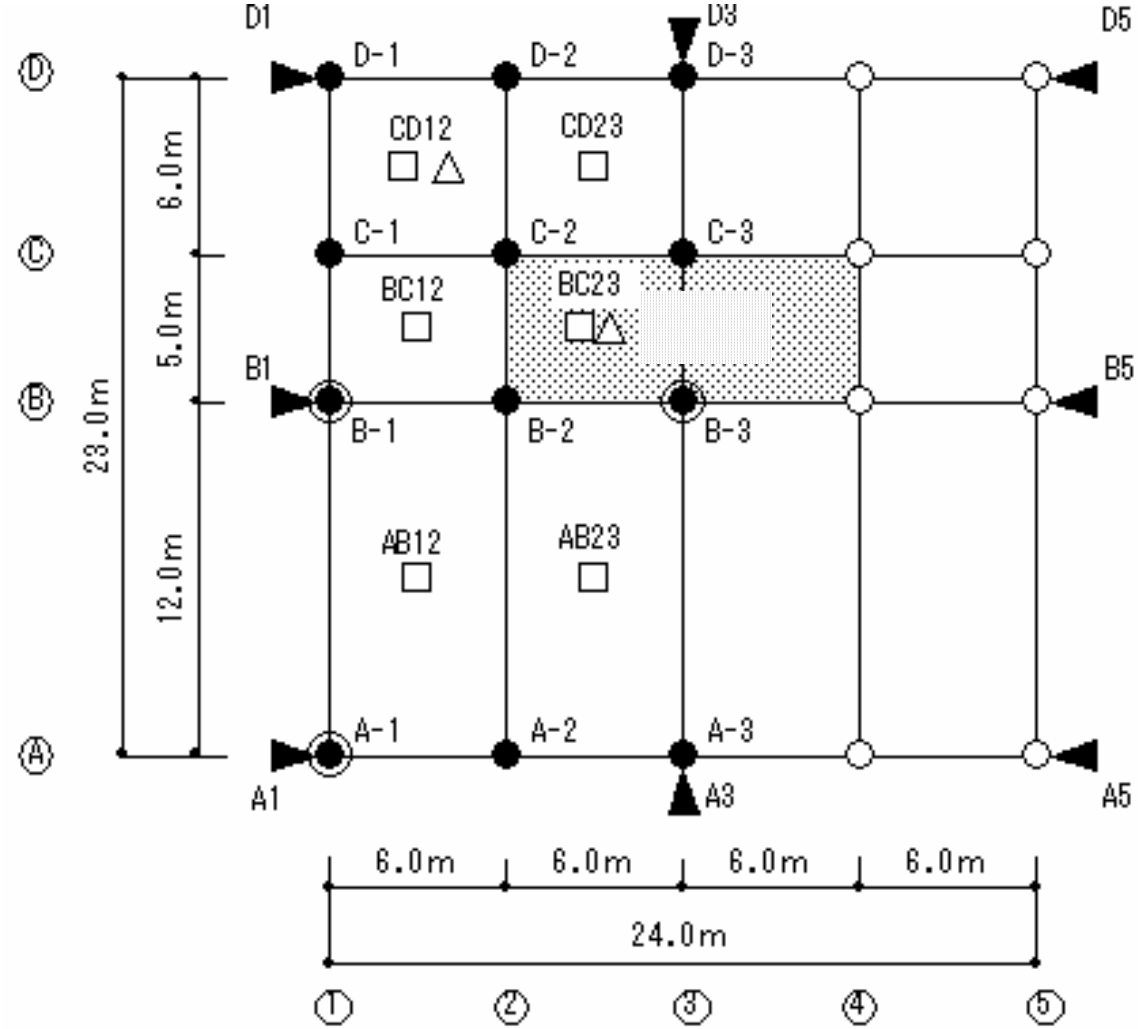
Soil-cement pile with H-steel

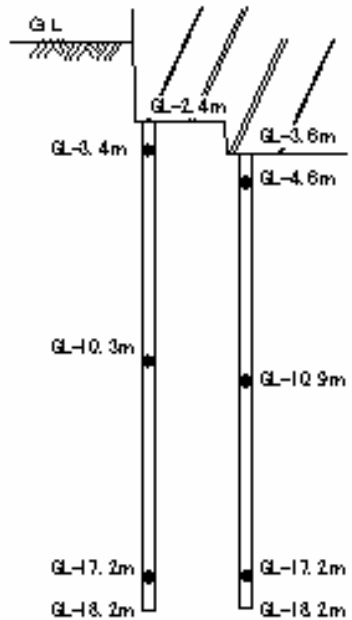
D = 700 mm & 800 mm



RC building #4 in Diluvial ground

Field measurements

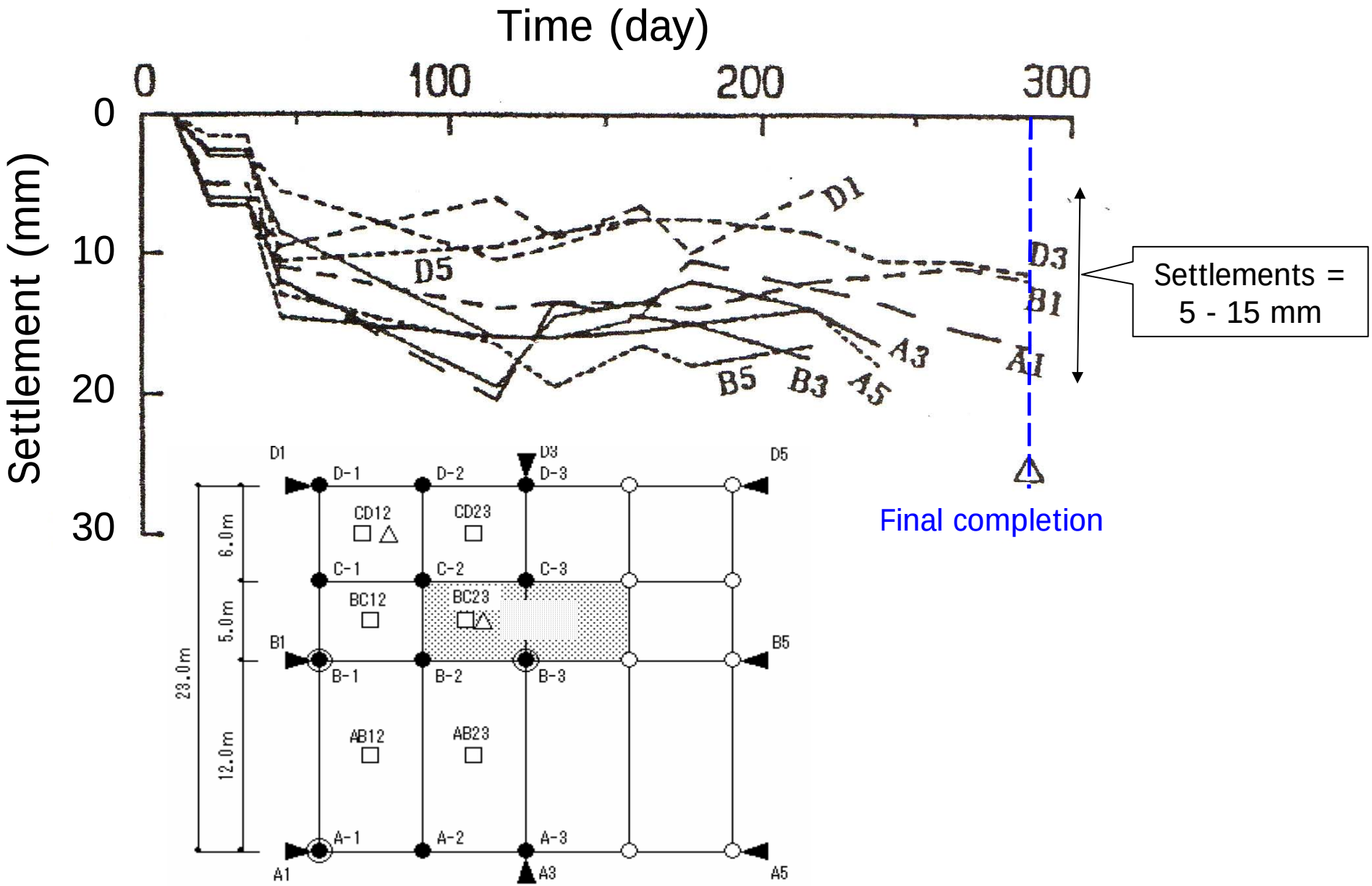




- ● Pile head force
- ◉ Distribution of axial forces of pile
- □ Earth pressure
- △ Water pressure

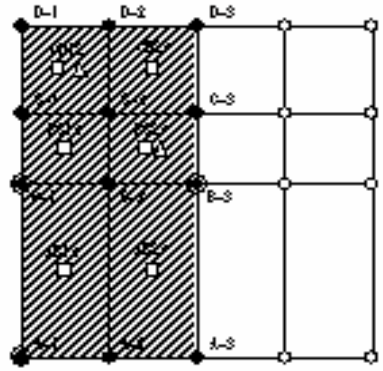
RC building #4 in Diluvial ground

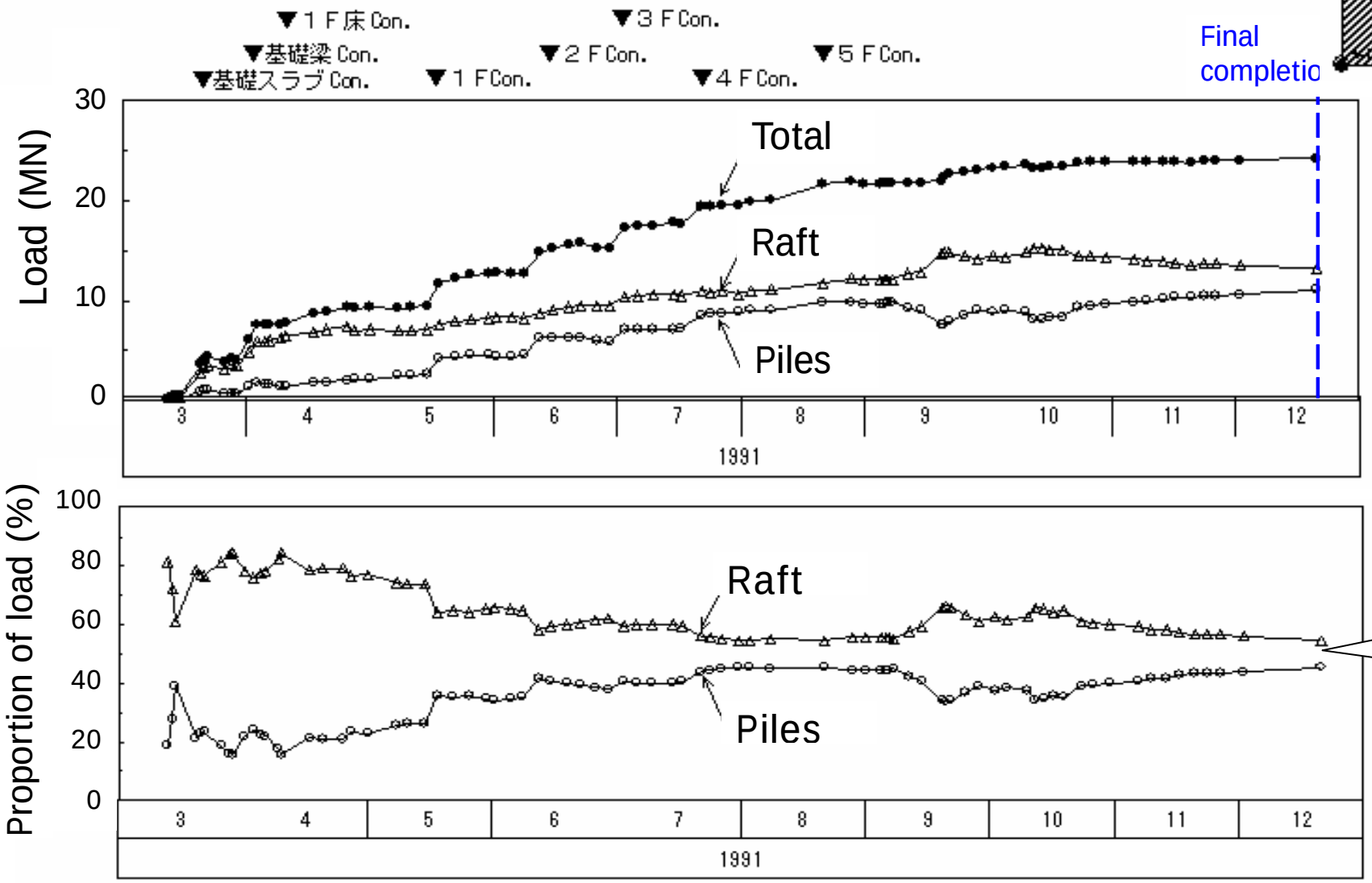
Field measurements



RC building #4 in Diluvial ground

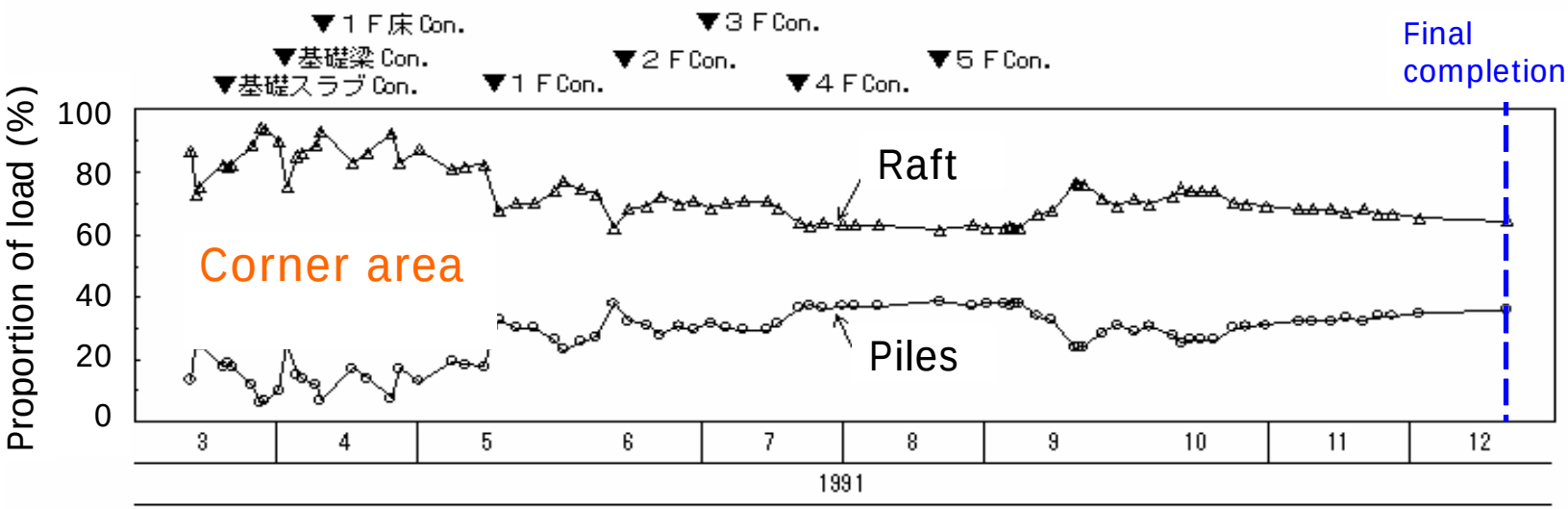
Time histories of loads (for whole monitored area)

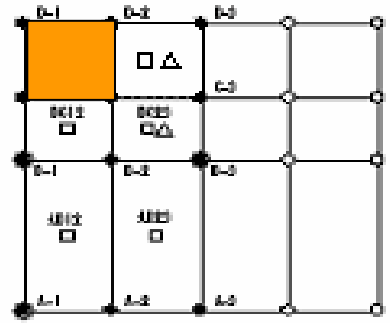


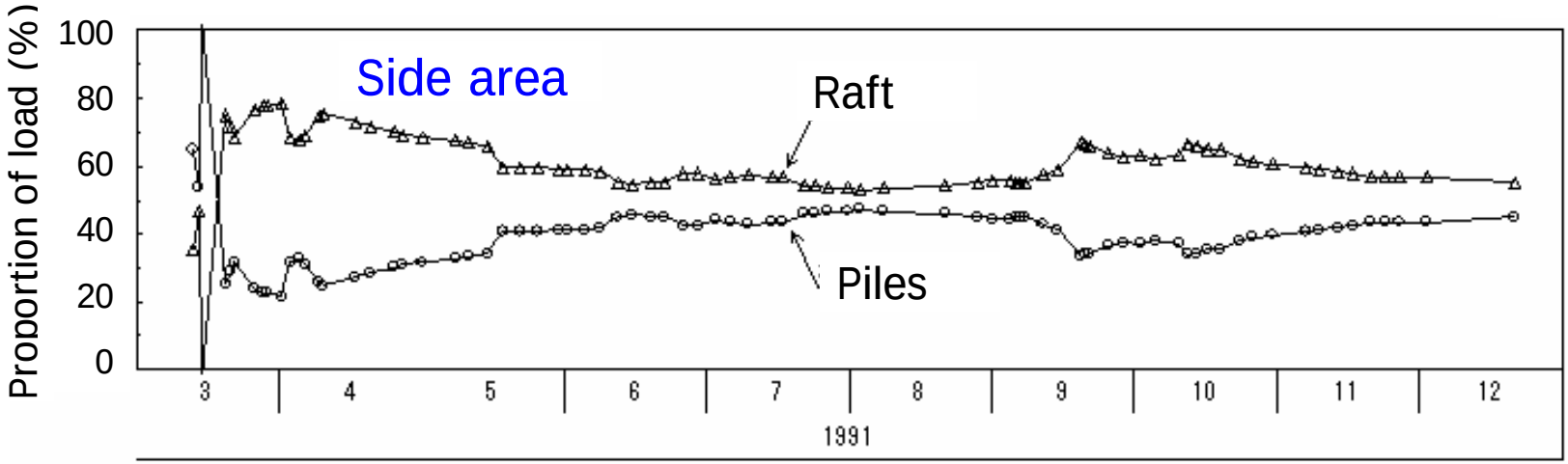


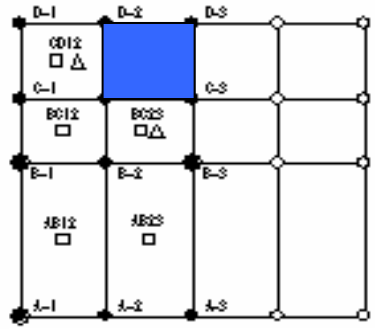
RC building #4 in Diluvial ground

Time histories of loads for separated monitored areas









Summary of case studies of piled raft foundations

- In all the 5 cases of piled raft foundations, proportion of total load carried by the raft was larger than that by the piles at early stages of construction, and then the proportion of total load carried the piles increased as the construction of the superstructure progressed.

  (Typically, 40 to 60% of the total load was carried by the raft at the final completion.)

- In some cases where long-term observations were performed, load proportion at the final completion remained for a long time.

Piled raft foundations are stable for long-term.