Water logged wood and wooden foundations

Dr. René Klaassen

October 17th and 18th 2011

Workshops Estonia

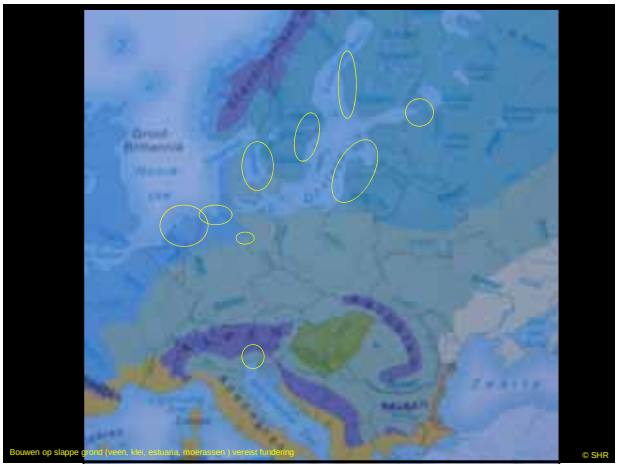
content

wooden foundation piles: history and use

wooden foundations: threats

wood decay under water

wooden pilings - protection cultural heritage



Bouwen op slappe grond (veen, klei, estuaria, moerassen) vereist fundering

Reichstag Berlin

Parlementsgebouw Stockholm, Foto´s universiteit van Uppsala,

Spechterstadt Hamburg


Venetië 2010
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Brug Venetië "De Kloosterbrug" 16de eeuw BACPOLES
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Toren Monnickendam 1355
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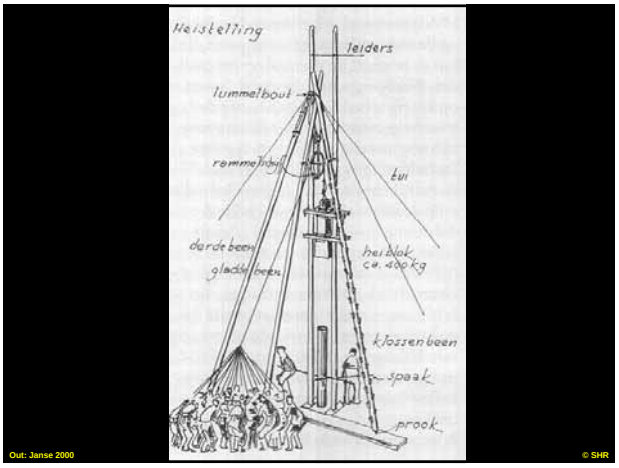
Heistelling
leiders
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Naarden kademuur, 2008
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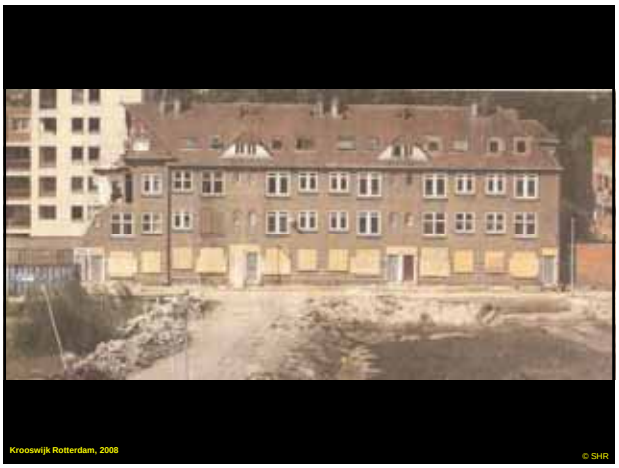
Magere brug Amsterdam, 2007 © SHR

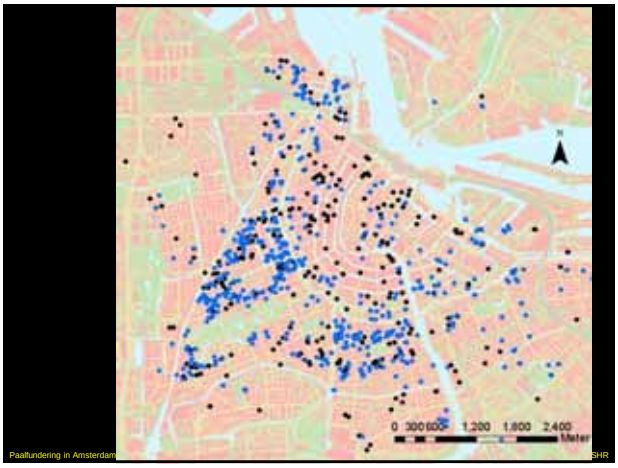

Brug prinsenburgen eiland Amsterdam © SHR


Brug prinseneiland Amsterdam op Basralocus palen © SHR


Grachtenpand Amsterdam 1591 © SHR


Zaandam © SHR





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water logged wood and foundation piles

25.000.000

wooden piles

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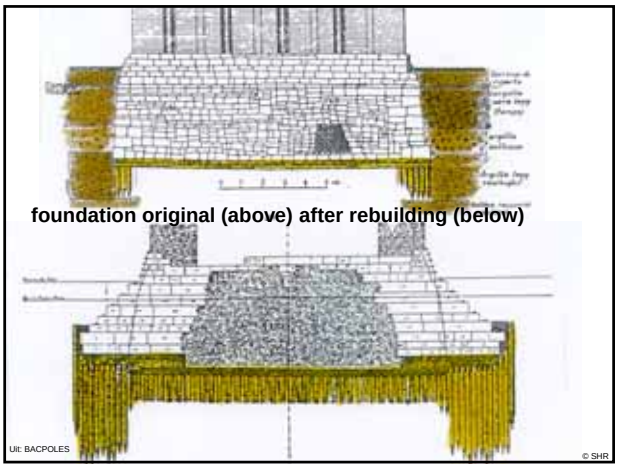
25 million piles, tekst

water logged wood and foundation piles

It is estimate that in the Netherlands still 25 million piles are in service. Not taken in to account are construction younger than 1980. In the three decades annually app. 200.000 piles are used for founding sewage systems, enlargements of standing houses, greenhouses and special projects like founding trees, dicks and even roads.
Many wooden foundations function well but if damages appear they determine the idea of the public of the stability of wood in foundation. Like house with settlement and cracks or house with piles below a affront. How to deal with wooden piles during renovation like at the Rijksmuseum were deep piths and pipeline were built aside and through the piling. Or the subway below the piling were leakage of the sheet piling caused sand flow and severe settlement of house aside.



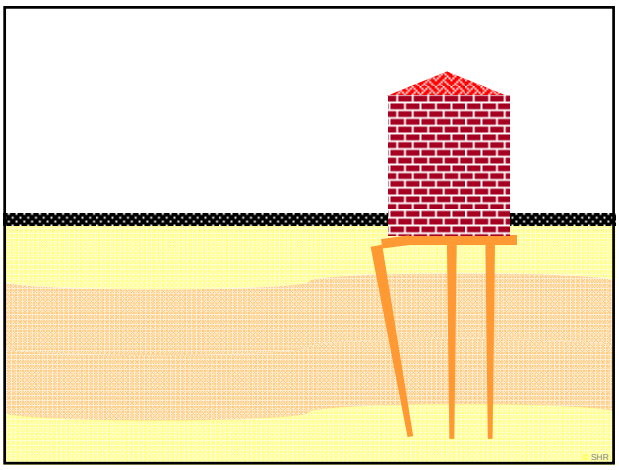
water logged wood and foundation piles

bad image wooden foundation

water logged wood and foundation piles

Causes

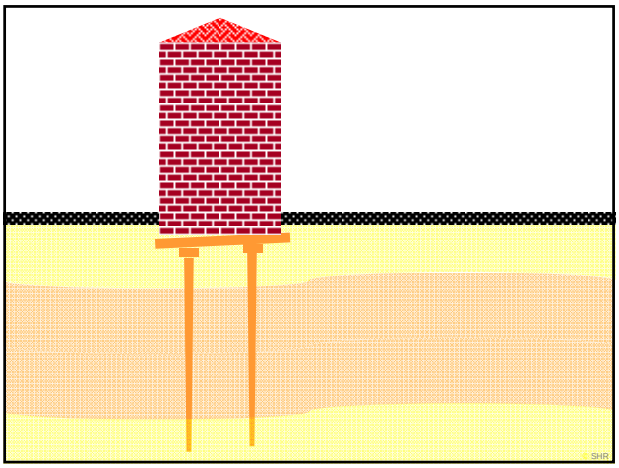
1. bad design / constructed

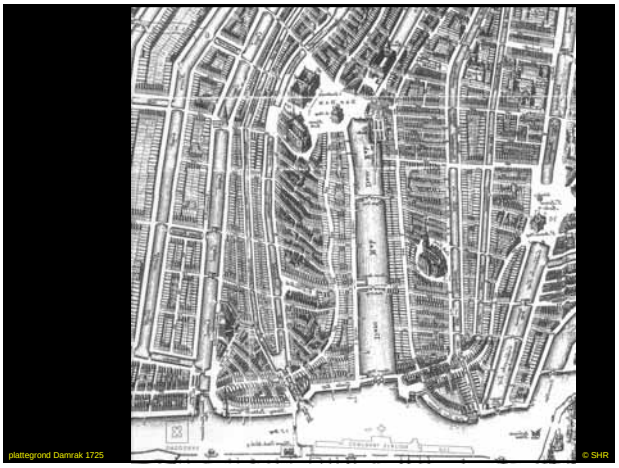


water logged wood and foundation piles

Causes

1. Bad design / constructed
2. Negative skin friction

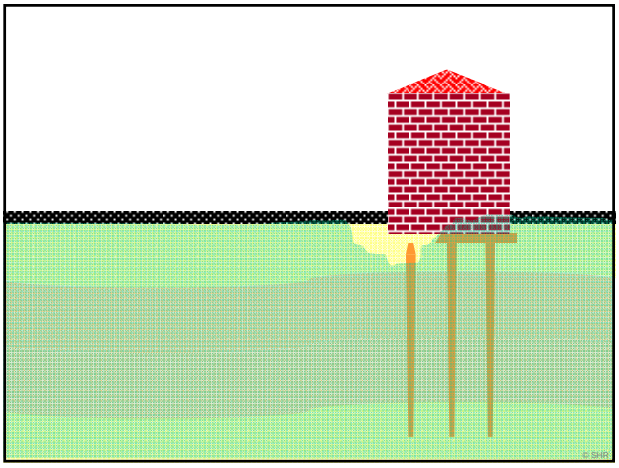




water logged wood and foundation piles

Causes

1. Bad design / constructed
2. Negative skin friction
3. Too low water table



Softrot, velocity

water logged wood and foundation piles

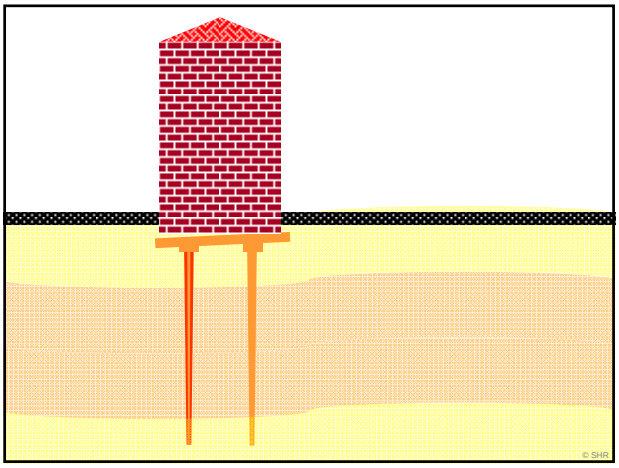
Optimal conditions

Air contact, wood water satirized	**10 mm/year**
Air contact, wood drying	**100 mm/year**
No air contact, open water oxygen satirized	**0.01 mm/year**

Causes

water logged wood and foundation piles

1. **Bad design / constructed**
2. **Negative skin friction**
3. **Too low water table**
4. **Decay under water**



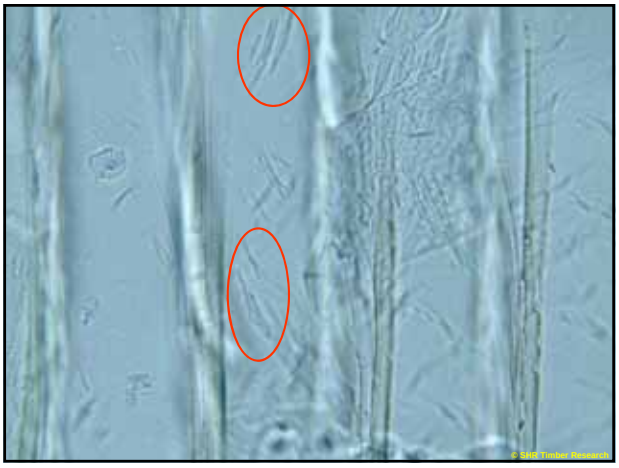
Problems, text

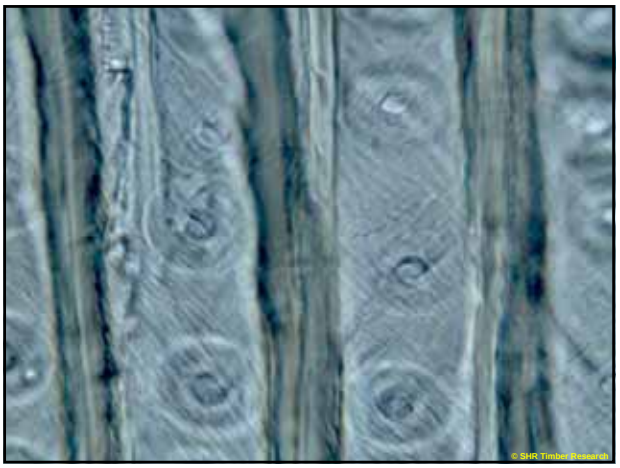
water logged wood and foundation piles

The fourth cause is related to bacterial decay, decay under water. All piles driving into the ground will be invaded by bacteria. This process stops in many piles after several years, however in other piles it can continue for many years a cause severe problems in time like this 100 years old piles which look sound, but have an soft peal over their whole length. This soft peal can vary in thickness from less than one mm to several cm's.

Here the soft peal of pine piles was scratched off with a knife and you can say that houses in Haarlem are not standing on wooden foundation piles of 12 cm in diameter but are actually standing on broom stick alike piles.

Fast growing Dutch pile is very sensitive or it





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Bacterial decay in wooden foundation piles—Patterns and causes: A study of historical pile foundations in the Netherlands

René K.W.M. Klaassen

water logg

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Degradation, text

water logged wood and foundation piles

As individual bacteria are not visible with a light microscope we focus on first signs of decay. I call that the invasion of bacteria in the wood. Here an example of weak erosion bacterial decay in an Amsterdam pine of 100 years old. Individual (or groups of) grooves where the cell wall is eroded, are typical. Compression strength is almost not effected.

Here you see an example of severe decay in a 100 year old Amsterdam pine pile. The grooves appear along the whole cell wall and compression strength is collapse.

For my classification of the degree of decay I used the system I published a few years ago.

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Bacterial decay in the Netherlands

water logged wood and foundation piles

	Velocity bacterial decay [mm/year]			
	invasion		*severe*	
	Pine	Spruce	Pine	Spruce
Mean	0.58	0.33	0.33	0.19
Maximum	1.1	0.8	0.8	0.6

Velocities much lower in piles in open water (underneath quay walls)

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Results, text

water logged wood and foundation piles

As the service life of most piles is known, it was possible to calculate the yearly bacterial decay velocity. It was done for invasion speed as well as for severe decay.
As spruce and pine are the most common species, only for these two species app. 1500 mean values were calculated.

These are mean values for the whole of my country. We know that there are differences between cities (e.g. low speed in Rotterdam compared to Amsterdam or Zaandam) related to soil constitution. But we notice also differences within cities and in order to study this phenomenon we did a case study in Amsterdam based on app. 2000 samples of pine and spruce.

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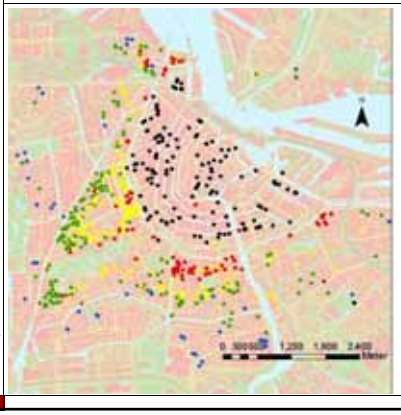
Amsterdam location piles

water logged wood and foundation piles



service life pine and spruce piles

- **60 – 80 year**
- **80 – 100 year**
- **100 -120 year**
- **120 -140 year**
- **> 140 year**

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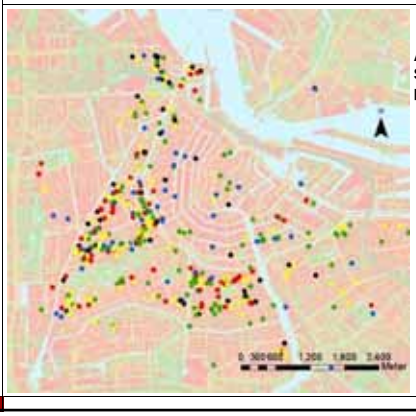
Amsterdam location piles



Amsterdam
Severe decay in pine piles [mm/year]

- 0.00 - 0.12
- 0.13 - 0.25
- 0.26 - 0.37
- 0.38 - 0.50
- 0.51 - >1.00

water logged wood and foundation piles

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Case study Amsterdam pine, text

Here the results. First the distribution of he species over the city. In the old town more spruce.

Here the service life of the piles and of course most old piles are found in the old town and the expansion is also visualised in the piles.

Finally the velocity of severe bacterial decay in pine Remarkable are the low velocities in the old town and the wide variation around it. On each location the velocity can be high and low. As we dealing with one species on one location it has to be effected by variation in the wood.

water logged wood and foundation piles

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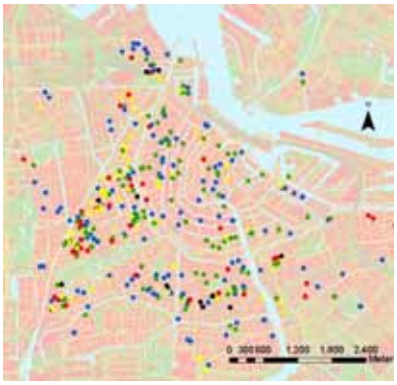
Amsterdam location piles



Amsterdam
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water logged wood and foundation piles

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Case study Amsterdam, spruce, text

Here we see spruce and it is remarkably that there are much more blue points compared to pine. As we know that in all most 95% of all pine stem > 100 year the whole sapwood layer is degraded and the heartwood is sound. In spruce the distinction between sapwood en heartwood is more difficult to see and the variety in degree of decay is also much higher. We assume that the permeability of wood is the key factor in the process of bacterial decay because it allows water movement and so mix the degrading consortium and keep it active. There-fore pine sapwood with its very open structure is sensitive to bacterial decay and pine heart wood not. In spruce this relation is more complicated.

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water logged wood and foundation piles

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Stem age effect

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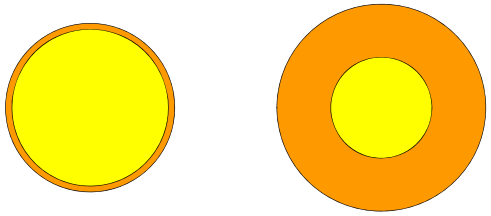
spruce piles same location, 100 years in service

Ø 210 mm / 70 year rings
EB_s decay 13 mm

Ø 260 mm / 20 year rings
EB_{s-w} 60 mm



water logged wood and foundation piles

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Stem disc of 350 years, text

In general the sapwood is more open to water transport than the heartwood but there is a lot of variation. First and example of spruce pile which was in the soil for 350 years. The out-side layer is degraded and the rest is sound. It seems that boundary layers around the heartwood. It is concentric and even the start of a branch is visible. A possible scenario is that fast decay took place in the sapwood (0.2 – 0.5 mm/year) and after the heart-wood boundary is reached the velocity is almost zero. This pile disk is telling us that the Royal Palace is standing on wooden piles that very little in quality will reduce in the next centuries. A second example of two spruce piles found under the same construction beside each other have a different degree of decay and seems to be restrict to the sapwood.

water logged wood and foundation piles

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Decay over the pile length, text

A possible scenario is that fast decay took place in the sapwood (0.2 – 0.5 mm/year) and after the heart-wood boundary is reached the velocity is almost zero. This pile disk is telling us that the Royal Palace is standing on wooden piles that very little in quality will reduce in the next centuries.
As sapwood also in spruce can vary this the first parameter which is important.
As we know too little over the gradient of decay of the pile length we try to do research on extracted piles. However it is expensive and rare.

Decay over the pile length, text

At the moment data 40 piles is available and always the degree at the top was more or less similar to the tip. The consequences are enormous while piles can have length until 18 meter meaning a reduction of the diameter because of TAPSHEID. With the same degree of decay the strength reduction on the caring level is dramatic
Here research on 8 Amsterdam / Leiden / Rotterdam piles from locations 118 / 100 years old. The graph shows clearly that at the tip the decay can be more, equal or less than at the top. It appears at high degradation speeds as well at low speeds.

Decay over the pile length, text

In addition we looked at the number of year rings and we expected a difference between tip and top of 15 years (11 m long, year grow of 80 cm).
Within one location old and young tree were used (40 – 100 years), and the shoot growth was fast and show. With 40 years at the top one should expect 25 at the tip, 60-45, 80-65, 90-75 and 100-85. So beside tree ages there is also variation in shoot growth.
So here is the variation we are looking for, which could explain variation in decay between piles of the same species of the same location.
Research is initiated to extract piles and learn more about this interaction.

Less attention

slow decrease in stability

not visible

Assessment wooden foundation

Distinction between good - bad

Estimate life expectation

Specific approach

Geotechnical load > 1950 empiric
calculate with negative skin fraction < 1950
Strength wet round timber unknown
Standardisation - calculated strength

water logged wood and foundation piles

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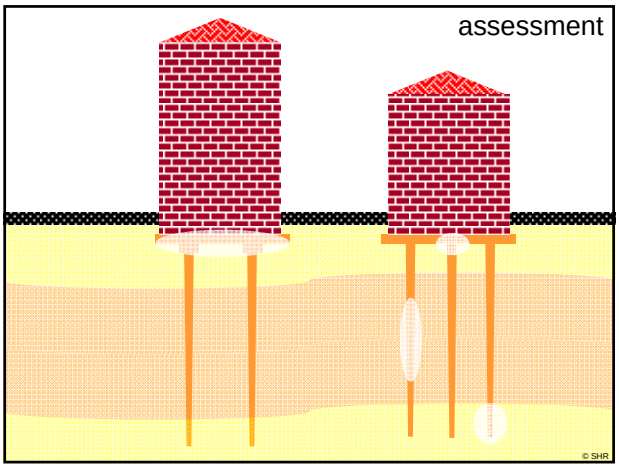

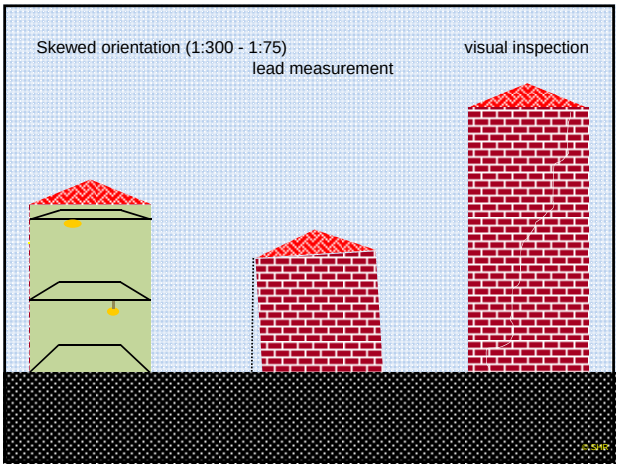

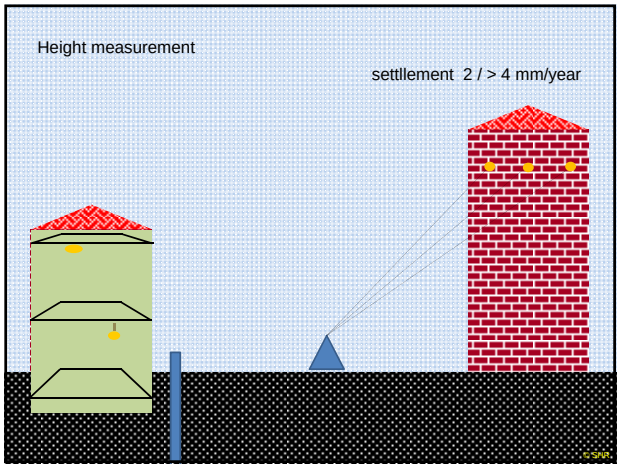

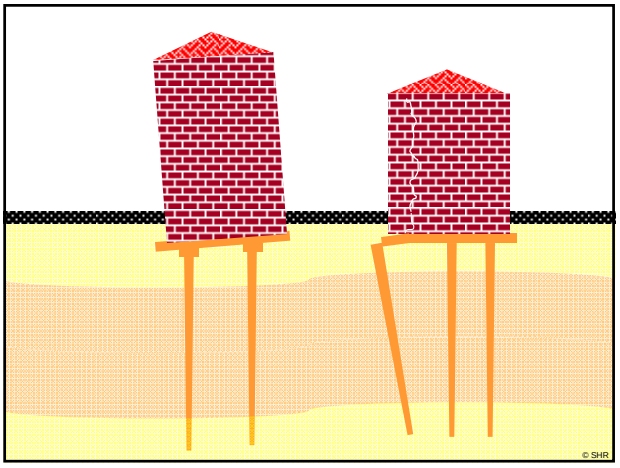

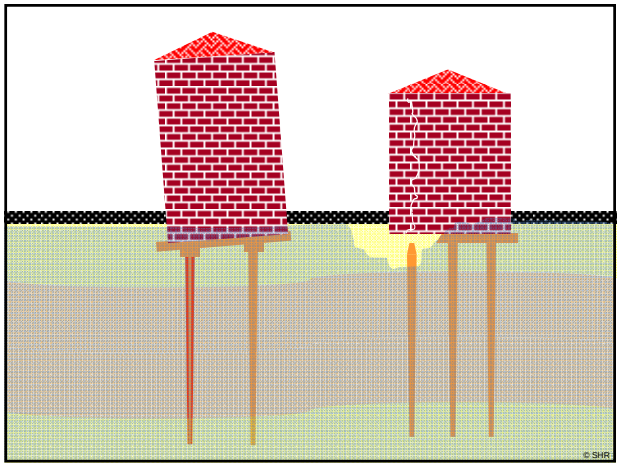


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boormonster uit houten heipaal
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Conclusions, text

We learn from our Dutch foundation piles and it gives us a better understanding of the process of bacteria wood decay. This knowledge enable us it to avoid these problems while the quality of wooden foundations is better predicted.

If buildings are getting an other function (storage of materials to apartments), It should be clear that the foundation is strong enough for the next few decades. This prediction should be made for these buildings here in Amsterdam but at the moment the same process is going on here in HH the Speicherstadt.

Final the conservation of archaeological remains can profit of the finding based on the research of the Dutch wooden foundation piles.