

Noise and Impact Hammers

by
John White

Made for the Pile
Driving Unions



Introduction

The purpose of this presentation is to discuss noise created by pile driving equipment with a focus on impact hammers.

Presentation outline

- What is noise. Where does it come from?
- How is it measured.
- The two main types of noise pile driving creates.
- What kind of regulations are we facing.
- Where is the noise coming from?
- What has been done in the past.
- What's being done now.
- What should be looked at in the future.

What is noise? Where does it come from?

Noise is a vibration. The kind of vibrations we are discussing are those created by impact pile driving. As we will see, these noise vibrations may not be coming from the hammer, but from the pile driving system as a whole.



APE D-46-32 at full stroke on test stand in California undergoing sound tests.

Measuring noise:

Noise can be measured using a decibel meter.

The name comes from Alexander Graham Bell and the unit of measurement is called- the bel.

Usually the value in bels is multiplied by ten and the sound level is expressed in decibels (dB).

More advanced devices are being used to determine the type of sound coming from impact pile hammers.



This meter totals all noise.

The two types of noise

we are interested in:

1) Point Source

2) Line source

Point source

An example of a point source is sound coming from a single point, such as the noise coming from the anvil striking the striker plate.

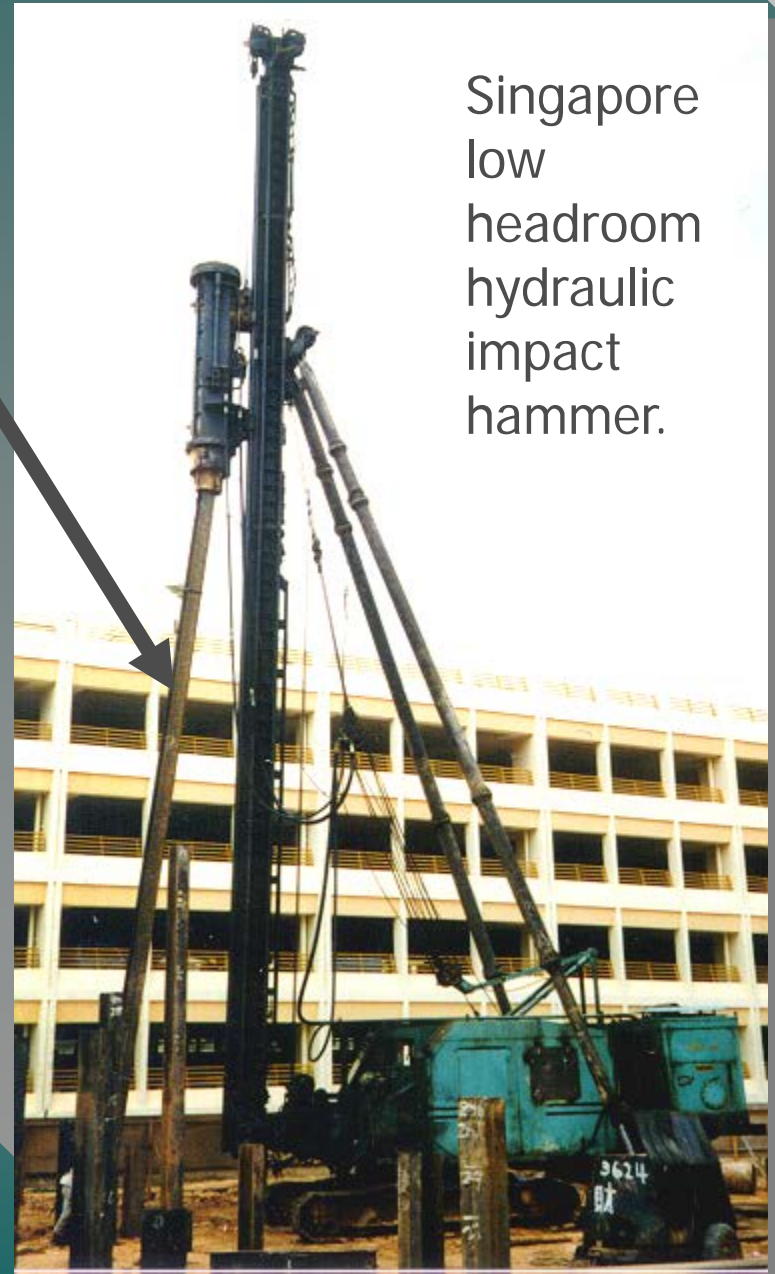


D30 anvil hits
striker plate

Line Source

An example of a line source is sound coming from a long pile as shown in this picture from Singapore of a Hydraulic drop hammer driving an H-beam pile.

Type: Hydraquip



Singapore
low
headroom
hydraulic
impact
hammer.


Measuring facts:

Noise from a point source will drop 6 dBA for each doubling of distance.

Noise from a line source will only drop 3 dBA for each doubling of distance.

Noise from a point source

Noise	50 ft	100 ft	200 ft
Source	80 dBA	74 dBA	68 dBA



Noise from a point source will drop 6 dBA for every doubling of distance.

Note: Noise from a line source will only drop 3 dBA.

What regulations are we facing?

Seattle's maximum permissible sound levels and construction noise limits.

Seattle's Maximum Permissible Sound Levels and Construction Noise Limits

Zoning District of Noise Source [25.08.410 & 420]	Zoning District of Receiving Property (all limits dba)		
	Residential Day / Night	Commercial	Industrial
Rural	52 / 42	55	57
Residential	55 / 45	57	60
Commercial	57 / 47	60	65
Industrial	60 / 50	65	70
Daytime Construction Noise Limits - at 50' or a real property line, whichever is greater. All limits are in dba. Construction noise is limited to the higher levels listed below, during daytime hours only, which are defined as 7 AM to 10 PM weekdays and 9 AM to 10 PM weekends. These limits effectively prohibit construction at night except in special cases.			
<i>On-site sources</i> like dozers, loaders, power shovels, cranes, derricks, graders, off-highway trucks, ditchers, and pneumatic equip (maximum +25 dba) [25.08.425 A.1]			
Residential	80	82	85
Commercial	82	85	90
Industrial	85	90	95
<i>Portable</i> equip used in temporary locations in support of construction like chain saws, log chippers, and powered hand tools (maximum +20 dba) [25.08.425 A.2]			
Residential	75	77	80
Commercial	77	80	85
Industrial	80	85	90
<i>Impact types of equipment</i> like pavement breakers, pile drivers, jackhammers, sand-blasting tools, or other impulse noise sources - may exceed maximum permissible limits between 8 a.m. and 5 p.m. weekdays and 9 a.m. and 5 p.m. weekends, but may not exceed the following limits [25.08.425 B]			
All Sources	All Receivers		
	Leq(1 hr) 90 dba		
	Leq(30 minutes) 93 dba		
	Leq(15 minutes) 96 dba		
	Leq(7.5 minutes) 99 dba		
Sounds created by <i>motor vehicles, including trucks</i> , are exempt from the maximum permissible sound levels, except that sounds created by any motor vehicle operated off public highways shall be subject to the sound level limits III when the sounds are received within a residential district of the City. [25.08.480]			

Pile driving noise. Where is the noise coming from? Depends on the following:

- Impact hammer type- hydraulic, air/steam, diesel
- Height of hammer off the ground
- Leader system
- Pile type- wood, steel, concrete, pipe, plastic
- Pile dimensions-length, diameter, thickness
- Cushion type
- Energy output of hammer- stroke
- Type of soils- soft driving, hard driving
- Rebounding
- Ground surfaces- water, land, buildings
- Weather

Hammer
type-
hydraulic
low
headroom.

No
provisions
for sound
reduction.



Junttan free
fall made in
Finland



Hydroquip
lowhead room
manufactured
in Singapore



Low head room
Junttan
hammer. HHK3
5 feet and
HHK12
14 feet tall



Low head
room hammer
working in
Singapore.

Hammer type-closed



Twinwood



BSP
with sound proofing



Delmag
with sound proofing

Hammer type- Air/steam

Open type

Stroke is
fixed, or
semi-fixed.
Noise does
not vary as
much as
diesels.



Hammer type- Diesels



**ICE 100S with
sound shielding (ICE Seattle)**



American Pile
Driving
Construction

Pleasanton
California

**APE D30 without sound
shielding**

Height off the ground

Does the height of the hammer really matter.
Yes.

Depends on:

Hammer type: single acting diesels stroke up.
They make less noise at first, but as pile meets soil resistance, hammer strokes up, increasing energy. More energy, more noise.

May seem louder because hammer is closer to you. However, tests show differently, depending on pile type.

Leader systems

American style lead systems reflect sound waves. Not a big factor over European style leads, but could be.



Junttan in box leads



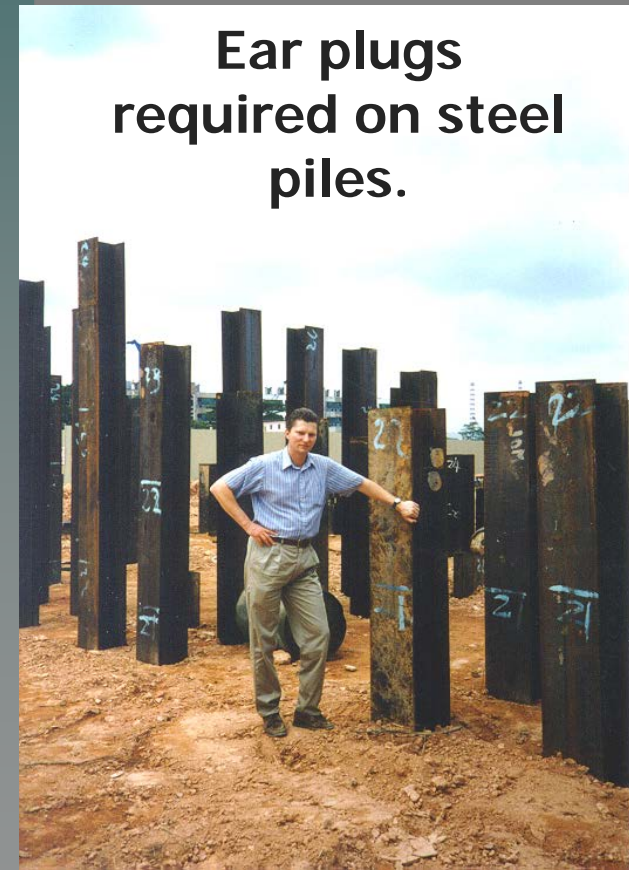
European style leads in China with Chinese water cooled diesel

Pile type

Pile type is the major factor because the pile can be the source of the noise.



Concrete piles make far less noise. Cushion a factor.



Ear plugs required on steel piles.

Steel piles transmit vibrations. Noise is a line source.

Pile type-continued

Tests show that wood and concrete piles make less noise than steel piles, such as H-beams, pipe, or sheet piles. This is due mainly to the lack of a wood cushion material. If steel piles were driven with a wood cushion the noise level would be greatly reduced.

Pile type-continued

Tests comparing D62 with no sound reduction technology created less noise than Junttan HHK9a with latest sound reduction technology available. Why? Noise came from steel pile.

Noise dropped as pile sank into soil.



Junttan on steel pile was louder than D62



APE D62 produced less noise. Energy was slightly lower.

Pile dimensions

Does not matter much on concrete piles.

Makes big difference with steel piles.

Steel piles are the killer. Can be solved.

Noise output will change depending on wall thickness, length, etc.

Some piles vibrate more than others.

Cushion type

Tests show almost no difference between drive cap (hammer) cushion materials.

However, pile cushion, such as the wood cushion on a concrete pile, is a major factor in reducing noise.

Wood cushions on steel piles would make a big difference in noise reduction.

Cushion test

Tests show that steel pile noise is greatly reduced by using a concrete wood cushion. Energy loss is a factor.

Singapore drive cap design makes it easy to use wood cushion on all types of steel piles. Burlap works.



Singapore adapter design adapts round drive cap base to any size pile.

Cushion-continued

In Singapore, pile drivers use burlap bags instead of thick wood cushion when starting piles. Purpose-to drive piles faster. Burlap reduces the noise factor while allowing energy transfer. Crew adds thick wood cushion when driving gets more difficult.



Pile crew loads burlap bag for next pile.

In Singapore, all drive caps are round. Light weight adapters are fabricated to hold wood cushion and center pile in drive cap. See next slide.

Cushion-continued

Twinwood hammer



Notice Singapore adapters for various pile sizes. Round drive cap can fit large piles. Adapter centers piles in large round drive cap. Various adapters are cheaply fabricated. Adapter allows wood cushions on steel piles.

Other noise factors

Energy output of hammer

Type of soils

Rebounding- causing repeated metal contact

Ground surfaces- water, land, buildings

(warning: avoid nice days on water.)

Weather

What has been done?

- Scheduled operating times- peak hours only.
- HUSH system
- Augered cast-in-place piles
- Drilled shafts
- Still worker
- Burlap bags in Singapore
- Extreme engineering experiments

Scheduling times

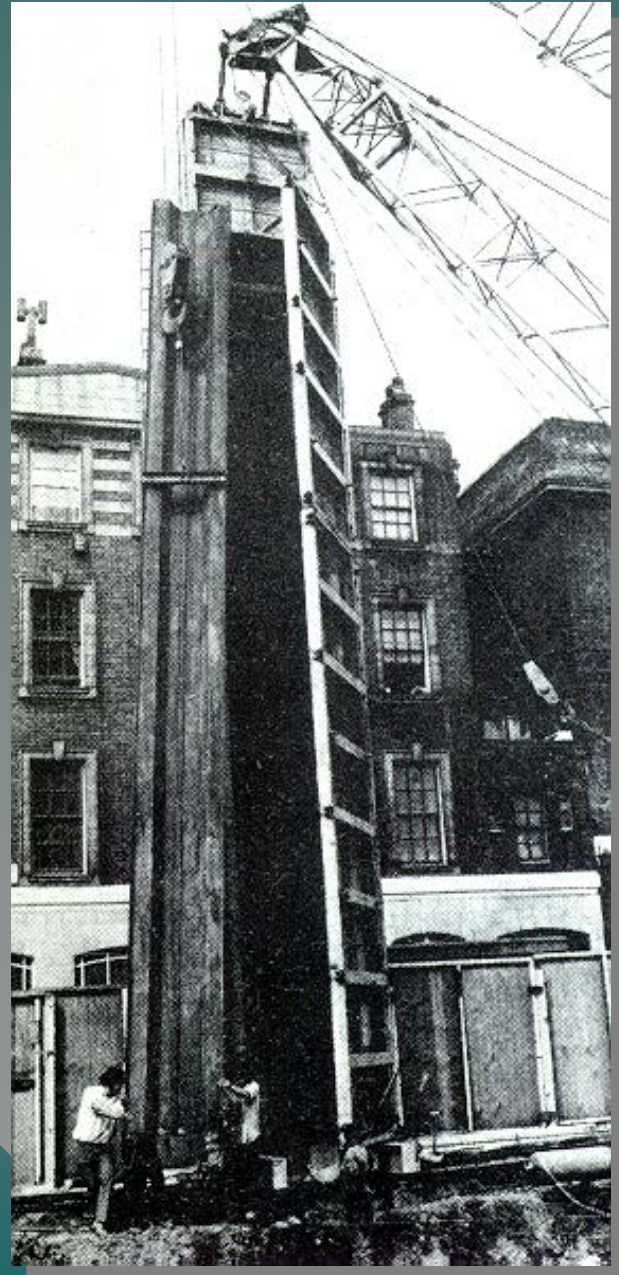
- Drive during day when noise is more acceptable.
- Avoid driving during off peak hours.
- Drive when weather blocks sound waves.
- Know when you make the loudest noise and schedule it to your advantage.

What has been done?

The HUSH system

Consisted of a lead system that completely enclosed the hammer and pile.

Excellent sound reduction.



What has
been done?

Augered
cast-in-place
piles
as a alternate
foundation



**What has
been done?**

Drilled shafts



**What has
been done?**

**Silent pile
hammer**

**This is not
an impact
hammer.**



What has
been done?

Burlap
bags



•Past extreme inventions

Chinese hydraulic press

Oil as a cushion material

Compressed air as a cushion

What is being done now?

- Shielding the diesel hammer.
- Crane suspended sound barrier
- Twinwood enclosed hammer.
- Junttan enclosed hammer with sound reduction foam.
- Burlap bags.
- Plastic piles

What is being done now? Hammer shielding.



Attempts to shield hammer noise had little effect on test at pier 91 in Seattle. Steel piles were a factor.

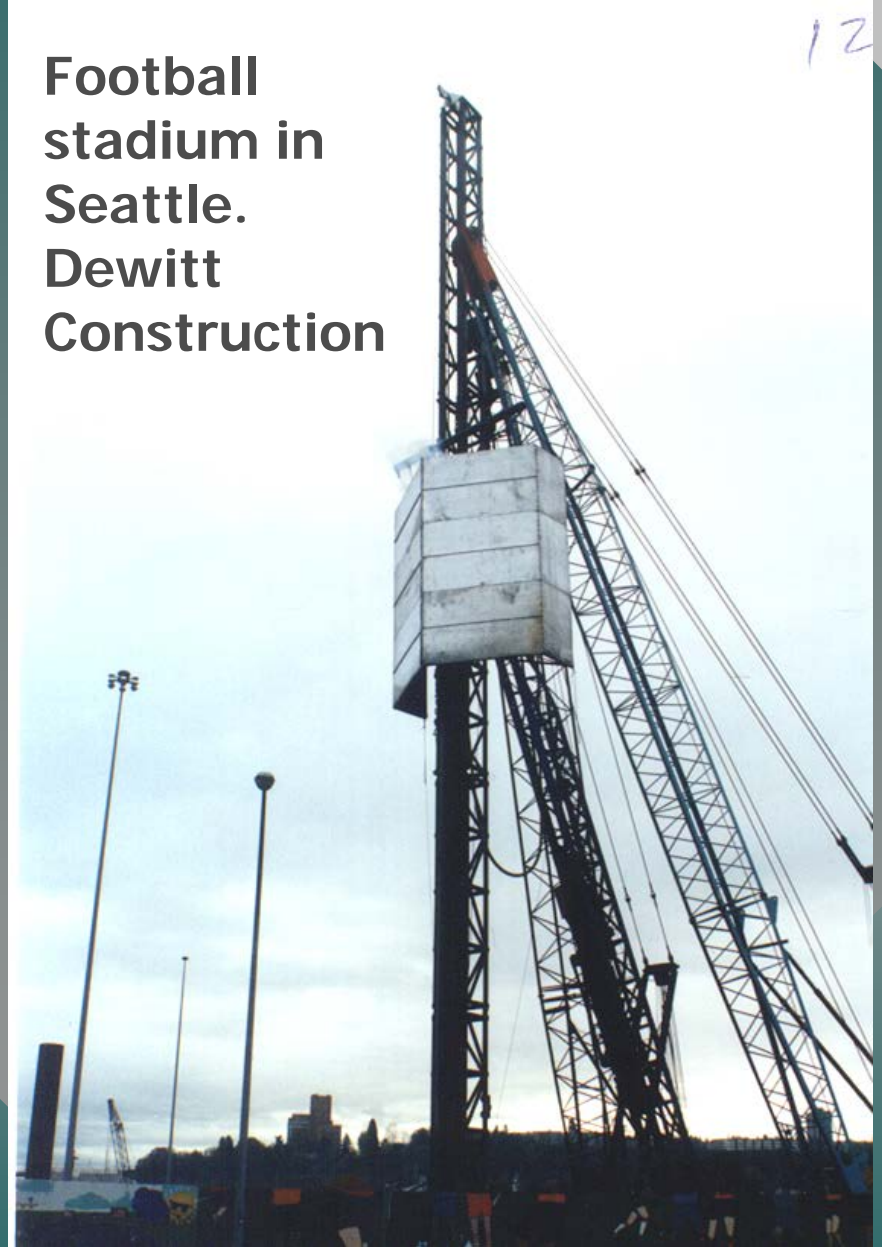


Diesel Hammer with Sound Wall

**What is
being
done
now?**

**Hammer
shielding.**

**Football
stadium in
Seattle.
Dewitt
Construction**



Massive shield had very little effect on noise from D62. Crew reports stated that shield was political not practical.

What to expect in the future.

- A better understanding of what causes the noise will help in the development of better systems to reduce noise.
- Enclosed lead systems using foam pads.
- Drive caps using wood cushion on steel piles.
- Pile rabbits that also serve as sound deadening devices.
- Foam coated piles.
- Plastic or other types of piles designed to reduce noise.
- Continuation of switch to other types of foundations such as augered cast-in-place piles, bored piles, and drilled shafts.

Vibration near concrete

Pile Driving With A Vibratory Driver From or Near Adjacent Structures

The contractor shall not drive piling, with a vibratory driver from an existing structure unless all of the following conditions are met.

1. The existing structure will be demolished within the contract.
2. The existing structure is permanently closed to traffic, and
3. Working drawings are submitted in accordance with Section 6-01.9 and 6-02.3(16), showing the structural adequacy of the existing structure to safely support all of the construction loads.

To minimize the detrimental effects of pile driving vibrations on new concrete less than 28 days old, piles shall not be driven closer to the new concrete than the distance determined from the following formula:

$$D = C \text{ times the square root of } E \text{ times } 10 = C(\sqrt{E*10})$$

Where : D= distance in feet

E= rated hammer energy in foot pounds

C= coefficient shown below based on the number of days of curing time

Curing Time (days)	Coefficient (C)	Curing Time (days)	Coefficient (C)
1	0.34	6	0.12
2	0.23	7-9	0.11
3	0.18	10-13	0.10
4	0.15	14-20	0.09
5	0.13	21-28	0.08

This distance may be reduced if approved in writing by the Engineer.