Pile Driving Basics

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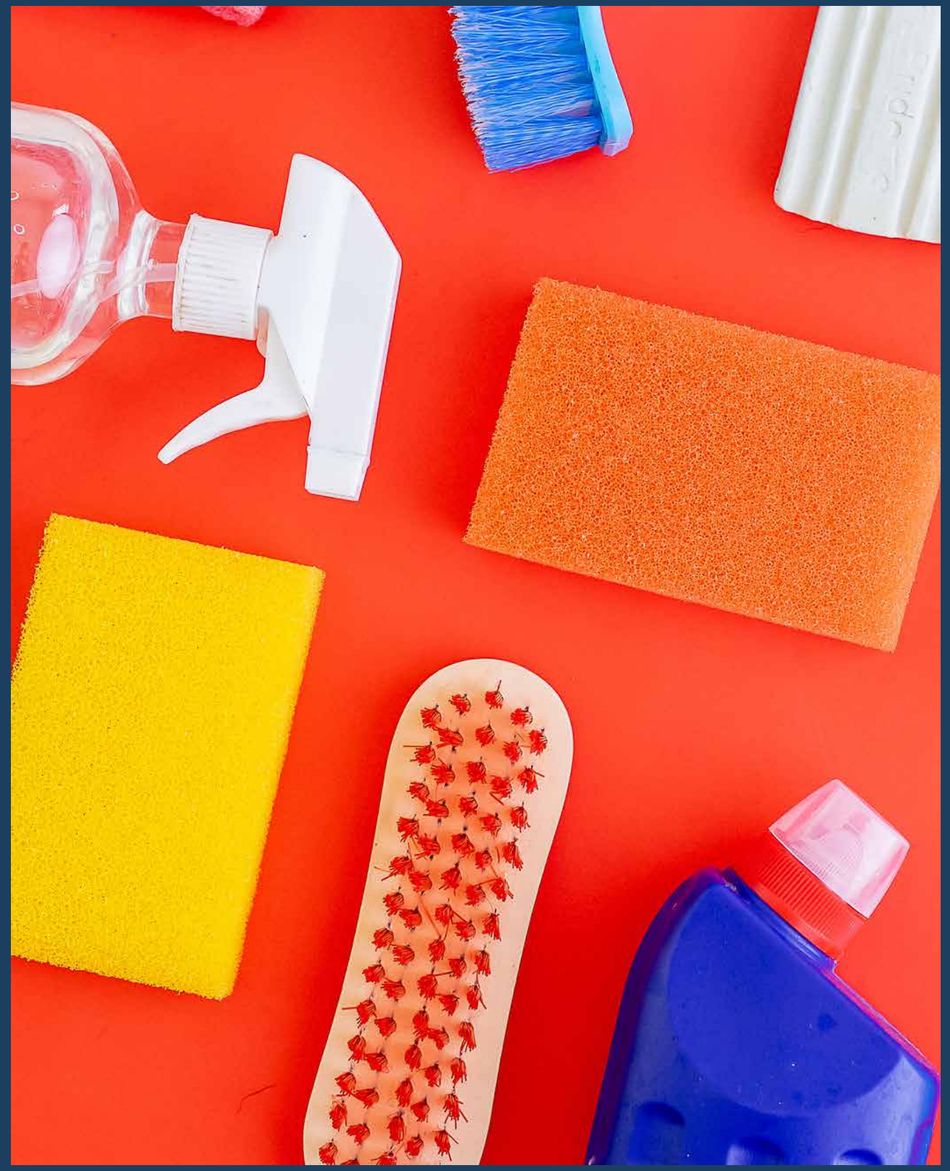
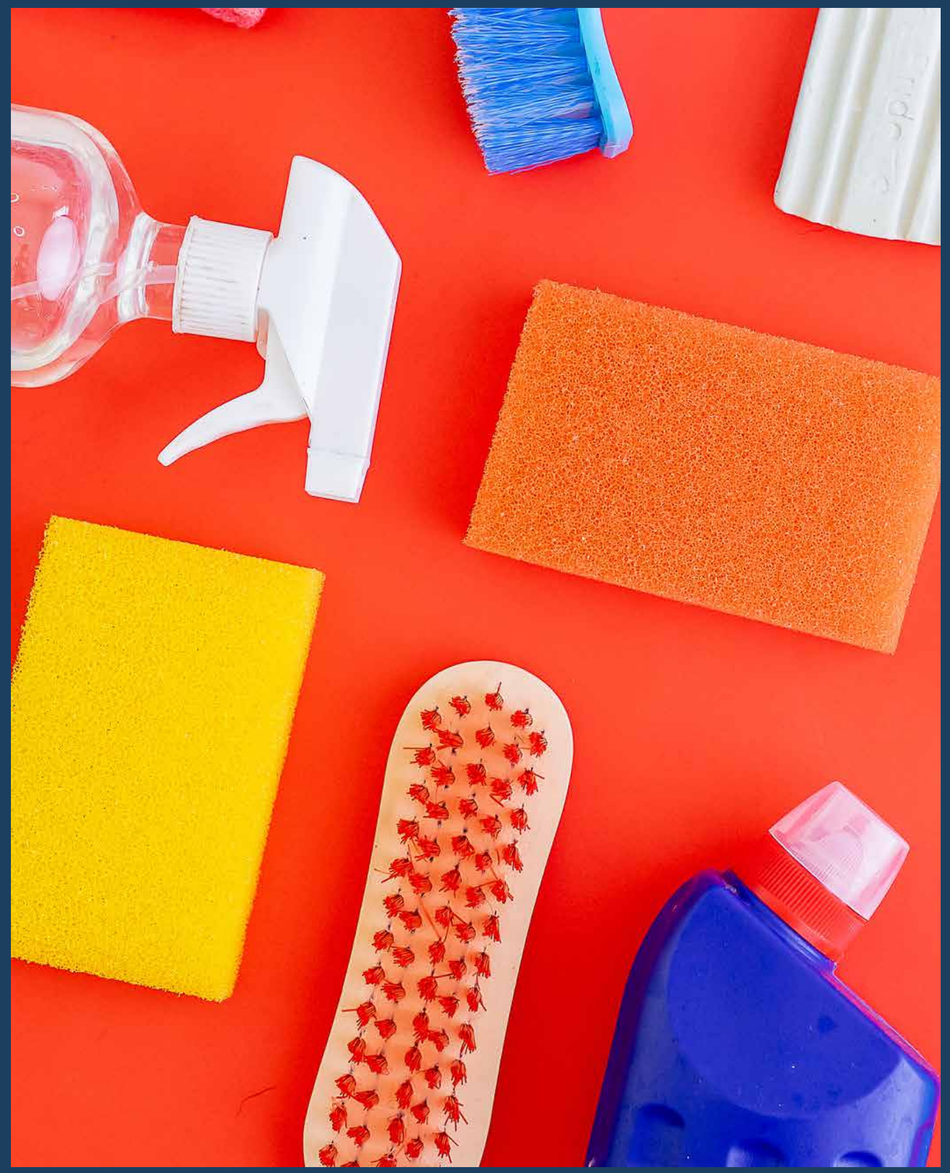
Michigan Local Technical Assistance Program



Housekeeping

Afternoon Workshops

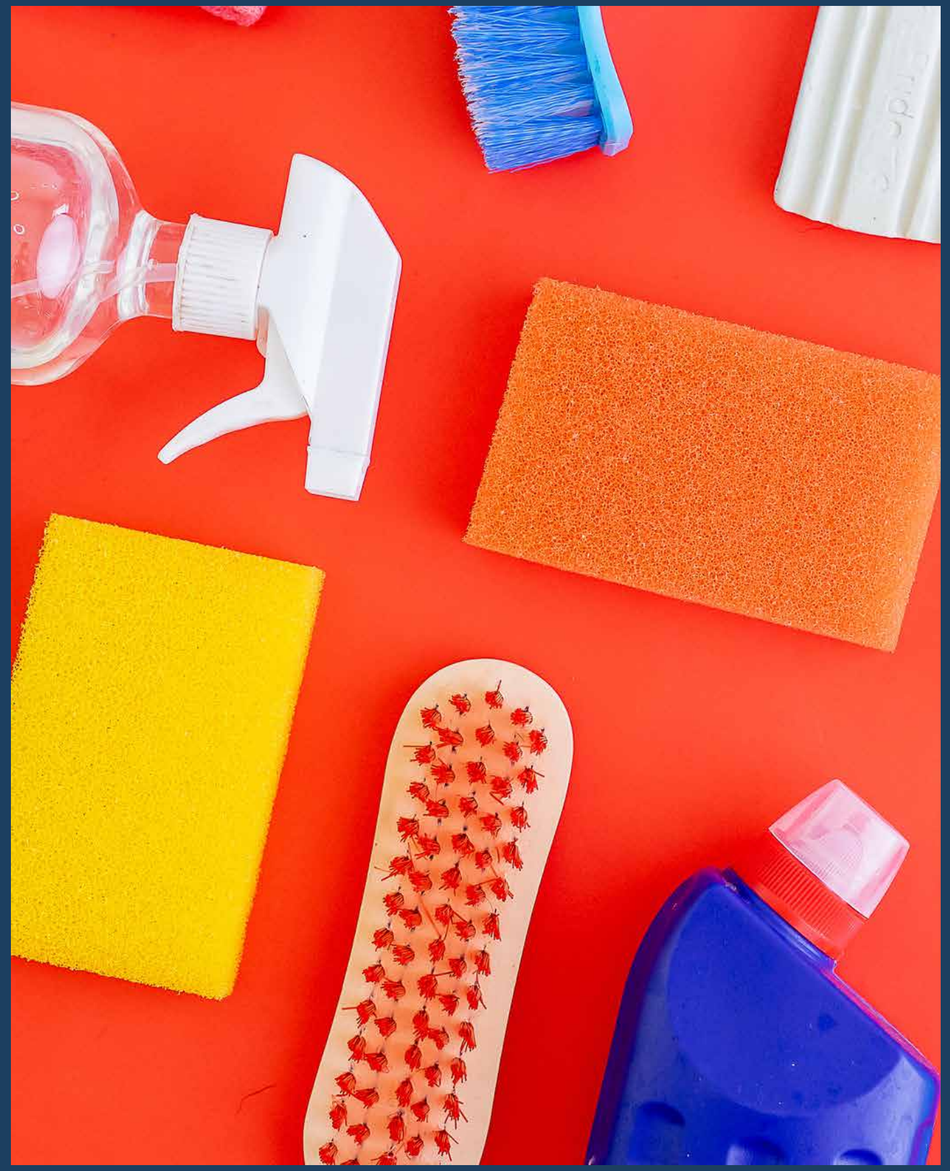
- Track A - Bridge QC/QA
  - Downstairs (elevator available)
- Track B - Scour
  - Same Room



Housekeeping

Certificate of Attendance

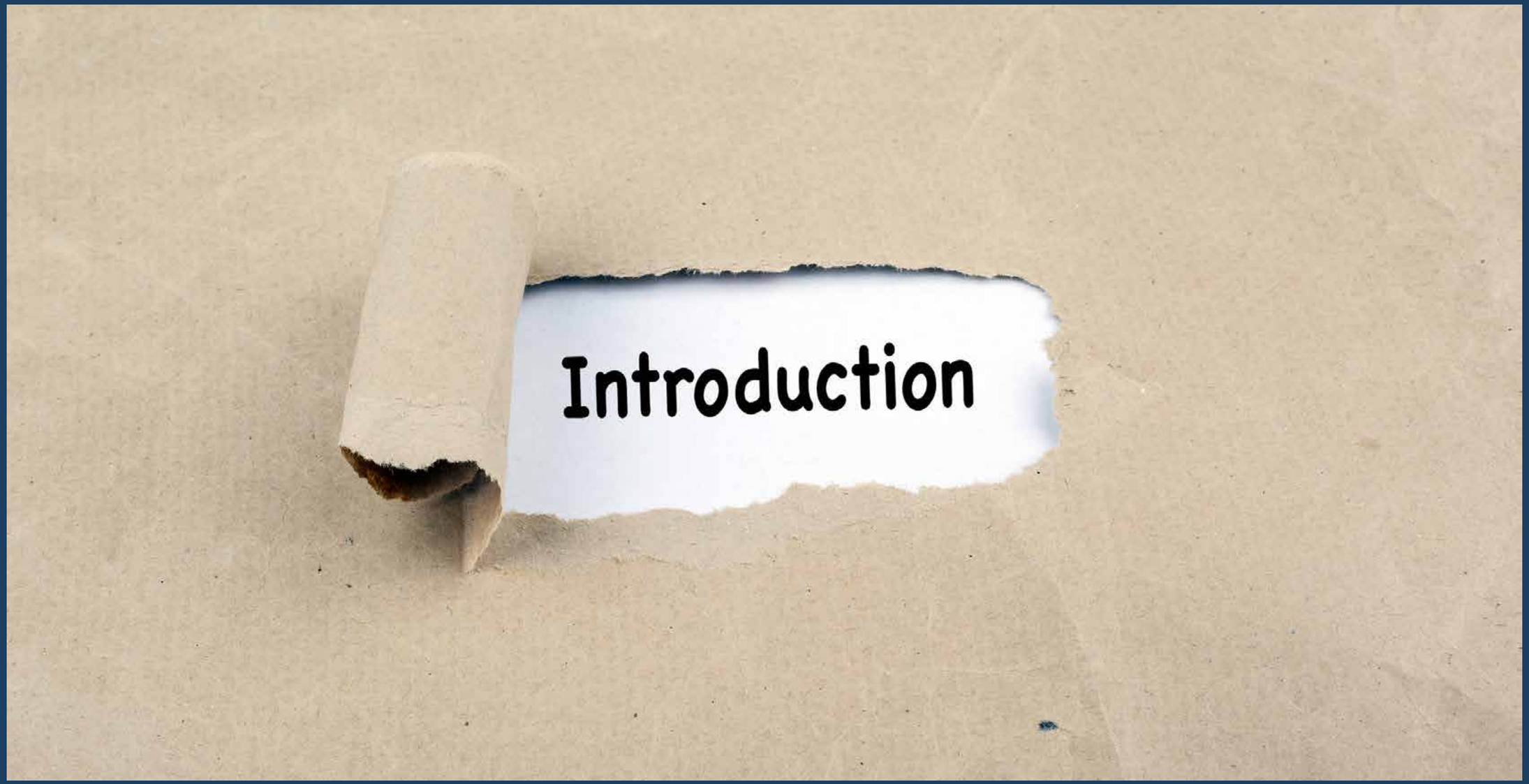
- In-person
  - Sign in sheet at registration table
- Online Attendees
  - SurveyMonkey at end of day



Housekeeping

- Zoom Closed Caption
- Slides are available
- Vevox for Interaction

Vevox Demo


Introduction

Poll Question

What are you expecting to learn today?

What are you expecting to learn from today's presentation?

What are you expecting to learn from today's presentation?

RESULTS SLIDE

What we are not covering today

- Design of driven piles
- Sheet piling installation
- Sheet piling design
- WWE moves

What we are covering today

Pile Basics

Break

What happens before you go onsite

Break

What happens when you're onsite

Poll Question

What is your role?

Question slide

What best describes your role

What best describes your role

RESULTS SLIDE

Poll Question

What’s your agency?

Question slide

What best describes your organization/agency

What best describes your organization/agency

RESULTS SLIDE

Why does this matter?

What's the worst that can happen?

Bridge Basics

Superstructure

Substructure

Hidden Depths

Pavement Project Risk

Construction inspection

Directing work?
Compliance?
Documenting?
Authority?
Changed conditions?

Construction observation

Poll Question

Have you observed driven piles ?

Question slide

Have you observed pile driving? (watching installation, but not responsible for any decisions or documentation)

Yes	0%
No	0%
I don't know	0%

Have you observed pile driving? (watching installation, but not responsible for any decisions or documentation)

Yes ##.##%

No ##.##%

I don't know ##.##%

RESULTS SLIDE

Poll Question

Have you inspected driven piles ?

Question slide

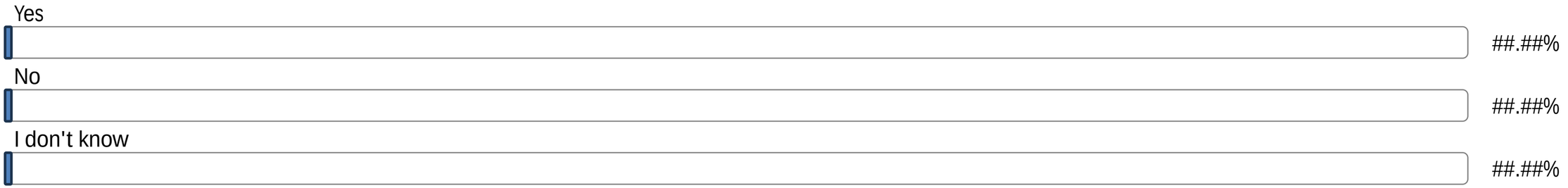
Have you inspected driven piles? (documenting conditions and had authority to determine end of drive)

Yes 0%

No 0%

I don't know 0%

Have you inspected driven piles? (documenting conditions and had authority to determine end of drive)



RESULTS SLIDE

Shared Risk

Roles

MDOT

Bridge Owner

Contractor

How we are trained

- Our experiences
- Your experiences

Poll Question

How were you trained to inspect piles?
Did you feel prepared?

How were you trained to inspect pile driving? Did you feel prepared?

How were you trained to inspect pile driving? Did you feel prepared?

Poll Question

When was the last time you inspected pile driving?

Question slide

When was the last time you inspected pile driving?

When was the last time you inspected pile driving?

Never
##.##%

More than 10 years ago
##.##%

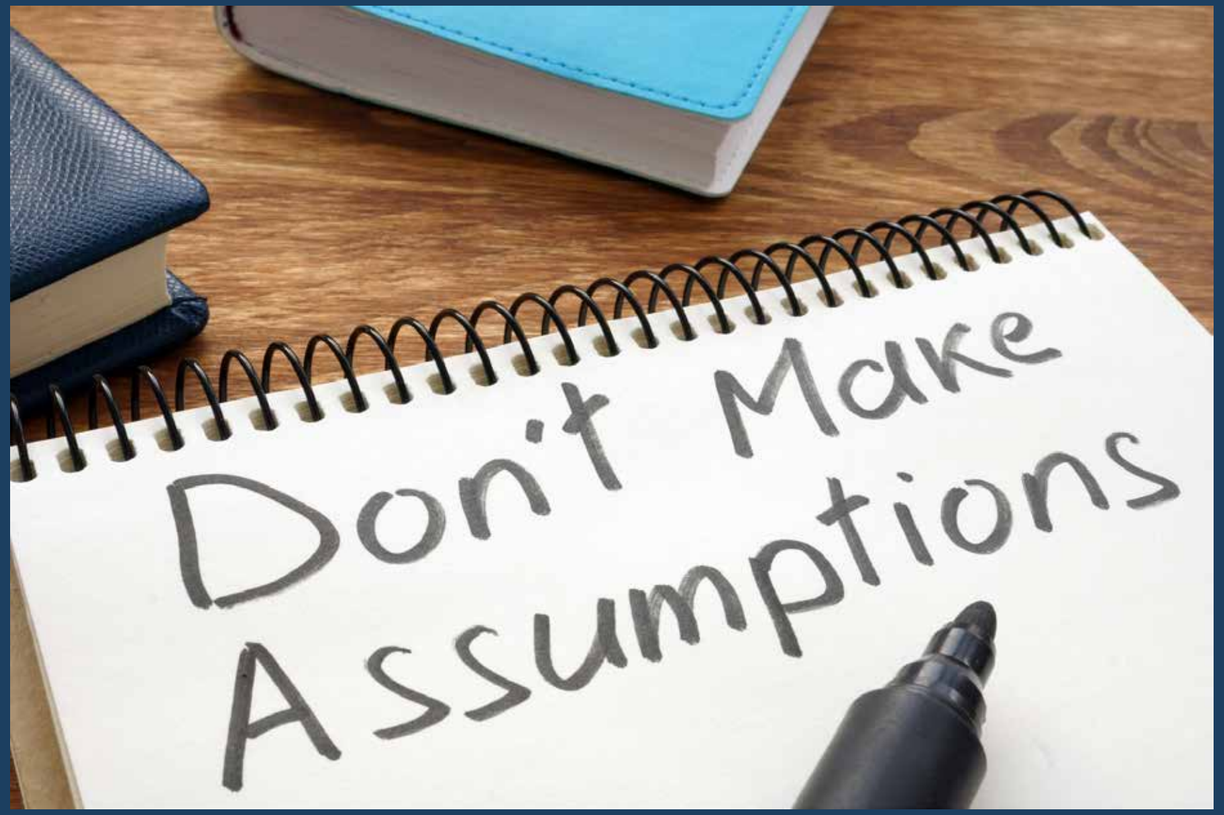
Between 5 and 10 years ago
##.##%

Between 2 and 5 years ago
##.##%

Within the last 2 years
##.##%

RESULTS SLIDE

Train the Trainer



Assumed Knowledge & Assumed Experience

What do piles do?

Hold stuff up!

What are piles used for?

Bridges

Retaining Walls

Buildings

Cost vs Conservative Design

Driving piles deeper than necessary is a waste of money

Driving piles shallower than necessary may not support the bridge as designed

Poll Question

Who is doing your pile inspection at your agency?

Question slide

Who is doing pile inspections at your agency? (You can select multiple)

Entry-level engineers (Engineer-In-Training)	0%
Licensed engineers (P.E.)	0%
Field Technician	0%
Interns	0%

Who is doing pile inspections at your agency? (You can select multiple)

Entry-level engineers (Engineer-In-Training) ##.##%

Licensed engineers (P.E.) ##.##%

Field Technician ##.##%

Interns ##.##%

RESULTS SLIDE

Poll Question

Who determines when driving is complete?

Who determines when pile driving is complete?

Who determines when pile driving is complete?

Ask Tony

How many pile driving projects do you have scheduled this summer?

When do we stop driving?

Who determines "End of Drive"?

How do piles work?

And why do we have different kinds?

End bearing piles

Like stilts! The pile rests on a sturdy subgrade layer.

Friction piles

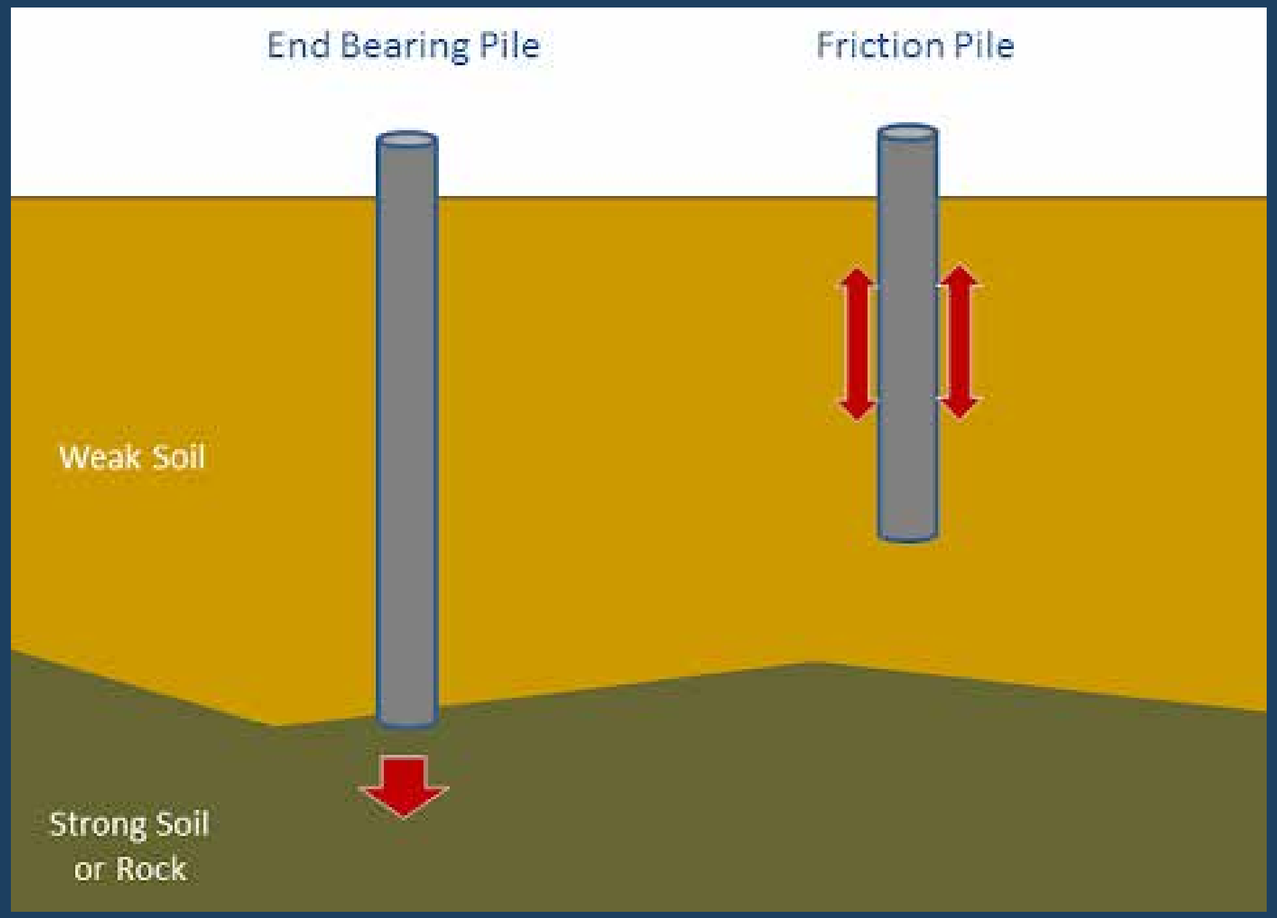
The soil around the pile resists the pile moving up and down

Lateral piles

The size or angle of the pile resists a sideways force

End Bearing Piles

End bearing piles sit on top of a sturdy layer of soil or rock



Friction Piles

Friction piles use the friction between the pile surface and the soil around the pile to resist forces moving the pile up or down

Lateral Piles

Lateral piles resist sideways forces that are applied to the piles. Sometimes these piles are installed at an angle (battered piles)

Common Pile Materials In Michigan

Pile Materials

CIP Piles

CIP piles consist of a steel pipe that is filled with concrete

H Piles

H piles are a steel section that is shaped like a letter H

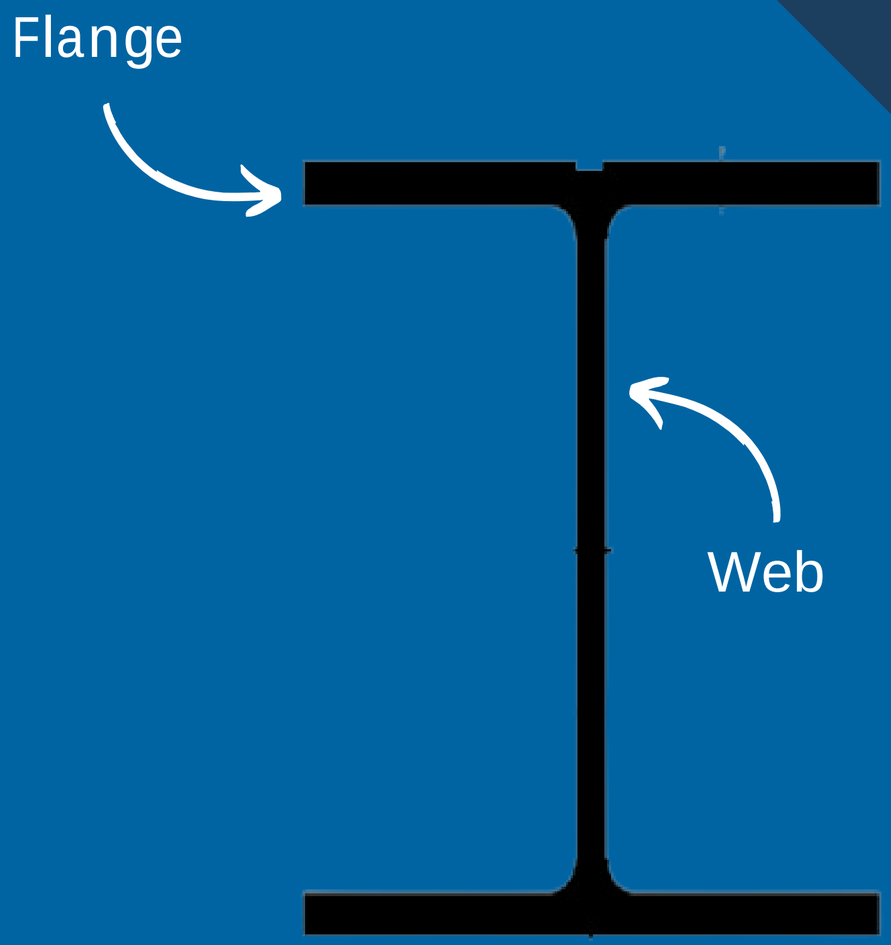
Timber Piles

Timber piles are a solid piece of wood and they can be rectangular or round

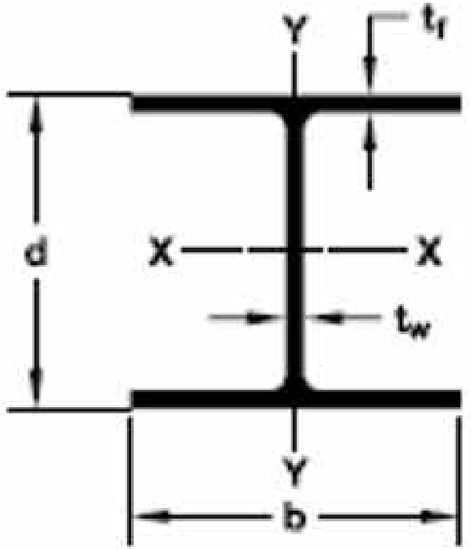
Ask Tony

What trends are you seeing with bridge foundations in terms of pile type/material?

H Piles



Don’t assume knowledge



SECTION	Weight	Area	Depth	Flange Width	THICKNESS		Coating Area	PROPERTIES							
								AXIS X-X				AXIS Y-Y			
			d	b	Flange (t_f)	Web (t_w)		I	S	Z	r	I	S	Z	r
	lb/ft (kg/m)	in² (cm²)	in (mm)	in (mm)	in (mm)	in (mm)	ft²/ft (m²/m)	in⁴ (cm⁴)	in³ (cm³)	in³ (cm³)	in (cm)	in⁴ (cm⁴)	in³ (cm³)	in³ (cm³)	in (cm)
HP 8 HP 200	**36** 54	**10.6** 68.4	**8.02** 204	**8.16** 207	**0.445** 11.3	**0.445** 11.3	**3.92** 1.19	**119** 4953	**29.8** 488	**33.6** 550.6	**3.36** 8.53	**40.3** 1677	**9.88** 162	**15.2** 249.1	**1.95** 4.95
HP 10 HP 250	**42** 63	**12.4** 80.0	**9.70** 246	**10.10** 257	**0.420** 10.7	**0.415** 10.5	**4.83** 1.47	**210** 8741	**43.4** 711	**48.3** 791.5	**4.13** 10.5	**71.7** 2984	**14.2** 233	**21.8** 357.2	**2.41** 6.12
	57 85	**16.7** 108	**9.99** 254	**10.20** 259	**0.565** 14.4	**0.565** 14.4	**4.91** 1.50	**294** 12237	**58.8** 964	**66.5** 1089.7	**4.18** 10.6	**101** 4204	**19.7** 323	**30.3** 496.5	**2.45** 6.22
	53 79	**15.5** 100	**11.80** 300	**12.00** 305	**0.435** 11.0	**0.435** 11.0	**5.82** 1.77	**393** 16358	**66.7** 1093	**74.0** 1212.6	**5.03** 12.8	**127** 5286	**21.1** 346	**32.2** 527.7	**2.86** 7.26
	63 94	**18.4** 119	**11.90** 302	**12.10** 307	**0.515** 13.1	**0.515** 13.1	**5.86** 1.79	**472** 19646	**79.1** 1296	**88.3** 1447.0	**5.06** 12.9	**153** 6368	**25.3** 415	**38.7** 634.2	**2.88** 7.32
	74 110	**21.8** 141	**12.10** 307	**12.20** 310	**0.610** 15.5	**0.605** 15.4	**5.91** 1.80	**569** 23683	**93.8** 1537	**105** 1720.6	**5.11** 13.0	**186** 7742	**30.4** 498	**46.6** 763.6	**2.92** 7.42

= 0.435

11.80 =

= 0.435

b =
12.00

HP 12 HP 310	**53** 79	**15.5** 100	**11.80** 300	**12.00** 305	**0.435** 11.0	**0.435** 11.0	**5.82** 1.77	**393** 16358	**66.7** 1093	**74.0** 1212.6	**5.03** 12.8	**127** 5286	**21.1** 346	**32.2** 527.7	**2.86** 7.26
	63 94	**18.4** 119	**11.90** 302	**12.10** 307	**0.515** 13.1	**0.515** 13.1	**5.86** 1.79	**472** 19646	**79.1** 1296	**88.3** 1447.0	**5.06** 12.9	**153** 6368	**25.3** 415	**38.7** 634.2	**2.88** 7.32
	74 110	**21.8** 141	**12.10** 307	**12.20** 310	**0.610** 15.5	**0.605** 15.4	**5.91** 1.80	**569** 23683	**93.8** 1537	**105** 1720.6	**5.11** 13.0	**186** 7742	**30.4** 498	**46.6** 763.6	**2.92** 7.42
	84 125	**24.6** 159	**12.30** 312	**12.30** 312	**0.685** 17.4	**0.685** 17.4	**5.97** 1.82	**650** 27055	**106** 1737	**120** 1966.4	**5.14** 13.1	**213** 8866	**34.6** 567	**53.2** 871.8	**2.94** 7.47
	89 132	**25.9** 167	**12.36** 314	**12.32** 313	**0.720** 18.3	**0.720** 18.3	**6.04** 1.84	**689** 28700	**111.6** 1830	**126.3** 2070	**5.16** 13.1	**225** 9370	**36.5** 599	**56.2** 922	**2.94** 7.48
	102 152	**29.9** 193	**12.56** 319	**12.64** 321	**0.819** 20.8	**0.819** 20.8	**6.17** 1.88	**811** 33800	**129.3** 2120	**147.6** 2420	**5.20** 13.2	**276** 11500	**43.7** 716	**67.1** 1100	**3.04** 7.71
	117	**34.4**	**12.76**	**12.87**	**0.929**	**0.929**	**6.26**	**946**	**148.2**	**170.8**	**5.24**	**331**	**51.4**	**79.3**	**3.11**

Poll Question

What kind of pile cannot be spliced?

Question slide

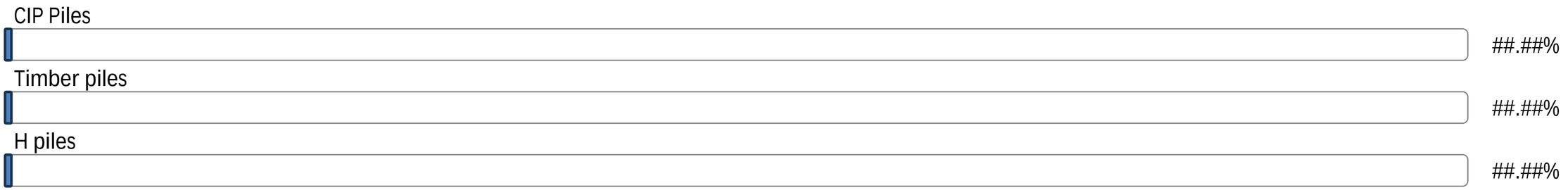
What kind of piles cannot be spliced?

CIP Piles 0%

Timber piles 0%

H piles 0%

What kind of piles cannot be spliced?



RESULTS SLIDE

Poll Question

Can piles be driven too deep?

Can piles be driven too deep?

Yes

0%

No

0%

I don't know

0%

Can piles be driven too deep?

Yes ##.##%

No ##.##%

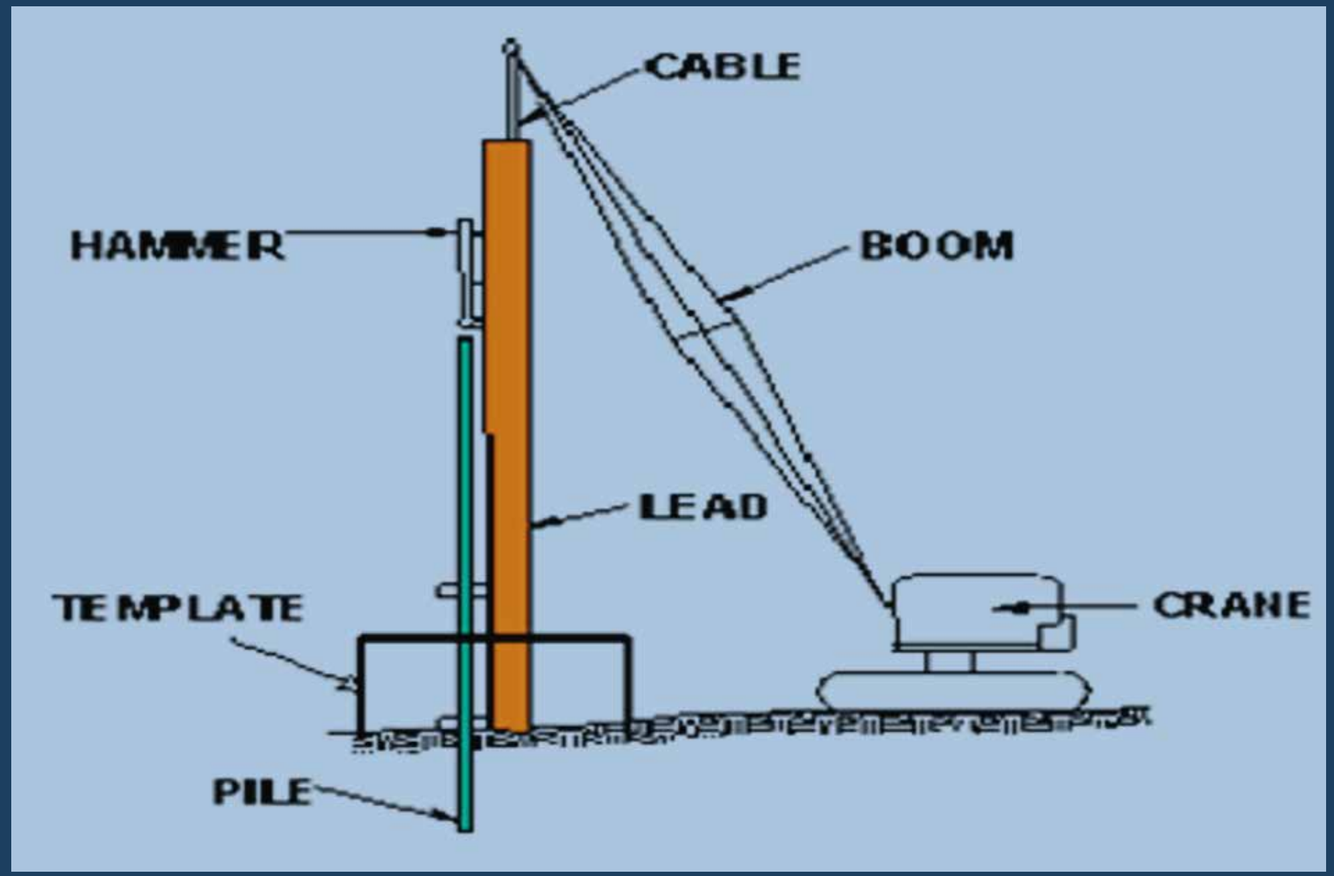
I don't know ##.##%

RESULTS SLIDE

Embedment

Minimum embedment
- stability
Maximum embedment
- avoiding undesirable conditions

Pile Driving Equipment



Stop,

Hammer Time!

- Air Hammer
- Hydraulic Hammer
- Vibratory Hammer
- Drop Hammer
- Diesel Hammer
  - Closed
  - Open-ended
- MC Hammer

Types of hammers

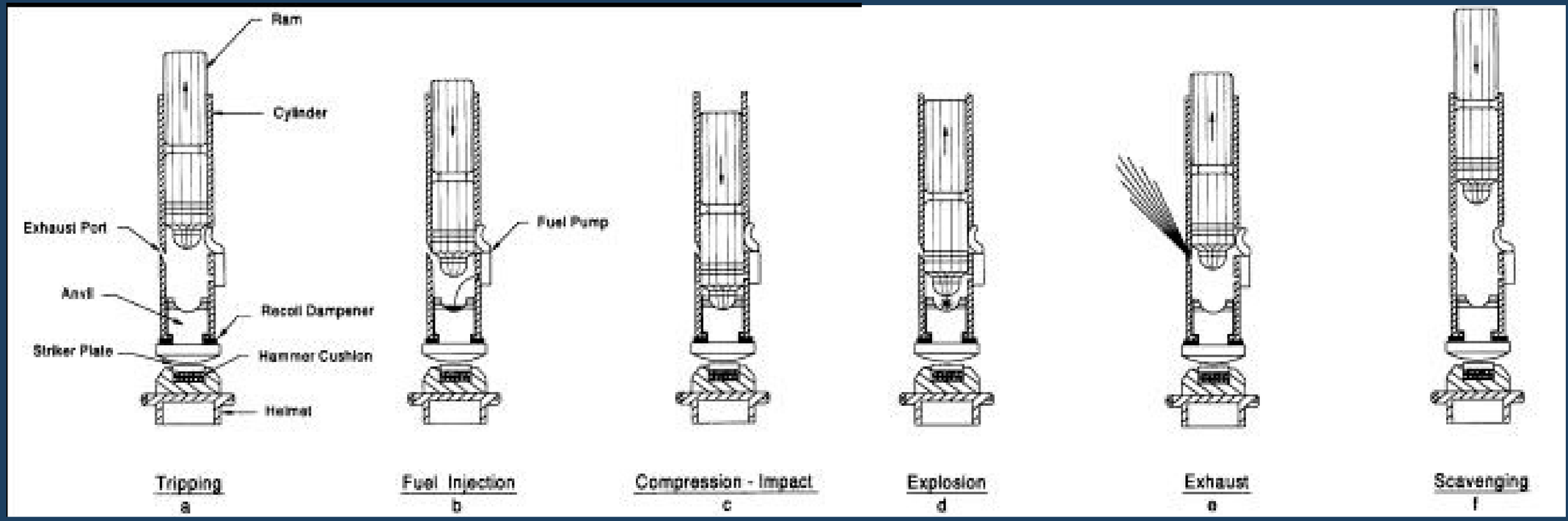
Vibratory Hammers

Piles are installed by vibrating (shaking) into the ground

Impact Hammers

Piles are installed by a large weight (ram) hitting them incrementally

Diesel Impact Hammer



Open-ended Diesel Hammer

Diesel Impact Hammer

Closed

- Explosion shoots the ram up
- Air compresses against to the top and accelerates the ram down
- Gravity also pulls the ram down
- Energy is transferred to the pile

Poll Question

What is a factor that could effect the efficiency of a hammer?

What is a factor that could effect hammer efficiency?

What is a factor that could effect hammer efficiency?

Hammer Selection

Hammer Size &
Settings

Pile Size &
Required Capacity

Pile Driving Chart

Hammer Sizing

Too big

Pile damage during driving

Too small

Unable to achieve required resistance or depth

Just right

Able to drive pile without damage

Ask Tony

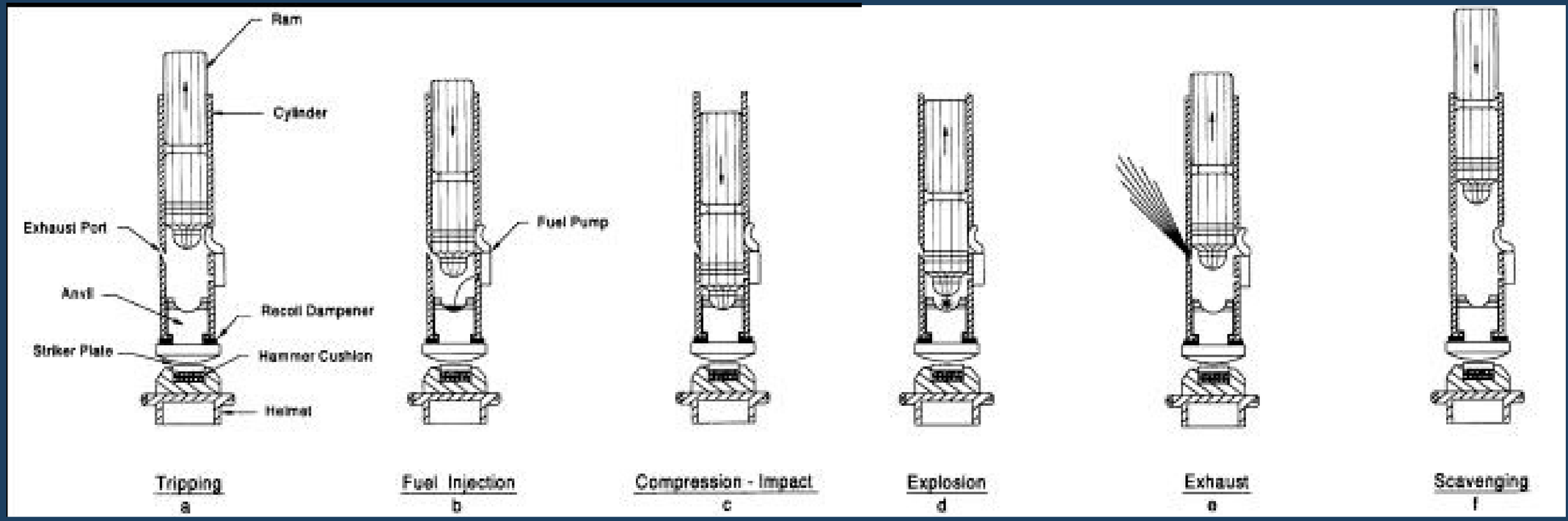
What happens if the contractor shows up with a different hammer than they submitted?

Hammer Selection

Hammer energy is the combination of two things:

- Hammer weight
- Hammer stroke

What is stroke?



Open-ended Diesel Hammer

Stroke

Too large

Too much energy transferred

Too small

Not enough energy transferred

Just right

Correct energy transferred as resistance increases

Things that effect stroke

Hammer vs Pile size

Under or oversized hammers for that size pile

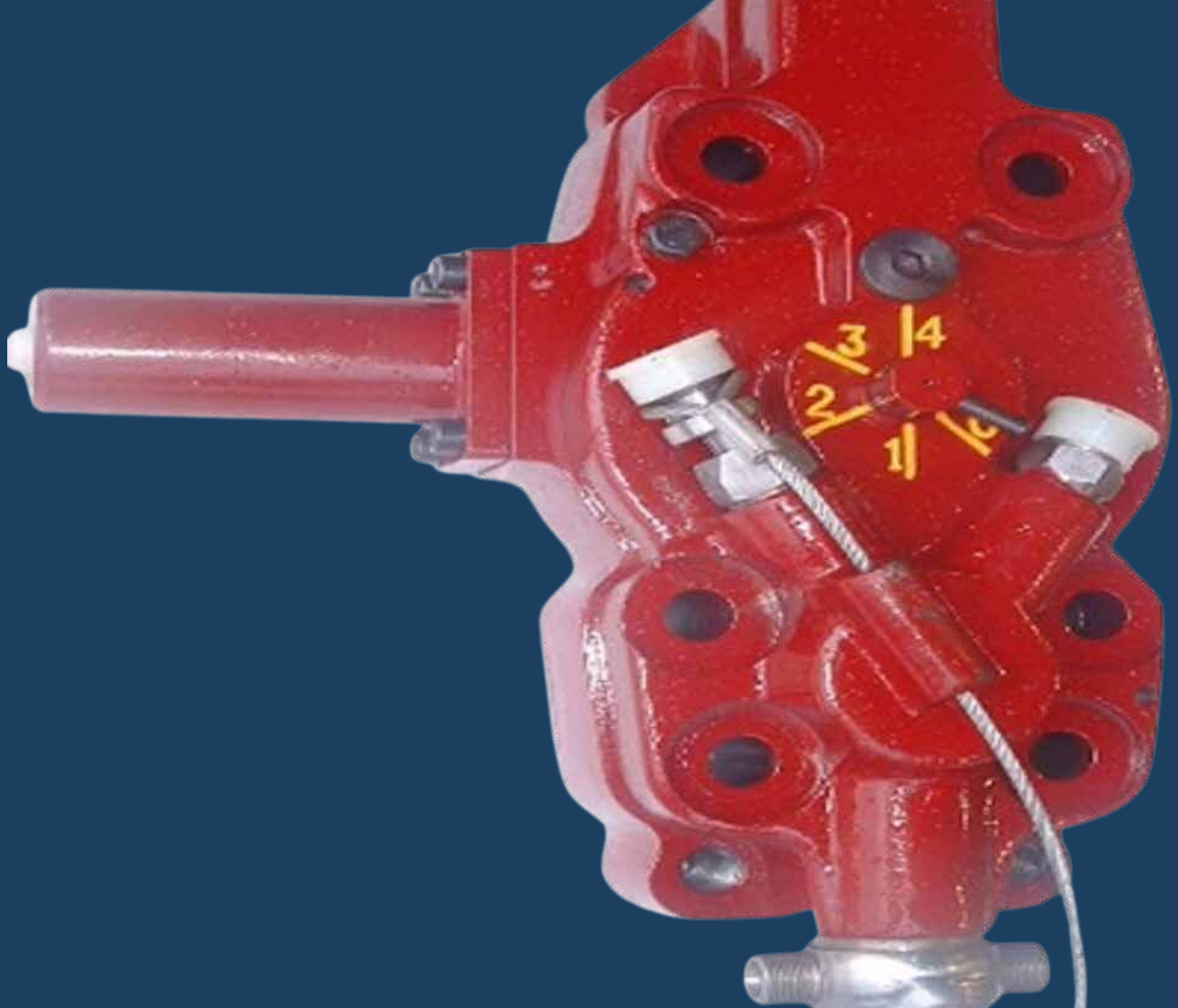
Soil conditions

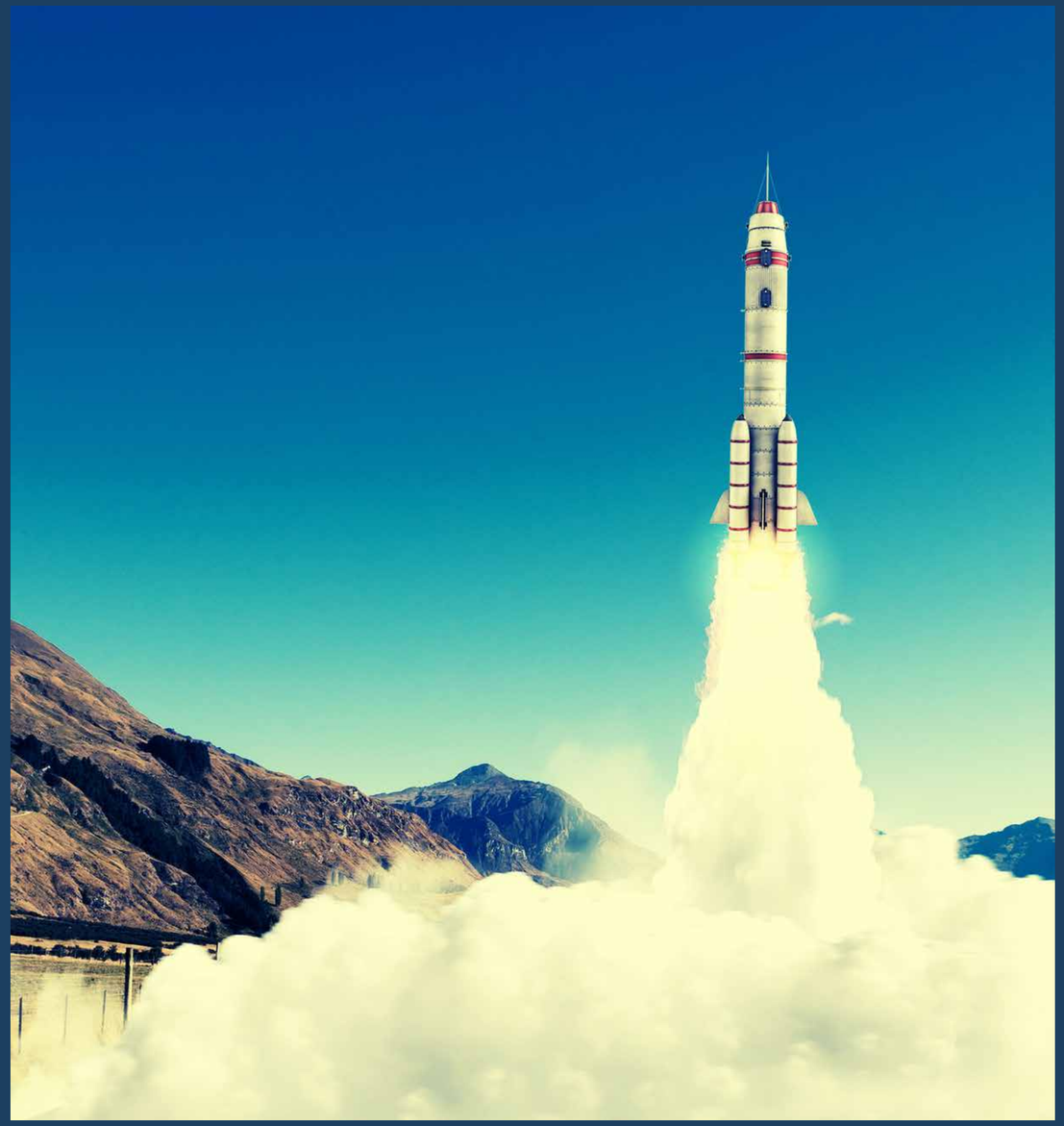
Harder conditions - more bounce

Fuel settings

More fuel - more energy

How is stroke adjusted?





“

If they're running, you should also be running

Hammer gap

Manually stopping the hammer

The hammer will continue to drive until the fuel is no longer available

Ask Tony

What are some situations where you might stop the hammer before you've reached the desired pile resistance?

Ask Tony

What are some considerations for when you resume driving the pile?

Poll Question

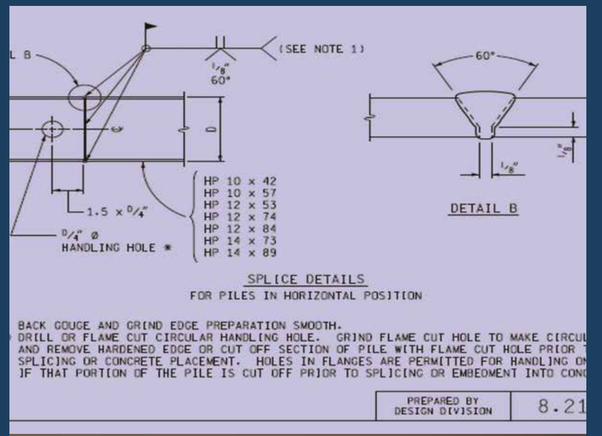
What else can be used to prevent damage to the pile and evenly distribute the hammer energy?

What else can be used to prevent damage to the pile and evenly distribute the hammer energy?

What else can be used to prevent damage to the pile and evenly distribute the hammer energy?

Hammer Cushions

What to bring



Construction documents & Forms

Inspection Tools

PPE

What to bring

Equipment

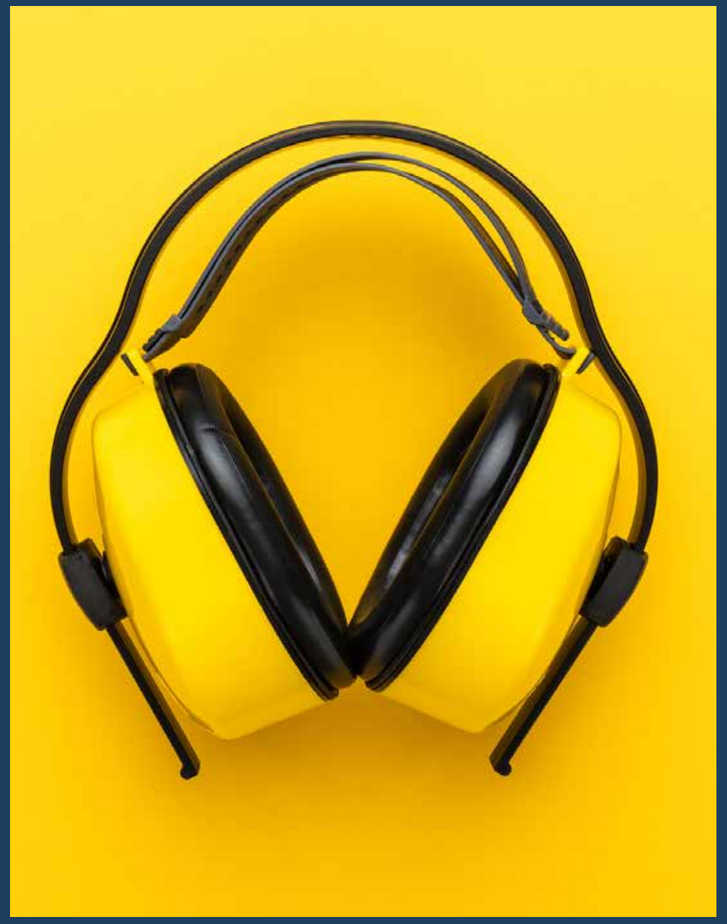
Clipboard for your forms

Forms

Saximeter, stopwatch

Measuring tape, level, plumb bob

Mirror, flashlight



Hearing protection

Pile driving is LOUD. You may need double hearing protection depending on how close you are to the hammer.

Poll Question

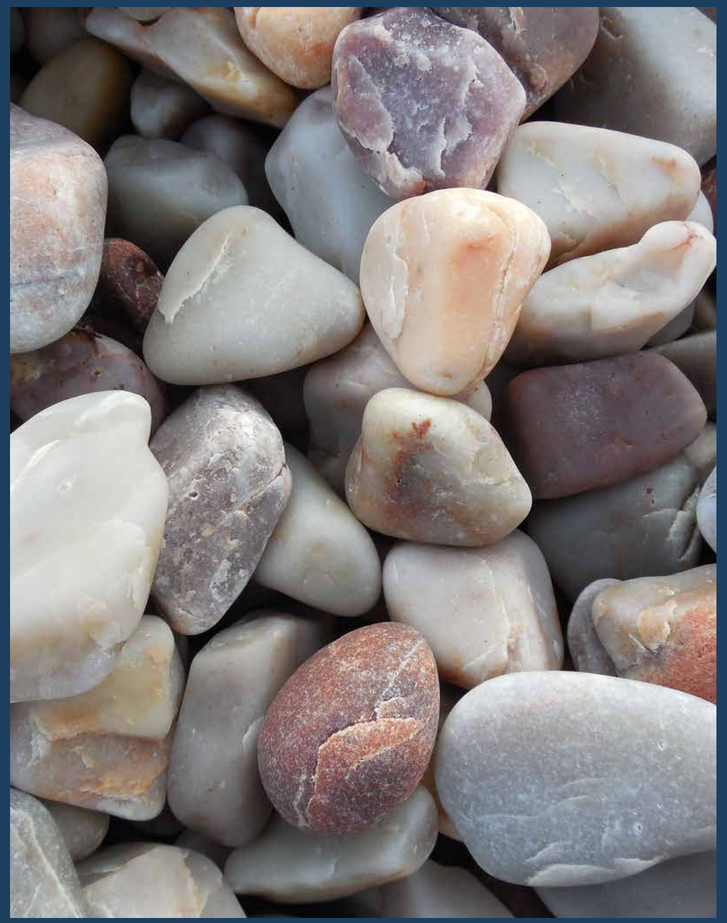
What are some other things to bring with you for pile inspection?

What are some things you should bring with you when you go out to inspect a pile installation?

What are some things you should bring with you when you go out to inspect a pile installation?

Construction Documents & Forms

- Plans
- Specifications
- Reports
- Construction Manual



Geotech Report or Soil Borings

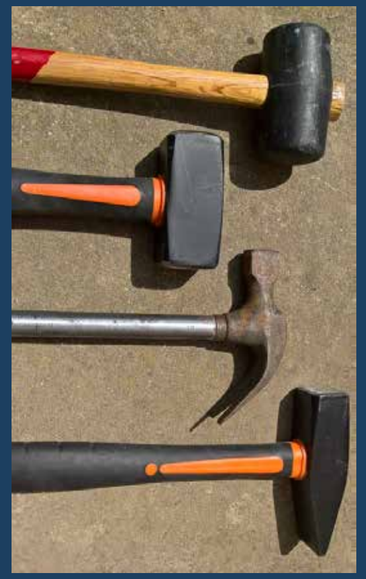
You don't need to be a geologist - but should get a sense of the soil types

Where are your borings?

Ask Tony

What are some common questions you get about the forms?

Measure to confirm length and size



Confirm the hammer on-site matches the approved equipment

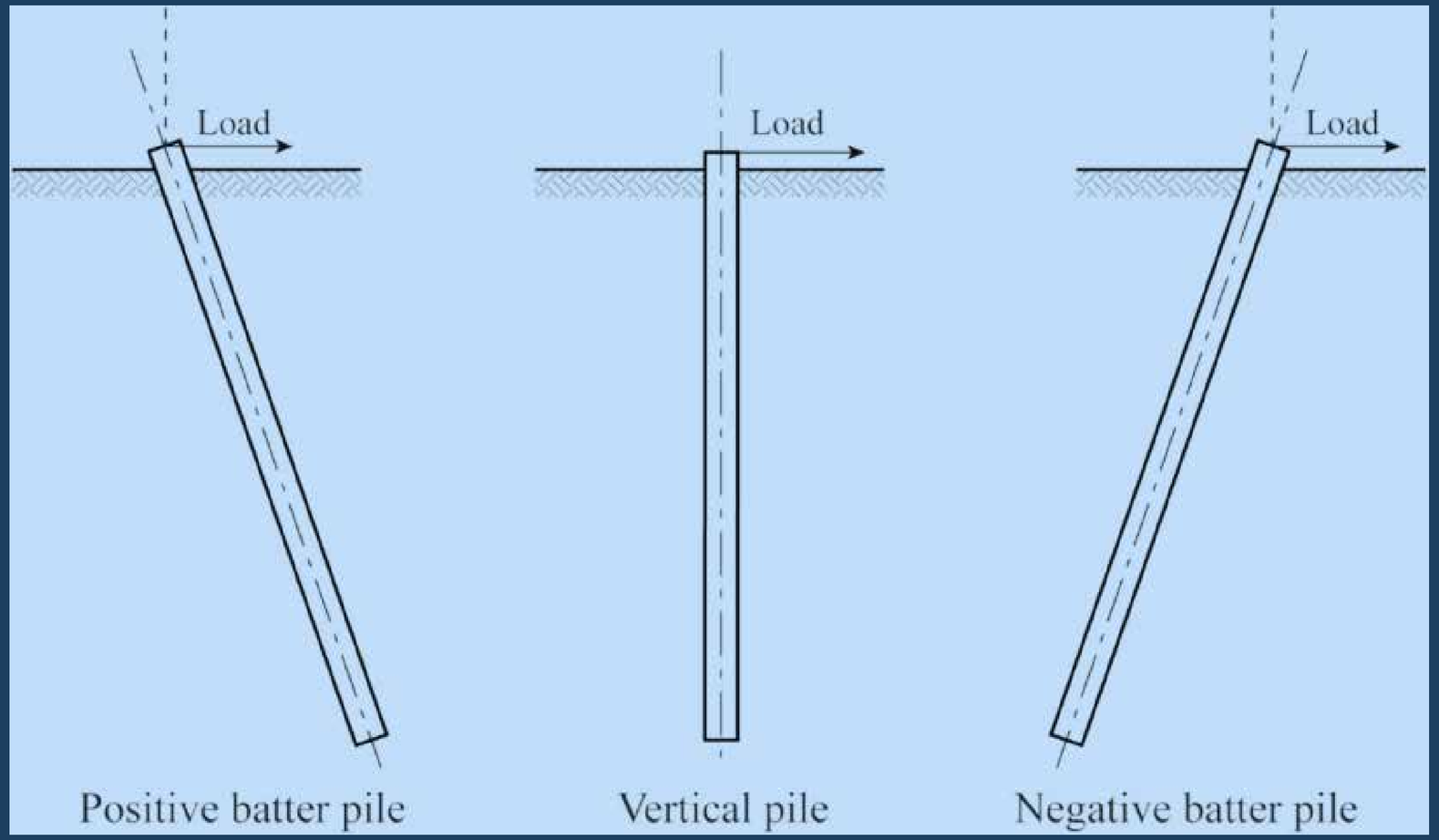
Check for material stamps indicating the steel is as approved

Make sure you understand end of drive criteria

Confirm field locations match the drawings

Battered Piles

Lateral support



Poll Question

How do you measure batter?

Question slide

How do you measure batter?

Results slide

How do you measure batter?

Poll Question

What is a reason that a pile might be rejected?

Question slide

What are some reasons that a pile might be rejected?

What are some reasons that a pile might be rejected?

Pile Location Accuracy

Using a template

Pile Damage

Before driving

Mishandling of piles

During driving

Overdriving piles

After driving

Struck by equipment

Ask Tony

How much deformation is too much deformation?

Other Potential Pile Installation Problems

1. Pile surface is dirty
2. Pile cutoff is incorrect
3. Pile heave
4. Pile splitting (timber)
5. Pile welding

Ask Tony

In your experience what is the most common reason piles are rejected?

Placing Concrete

Concrete may not be placed so that there are cold joints

Poll Question

How close to a freshly poured CIP pile can you drive a new pile?

Question slide

How close to a freshly poured CIP pile can you drive a new pile?

6 inches 0%

10 feet 0%

20 feet 0%

50 feet 0%

100 ft 0%

How close to a freshly poured CIP pile can you drive a new pile?

RESULTS SLIDE

Splicing

Welding CIP or H Piles
*Remember that you cannot splice timber piles

Splicing Piles

Welding considerations

Poll Question

What is the maximum number of splices per pile?

Question slide

What is the maximum number of splices?

1 0%

2 0%

3 0%

4 0%

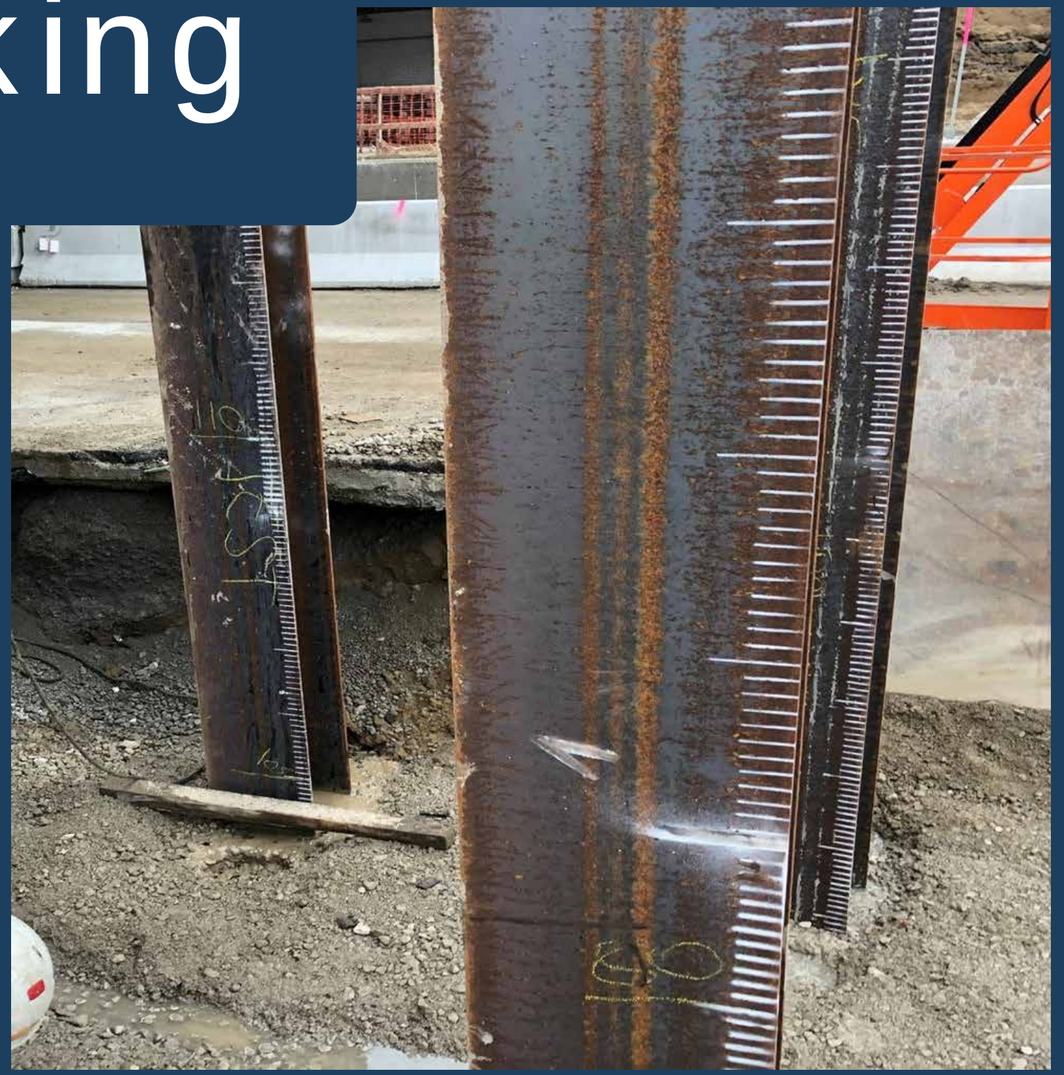
What is the maximum number of splices?

RESULTS SLIDE

Ask Tony

Who inspects pile splice welds?

Pile Marking

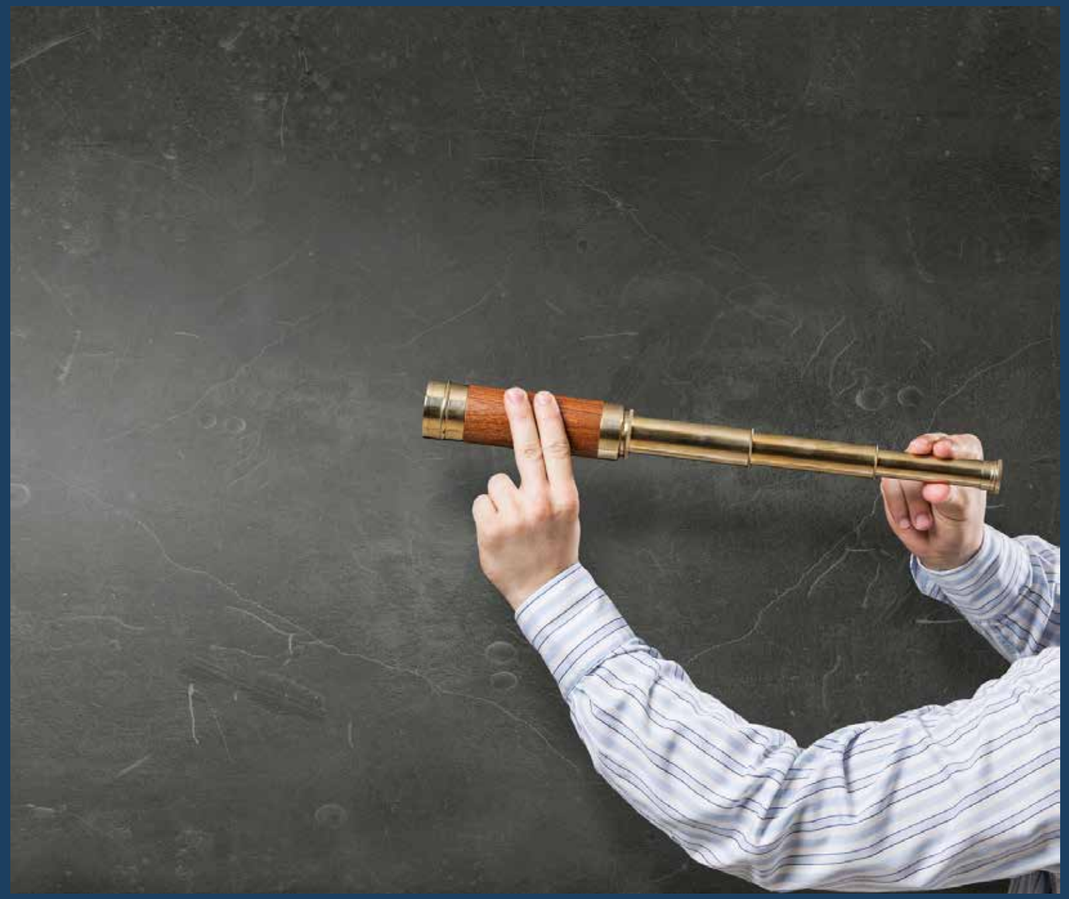


- Piles should be marked with a template for accuracy
- Piles should be marked so that the markings are visible during driving

Pile Marking

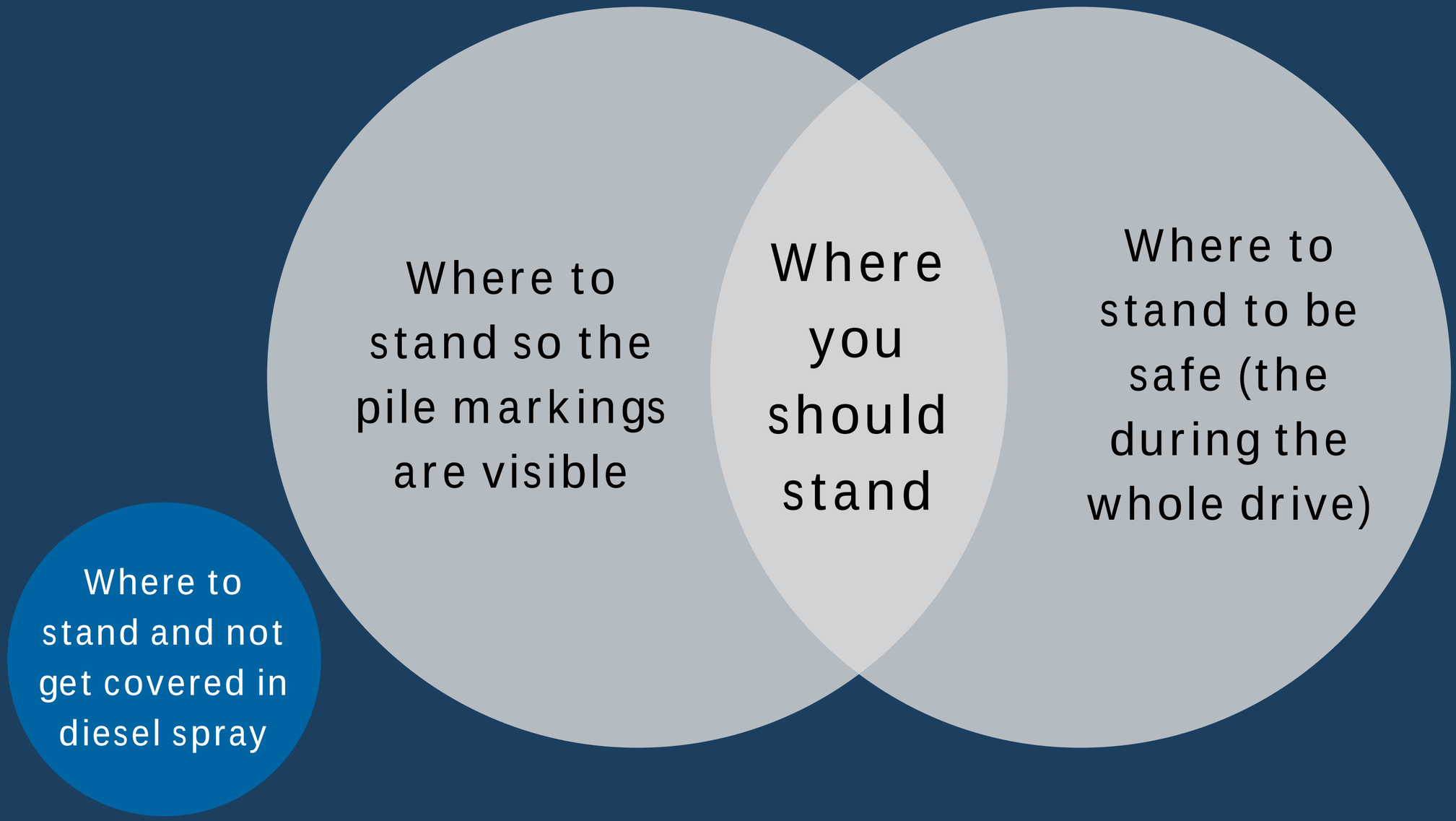
Site Safety

Pay attention to your surroundings!



Where to stand

- Pick a reference point for pile markings
- Try not to stay in the same spot while an individual pile is being driven
  - Especially moving your line of sight up and down


Where to stand so the pile markings are visible
Where you should stand
Where to stand to be safe (the during the whole drive)
Where to stand and not get covered in diesel spray

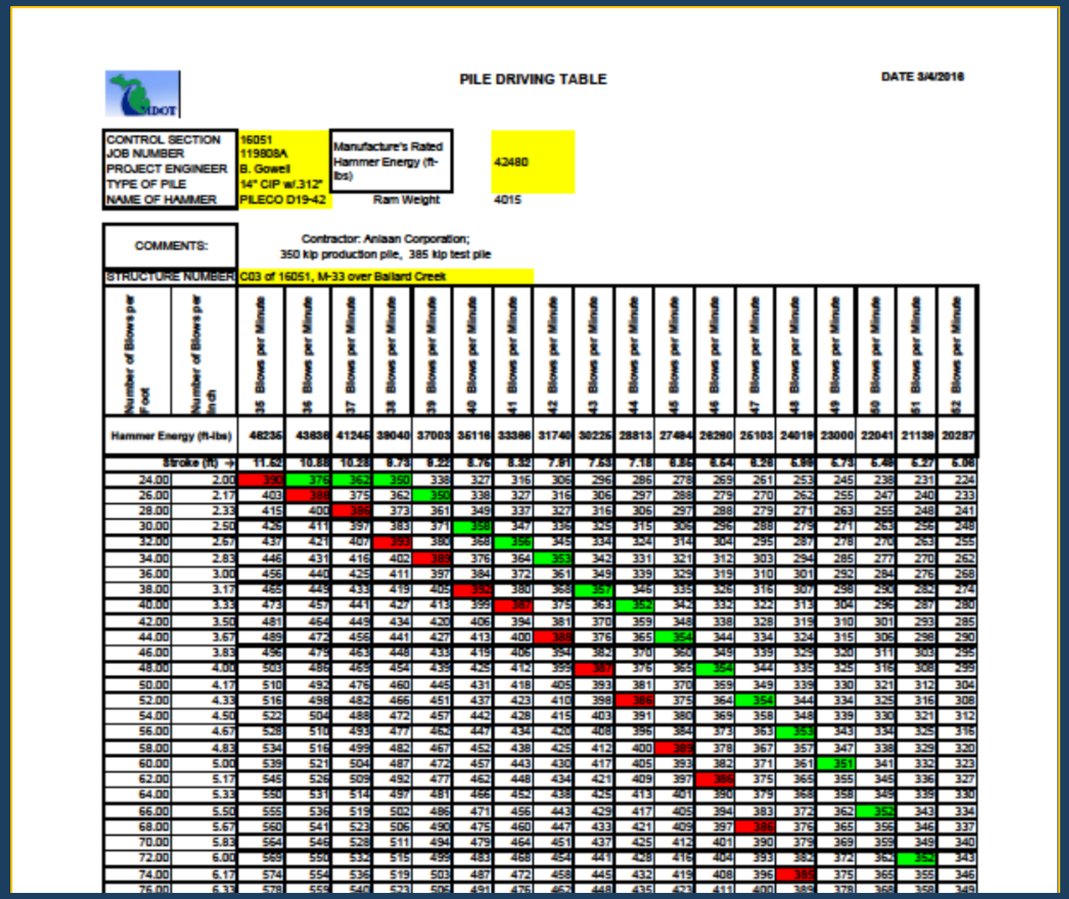
How do we know when we are done driving?

Determining nominal pile resistance

Project Driven Pile Cost	Pile Certification Method	Resistance Factor(φ_{dyn})
<$300,000	FHWA-Modified Gates Formula	0.50
≥$300,000	Dynamic Testing/ Signal Matching (PDA Testing)	0.65 *
>$500,000	Static Load Test with Dynamic Testing/ Signal Matching (PDA Testing)	0.80

Resistance Determination Method

Based on the cost of the pile installation portion of the project



PILE DRIVING TABLE

DATE 3/4/2016

CONTROL SECTION	16051
JOB NUMBER	119808A
PROJECT ENGINEER	B. Gowell
TYPE OF PILE	14" CIP w/.312"
NAME OF HAMMER	PILECO D19-42

Manufacture's Rated Hammer Energy (ft-lbs): 42480

Ram Weight: 4015

COMMENTS: Contractor: Aniaan Corporation; 350 kip production pile, 385 kip test pile

STRUCTURE NUMBER: C03 of 16051, M-33 over Ballard Creek

Number of Blows per Foot	Number of Blows per Inch	35 Blows per Minute	36 Blows per Minute	37 Blows per Minute	38 Blows per Minute	39 Blows per Minute	40 Blows per Minute	41 Blows per Minute	42 Blows per Minute	43 Blows per Minute	44 Blows per Minute	45 Blows per Minute	46 Blows per Minute	47 Blows per Minute	48 Blows per Minute	49 Blows per Minute	50 Blows per Minute	51 Blows per Minute	52 Blows per Minute
Hammer Energy (ft-lbs)		48236	43836	41245	39040	37003	35118	33388	31740	30226	28813	27484	26280	25103	24019	23000	22041	21138	20287
Stroke (ft) →		11.52	10.88	10.28	9.73	9.22	8.76	8.32	7.91	7.53	7.18	6.86	6.54	6.26	6.00	5.75	5.49	5.27	5.06
24.00	2.00	390	376	362	350	338	327	316	306	296	286	278	269	261	253	245	238	231	224
26.00	2.17	403	388	375	362	350	338	327	316	306	297	288	279	270	262	255	247	240	233
28.00	2.33	415	400	386	373	361	349	337	327	316	306	297	288	279	271	263	255	248	241
30.00	2.50	426	411	397	383	371	358	347	336	325	315	306	296	288	279	271	263	256	248
32.00	2.67	437	421	407	393	380	368	356	345	334	324	314	304	295	287	278	270	263	255
34.00	2.83	446	431	416	402	389	376	364	353	342	331	321	312	303	294	285	277	270	262
36.00	3.00	456	440	425	411	397	384	372	361	349	339	329	319	310	301	292	284	276	268
38.00	3.17	465	449	433	419	405	392	380	368	357	346	335	326	316	307	298	290	282	274
40.00	3.33	473	457	441	427	413	399	387	375	363	352	342	332	322	313	304	296	287	280
42.00	3.50	481	464	449	434	420	406	394	381	370	359	348	338	328	319	310	301	293	285
44.00	3.67	489	472	456	441	427	413	400	388	376	365	354	344	334	324	315	306	298	290
46.00	3.83	496	479	463	448	433	419	406	394	382	370	360	349	339	329	320	311	303	295
48.00	4.00	503	486	469	454	439	425	412	399	387	376	365	354	344	335	325	316	308	299
50.00	4.17	510	492	476	460	445	431	418	405	393	381	370	359	349	339	330	321	312	304
52.00	4.33	516	498	482	466	451	437	423	410	398	386	375	364	354	344	334	325	316	308
54.00	4.50	522	504	488	472	457	442	428	415	403	391	380	369	358	348	339	330	321	312
56.00	4.67	528	510	493	477	462	447	434	420	408	396	384	373	363	353	343	334	325	316
58.00	4.83	534	516	499	482	467	452	438	425	412	400	389	378	367	357	347	338	329	320
60.00	5.00	539	521	504	487	472	457	443	430	417	405	393	382	371	361	351	341	332	323
62.00	5.17	545	526	509	492	477	462	448	434	421	409	397	386	375	365	355	345	336	327
64.00	5.33	550	531	514	497	481	466	452	438	425	413	401	390	379	368	358	348	339	330
66.00	5.50	555	536	519	502	486	471	456	443	429	417	405	394	383	372	362	352	343	334
68.00	5.67	560	541	523	506	490	475	460	447	433	421	409	397	386	376	365	356	346	337
70.00	5.83	564	546	528	511	494	479	464	451	437	425	412	401	390	379	369	359	349	340
72.00	6.00	569	550	532	515	499	483	468	454	441	428	416	404	393	382	372	362	352	343
74.00	6.17	574	554	536	519	503	487	472	458	445	432	419	408	396	385	375	365	355	346
76.00	6.33	578	558	540	523	507	491	475	462	448	435	423	411	400	389	378	368	358	349

Pile Driving Chart

Interpreting the pile driving chart

Interpreting a Pile Chart

Let's look at one in depth

PILE DRIVING TABLE

DATE 3/4/2016

CONTROL SECTION	16051	Manufacture's Rated Hammer Energy (ft-lbs)	42480	
JOB NUMBER	119808A			
PROJECT ENGINEER	B. Gowell			
TYPE OF PILE	14" CIP w/.312"			
NAME OF HAMMER	PILECO D19-42	Ram Weight	4015	

COMMENTS: Contractor: Anlaan Corporation; 350 kip production pile, 385 kip test pile

STRUCTURE NUMBER: C03 of 16051, M-33 over Ballard Creek

Number of Blows per Foot	Number of Blows per Inch	35 Blows per Minute	36 Blows per Minute	37 Blows per Minute	38 Blows per Minute	39 Blows per Minute	40 Blows per Minute	41 Blows per Minute	42 Blows per Minute	43 Blows per Minute	44 Blows per Minute	45 Blows per Minute	46 Blows per Minute	47 Blows per Minute	48 Blows per Minute	49 Blows per Minute	50 Blows per Minute	51 Blows per Minute	52 Blows per Minute
Hammer Energy (ft-lbs)		46236	43836	41246	39040	37003	36116	33388	31740	30225	28813	27484	26280	26103	24019	23000	22041	21138	20287
Stroke (ft) →		11.62	10.88	10.28	9.73	9.22	8.76	8.32	7.91	7.53	7.18	6.86	6.64	6.26	6.98	6.73	6.48	6.27	6.08
24.00	2.00	390	376	362	350	338	327	316	306	296	286	278	269	261	253	245	238	231	224
26.00	2.17	403	388	375	362	350	338	327	316	306	297	288	279	270	262	255	247	240	233
28.00	2.33	415	400	386	373	361	349	337	327	316	306	297	288	279	271	263	255	248	241
30.00	2.50	426	411	397	383	371	358	347	336	325	315	306	296	288	279	271	263	256	248
32.00	2.67	437	421	407	393	380	368	356	345	334	324	314	304	295	287	278	270	263	255
34.00	2.83	446	431	416	402	389	376	364	353	342	331	321	312	303	294	285	277	270	262
36.00	3.00	456	440	425	411	397	384	372	361	349	339	329	319	310	301	292	284	276	268
38.00	3.17	465	449	433	419	405	392	380	368	357	346	335	326	316	307	298	290	282	274
40.00	3.33	473	457	441	427	413	399	387	375	363	352	342	332	322	313	304	296	287	280
42.00	3.50	481	464	449	434	420	406	394	381	370	359	348	338	328	319	310	301	293	285
44.00	3.67	489	472	456	441	427	413	400	388	376	365	354	344	334	324	315	306	298	290
46.00	3.83	496	479	463	448	433	419	406	394	382	370	360	349	339	329	320	311	303	295
48.00	4.00	503	486	469	454	439	425	412	399	387	376	365	354	344	335	325	316	308	299
50.00	4.17	510	492	476	460	445	431	418	405	393	381	370	359	349	339	330	321	312	304
52.00	4.33	516	498	482	466	451	437	423	410	398	386	375	364	354	344	334	325	316	308
54.00	4.50	522	504	488	472	457	442	428	415	403	391	380	369	358	348	339	330	321	312
56.00	4.67	528	510	493	477	462	447	434	420	408	396	384	373	363	353	343	334	325	316
58.00	4.83	534	516	499	482	467	452	438	425	412	400	389	378	367	357	347	338	329	320
60.00	5.00	539	521	504	487	472	457	443	430	417	405	393	382	371	361	351	341	332	323
62.00	5.17	545	526	509	492	477	462	448	434	421	409	397	386	375	365	355	345	336	327
64.00	5.33	550	531	514	497	481	466	452	438	425	413	401	390	379	368	358	348	339	330
66.00	5.50	555	536	519	502	486	471	456	443	429	417	405	394	383	372	362	352	343	334
68.00	5.67	560	541	523	506	490	475	460	447	433	421	409	397	386	376	365	356	346	337
70.00	5.83	564	546	528	511	494	479	464	451	437	425	412	401	390	379	369	359	349	340
72.00	6.00	569	550	532	515	499	483	468	454	441	428	416	404	393	382	372	362	352	343
74.00	6.17	574	554	536	519	503	487	472	458	445	432	419	408	396	385	375	365	355	346
76.00	6.33	578	559	540	523	506	491	476	462	448	435	423	411	400	389	378	368	358	349
78.00	6.50	582	563	544	527	510	495	480	465	452	439	426	414	403	392	381	371	361	352
80.00	6.67	586	567	548	531	514	498	483	469	455	442	429	417	406	395	384	374	364	355
82.00	6.83	590	571	552	534	518	502	486	472	458	445	432	420	409	398	387	377	367	357
84.00	7.00	594	574	556	538	521	505	490	475	461	448	435	423	412	400	390	379	369	360
86.00	7.17	598	578	559	542	525	508	493	478	464	451	438	426	414	403	392	382	372	362
88.00	7.33	602	582	563	545	528	512	496	482	468	454	441	429	417	406	395	385	375	365
90.00	7.50	606	585	566	548	531	515	499	485	470	457	444	432	420	409	398	387	377	367
92.00	7.67	609	589	570	552	534	518	502	488	473	460	447	434	423	411	400	390	380	370
94.00	7.83	613	592	573	555	538	521	505	490	476	463	450	437	425	414	403	392	382	372
96.00	8.00	616	596	576	558	541	524	508	493	479	465	452	440	428	416	405	394	384	374
98.00	8.17	619	599	580	561	544	527	511	496	482	468	455	442	430	419	407	397	386	377
100.00	8.33	623	602	583	564	547	530	514	499	484	471	457	445	433	421	410	399	389	379
102.00	8.50	626	605	586	567	550	533	517	502	487	473	460	447	435	423	412	401	391	381
104.00	8.67	629	608	589	570	552	535	519	504	490	476	462	450	437	426	414	403	393	383
106.00	8.83	632	611	592	573	555	538	522	507	492	478	465	452	440	428	417	406	395	385
108.00	9.00	635	614	595	576	558	541	525	509	495	481	467	454	442	430	419	408	397	387
110.00	9.17	638	617	597	578	561	543	527	512	497	483	469	456	444	432	421	410	399	389
112.00	9.33	641	620	600	581	563	546	530	514	499	485	472	459	446	434	423	412	401	391

Poll Question

Pile Chart Interpretation

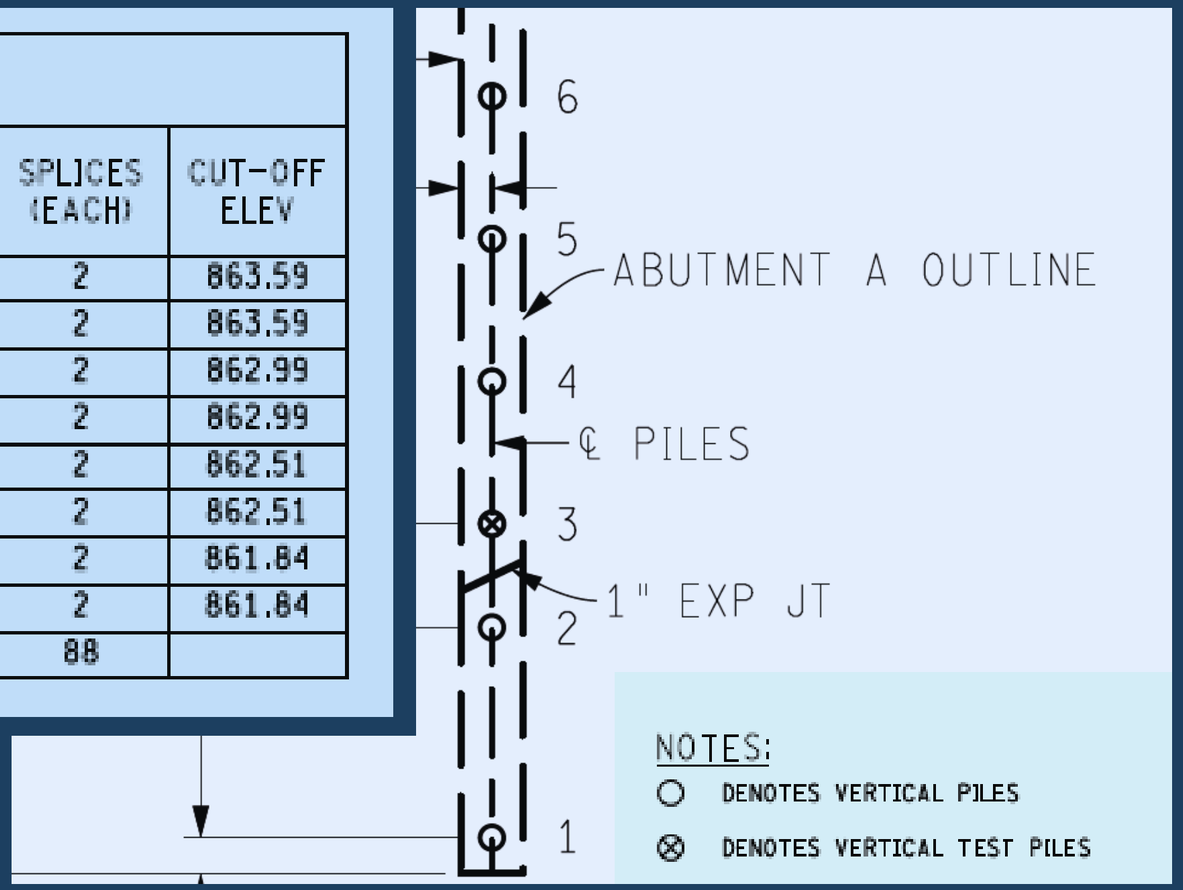
Only valid if nothing changes

If anything changes, contact MDOT Geotechnical Services

Pile Driving Analyzer (PDA)

Specialized Contractor

500 KIPS 16"ø C.I.P PILES							
LOCATION	PILE TYPE	NUMBER OF PILES	ESTIMATED LENGTH FURNISHED & DRIVEN		PILE POINTS (EACH)	SPLICES (EACH)	CUT-OFF ELEV
			EACH LFT	TOTAL LFT			
ABUT A	TEST	1	115	115	1	2	863.59
	VERTICAL	10	105	1050	10	2	863.59
ABUT B	TEST	1	115	115	1	2	862.99
	VERTICAL	10	105	1050	10	2	862.99
ABUT C	TEST	1	110	111	1	2	862.51
	VERTICAL	10	100	1000	10	2	862.51
ABUT D	TEST	1	115	115	1	2	861.84
	VERTICAL	10	105	1050	10	2	861.84
TOTAL		44		4605	44	88	



Test Pile

May or may not be a production pile

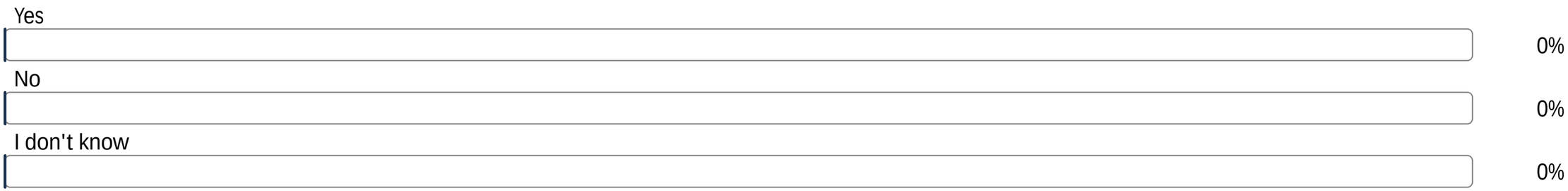
Static Load Test

Least common method

Poll Question

Have you seen a static load test?

Have you seen a static load test?



Have you seen a static load test?

Yes ##.##%

No ##.##%

I don't know ##.##%

RESULTS SLIDE

Poll Question

Have you used a saximeter before?

Question slide

Have you ever used a saximeter?

Yes 0%

No 0%

Have you ever used a saximeter?

RESULTS SLIDE

Saximeter

Output

BREVORTB - Notepad

File Edit Format View Help

```
 20.00    44   7.0     28.0
 21.00    52   6.3     25.5
 22.00     2   6.3     25.2
STOP:13:18
Total Bcnt: 501


PN B18
LE  50.00ft
DT 2019-09-16, 11:55/12:09
PJ 119052A
OW PILE_DYNAMICS
HN I19
HW   4.02kips
START:11:55
   PEN    BN     H      PE
    ft          ft    kip-ft
   8.00
   9.00    28   5.9     23.8
  10.00    32   5.8     23.5
  11.00    42   5.9     23.9
  12.00    41   6.4     25.6
  13.00    46   6.5     26.3
  14.00    49   6.6     26.5
  15.00    51   6.6     26.6
  16.00    70   6.2     25.0
  17.00    73   6.3     25.2
  18.00    72   6.3     25.3
  19.00    72   6.3     25.2
  19.92    64   6.2     24.9
STOP:12:09
Total Bcnt: 640
```

What is a saximeter?

Records blow count and hammer energy

How does it do that?

You input hammer & pile information

Saximeter listens for blows

You input each foot of penetration

Saximeter calculates hammer energy

Saximeter

Inputs

Ask Tony

How do I get a saximeter for my project?

INSTRUCTIONS FOR USING A SAXIMETER

I'm not going to remember this...

Joe Fox (MDOT Geotech Services) has you covered!

Troubleshooting a Saximeter

Manual mode

Should automatically register each blow, if not it's in Manual mode

Cold temps

The screen is liquid crystal and can get sluggish in the cold

Microphone sensitivity

Too loud - double counted blows
Too quiet - missing blows

Foundation Pile Installation

Layout

Are the piles in the correct locations? And correct orientations? And the correct batter?

Elevation

Is there a minimum tip elevation? Is there a maximum tip elevation?

Cutoff Elevation

Check plans for requirements

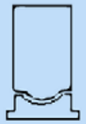
1956 (02/20)

LRFD PILE AND DRIVING EQUIPMENT DATA

Clear Form

DISTRIBUTION: ORIGINAL – Project/Resident/Delivery Engineer Files,
COPIES – Bureau of Bridges and Structures - Geotechnical Services Section, Bridge Construction

CONTROL SECTION	PROJECT NO.	DATE
STRUCTURE NO.	STRUCTURE LOCATION	
PRIME CONTRACTOR		
PILING CONTRACTOR		
ENGINEER	INSPECTOR	

HAMMER COMPONENTS	Ram  Anvil	**Hammer**	Manufacturer: _____ Model: _____ Type: _____ Serial No: _____ Manufacturer's Maximum Rated Energy: _____(ft-lbs) Stroke at Maximum Rated Energy: _____(ft) Blow Count at Maximum Rated Energy: _____(blows/min) Range in Operating Energy: _____ to _____(ft-lb) Range in Operating Stroke: _____ to _____(ft) Modifications: _____
		Ram	Ram Weight: _____ (lbs) Ram Length: _____ (ft) (for diesel hammers)
		Anvil	Anvil Cross Sectional Area: _____(in^2) (With diesel hammers) Anvil Weight: _____(lbs)
		**Hammer Cushion**	Material # 1 / Material # 2 Name: _____ _____ Area (in^2): _____ _____ No. of Plates: _____ _____ Thickness: (in): _____ _____ Mod. of Elasticity - E: (psi) _____ _____ Stiffness: (kips/in) (Area*E)/(Thickness) _____ _____ Coefficient of Restitution - e: _____ _____
		**Drive Head**	Helmet(Drive head) + Adapter (Pile Insert) Weight: _____(lbs) + _____ (lbs) = _____(lbs)
		**Pile Cushion (Only for Timber Piles)**	Material: _____ Area: _____ (in^2) No. of Sheets: _____ Thickness/Sheet: _____ (in) Total Thickness of Pile Cushion: _____ (in) Mod. of Elasticity - E: _____ (psi) Coefficient of Restitution - e: _____
PILE		**Pile**	Diameter: _____ (in) Wall Thickness: _____ (in) Taper (if any): _____ Ordered Length: _____(ft) Required Nominal Pile Driving Resistance (Rndr)_____ (kips) Description of Splice: _____ Tip Treatment/Pile Points/Plate Description: _____

Submit Data Sheet for Each Proposed Hammer and Unique Driving Condition.

Forms

Pile Record Forms

1157L - Test Pile Record

1161L Foundation Piling Record

1956L Pile and Driving Equipment Data

Document Cam

Pay Items Paid Per Foot

1. CIP (furnished and driven)
2. Steel (furnished and driven)
3. Treated timber (furnished)
4. Treated timber (driven)
5. Preboring

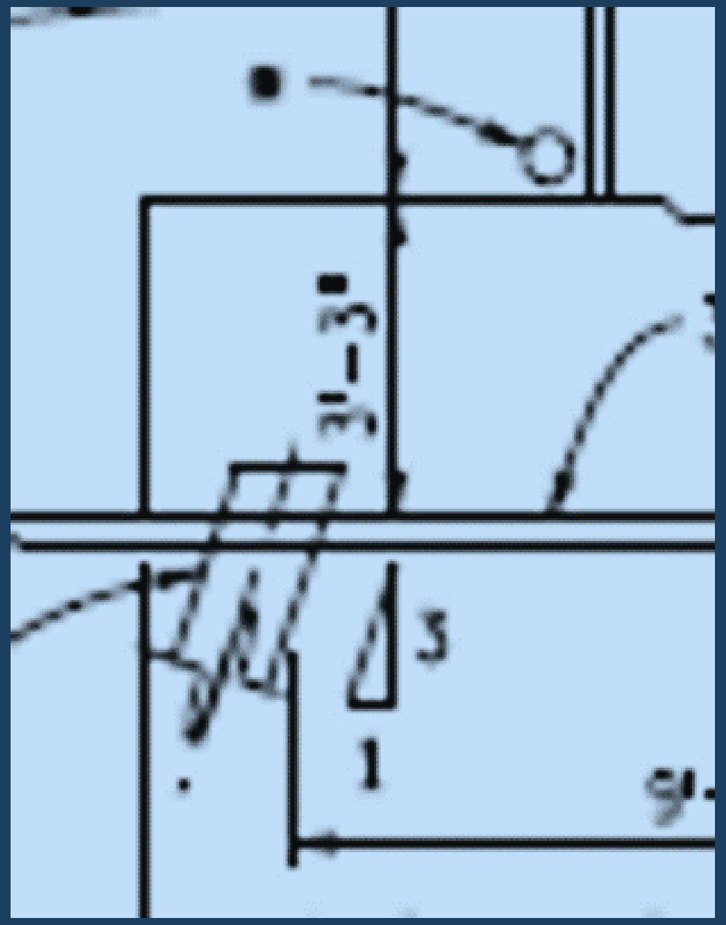
Other Pay Items

- 01 Pile Driving Equipment (lump sum)
- 02 Test piles (any material - paid as each)
- 03 Pile points (CIP or Steel - paid as each)
- 04 Test pile (furnished equipment for dynamic analysis - paid as each)
- 05 Test pile (dynamic analysis - paid as each)

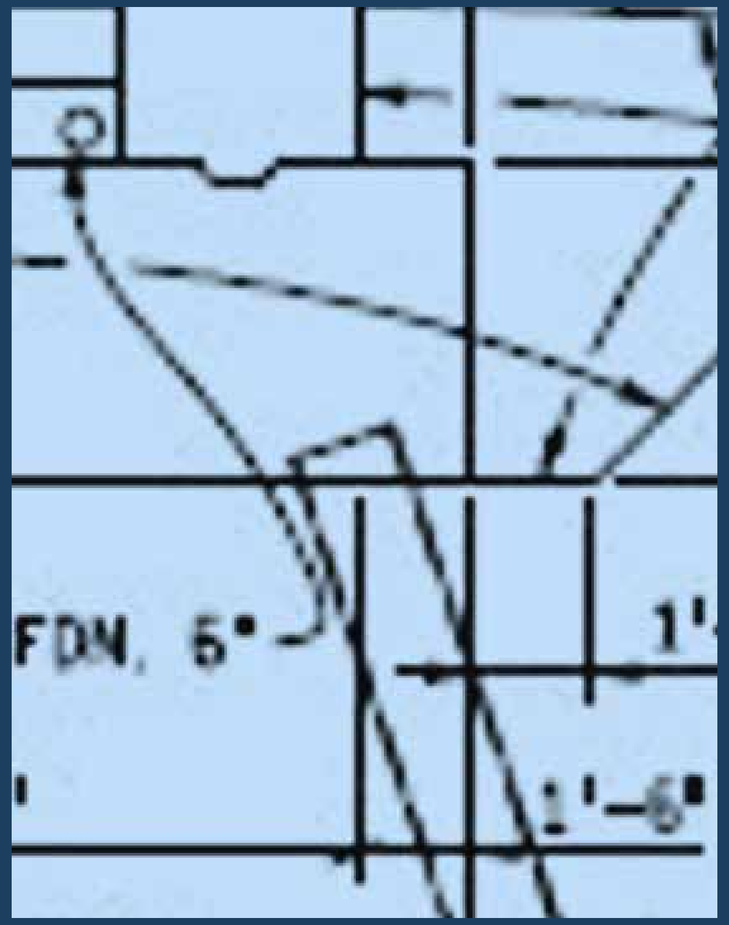
Cutoff Elevation

Do not pay for piling cutoff from previous sections or for the length of the pile tips

Change to cutoff elevation



2020 Specification

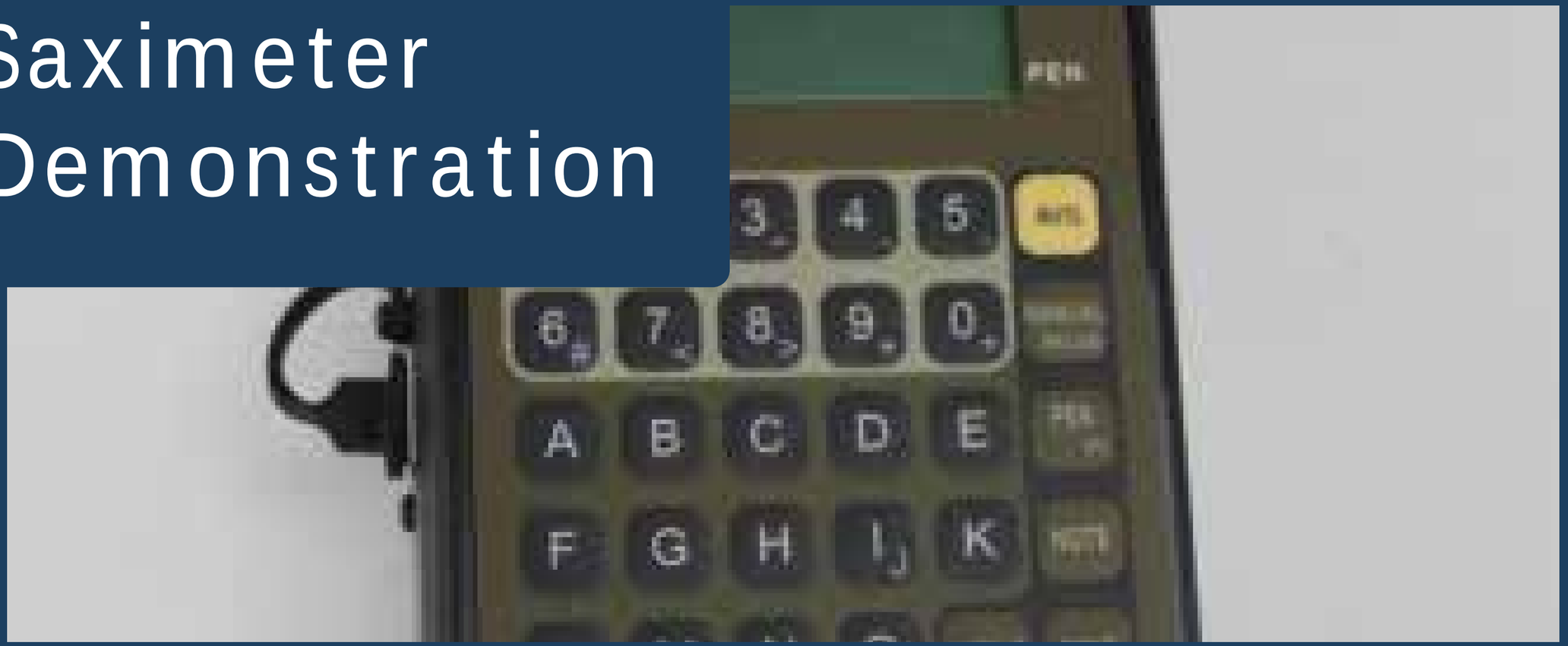


2012 Specification

Tremie Pour

Putting it all together

Saximeter Demonstration



Pile Driving Example

Thank you!

ctt@mtu.edu