

Lesson 8 – Piles Bearing & Acceptance Transcript

Welcome to the Pile Driving Inspector Course. This is Lesson 8 – Piles Bearing & Acceptance. To begin, select the start button or press Shift+N on your keyboard.

The learning outcomes you will achieve during this lesson:

- Identify the 4 alternative methods and specs to accept piles
- Identify Bearing requirements
- Identify when to stop driving and Accept the pile
- Identify when to stop driving and contact the Project Administrator
- Identify when to stop driving and request a Set- Check

Here are the four methods acceptable to the Department to accept piles:

- Standard Test Pile and Driving Criteria
- 100% Instrumented Piles with Test Piles
- 100% Instrumented Piles without Test Piles
- Driving Criteria without Test Piles

We will cover in detail the first method which is the more frequently used. After we understand the principles behind this method will be easy to understand the other three methods.

Standard Test Pile and Driving Criteria: It's how our Standards Specifications have been written so far. In this method, Test Piles are driven first and monitored. Information obtained during the Dynamic Load Testing and is used to determine production pile lengths and driving criteria. The driving criteria includes a blow count criteria which is a minimum combination of stroke and blows per foot that the piles must meet to accept them. Piles will be accepted when at least 24" of consecutive driving achieves a blow count (generally increasing) that meets or exceeds the blow count criteria and the minimum penetration/minimum tip elevation requirements are met.

100% Instrumented Piles with Test Piles: This method is covered in a developmental specification and may be used with Department's approval. Designers might desire to use this method as the required nominal bearing capacity would be less. In this method:

- All Piles, test piles and production piles are dynamically tested and monitored. This can be done with a PDA.
- Test Piles are driven first to determine production pile lengths.
- No Driving Criteria is required. Capacity is read directly from the instrumentation.
- The PDA/EDC operator will stop the driving at 6" of capacity if the minimum penetration/minimum tip elevation requirements are met.

100% Instrumented Piles without Test Piles: This method is covered in a developmental specification and may be used with Department's approval. Designers might desire to use this method as the required nominal bearing capacity would be less. This option has certain risk since there is no test piles.

However, designers would increase the production lengths to minimize the risk of splicing. In this method:

- No Test Piles. All production pile lengths are already indicated in the plans.
- All production piles are dynamically tested and monitored with PDA or EDC systems.
- No Production lengths letter is required. No Driving Criteria is required. Capacity is read from the instrumentation.
- The PDA/EDC operator will stop the driving at 6" of capacity if the minimum penetration/minimum tip elevation requirements are met.

Driving Criteria without test piles. In this method:

- No Test Piles. All production pile lengths are already indicated in the plans.
- The first production pile of every bent or pier is monitored to establish driving criteria.

- Piles will be accepted when at least 24" consecutive driving achieves a blow count (generally increasing) that meets or exceeds the blow count criteria and the minimum penetration/minimum tip elevation requirements are met.

Let's review the spec regarding stopping the driving for acceptance: The Engineer may accept a driven pile when the pile has achieved minimum penetration, the blow count is generally increasing and the minimum required bearing capacity obtained for 24 inches of consecutive driving. At his discretion, the Engineer may also accept a driven pile when the minimum penetration is achieved and driving has reached practical refusal in firm material.

An increasing blow count should not be a result of a change in fuel settings. On the other hand the blow count may drop with an increase in stroke height (OED hammers). Though the blow count is decreasing, with an increased stroke height, we are putting more energy into the pile, so not necessarily a drop in blow count means a drop in capacity. Prior to starting the Project, the Inspector should ask the PA how they want a decrease in blow counts, with an increased stroke height, handled. Because an increased stroke height equates to more energy being imparted to the pile, less blows are required, as you will see in Driving Criteria Letters for Blow Count Vs Stroke Height criteria.

Let's review the spec regarding blow count acceptance: The Engineer will determine the number of blows required to provide the required bearing according to the methods described herein. Determine the pile bearing by computing the penetration per blow with less than 1/4 inch rebound averaged through 12 inches each of penetration. When it is considered necessary by the Engineer, determine the average penetration per blow by averaging the penetration per blow through the last 10 to 20 blows of the hammer. Basically if the piles start exhibiting high rebound the blow count is not valid. You should contact the PA for further direction when rebound happens. The Geotechnical Engineer will get involved in addressing this issue.

Let's Review the practical refusal specification. Practical refusal is defined as 20 blows per inch with the hammer operating at the highest setting or setting determined by the Engineer and less than 1/4 inch rebound per blow. Stop driving as soon as the Engineer determines that the pile has reached practical refusal. The Engineer will generally make this determination within 2 inches of driving. When the required pile penetration cannot be achieved by driving without exceeding practical refusal, use other penetration aids such as jetting or Preformed Pile Hole. Please note that nowhere here says that refusal is 240 blows per foot.

Now, let's cover set-checks and re-drives. Both are restrikes after a certain time of the initial drive. During test piles, restrikes are done to evaluate the variation of capacity with time. Soils may experience capacity increase, in which case it is called freeze. In few areas we also have seen piles decrease capacity with time, in which case we call it relaxation. In production piles when we are running out of pile without getting capacity we will stop and give the pile an opportunity to achieve capacity with time.

In the specs, the difference between set-check and re-drive is the time after initial drive we wait before restriking the pile. As we saw when we studied the pay items, a restrike within one working day after the initial drive is considered a set-check. The Department may require without additional pay up to two set-checks. More set-checks even if done within the one working day after the initial drive will require extra pay. A restrike beyond the working day following the initial drive is a re-drive and it is always paid. Here is what the specs says about set-checks:

Set-checks: In the event that the Contractor has driven the pile to approximately 12 inches above cut-off without reaching the required resistance, the Engineer may require the Contractor to interrupt driving to perform a set-check. Provide an engineer's level or other suitable equipment for elevation determinations to determine accurate pile penetration during the set-checks. There will be no separate payment for an initial set-check. In the event the result of an initial set-check is not satisfactory, the Engineer may direct additional set-checks. The Engineer may accept the pile as driven when a set-check shows that the Contractor has achieved the minimum required pile bearing and has met all other requirements of this Section.

Now, let's review the set-check in the specs: Pile Redrive: Pile redrive consists of redriving the pile after the following working day from initial driving to determine time effects, to reestablish pile capacity due to pile heave, or for other reasons determined by the Engineer. Redrive piles as directed by the Engineer.

Perhaps the most important duty that the Inspector performs is determining when to Stop Driving. This decision can be made to do a set-check, or practical refusal has been encountered or to accept the pile, to name a few.

The Driving Criteria Letter (Covered in detail in Lesson 5) generally provides all of the guidance needed for determining when to accept a pile. The inspector needs to consider the following factors before stopping the pile:

- Driving Criteria Letter
- Minimum Tip Elevation
- Penetration Requirements
- Practical Refusal
- Cutoff Elevation

Here is an excerpt from a driving criteria letter. Note that it says the piles may be stopped if one of the following:

1. When a practical refusal has been met. It will also include of a definition for refusal...
2. A blow count vs. stroke is met or exceeded for at least two feet (24 inches).

In either of the previous two scenarios the minimum tip elevation must be met. However, if you achieve practical refusal before reaching the minimum tip elevation, you must ask the contractor stop pile driving immediately. Piles cannot be driven beyond practical refusal in an attempt to meet minimum tip. Otherwise piles may be damaged. In this circumstance please contact your PA for directions.

Inspectors need to be aware of the following:

- Avoid potentially driving pile past the cutoff elevation. The main idea is to avoid as much as possible splicing a pile.
- If piles are in a situation where the soil is weaker than expected and we are not getting the capacity, we want to have the opportunity to perform Set-Check or a re-drive, or both, before giving up and decide to build a splice.
- Our decision can have financial ramifications. Remember in Lesson 4 how much the costs increased when we needed to perform set-checks, redrives and specially splices.

Here is a flow chart that shows how our mental process should be when we think about stopping or accepting a pile. We will cover decisions in detail in the upcoming slides.

Look at the first question in the Acceptance chart - Is there a Minimum Tip Elevation specified? In this case, for end bents 1 and 4, from the Driving Criteria Letter, we can see there is a Minimum Tip elevation specified, - 32.0 ft. So the answer is YES.

Now in this case, for the intermediate bents, from the Driving Criteria Letter, there is no minimum Tip elevation specified. So the answer is NO. A warning note though. You need to check the Foundation Layout plans and particularly the Pile Data table. The engineer who writes the driving criteria letter will extract this information from the Pile data table anyway. However, very often the driving criteria letter does not include a minimum tip elevation. But this does not necessarily mean there isn't one. So please check with the plans.

If there is a minimum tip specified you would go to the next question. Have you reached the minimum tip?

To answer this, you need to know what the tip of the pile is at the moment you are making the decision.

Remember you can determine the tip of the pile by a simple calculation, which is: Reference Elevation minus the Length of Pile below the Reference Elevation.

If there was no minimum tip elevation required, then the minimum penetration of the specs control. Again, you would have to check at what elevation is the tip of the pile now. This can be done with the same calculation: Reference Elevation minus the Length of Pile below the Reference Elevation.

Depending upon the answer to the two previous questions, these two must be addressed. If Min. Tip elevation was met, has the Driving Criteria been met for 2 consecutive feet? The Inspector would review drive log for determination. If you answered No previously, has Practical Refusal been encountered? Should the Contractor choose to continue the driving of the pile after achieving the specified criteria and being accepted by you, he would do so at their own risk.

Should the answer to the Practical Refusal question be No and the answer to having met the criteria be NO, then we would ask: is the pile within 1 foot of the Cutoff elevation? We don't want to drive the pile beyond cutoff if not necessary. That commits the State to paying additional funds for splicing, etc. Because a set-check performed within a working day after initial drive is free, we want to take advantage of it, especially if we are close to the criteria. Contact the Project Administrator. The Geotechnical Engineer may even decide to instrument the set-check with PDA (or EDC if gauges are available).

We will now work out four examples. We will decide at every of the four scenarios what to do next. We will work through the Acceptance Determination Chart based upon given information. The first Driving Criteria Letter is to be used for Situations 1-3. The second Driving Criteria Letter is to be used for Situation 4.

Let's work this exercise. Here is the driving criteria letter. Is there a minimum tip specified? What is it? The letter indicates a minimum tip elevation of -32.0 ft. Let's see where we are in our flow chart process.

Here is the pile driving information. The minimum tip is included here. Also the template or reference elevation at +12 feet is indicated here. One side comment here. Please note that the Department requires in

the Driving Criteria Field to write the actual blow count and stroke combination. Writing "See driving Criteria Letter" like this log is showing, is a violation of the form instructions

Here is the driving record. The pile is at 45 ft. deep below the template or reference elevation. For a template or reference elevation of +12 ft. what is the tip elevation right now of the pile? (add continue button)

The tip elevation is the Reference Elevation minus the Length of Pile below the Reference Elevation. In other words $+12 - 45$ equals -33 feet. So have we reached the minimum tip? (continue button) Yes we have. The pile is at -33 feet which is deeper than the minimum tip elevation required of -32 feet. This is where we are in our mental process.

Now that we know we are past the minimum tip elevation, let's check if we have met the bearing requirements. Have we met the driving criteria for 2 feet? (add continue button)

At 43 to 44 feet: We counted 70 blows and 7.6 ft. stroke. The criterion requires for 7.5 ft. 52 blows per foot. At 7.6 feet stroke we would even require less, but let's stick with 52 blows because there is no more information in the letter. So we are Ok for this foot increment. For the last foot, between 44 and 45 ft., we counted 73 blows at 7.7 ft. stroke. Again this is much higher than the 52 blows per foot required at 7.5 feet stroke. In conclusion we have two continuous feet of driving that meets the driving criteria. The answer is YES.

This is where we are. We can stop and accept the pile.

Situation 2 is for the intermediate bents of the same bridge. You will work this by yourself. There is again a minimum tip elevation specified at -32 feet. The blow count criterion is shown as well as the refusal criterion.

Here is the pile driving information with the minimum tip elevation information and the template or reference elevation indicated as well. Look at note # 5 in the record, at the lowest part of the slide.

Here is the driving part of the record. We have included the blow count criterion, the template or reference elevation and the minimum tip elevation. This particular pile has been driven to 44 ft., and according to note #5 of the previous slide, they stopped to check for refusal. They drove 2 inches after the 44 foot length below template. What should be decision on this pile at this moment? Please work this on your own now. When you are ready to continue, please select the "continue" button or press Shift+N on your keyboard.

Let us check the mental process chart. There is a minimum tip elevation specified at -32 feet. The pile is at a depth of 44' 2" below template, or 44.17 ft. below template. Since the template is at elevation +12, the tip elevation is at $+12 - 44.17$ equals -32.17 feet. The pile has met the minimum tip elevation of -32 feet.

Have you met driving criteria for two consecutive feet? NO. There are not 2 consecutive feet meeting the blow count criterion for bearing. Have you reached practical refusal? The answer is YES. The last two inches they achieved 20 blows per inch and 25 blows per inch at a stroke of 7.5 feet which is higher than the minimum stroke of 6.0 ft. the criterion was asking to consider refusal. Therefore, the decision is to stop and accept the pile.

Situation 3 is for another intermediate bent pile. You will be asked to work this by yourself. There is again a minimum tip elevation specified at -32 feet. The blow count criterion is shown as well as the refusal criterion. Here is the pile driving information. Template elevation is +12 foot. Minimum tip elevation is -32 feet.

Here is the driving part of the record. The pile has just gone from 34 to 35 ft. below template. The blow count criterion as well as the minimum tip elevation and the template or reference elevation are indicated here. Also the cut-off elevation at +13 feet and the pile length of 50 feet are indicated here. What should be the decision at this point? See if you can work out path through the mental process chart. (add continue button)

Here is the answer. There is a minimum tip specified. It is Elevation -32 ft. Have you reached minimum tip elevation? The pile is at 35 feet below the template or reference elevation. Therefore the pile tip elevation is +12 minus 35 equals -23 feet. The answer is NO, we have not reached minimum tip elevation.

Following the chart now, we ask ourselves, have you reached practical refusal? The answer is NO. The blow count is 11 blows/ft. which is the equivalent of 0.55 blows per inch. Following the path, the following question now is: Is the pile 1 ft. or less of the pile cutoff elevation? At this point it is useful to compute the set-check target as we did in lesson 4.

Pile length is 50 feet, cut-off elevation is +13 feet, and the reference elevation is +12 feet. The set-check target which is the length of the pile below template that you would read when the pile is at 1 ft. above the cut-off elevation.

The computation yields 48 feet. This means that when you see the 48 foot mark at the template, the top of the pile will be at 1 foot above cut-off. In situation 3, the pile is at 35 feet below template. We are still many feet away from the 48 feet we computed above. So the answer to the last question is NO. The pile is not 1 ft. or less from cut-off.

Here is where we are in the flow chart. Since the pile is not 1 ft. or less from the cut-off elevation we keep driving.

Situation 4 is for a case where no minimum tip is specified. In addition the driving criteria letter includes this following requirements. Again, you are asked to work this by yourself. Hint: Since there is no minimum tip elevation you will have to check for a minimum penetration below ground, scour or excavation; whichever is deeper.

Here is the pile driving information part of the log, with the elevation information.

Blow count Driving Criterion is indicated here. Also template elevations, ground elevation, pile cut-off elevation.

There is no scour elevation. There is no excavation to consider. As you can see the top of the piles (cut off elevation) are higher than the ground elevation by 5 ft. This means we are talking about a bent situation.

From what elevation will you need to check the minimum penetration? Ground? Excavation? Scour?

What is this elevation? The answer is ground elevation. There is no excavation and there is no scour elevation. The ground elevation is + 108. Looking at the log, have you reached the minimum penetration?

See if you can work out path through the mental process chart. When you are ready to continue, please select the "continue" button or press Shift+N on your keyboard.

Here's the solution: There is no excavation and there is no scour elevation. The elevation from which penetration should be counted is + 108 which is the ground elevation. Looking at the log we don't get the minimum required blow count for firm material, which is 15 blows per foot at a minimum 5 ft. stroke for the pile length that has been driven.

Assuming everything is soft material you would need at least 20 feet penetration. The minimum penetration tip elevation would be: $+108 \text{ minus } 20 = +88 \text{ ft.}$ Let's see if we have met the penetration requirements with the current pile tip. The log indicates the pile tip now is at 35'-11" below template. This is 35.92' below template. Therefore the tip elevation is equal to: Reference Elevation minus Length below reference which is $+112 - 35.92 = -76.08 \text{ feet.}$ Therefore, the pile tip has reached the minimum penetration requirements.

Here is where we are in the chart. Have we met the driving criteria? Let's see. There are two alternative driving criteria. See where the criteria have been copied from the letter. Criterion 1 is met. 5 blows per inch for three consecutive feet at a stroke of 6 ft., which is greater than the minimum of 5 ft. specified. Therefore the

answer is YES, we met driving criteria. We have met driving criteria, and therefore can stop and accept the pile.

Let's give an overview of the process to follow when 100% of the piles are instrumented to accept the piles.

The flow chart would be almost the same. In this case, when no capacity is achieved, piles may be stopped for set-check at about 6" above cut-off. You may want to estimate set-check targets for both 6" and 1 ft. just to be on the safe side.

The flow chart is similar to the Driving Criteria acceptance process. The differences are:

- No Driving Criteria. Capacity is measured by instrumentation.
- Only 6 inches are required (as opposed to 24 inches) of capacity.

Since the piles are instrumented; there will be a PDA or EDC operator determining when the capacity is achieved and making sure the minimum amount of inches of capacity will be achieved. An inspector is still required to complete the record of all the installation activities. Sometimes dynamic testers may miss to record some foot marks and they will need your record for supplemental information and for verification. You will also be assisting the PDA/EDC operator in letting him/her know when the pile is within 1 ft. or 6" from the cut off elevation.

In this lesson we have covered the following topics:

- 4 alternative methods and specs to accept piles
- Bearing requirements
- Learned and practiced when to stop driving and Accept pile
- Learned when to stop driving, when to accept the pile and when to contact the PA
- Identified when to stop driving and request a Set- Check

This concludes Lesson 8. Thank you for completing the Pile Driving Inspector computer based training.