

## CHAPTER NO. 21

## PILE, DRIVING

## SPECIFICATION NO. 21.1—Pile Driving—General

1. Piles may be classified into the two main groups; bearing piles and sheet piles. The bearing piles may again be divided into four sub-divisions: timber, concrete, composite and steel. Sheet piles may be divided into three groups: wood, steel, and concrete. In the Punjab, at present steel sheet piles and precast concrete bearing piles are being generally used and therefore specifications for these two types of piles only have been laid down.

General.

2. Equipment for driving piling shall be in accordance with the requirements hereinafter set forth.

(a) General.—Piles may be driven with a gravity hammer, a steam or air hammer or a combination of water jets and hammer but a steam hammer is preferred. Precast concrete piles preferably shall be driven by means of a combination of hammer and jets.

Equipment for driving of piles.

(b) Hammers.—Unless otherwise specified, precast concrete or steel piles shall be driven with a steam hammer which shall develop an energy per blow at each full stroke of the piston of not less than one foot pound (0.14 kilogram metre) for each pound (0.45 kg.) of weight driven. In no case shall the total energy developed by the hammer be less than 6,000 foot pounds (825 kilogram metres) per blow. If a gravity hammer is used, it shall have a weight not less than that of the driving head and pile, and the maximum drop shall not exceed 8 feet (2.5 metres) in case of concrete piles and 15 feet (4.5 metres) in case of steel piles.

In case, the required penetration is not obtained by the use of a hammer as specified above, the contractor shall provide a heavier hammer or resort to jetting at his own expense.

(c) Leads.—Leads shall be required for all types of hammers. They shall be constructed in such a manner as to afford freedom of movement to the hammer and shall be held in required position by guys or stiff braces. Leads shall be of sufficient length so that the use of a follower will not be necessary.

(d) Followers.—The driving of piles with followers should be avoided and shall be done only if approved by the Executive Engineer.

(e) Water Jets.—When water jets are used, the number of jets and the volume and pressure of water at the jet nozzle shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient

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capacity to deliver at all times at least 100 pounds per square inch (7kg./sq. cm.) pressure at each of two  $\frac{1}{2}$  inch (20 mm.) jets nozzles while both are in operation. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration and bearing.

(f) Caps.—The heads of concrete piles when the nature of the driving is such as to unduly injure them, shall be protected by caps of oved design, preferably having a rope or other suitable cushion next e the pile head and fitting into a casting which in turn supports a er shock block.

or steel piling the heads shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

Accuracy in  
placing and  
driving piles.

3. In spotting the points of piles preparatory of driving, care shall be taken to locate them as shown on the plans or as directed by the Executive Engineer, and the deviation from such designated locations shall not exceed 3 inches (7.5 cm.) at the time driving is begun, except as may be made necessary by the presence of large boulders, broken piling or other unavoidable obstructions. While being driven, the piles shall be so held by toggles, shores, or cables as to deviate the minimum possible amount from the vertical, or the batter line shown on the plans.

Cutting of Piles.

4. All piles driven and accepted shall be cut off to a true plane at the levels indicated on the drawings from tops of piles, or below and un-sound portion of pile as directed by the Engineer.

Test Piles.

5. Test piles shall be of the same size and materials as the permanent piles and shall be driven with the same equipment and in the same manner as specified for such piles. Load tests shall be made with equipment approved by the Engineer-in-charge and the charges for conducting such tests shall be borne by the department unless otherwise specified.

## SPECIFICATION NO. 21.2—Steel Sheet Piles

1. Steel used, in pile section and clutches shall conform to category 'A' of structural steel as laid down in specification no. 3.19. For universal sheet piles, standard beams of 5 inches (12.5 cm.) flange will generally be used. The clutch bars will be specially rolled sections. Different sections are rolled out by manufactures for piling bars but latest list should be obtained while new work is in the design stage.

Materials.

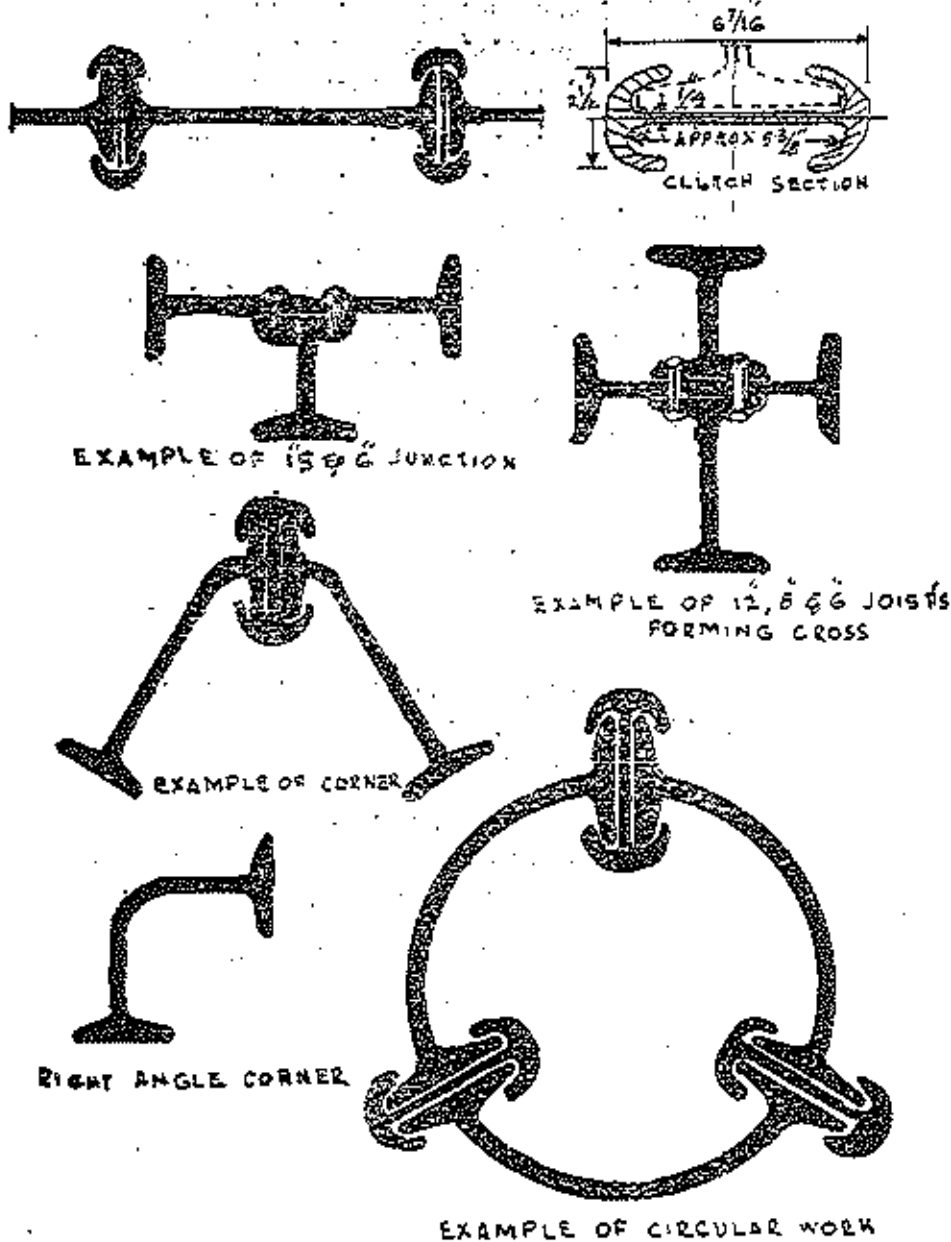


FIG. 212 (2)

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## SPECIFICATION NO. 21.2—Steel Sheet Piles

Corners and  
Splicing.

2. All makers of steel sheet piling make special sections to form corners and T connections. The diagrams in fig. 21.2(a) show the sections of the clutch bar and types of corners, junctions, and circular work possible with universal piling bars. Standard details for splicing on additional lengths are available but, unless the connection has the same moment of inertia as the plain section, the ability to transmit the full moment is not obtained, so that it is always desirable to avoid splicing. If, however, splices must be provided, the method of splicing shall be as shown on the plans or as approved by the Executive Engineer.

Driving steel  
sheet Piles.

3. Care shall be exercised in handling steel piling because small bends may produce excessive driving and pulling resistance. Efforts shall be made while driving to keep each pile plumb. If the first pile driven is vertical, maintaining a wall straight or in true form and making closures will not be difficult. Piling that deflects badly or refuses to penetrate on account of serious buried obstructions shall never be forced, otherwise it may, separate at the inter-lock and be twisted out of usable shape. Where the decreased movement of the piling under the hammer blows indicates serious obstruction, it is advisable to continue the line, barring the obstinate piles projecting above the rest. When all other piles have been driven, the obstruction may be removed and the obstinate piles may then be taken up for driving.

To provide protection for the piling or to procure good alignment or to affect a quick closure, sheet piles will not be usually driven to final penetration singly. Several piles should be fixed in the driving position. Then each should be driven a short distance in turn until the desired penetration of all the piles is reached.

Removing sheet  
piling.

4. Steel sheet piles may be pulled by use of special tackle pile extractors, or inverted steam hammers. When inverted steam hammers are used, a steady pull on the cable shall also be maintained.

Defective Piles.

5. No payment will be made for piles driven out of place or for imperfect piles, or for piles which are damaged in handling or driving.

### SPECIFICATION NO. 21.3—Precast Reinforced Concrete Piles

1. Precast reinforced concrete piles shall be manufactured in accordance with the design, including shoes, made of cast steel, wrought iron or chilled cast iron, as indicated on the drawings, and shall conform to the following specifications. The reinforcement should be designed to resist the stresses developed in handling and driving.

**General.**

2. Materials for use in precast reinforced concrete piles shall conform to the specification no. 10.8 for reinforced cement concrete.

**Material.**

3. When the length of the piles required is not specified on the plans, or cannot be determined satisfactorily by other means, test piles of the lengths and in the locations designated by the Executive Engineer shall be driven so that they may be incorporated in the permanent work. These test piles shall be of greater length than the length assumed in the design in order to provide for any variation in soil conditions.

**Length of Piles.**

The Executive Engineer shall estimate the length of piles to secure the proper bearing and shall record in writing as to the number and length of piles.

If the work is done by the contractor, he shall not order material for, begin casting preparations for, nor place an order for the precast concrete piling until he has driven test piling and the Executive Engineer has determined, from the data thereby obtained, the lengths of piling to be constructed or to be ordered by the contractor. If the contractor furnishes concrete piling in lengths other than those determined by Executive Engineer subsequent to the driving of the test piling, all unsatisfactory, unsuitable, or excess lengths of piling so furnished will not be measured for payment.

4. Forms for precast concrete piles shall be of wood or metal and shall conform to the general specification requirements for concrete form work. They shall be sufficiently tight to prevent leakage of mortar and shall be sufficiently strong and adequately braced together so as to effectively withstand tamping and vibrating. Forms shall be removed at times and in the manner specified by the Engineer-in-charge.

**Forms.**

5. (a) When concreting is once started, it shall be carried on as a continuous operation until the pile is completed, beginning at the head and working toward the point of the pile. The top surface shall be screeded and brushed to a uniform even texture similar to that produced by

**Manufacture.**

**SPECIFICATION NO. 21.3—Precast Reinforced Concrete Piles**

the forms. No concrete that has partially hardened or been contaminated by foreign material shall be deposited in the forms, nor shall retempered concrete be used.

(b) Vibrated concrete conforming to specification no. 10.8 shall be used in precast cement concrete piles. To secure even and dense surfaces free from honey-comb, vibration shall be supplemented by spading or rodding by hand while concrete is plastic under the vibrating action.

(c) Each pile shall be stamped or marked with the date of its manufacture. Lifting points indicated on the drawings shall be plainly marked on the piles

**Protecting and curing.**

6. Side forms may be removed 24 hours after concrete is placed, provided the concrete has hardened sufficiently.

Piles shall be cured for a period of at least 28 days.

**Handling.**

7. Piles shall be handled carefully to avoid dropping or severe jarring or causing excessive bonding stress. While in horizontal position piles shall be lifted and handled only when the concrete has attained the designed strength as determined by the tests. Any piles that are, in the opinion of the Engineer-in-charge, considered damaged on account of handling stresses, shall be rejected and shall not be paid for.

**Determination of bearing.**

8. Piles shall be driven to a bearing value not less than that shown on the plans.

Theoretical bearing values shall be computed according to the following formulae:—

$$P = \frac{2 WH}{S+1.0} \text{—for gravity hammers}$$

$$P = \frac{2WH}{S+0.1} \text{—for single-acting hammers (steam or air)}$$

$$P = \frac{2H (W+AP)}{S+0.1} \text{—for double-acting hammers (Steam or air)}$$

in which

P=Safe bearing power in pounds.

W=Weight of striking parts of hammers in pounds.

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H=Height of fall in feet,

A=Area of piston in square inches,

P=Pressure (steam or air) at the hammer in pounds per square inch.

S=The average penetration in inches per blow for the last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam (or air) hammers.

The above formulas are applicable only when:—

- (i) The hammer has a free fall.
- (ii) The head of the pile is not broomed or crushed.
- (iii) The penetration is reasonably quick and uniform.
- (iv) There is no sensible bounce after the blow.
- (v) The follower is not used.

Twice the height of the bounce shall be deducted from 'H' to determine its value in the above formulae.

The bearing value of piles as determined by the foregoing formulae, shall be considered effective only when they are less than the crushing strengths of the piles. The character of the soil penetrated, conditions of driving, the distribution, sizes and lengths of the piles involved, and the computed load per pile shall be given due consideration in determining the reliability of the driven piles.

In case water jets are used in connection with the driving, the bearing values shall be determined by the above formulae from the results of driving after the jets have been withdrawn.

Such hammer tests in conjunction with pile formulae shall be considered only as rough indications and not as a final criterion of the bearing power of the piles. Pile tests shall be made with varying static intensities of load on single pile and on group of piles as required. The test load shall not be applied until the pile has been allowed to rest at least 24 hours after driving.

In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, with suitable apparatus for accurately measuring the test load and the settlement of pile.

In lieu thereof hydraulic jacks with suitable yokes and pressure gauges may be used.

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The safe allowable load shall be considered as 50 per cent of that load which, after a continuous application of 48 hours, produces a permanent settlement not greater than  $\frac{1}{4}$  inch (6mm.) measured at the top of the pile. The maximum settlement shall not be increased by a continuous application of the test load for a period of 60 hours or longer. At least one pile for each group of 100 piles shall be tested.

**Driving pre-cast concrete Piles.**

9. These piles shall be driven plumb or to the better indicated in one continuous operation, and in the required locations. Piles shall be driven to refusal, or until the penetration per blow indicates a minimum bearing value as indicated on the drawings or specified. Accurate record of penetration per blow till the last foot shall be kept for all piles by the contractor. Where driving is interrupted before final penetration is reached, the record of penetration shall not be taken until after at least 12 inch (30cm.) penetration has been obtained on resumption of driving. Any pile damaged in driving which cannot be rebuilt or extended, or is unsatisfactory after being driven shall be removed and the hole filled to the satisfaction of the Executive Engineer at the expense of the contractor, after which another pile shall be driven as closely as possible to the required location, within the indicated distance from the edges of the footing.

Concrete piles shall be driven to final penetration and bearing before it is rebuilt or extended and no piles shall be driven within twenty-five feet of any concrete which is curing.

Concrete piles are preferably driven by hammer and jet. The piles shall be secured against lateral movement during driving by leads or other suitable means and shall be so driven that these shall not deviate more than  $\frac{1}{4}$  inch per foot (10 mm. per metre) from the vertical, nor more than 3 inches (75 mm.) horizontally from the location shown on the plans. If these deviations are exceeded, proper additional constructions should be provided at the contractor's expense.

**Splicing of Piles.**

10. Full length piles shall be used as far as possible. In exceptional circumstances splicing of piles may be permitted. The method of splicing shall be approved by the Engineer-in-charge and shall be in general as given below :—

After the driving is completed, the concrete at the head of the pile shall be cut off, leaving the reinforcing steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the piles. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary forms shall be placed and the concrete poured, care being

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taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to placing concrete the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement, or cement slurry or other suitable bonding material. The forms shall remain in place not less than seven days and shall then be carefully removed. Driving shall not be commenced until concrete has hardened for 28 days.

11. Payment for driving piles per linear foot shall include the cost of labour, tools, material, supply, equipment and other necessary incidental cost of rehandling, unloading at convenient place at the site of driving, lifting, placing in correct position and driving piles, etc. The cost of pile cap, etc. is also included in the rate. The length of driving of pile shall be the portion of the pile which has been embedded in the ground and shall not include portion of the pile near the head which is to be broken for embedment in the footings. Cutting or stripping head of the pile by means of manual labour, removal of concrete or cement mortar, etc., from the head of the pile shall be paid for separately.

Payment.

No payment will be made for piles driven out of place or for imperfect piles, or for piles which are damaged in handling or driving.

All piles pushed up during driving shall be driven down to the original level and the level shown on the drawings. No extra cost will be paid for this driving.