

## ***Memo: Doris-Windy All-Weather Access Road***

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<b>To:</b>	Tom Logan (Newmont)	<b>Date:</b>	November 10, 2008
<b>cc:</b>	Chris Hanks (Newmont) Geoff Akehurst (SNC) Michelle Murphy (SRK) Seema Kang (SRK)	<b>From:</b>	Lowell Wade (SRK) Maritz Rykaart (SRK)
<b>Subject:</b>	Doris-Windy Road – Pile Foundations for Arched Culverts	<b>Project #:</b>	1CH008.007.400

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### **1 Introduction**

It has been proposed to replace the excavated trench foundation with a pile foundation for the Arched Culvert installation along the Doris-Windy Road. Newmont Mining Corporation (NMC) requested SRK to proceed with design of the pile foundations. After completing the design, the material quantities were estimated as well as several construction risks were identified. This information is presented to allow the contractor to obtain budget quotes which the Owner may use to decide if the pile design will be implemented.

Due to the complexity associated with the proposed pile design, SRK has initiated an external peer review of the design. Once this review has been completed SRK will prepare and issue construction drawings.

### **2 Pile Foundation Design**

#### **2.1 Piles**

Piles of circular hollow section steel filled with grout have been selected for the pile design. The piles are to be spaced every 2.0 m [centre to centre] along the length of the arched culvert foundation.

Circular hollow section steel 4" Schedule 40 pipe of either Class C [ASTM 500] or Class H [G40.21 350W] has been selected for the pipe piles. Each steel pipe pile will extend 9.0 m below grade with an additional 0.5 m extending above grade. The additional steel pipe above grade will be precision cut after pile installation for construction of the pile cap. The total length of each pipe pile exceeds the standard length of fabricated 4" Schedule 40 pipe. Depending on transportation the steel pipe may have to be cut to fit in the cargo hold. Each pipe pile will therefore require on-site welding of pipe sections to make up the total length.

The steel pipe will have 100 mm long slots cut every 1.0 m along the length of the pipe. Two sets of slots will be cut around the circumference of the pipe offset by 90° and translated by 425 mm along the length of the pipe. This will allow the grout to flow from inside the pipe to the annulus of the drill hole.

Between the two sets of slots, rings of 10M rebar are to be welded every 1.0 m along the length of the pipe. Two pieces of 10M rebar will be welded at 90° to the bottom of the steel pipe pile.

## 2.2 Drill Hole

Standard practice for pile installation is an annulus of 50 mm around the pile. The outside diameter of a 4" schedule 40 pipe is 4.5" [114.3 mm]. This would require a drill hole of 8.5" [214.3 mm]. It is understood the largest diameter drill hole the air track drill on site can drill is 5.5" [139.7 mm]. This will only provide a 0.5" [12.7 mm] annulus. The risks associated with this is discussed in Section 4.1

## 2.3 Pile Cap

The pile cap will be constructed of three components:

- 1) 100 mm length of 5" Schedule 40 pipe of either Class C [ASTM 500] or Class H [G40.21 350W] will act as a sleeve and slide over the 4" Schedule 40 pipe pile.
- 2) A 1 1/8<sup>th</sup> inch [29 mm] thick plate steel measuring 8" x 8" [200mm by 200 mm] will be welded to one end of the 5" sleeve.
- 3) A W200x36 I-Beam will be placed on the 1 1/8<sup>th</sup> inch [29 mm] thick plate steel. The I-Beam will be welded to the plate steel on all four edges. Like the pipe piles, the I-Beam will require welding of sections to make up the total length. Welds should be located where the I-Beam passes over a pile.

## 2.4 Arched Culvert

The C-Channel along the bottom of the arched culvert is to be connected to the I-Beam by welding on both sides of the C-Channel. The steel footing will not be required.

## 3 Estimated Quantity of Materials

An estimated quantity of materials has been compiled based on the above design for all four culverts of 27 m in length as shown on the IFC drawings. The quantity of material is provided in Table 1. All quantities are neat values for all arched culvert pile foundations.

**Table 1. Estimated Quantity of Pile foundation Materials [All Culverts, Each 27 m in length]**

Category	Material	Quantity
Drill Hole	Drilling [Independent of drill hole diameter] [Includes 0.5 m over drilling]	1,140 m
Pile	4" Schedule 40 Steel Pipe Pile [Includes 1.0 m stick-up above grade (0.5 m) and over drilling (0.5m)]	1,200 m
	SET 45 Grout [Or similar cold set grout] [Includes 0.5 m over drilling]	17.5 m <sup>3</sup> [Based on an 5.5" (139.7 mm) diameter drill hole] [Assume 0.011 m <sup>3</sup> /bag = 1,589 bags] OR 41.7 m <sup>3</sup> [Based on an 8.5" (215.9 mm) diameter drill hole] [Assume 0.011 m <sup>3</sup> /bag = 3,795 bags]
	10M Rebar Rings and Pile End Cross	505 m [can only be used in 8.5" drill hole]
Pile Cap	5" Schedule 40 Steel Pipe Sleeve	12.0 m
	1 1/8 <sup>th</sup> inch [29 mm] thick plate steel measuring 8" x 8" [200mm by 200 mm]	4.8 m <sup>2</sup>
	W200x36 I-Beam	216 m

## **4 Risks**

### **4.1 Drill Hole Requirements**

The air track drill onsite has the ability to drill a 5.5" [139.7 mm] diameter hole. The pile design requires a 4" Schedule 40 pipe with a diameter of 4.5" [114 mm]. This will leave an annulus of only 0.5" [12.7 mm]. This creates two risks:

- 1) There is a good chance the drill hole may not be vertical or straight. This will prohibit installation of the steel pipe to the required 9.0 m embedment depth.
- 2) The rings of 10M rebar will increase the diameter of the pipe pile by 22.6 mm. The total diameter of the pipe pile becomes 136.9 mm. This leaves an annulus of 1.4 mm. The rings of 10M rebar cannot be included in the design. The rebar rings increase the surface area of the piles to provide additional shear resistance to prevent settlement or frost heave.

If the pipe pile foundation is the selected design option, it is recommended a drill hole of 8.5" [214.3 mm] be used to ensure installation of the designed pipe pile.

### **4.2 Tolerance Requirements**

The precise location of the pipe piles is critical for the following reasons:

- 1) The proposed design allows for installation of the pipe piles with a horizontal tolerance of +/- 57.5 mm laterally over the 27 m length of the arched culvert. The piles must carry the heavy loads transferred from the arched culverts axially. If the loads are eccentric a moment is introduced into the pipe piles and they will fail. To increase the lateral horizontal tolerance, for pipe pile placement larger diameter steel pipe [7" to 10" in diameter] will be required. This will also require a larger diameter drill hole [11" to 14" in diameter].
- 2) A horizontal tolerance of +/- 9.5 mm longitudinally over the 27 m length of the arched culvert is permissible. This also ensures the loads transferred from the arched culvert are transferred to the pipe piles axially.

The arched culvert is to be fully supported by the pile foundation:

- 1) The vertical tolerance of the pile foundation is determined by the specifications for the arched culvert. A maximum vertical tolerance of +/- 15.2 mm laterally over the 27 m length of the arched culvert is acceptable.
- 2) A maximum vertical tolerance of +/- 25.3 mm longitudinally over the 27 m length of the arched culvert is permissible.
- 3) The arched culvert is to be fully supported by the pile foundations. The pile foundation may be longer than the arched culvert but the arched culvert is not permitted to be longer than the pile foundation.

If the pipe pile foundation is the selected design option, the survey and construction accuracy must therefore be of the highest standard. Survey accuracy will be such that GPS surveying would not suffice.

### **4.3 Grout Requirements**

Significant load bearing capacity of the pile is carried by the grout. The grout must be allowed sufficient time to set and attain the required compressive strength required to carry the design load. The product data for Set 45 indicates three days at 36°F [2°C] are required to reach a compressive strength of 48.3 MPa.

To prevent premature freezing of the grout, heating the pile prior to installation in the drill hole is suggested. Pouring the warm grout inside the pile using the pile as a tremie pipe would decrease the cooling of the grout. Preheating the water used to mix the grout is also recommended.

Thermistor data indicates permafrost temperatures at depth are approximately  $-8^{\circ}\text{C}$ . This is colder than the  $-5^{\circ}\text{C}$  which will stall hydration of Set 45 grout. No in-situ testing will be conducted so it will be unknown if the grout will have reached the design compressive strength prior arched culvert construction and backfill operations.

#### **4.4 Pile Cap Requirements**

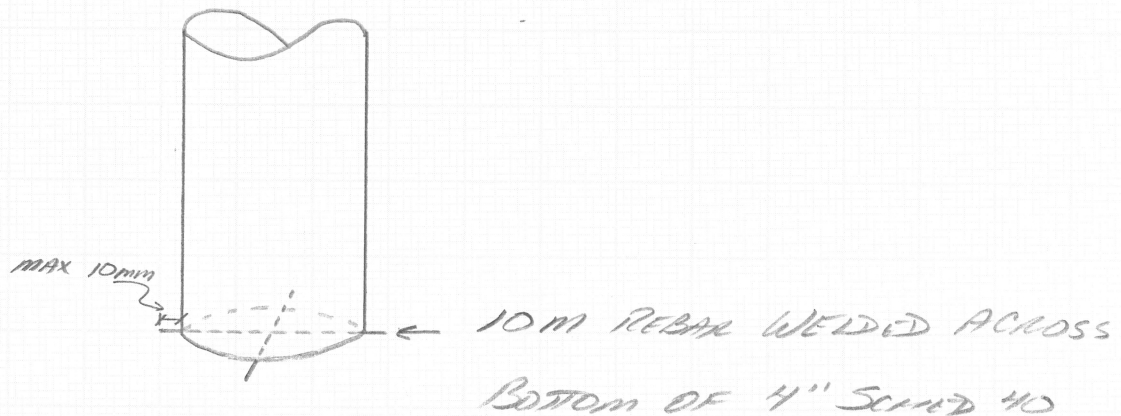
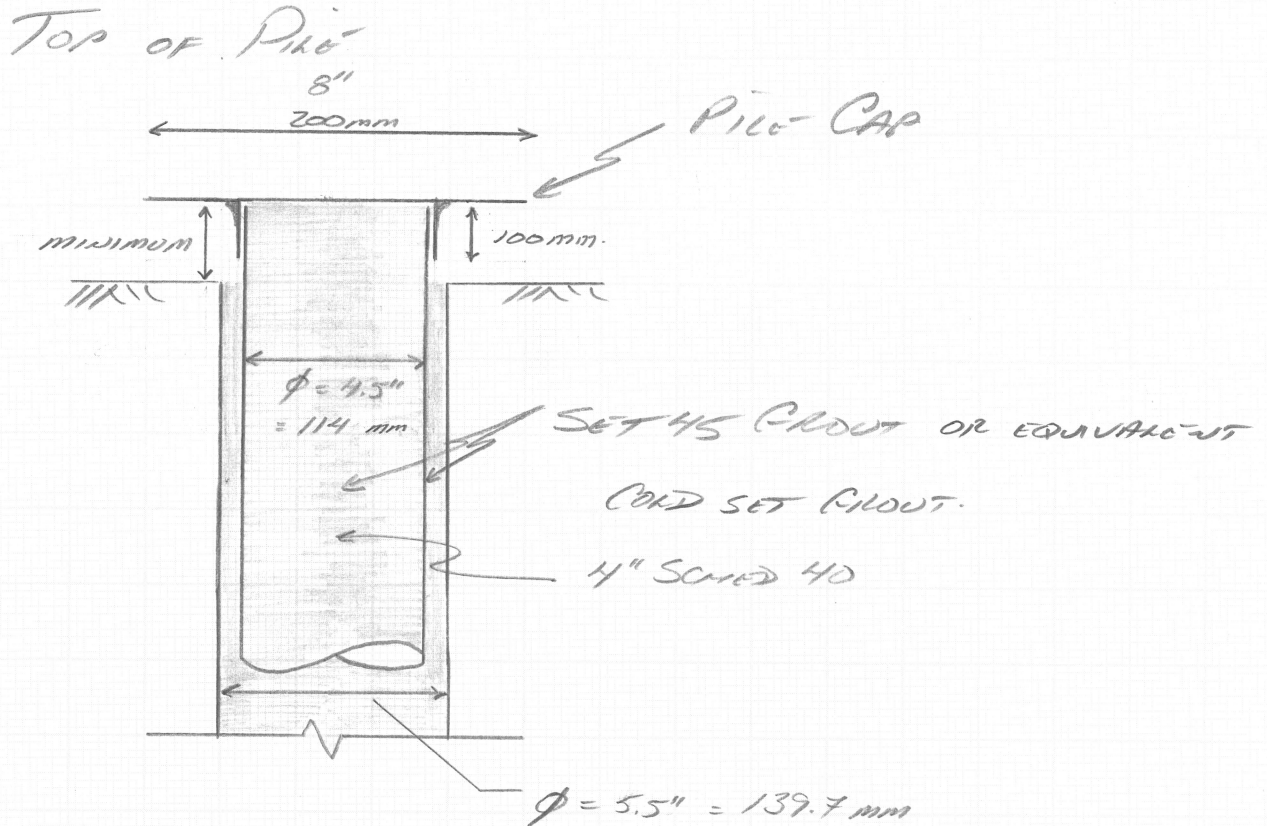
A steel wedge may be required between the I-Beam and the C-Channel of the arched culvert to account for the  $2.23^{\circ}$  re-entrant angle of the arched culvert footing. This will allow the vertical loads to be transferred from the arched culvert to the I-Beam and into the piles.

The gap between the arched culvert C-channel and the I-Beam are estimated to be 2 mm or less and it is assumed it will be filled by the welding process rather than the steel wedge.

----- **END OF MEMO** -----



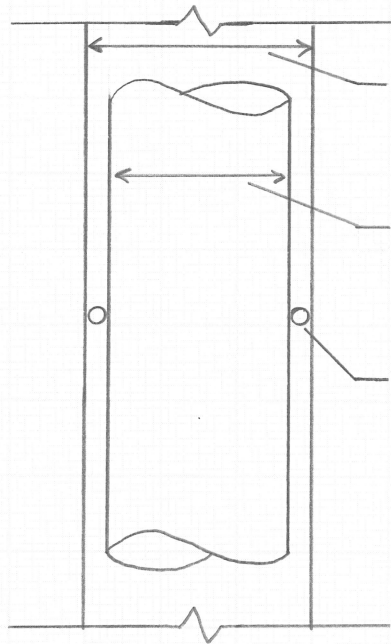




Bottom of Pile

Not For Construction

REBAR



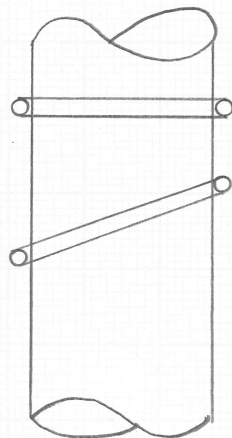
$$\phi = 5.5" = 139.7 \text{ mm}$$

$$\phi = 4.5" = 114 \text{ mm}$$

$$\phi = 10 \text{ M REBAR} = \phi = 11.3 \text{ mm}$$

$$\begin{aligned} \text{TOTAL } \phi \text{ STEEL} &= 114 + 2(11.3) \\ &= 136.6 \text{ mm.} \end{aligned}$$

∴ VERY TIGHT TOLERANCES



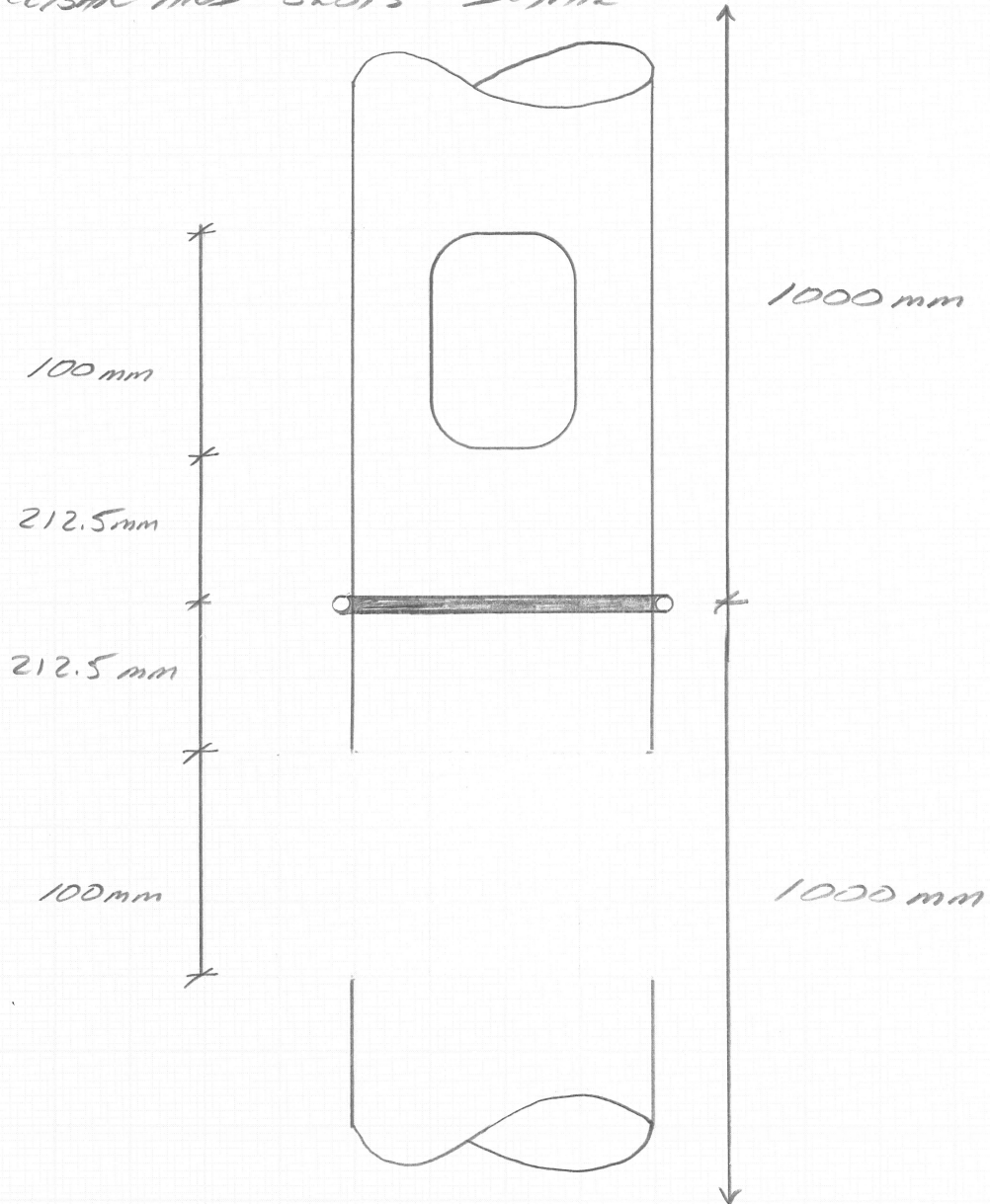
10M REBAR RING [SPACED 1000 mm]

10M REBAR SPIRAL [SPACED 1000 mm]

\* SEE DETAIL

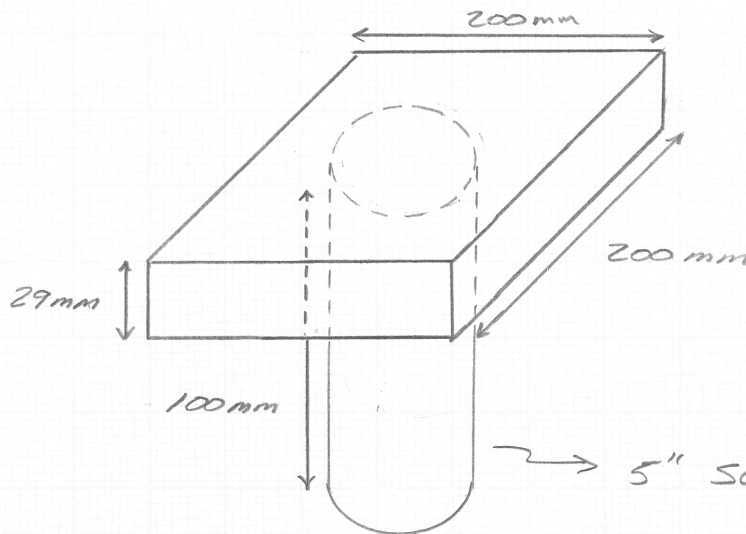
NOT FOR CONSTRUCTION

# *REBAR AND SLOTS DETAIL*



*Not For Construction*

Pile Cap



5" SCH 40  $\phi_{OD} = 5.56"$

$\phi_{ID} = 5.05"$

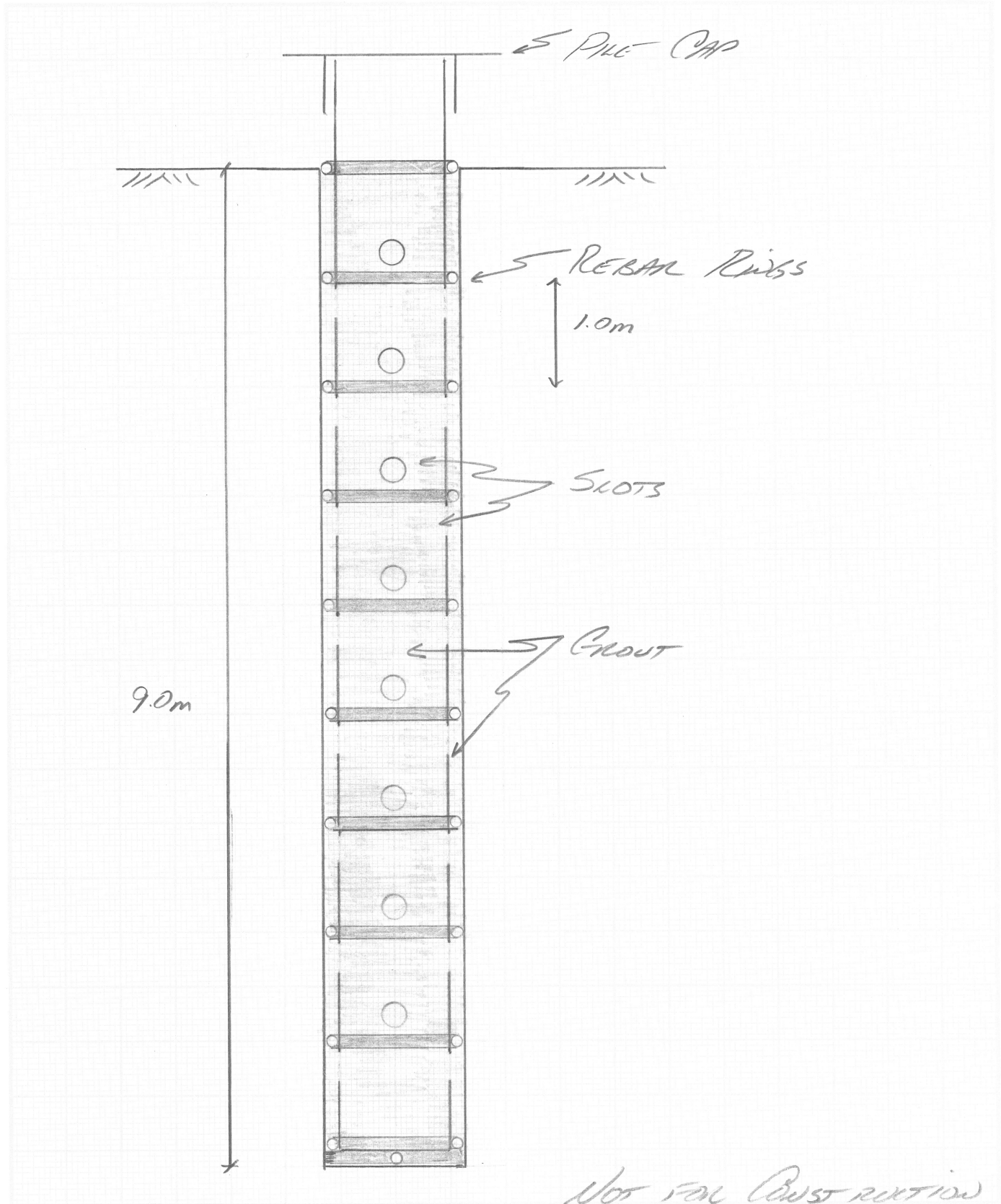
TO FIT OVER 4" SCH 40

$\phi_{OD} = 4.5"$

$\phi_{ID} = 4.03"$

NOT FOR CONSTRUCTION





Subject Pier Cap

Sheet \_\_\_\_\_ of \_\_\_\_\_

