2011, November, 22

Design Criteria for the Shoring Walls submitted by the Consultant / Contractor

Changes in this guideline verses 2011/Jan/06:

- Item # 32: The very lean concrete used in filler caissons shall have minimum compressive strength of **6.0 (Six)** MPa.

Solider Piles with Timber lagging:

1. The schemes for the temporary component of the track protection system will be considered, subject to the review of the Engineer. For any deviation from this guideline, it is required to obtain a written approval by CN senior engineer, prior to design and/or construction.

2. The Consultant / Contractor shall design the track protection system to resist the design loads for all tracks, in accordance with AREMA-2010, indicated on the following sketches;
   2.1.1. Temporary-Shoring-Design-Load-Diagrams.pdf
   2.1.2. Temporary-Shoring-Construction Procedure.pdf

3. The Contractor shall investigate all staged excavation.

4. The Consultant / Contractor shall provide for review by the Engineer a copy of;
   4.1. signed and sealed detailed design calculations and
   4.2. signed and sealed proposed shoring wall drawings.

5. The Consultant / Contractor design calculations shall clearly identify the interaction between soil and the track protection system, considering the possible passive reaction of soil in case the soil behind the track protection mobilized due to the pre-stressing of the tiebacks.

6. The Consultant / Contractor shall consider that while prestressing the anchors, the prestressing shall not load the soil behind the wall more than it's available passive resistance (specially for the top row where the passive wedge resistance is limited).

7. The Consultant / Contractor design calculations shall clearly identify the allowable design bond capacity, ultimate bond capacity between anchors and soil, and applied safety factors.

8. The Consultant / Contractor design calculations shall include;
   8.1. all assumptions,
   8.2. detailed design of all structural members, and
   8.3. estimated lateral displacement of the track protection system, especially at the location of all tie-backs or supports. The lateral displacement of the proposed track protection system shall be estimated for hydrostatic pressure (if any), soil pressure, lateral pressure due to all tracks considering the worst case.

8.4. all input and output files used for analysis and design of the proposed track protection system, both hard copy and electronic format.

9. The track protection shall be designed for the surcharge due to the Cooper-E90 loading as per AREMA-2010. (i.e. 90 kips axle load, 5 ft spacing between two consecutive axles. The effect of the strip load surcharge calculated with 8 ft tie length can be assessed as described in AREMA 2008, Chapter 8, Clause 20.3.2.2.

10. The coefficient of earth pressure is determined by the Geotechnical report but shall not be less than 0.50.

11. The distance between the 1st row of tiebacks and the bottom of rail and/or elevation of top of excavation (whichever is closer) shall be maximum 1.50m.

12. The distance between two rows of tiebacks shall be maximum 3.0m.

13. The distance between the lowest row of tiebacks to the bottom of excavation shall be maximum 3.0m.

14. It is required to model the wall based on nonzero deflections at the point of intersection of shoring piles and tieback anchors.

15. The lateral displacement of the track protection system shall be limited to 0.1% of the height of the excavated area.

16. The tieback design shall be in accordance with AREMA 8-20.5.7.a(2).

17. The tieback design load shall be specified on the proposed drawings.

18. The design of the anchorages shall be in accordance to AREMA 8-20.5.5.d,
    18.1. Performance test(s) (2.0 times of the tieback design load) shall be performed to validate the assumed allowable bond stress between soil/rock and tieback.
    18.2. A minimum Safety factor of 2.0 shall be applied to the ultimate bond stress between the tieback and rock/soil.
    18.3. The minimum bond length of the anchorages shall be 4.50 m (15 ft).
    18.4. The maximum bond length of the anchorages should be 10.0 m (33 ft).

19. The timber lagging shall be species (s-p-f), beams and stringers, grade no.1 or better, in accordance with AREMA chapter 7.
    19.1. The allowable bending stresses shall be 6.6 MPa (including all modification factors).
    19.2. The lagging thickness shall be 150 mm minimum for upper 2000 mm and 200 mm minimum for below 2000 mm.

20. As per AREMA 8-28.5.3.2., a minimum depth of 1.5 times of the width of the shaft/pile shall not been considered in providing passive lateral support. Furthermore, a minimum depth equal to 4 feet or 1.2 m shall not be considered in providing passive lateral support to the soldier

piles, this is considered due to possible frost.

21. As per AREMA requirement 8-28.5.1.2, for calculation of the depth of embedment, the passive resistance shall include a factor of safety of 1.5 and be reduced by multiplying Kp by 0.66.

22. The following items shall be written on the drawings:
    - 22.1. The total amount of force applied to one-meter width of the shoring wall for the entire excavated height, due to soil lateral pressure (triangular or trapezoidal) applied to, in kN/m unit.
    - 22.2. The total amount of force applied to one-meter width of the shoring wall for the entire excavated height, due to train load on each individual track, in kN/m.
        - 22.2.1. Total lateral force due to E-90 on track #1 = ### kN/m
        - 22.2.2. Total lateral force due to E-90 on track #2 = ### kN/m
        - 22.2.3. Total lateral force due to E-90 on track #3 = ### kN/m
    - 22.3. The total amount of force applied to one-meter width of the shoring wall for the entire excavated height, due to hydrostatic or any other load, in kN/m unit.
    - 22.4. The total design load applied to each individual tie back.
    - 22.5. The tie-back (thread-bars or strands) size, diameter, number of strands, grade etc.
    - 22.6. The total bonded length of the tie-backs.
    - 22.7. If the tie-back is anchored in rock, the bounded part of the tie-back, shall be started one meter (in vertical direction) below the assumed rock elevation.
    - 22.8. The total un-bonded length of tie-backs.

23. The minimum embedded length of pile into soil or rock shall be 3000 mm (10 ft).

24. The minimum distance between two tiebacks shall be +/- 3.5 times the diameter of the anchorage.

25. The distance between the line of potential failure surface and the anchor zone shall be 0.15 times of excavated height, minimum.

26. The Contractor shall provide a monitoring procedure with no cost to CN to the satisfaction of the Engineer. The monitoring shall be carried out during construction of the temporary shoring wall and must be continued up to the removal of the temporary shoring wall.

27. No skin friction, acting between back of the solider piles and soil above or below the level of bottom of excavation, shall be considered for design of the shoring wall.

28. It is required to establish vertical loads imposed on the pile from the tieback anchors without using any reduction for skin friction or adhesion from the soil behind the wall, (both between the soil-tieback, and soil-pile).

29. The concrete used for the solider piles shall have a minimum compressive strength of 30

(thirty) MPa below the dredge line.

30. The maximum movement of the piles toward the soil - at location of tiebacks - during the stressing of the tieback shall be limited to 5 mm (toward soil). If this recorded movement during the tieback stressing exceeded maximum allowable movement (5 mm toward soil), the tieback stressing shall be stopped, CN engineer shall be notified, and force shall be locked-in.

31. It is required that the design load on the drawings shall match the calculated design load for each row of tiebacks. This has to be done to ensure that excessive tieback force not to be applied to the shoring wall.

Caisson Walls

In addition to items above, the following items are required as well.

32. The very lean concrete used in filler caissons shall have minimum compressive strength of **6.0 (Six)** MPa.

33. The concrete used for the king piles shall have a minimum compressive strength of 30 (thirty) MPa above the dredge line.

34. The maximum spacing between the king piles shall be limited to 2.0 meters.

35. No skin friction, acting between back of the filler / king pile caisson and soil above or below the level of bottom of excavation, shall be considered for design of the caisson shoring wall.

36. It is required to establish vertical loads imposed on the pile from the tieback anchors without using any reduction for skin friction or adhesion from the soil behind the wall, (both between the soil-tieback, and soil-caisson).

Monitoring Plan:

37. The monitoring plan shall include both tracks and the shoring wall.

38. No open excavation shall be left without visual inspection during long period of time, i.e., holidays, etc.

39. Monitoring reading interval shall be daily from the first day of shoring wall installation, during shoring wall installation, during structure excavation, and at all times when the excavation is in an open condition and the shoring wall is under load during all stages of the work and until all the shoring wall is removed.

40. The monitoring plan of the shoring wall shall include the number of targets and location of the targets at each pile.

41. The most important tool in track monitoring is visual inspection of the track and shoring wall. If the track shifts, or deflects, visual inspection will be the most effective tool to prevent any track safety related incident.

42. Daily visual monitoring of the ground behind the shoring wall shall be performed. If any crack within or up-ward movement of the soil is/are observed, the following shall be immediately be reported to CN, location, with and length of the crack and location, length and height of heave.

43. Daily visual monitoring of the track(s) behind the shoring wall shall be performed. If any upward, downward or side movement of track is/are observed, the following shall be immediately be reported to CN, location, and length of the track movement.

44. Targets shall be placed at least on one third of the piles.

45. It is required that monitoring targets to be placed:
    - 45.1. At top of selected piles
    - 45.2. At the level of all tiebacks on each selected pile(s).
    - 45.3. At a mid point between two consecutive level of tie backs.
    - 45.4. If there is only one row of tieback on the selected pile, it is required to have two targets on the pile, one at the tieback level and the second one at mid point between the dredge line and the tieback.

46. It is required to monitor the track(s) as well as shoring wall piles. The maximum spacing between the targets on each rail of each track shall be 6 meters.

47. For filler caisson monitoring, it is required to install a series of inclinometers, to be placed on at least at one forth of bays between king piles, a minimum of 3 inclinometers for whole length of shoring wall is required.

48. All inclinometers shall be installed such that initial readings could be obtained a minimum of one week prior to first drilling for installation of the shoring wall.

49. Inclinometer reading interval shall be daily from the first day of shoring wall installation, during shoring wall installation, during structure excavation, and at all times when the excavation is in an open condition and the shoring wall is under load during all stages of the work and until all the shoring wall is removed.
    - 49.1. The only acceptable location of inclinometer is in the filler caisson.
    - 49.2. The location of each inclinometer shall be clearly shown, with respect to filler caissons and the king piles.
    - 49.3. the slope inclinometer(s) to be protected by steel casing at least 300 mm above the ground and 1000 mm below the ground.
    - 49.4. the threshold of the lateral displacement, 0.1% of the excavated height, to be shown

on the required graph(s).

50. Regarding the presentation of the data, it is required that monitoring report clearly show:
    - 50.1. The actual collected data (date, target #, pile #, northing, easting, elevation, actual lateral and vertical movements, etc)
    - 50.2. A graphical representation of the lateral displacement of targets placed along the selected piles, the unit shall be in mm.
    - 50.3. It is required to have one graph for each row of tie-backs, along the shoring wall
    - 50.4. Also, it is required that threshold of the lateral displacement, 0.1% of the excavated height, to be shown on the required graph(s).

General:

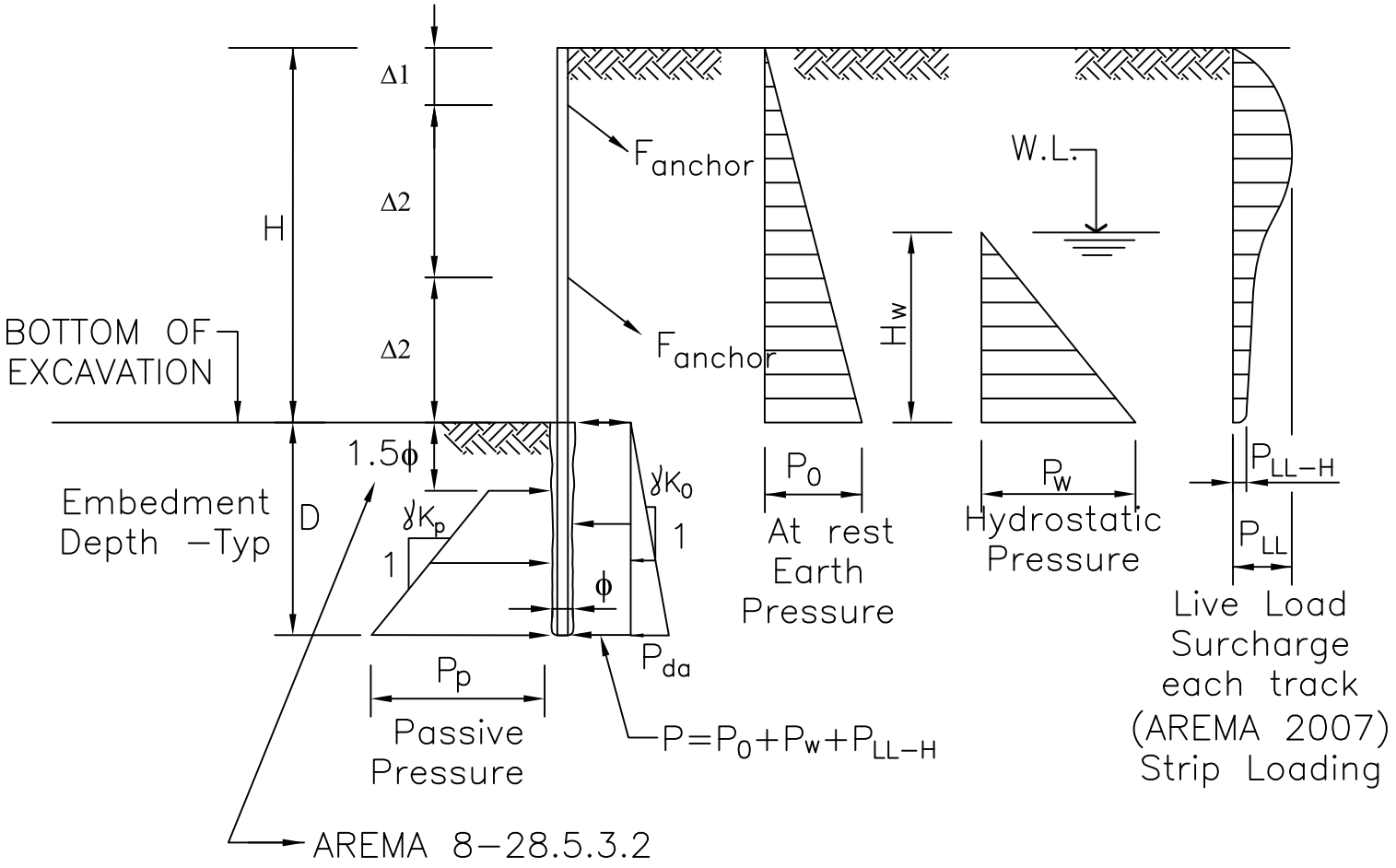
51. Wash-boring (or wet-drilling) method is not allowed to be performed for drilling tie-backs under CN tracks.

52. CN does not accept "pile splicing" on any shoring pile. However, if due to the excessive length of, etc, the pile splicing is absolutely necessary, CN standard S12m(a) for pile splicing shall be used.

53. All tie backs shall be de-stressed during the backfill.

2011 November 22

TRACK PROTECTION SYSTEM
DESIGN LOAD DIAGRAMS



LIVE LOAD SURCHARGE

TO BE CALCULATED IN ACCORDANCE WITH AREMA 2007, CHAPTER 8, SECTION 20,3,2,2.

LIVE LOAD = COOPER E90

WHERE:

γ_{soil} = 21 kN/m3
γ_w = 9.806 kN/m3
K_0 = 0.50 Minimum
K_p = 3.0
ϕ = DIAM. OF SHAFT

AT REST EARTH PRESSURE

$P_0 = K_0 \gamma_s H$ (kPa)

$P_{da} = K_0 \gamma_s D$ (kPa)

PASSIVE RESISTANCE

$P_p = K_p \gamma_s D$ (kPa)

HYDROSTATIC PRESSURE

$P_w = \gamma_w H_w$ (kPa)

$\Delta 1$ = Maximum 1.5 m

$\Delta 2$ = Maximum 3.0 m

2011 November 22

CONSTRUCTION PROCEDURE:

- DRILL HOLES TO SIZE AND DEPTH SHOWN. INSTALL PILES, ALIGN AND CAST CONCRETE TOES WHERE SHOWN
- WHEN CONCRETE IN TOES HAS SET (30 MPa), FILL VOID AROUND PILES WITH 0.5MPa STRENGTH CONCRETE.
- EXCAVATE TO FIRST STAGE AND INSTALL LAGGING. EXCAVATE SOIL FACES NEATLY TO ENSURE A TIGHT FIT FOR LAGGING. WEDGE AT PILE AS NECESSARY, PACK ALL VOIDS BEHIND LAGGING WITH GRANULAR MATERIAL RAMMED INTO PLACE.
- WHEN EXCAVATION REACHES 300mm MAX BELOW ANCHOR ELEVATION NOTED, DRILL AND INSTALL ANCHORS.
- FILL ALL VOIDS AROUND TIE BACKS WITH 3000 PSI CONCRETE GROUT.
- DO NOT FURTHER EXCAVATE BELOW ANCHOR ELEVATIONS UNTIL ALL ANCHORS ARE STRESSED AND LOAD LOCKED IN. ALL ANCHORS SHALL BE PROOF TESTED TO 1.33 TIMES DESIGN LOAD. THE LOAD SHALL BE REDUCED TO 1.1 TIMES DESIGN LOADS AND LOCKED IN. A NOMINAL LOAD SHALL BE USED TO STRESS ALL HORIZONTAL ANCHORS IN ORDER TO DRAW OUT ANY SLACK IN THESE ANCHORS.
- CONTINUE EXCAVATION TO INDICATED DEPTHS.
- TIMBER LAGGING SHALL BE SPECIES (S–P–F), BEAMS AND STRINGERS, GRADE No.1 OR BETTER, IN ACCORDANCE WITH AREMA CHAPTER 7. FOR ALLOWABLE BENDING STRESSES USE 6.6 MPa (INCLUDING ALL MODIFICATION FACTORS). THICKNESS SHALL BE 150 mm MIN. FOR UPPER 2000mm AND 200mm MIN. FOR BELOW 2000 mm.
- TIE–BACK ANCHORS SHALL BE DYWIDAG MULTISTRAND, 0.6" dia. 7–WIRE, GREASED AND COATED, LOW–RELAXATION, GRADE 270 ksi STRAND CONFORMING TO CSA G279–82 (ASTM A 416).
- DESIGN LOAD: # –0.6" TENDONS ### KN/ANCHOR
- LOCK–OFF LOAD = 1.10 x DESIGN LOAD.
- PROOF LOAD = 1.33 x DESIGN LOAD.
- PERFORMANCE LOAD = 2.0 x DESIGN LOAD.