ENCLOSURE 2

SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

SOIL BACKFILL CONDITIONS

Summary of the Evaluations of the
Buried Electrical Duct Banks

May 1985

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PURPOSE

This is in response to the NRC staff request of 2/14/85 to provide a summary report on the buried electrical conduits affected by the soil backfill conditions. The conduits are embedded in reinforced or unreinforced concrete rectangular beams. The information presented herein is derived from Reference 1.

CRITERIA

The criteria followed are described in Reference 2.

LOAD COMBINATIONS

In the evaluation of the duct banks, the following two loading combinations were considered:

I) Dead load + component seismic inertia loads + settlement during seismic shaking.

II) Dead load + total settlement.

Combination I addresses the load condition during the design basis earthquake and combination II addresses the load condition after the design basis earthquake. The duct banks were evaluated assuming total loss of support in the backfill areas, so that, loading combination I governs. In cases where the assumption was made that there will be no support due to the settlement of the soil during and after the earthquake the magnitude of the expected settlements are then of no consequence.

Due to the nature of the settlements, the critical governing direction for the duct banks is the vertical direction. Evaluation of the duct banks in the transverse and axial directions are not deemed necessary since the postulated settlement does not occur in those directions.

ANALYSES PROCEDURES AND ASSUMPTIONS

Manual calculations are made following simple beam theory. The evaluation steps and the assumptions are as described below:

a) The beams are assumed to have no support when transversing the backfill areas.

b) The beams are assumed to have simple end support conditions at the native soil/backfill interfaces. If the duct bank is embedded in concrete, for example in a footing, fixed support condition is assumed.

c) The dead weight of the duct bank includes the overburden soil.

d) The frequency of the simply supported duct bank, which includes the overburden soil as additional mass is computed. The seismic coefficient is the acceleration obtained from the 0.44g modified Housner vertical 7 percent ground spectra corresponding to the beam frequency.

e) The maximum moments are computed by combining the dead load moments and the seismic moments obtained from an equivalent static analyses.

f) The ultimate moment capacities are computed using the embedded conduit as reinforcement.

g) The duct banks are acceptable when the maximum moments are less than or equal to the ultimate capacities.

RY OF RESULTS

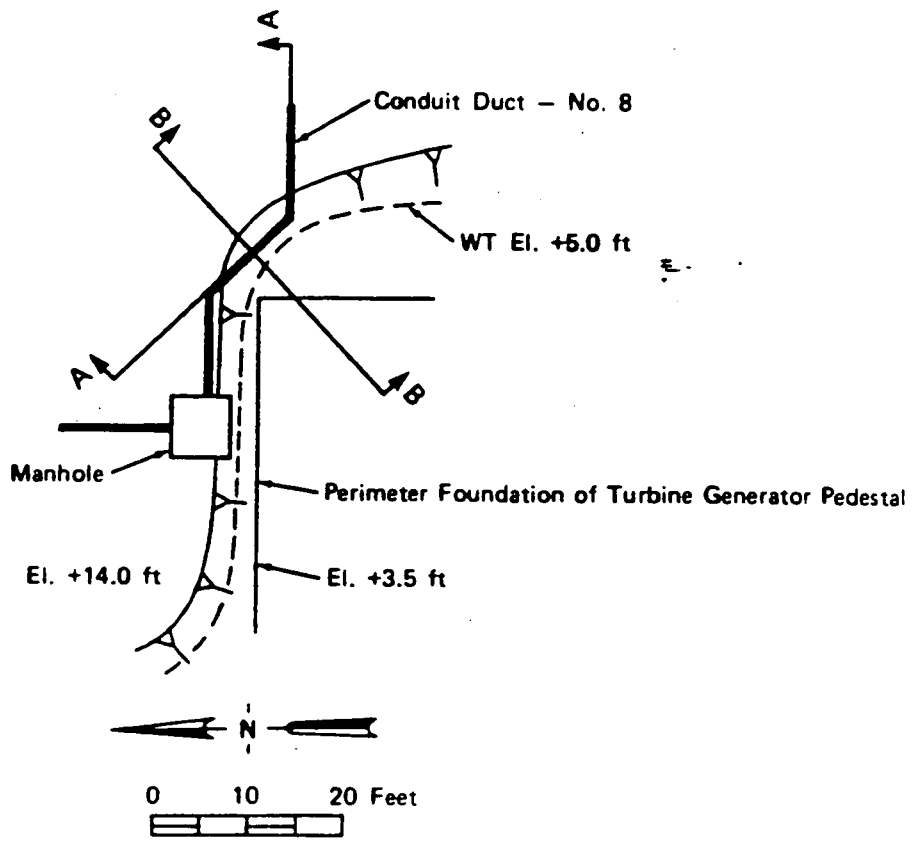
able I gives the summary of results. All item numbers and section umbers are identical to those of Reference 1. The figures are duplicated or ease of reference. The duct bank to North Tsunami Gate is not ncluded since it is no longer a part of the Seismic Reevaluation rogram. Based on the results given in Table I, it is concluded that the uct banks meet the seismic reevaluation criteria.

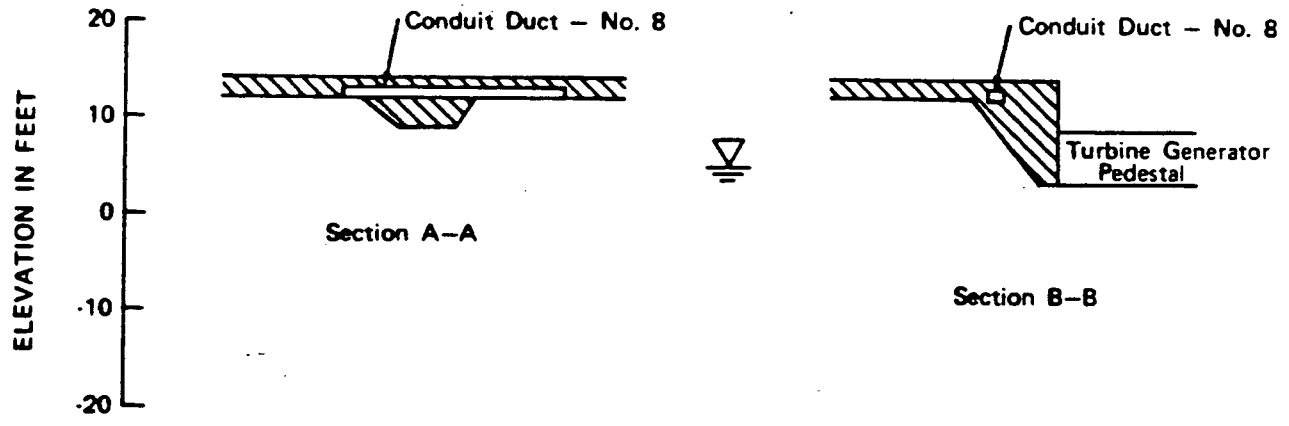
he luation calculation for item No. 8, East/West duct bank, east of ntake structure (north duct) is given as a sample in Appendix A.

ENCES

Enclosure to letter from R. W. Krieger to D. M. Crutchfield, dated September 1, 1983; "Soil Backfill Conditions, San Onofre Nuclear Generating Station, Unit 1, Chapters 4 and 5".

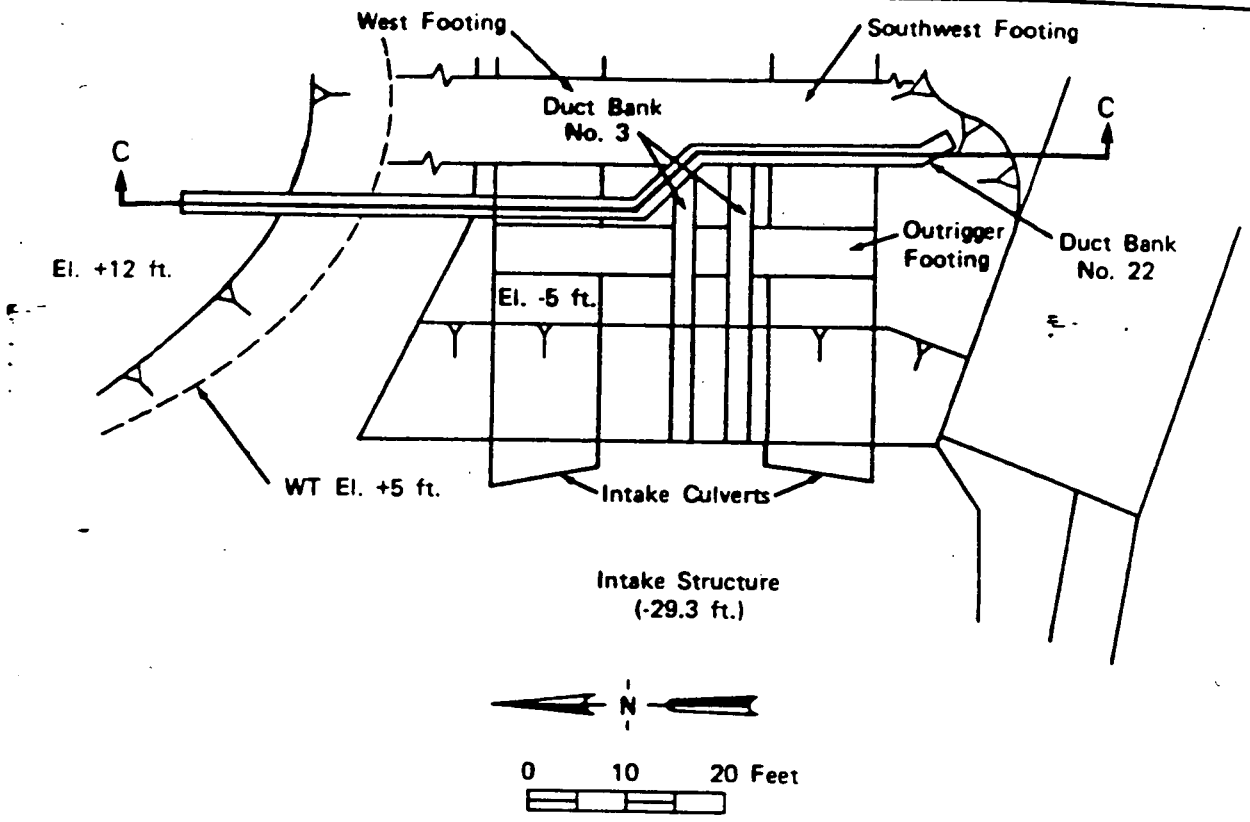
Enclosure to letter from K. P. Baskin to D. M. Crutchfield, dated 2/23/81.

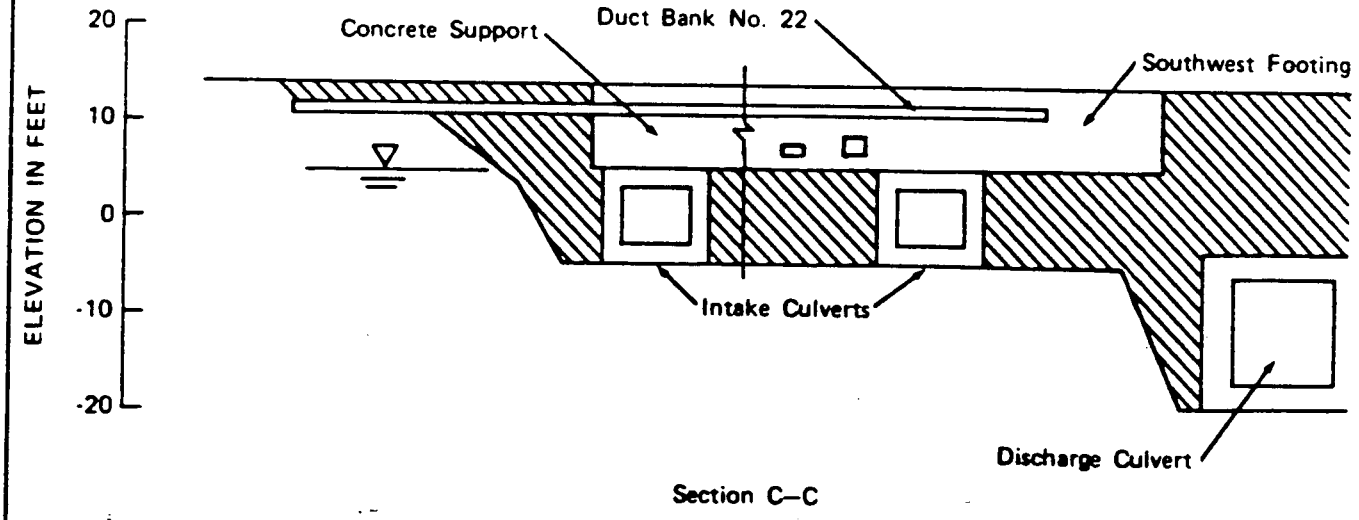




LOCAL SOIL CONDITIONS UNDER CONDUIT DUCT – NO. 8

FIGURE 5-9





Section C–C

LOCAL SOIL CONDITIONS UNDER
DUCK BANK – NO. 22
FIGURE 5-18

APPENDIX A

Duct Bank Sample Calculation

CALCULATION SHEET

LAO 8613 8-78

CALC. NO. LBC-CC Z.0

SIGNATURE Bill Ballard DATE 4-1-83 CHECKED WG DATE 4-1-83

PROJECT SONGS 1 JOB NO. 14000-466

SUBJECT I.S.I.E.D.B. SHEET 40 OF 60 SHEETS

CHECK UPS DUCT BANK (#2)

REF.: - ALWC. 5152317, 568372
- WOODWARD CLYDE SOILS REPORT FIG. 5-1. (REF #6)

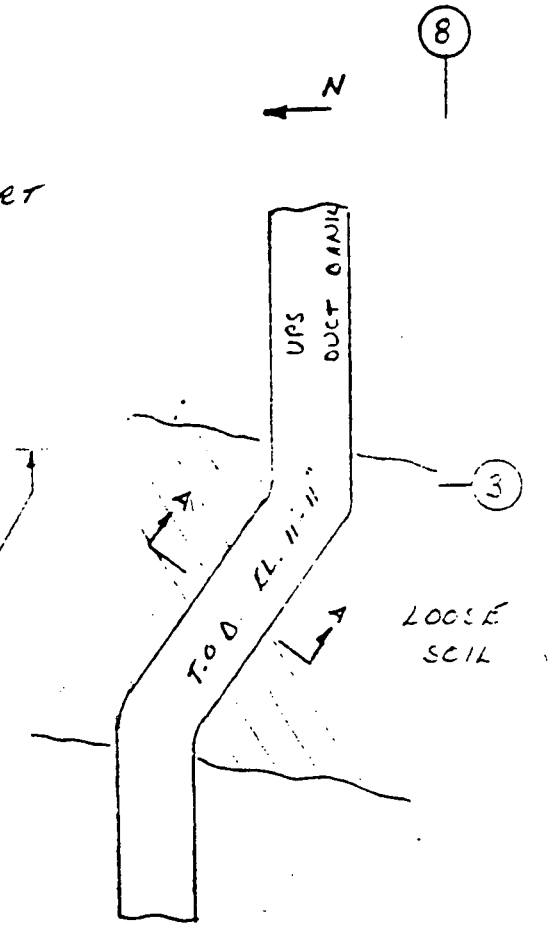
SOIL OVERBURDEN = (ASSUME 120 PCF)

$= \frac{19}{12} \cdot (14' - 11.92') \times .15\ KCF = .5\ ^{K}/_{ft}$

SELF WEIGHT

$= \frac{19 \times 36}{144} \times .15\ KCF = .72\ ^{K}/_{ft}$

$1.21\ ^{K}/_{ft}$



20'

CALCULATE STATIC DEFLECTION FOR 20'-0" SPAN. (CONSERVATIVELY ESTIMATED)

- ASSUME BACKFILL HAS SETTLED.
- ASSUME SINGLELY REINFORCED BEAM.
- ASSUME 40 ksi STEEL
- NEGLECT CONDUIT STRENGTH

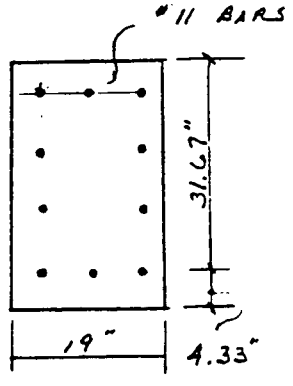
PLAN

(REF #1)

$$I_E = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr}$$ ACI EQ. 9-7

$I_g = \frac{1}{12}(19)(36)^3 = 73,872\ in^4$

$M_{cr} = \frac{f_r I_g}{y_t} = \frac{7.5\sqrt{4000}\,(73,872)}{18\,(12000)} = 102.2\ ^{K}/_{in}$



$nA_s = 8(1.56)(3) = 37.4\ in^2$

$M_a = \frac{1.21(20)^2}{8} = 60.5$ "k

$f'_c = 4$ ksi
$f_y = 40$ ksi ; ASSUMED, CONSERVATIVE
$E_s = 29000$ ksi
$E_c = 57\sqrt{4000}$
$= 3604$
$n = \frac{E_s}{E_c} = 8.0$

I_{cr} - N.A LOCATION

$$\frac{19x^2}{2} = 37.4(31.67 - x)$$

$$19x^2 = 2371.4 - 74.8x$$

$$x^2 + 3.94x - 124.8$$

$$x = \frac{-3.94 \pm \sqrt{(3.94)^2 - 4(1)(-124.3)}}{2(1)}$$

$$\frac{-3.94 + 22.69}{2}$$

$x = 9.37$ "

$$\therefore I_{cr} = \frac{1}{3}(19)(9.37)^3 + 37.4(31.67 - 9.37)^2$$

$= 23,809$ in^4

$$I_E = \left(\frac{162.2}{60.5}\right)^3 73\,872 + \left[1 - \left(\frac{162.2}{60.5}\right)^3\right] 23,809$$

$= 988,537 > I_g \therefore$ USE I_g

CALCULATION SHEET

LBC-CC
CALC. NO. 2.0

SIGNATURE Bill Ballard DATE 4-1-83 CHECKED WG. DATE 4-1-83

PROJECT SONGS 1 JOB NO. 14000-466

SUBJECT I.S.I.E.D.B. SHEET 42 OF 60 SHEETS

STATIC DEFLECTION $\Delta_{ST} = \frac{5wl^4}{384 E_c I_g}$

$$\Delta_{ST} = \frac{5(1.21)(20)^4(1728)}{384(3604)(73,872)}$$

$$= .016"$$

FUNDAMENTAL FREQUENCY:

$$T = 2\pi\sqrt{\frac{\Delta(c.f.)}{g}}$$

C.F. = CORRECTION FACTOR FOR CONTINUOS MASS. REF. & TIMOSHENKO "VIBR. PROBLEMS FOR ENG. PP. 33-34 (REF #7)

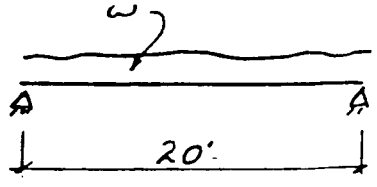
$$T = 2\pi\sqrt{\frac{.016(.79)}{386}}$$

$$= .036$$

$$f = \frac{1}{T} = 27.8 \text{ CPS}$$

$$g_r = .438$$

$$w = (1.21)(1 + .44) = 1.74^{K/ft}$$



$$M = \frac{wl^2}{8} = \frac{1.74(20)^2}{8}$$

$$= 87.12^{'-K}$$

CALCULATION SHEET

LBC-CC
CALC. NO. 2.0

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PROJECT SONGS 1 JOB NO. 14000-466

SUBJECT I.S.I.E.D.B. SHEET 43 OF 60 SHEETS

CALCULATE M_u

$d = 31.7"$

$$a = \frac{A_s f_y}{.85 f'_c} = \frac{3(1.56)(40)}{.85(4)(19)} = 2.9"$$

$$M_u = 3(1.56)(40)\left(31.7 - \frac{2.9}{2}\right)/12 = 472^{K-FT}$$

$> 87.1^{K-FT}$ ∴ OK

∴ UPS DUCT BANK IS ADEQUATE