CHAPTER 4

INTERMEDIATE WASTEWATER PUMPING STATION (PACKAGE C)

4.1

Civil Design

4.1.1

Design Standard

1. Design Standard

(1) Permanent Structure

(a) Unit Weight

Reinforced concrete γc = 2.5t/m^3

Backfill sand γs = 1.8t/m^3 (under Ground water 0.8t/m^3)

(b) Design Stress

・Concrete

Concrete	
Bending compressive stress σca	210(kg/cm^2)

・Reinforcement

Reinforcement	deformed bar
Tensile and compressive stress τsa	3,000(kg/cm^2)

(c) Allowable Stress

・Concrete

Concrete	210(kg/cm^2)
Bending compressive stress σca	70(kg/cm^2)
Shearing stress τca	3.6(kg/cm^2)

・Reinforcement

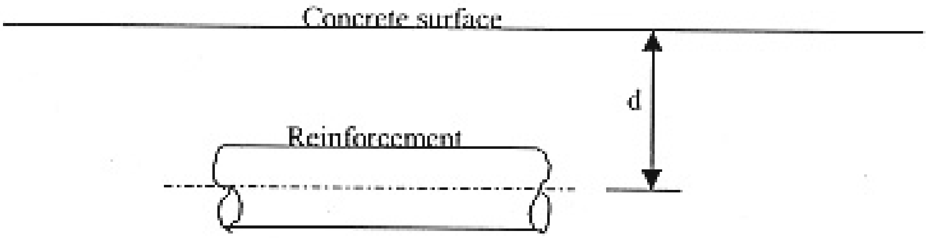
Reinforcement	deformed bar
Tensile and compressive stress τsa	1,600(kg/cm^2)

(d) Reinforcement Arrangement

・Diameter (mm)

6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 25, 28, 30, 32, 36

・Cover (d mm)



Underside of bottom slab d = 120 mm (with pile structure)
d = 100 mm (without pile structure)
Other slab and wall d = 70 mm (h ≧ 300mm)
d = 50 mm(h < 300mm)
Beam and Columnd = 70mm

・Minimum space between two bars of reinforcement (face to face)
For slab and wall t0 = 100mm
(In this calculation, the space between two bars (center to center) should be taken following two cases, 125mm or 250mm.)
For beam and column t0 = 50mm

・Minimum amount of reinforcement
Deformed bar

Beam	As =	0.002 b·d ≦ As ≦ 0.02 b·d
Column	As =	0.0015 A ≦ As ≦ 0.06 A

・Lap length
Plain bar and Deformed bar L = 35d (d = diameter of reinforcement)

(e) Design Load

・Basic parameters

Unit weight of soil	γ =	1.8(t/m^3),	friction angle φ = 30 °
Under ground water	γ' =	0.8(t/m^3)	
Vehicle load	H30 (30T)		

・Vertical load
Soil load p1 = h ×γ
Vehicle load p2 = (n × P)/A

Back axle weight = 12T
One tire weight P = 12/2 = 6T (The space of tire Is 1.6m)
Loading area
A = (0.2+2 × h × tan30°) × (0.6+2 × h × tan30°)
n : over load factor 1.3

(If depth of upper slab is more than 1.4m, two tire loads should be considered)

Under ground water load Pw (unit weight is $1.0t/m^3$)

・Horizontal load

Soil pressure P = (vertical soil load) × Ko

Ko = 0.5 (Earth pressure at rest)

Horizontal load pressure Pv = (Vertical load) × Ko

(For calculation of Box Culvert. Vertical vehicle load and horizontal vehicle load are not loaded at the same time.))

Axial load Pa = $1.0\ t/m^2$ (For calculation of under ground wall. If there is no road near the structure, axial load is $0.5t/m^2$))

Under ground water pressure Pw

・Inside of structure

Vertical water load

Horizontal water pressure

・Equipment weight

Mechanical equipment load (activity load)

Electrical equipment load

・Building load

・Uplift strength

(2) Temporary structure

(a) Sheet Pile : Stress for calculation

Tensile Stress	2,700 kg/cm^2
Bending Compressive Stress	2,700 kg/cm^2
Shearing Stress	1,300 kg/cm^2

(b) H section steel

Tensile Stress	2,100 kg/cm^2
Bending Compressive Stress (*)	2,100 kg/cm^2
Shearing Stress	1,200 kg/cm^2

* Bending Compressive Stress is according to length of H section

$l/r \leqq 20$ 2,100 kg/cm^2

$20 < l/r < 93$ $\{1,400 - 8.4(l/r - 20)\}$

$93 \leqq l/r$ $\{12,000,000 / (6700 + (l/r)^2)\} \times 1.5$

Here l : length of H section
r = radius gyration of H section

(c) Stress Iron Weld Connection

Allowable stress of Shop Welding is same as the above.
Allowable stress of Field Welding is 80 % of Shop welding.

(d) Stress for Bolt Connection

Shearing Stress	1,300 (kg/cm^2)
Surface Compressive	2,900 (kg/cm^2)

2. Design method of Spread Foundation

(1) Allowable Bearing Capacity of Soil

Allowable bearing capacity of soil is calculated by following equetion

$$qa = 1/3 \ (\alpha \times C \times Nc + \beta \times r1 \times B \times Nr + r2 \times Df \times Nq)$$

Here

Qa : Allowable bearing capacity of soil (t/m^2)

C : Cohesion of soil under the bottom of foundation (t/m^2)

r1 : Unit weight of soil under the bottom of foundation (t/m^3)
Use submerged unit weight if soil is under the ground water

r2 : Average unit weight of soil upper side of bottom foundation (t/m^3)
Use submerged unit weight if soil is under the ground water

α, β : Shape factor

Nc,Nr,Nq : Bearing capacity factor (function of internal friction of soil (ϕ))

Df : Depth from lowest point of ground which close to foundation, to bottom level of foundation (m)

B : Smallest width of bottom foundation (m)

Shape factor

Shape of bottom foundation	Continuous footing	Square	Rectangular	Circular
α	1.0	1.3	1.0+0.3(B/L)	1.3
β	0.5	0.4	0.5 - 0.1(B/L)	0.3

Bearing capacity factor

ϕ	Nc	Nr	Nq
0°	5.3	0	3.0
5	5.3	0	3.4
10	5.3	0	3.9
15	6.5	1.2	4.7
20	7.9	2.0	5.9
25	9.9	3.3	7.6
28	11.4	4.4	9.1
32	20.9	10.6	16.1
36	42.2	30.5	33.6
More than 40	95.7	114.0	83.2