# Design Specifications- Micropile Foundation System

| Zone | Total Piles | Average Length (ft) | Total Length |
|---|---|---|---|
| **1- Primary Area** | 233 | 65 | 15145 |
| **2-Radiotherapy Area (Linac Valuts)** | 70 | 65 | 4550 |
| **3-Shell Space & ED Canopy** | 84 | 65 | 5460 |
| **4- Bridge Connection** | 20 | 65 | 1300 |
| **Total** | **387 piles** | **65 ft** | **26455 ft** |

**Design Maximum Capacity:**

End-bearing Piles = 280 kips
Tension Piles = 180
Battered Piles = 300 kips axial, 4 kips lateral

## Geopier Calculations

(Based on GeoStructures Design Manual, Example Problem)

ZONE 1: PRIMARY AREA

**Structural Specifications:**

Column J5- 4 bearing piles, @ bearing design load of 280 kips each
4 Piles * 280 kips/pile = 1120 kips
Tributary Area = 992 sf
Distributed load = 1.13 ksf

**Soil Data:**

Undrained Shear strength, c(u) = 500 psf
Modulus of subgrade rxn. = 50 pci
Moist unit wt. = 120 pcf
Recommended allowable bearing capacity, shallow footings = 2000 psf

**Geopier Design Values**

For Silts and Clays, N=7 (Table 4.2 – Geopier Reference Manual)

Allowable composite footing bearing pressure, $q_f$ = 6000 psf
Geopier & Footing Segment Capacity, Qqp = 85 kips
Geopier Stiffness Modulus, Kp = 210 pci

Lower Zone Design Parameter, Es = 250 ksf (From Geopier Manual backup literature)

**Number of Geopiers required:**

Total Design Load = [1120 kips] / [90 kips per Geopier] = 12.4 → Try 12 Geopiers

**Footing Size and Composite Bearing Pressure:**

Est'd. Ftg size = 1120 kips / 6 ksf = 187 sf → Try 14' x 14' ftg.
Actual Ftg. Size = 196 sf
Composite bearing pressure, q = 1120 kips / 196 sf = 5.7 ksf = 5714 psf

**Upper Zone Settlement:**

Area Ratio, R(a) of footing area covered by Geopiers (30" diameter → 4.91 sf)

R(a) = 12 Geopiers * 4.91 / 196 sf = 0.30 = 30.06%

Stress Ratio (Geopier to Matrix soil stiffness ratio)

Matrix soil modulus, Km= [2000 psf] / [144 in^2 per ft^2] / [1 inch] = 13.9 pci
Stress Ratio, Rs = Kp / Km = 210 pci / 13.9 pci = 15.12

Maximum stress on Geopier:

q(qp) = q * Rs / (Ra*Rs –Ra +1) = [5714*15.12 ] / [.30*15.12 - .30 +1] = 16482.7 psf

Upper Zone Settlement Calc:

S(uz) = q(qp) / Kp = 16482.7 / 144 / 210 = 0.545 inches

**Lower Zone Settlement:**

Allowable LZ Settlement, S(lz) = 1.0" – 0.545" = 0.455 inches

Footing width, B = 14', UZ + LZ = 2B = 28 feet

*Try 10' Shaft Length*

UZ = shaft length + 1 diameter prestress zone = 10' +30 inches = 12.5 feet
LZ = 28' – 12.5' = 15.5 feet

Lower Zone Stress, qlz at center of Lower Zone (using Westergaard Stress Dist.)

Center of LZ depth = UZ + (LZ / 2) = 12.5' + (15.5 / 2) = 20.25 feet
f(B) = 20.25' / 14' = 1.45
From Westergaard- approximately 14% of composite footing bearing pressure

Q(lz) = 0.14 * 5174 = 776 psf = .776 ksf

Lower Zone Settlement

S(lz) = q(lz) / Es * LZ * 12 in/ft = 0.776 / 250 * 14 * 12 = 0.537 in > 0.455 in

*Settlement greater than 1", however still assume 10' shaft length for purposes of this investigation*

**Number of Geopiers required:**

31' x 31' Bay @ 10' x 8' Spacing → 36,733 sf / 992 * 12 = 444 Geopiers

Not all bays 31' x 31', Therefore use spacing standard to determine number required.

Per Grid Plan → 419 Total Geopier Elements

ZONE 2: RADIOTHERAPY ENCLOSURE

70 Piles * 280 kips/pile = 19600 kips
Total Area = 6000 sf
Distributed load = 3.26 ksf

**Number of Geopiers required:**

Total DL = [19600 kips] / [90 kips per Geopier] = 217 → Try 220 Geopiers

@ 5.5' x 5.5' Nominal Spacing → 228 Geopiers Total

ZONE 3: SHELL SPACE

84 Piles * 280 kips/pile = 23520 kips
Total Area = 13811 sf
Distributed load = 1.7 ksf

**Number of Geopiers required:**

Total DL = [23520 kips] / [90 kips per Geopier] = 261 → Try 260 Geopiers

The nature of this area requires a second look: 24 of the piles are located in a grade beam at the South end, all of which are battered (angled). However, 260 Geopiers will still be installed due to ambiguity in how this load distributes over a mat slab.

@ 8' x 7' Nominal Spacing → 269 Geopiers Total

**Geopier Summary:**

**Zone 1 = 419**
**Zone 2 = 228**
**Zone 3 = 269**
**Total = 916 Geopier Elements**

# Mat Slab Thickness Calculations

(Based on *Principles of Engineering,* Sixth Edition, Braja M. Das)

**Feasibility Analysis**: (uses foundation wall depth of 20' (typ.)

Soil Data**:** (from Geotechnical Report)

Undrained Shear strength, c(u) = 500 psf
Moist unit wt. = 120 pcf
D(f) = 20' + ?
Factor of Safety (shear) = 1.5 (typ.)
Φ = 22 degrees (internal angle of friction)
P = 1120 kips (from above)

D(f) calculation: q(net, ultimate) = 5.14*c(u)*[1+0.195B/L]*[1+ 0.4D(f)/B]

Zone 1: Using q(net, u) = P = 1120 kips:
Bay: 31' x 31' ftg. (B x L) (typical)

Using D(f) = 22' →3942.96 psf > 1129 psf OK- Determine Actual Thickness

**Mat Slab Thickness Determination**

Thickness Calculation: ΦV(c) = Φ4*sqrt(f'c)*b(0)*d
ΦV(c) = P
f'c = 4000 psi (based on structural specifications)
b = 2(b + d) + 2(c + d)
Φ = 0.85 (typical, punching shear)

**Zone 1**: Distributed Load = 1129 psf
Wall Depth = 20'
D(f) = ?
Column J-4: P = 1120 kips
Base Plate Dim's. = 22" x 22" (b x c)

→ d = 27" + 1" (dia. of reinforcing, 2 ways) + 3" (cover) = 33" = 2'-9" slab

**Zone 2:** Distributed Load = 3260 psf
Wall Depth = 20'
D(f) = ?

→ d = 49" + 2" (dia. of reinforcing, 2 ways) + 3" (cover) = 54" = 4'-6" slab
(Note, since no column point loads are in this area, b and c are assumed to be largest of base plates dimensions = 26" x 30")

**Zone 3:** Distributed Load = Not typical
Wall Depth = 20'
D(f) = ?
Pile Cap Q.5, 7.3: P = 560 kips
Base Plate Dim's. = 40.5" x 81" (b x c) (estimated)

→ d = 9" + 1" (dia. of reinforcing, 2 ways) + 3" (cover) = 13" → Use 15" slab

| FOUNDATION CONCRETE COSTS- EXISTING SLAB ON GRADE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CSI Code | Description | Qty. | Daily Output | Labor Hrs | Unit | Materials Unit Cost | Labor Unit Cost | Equipment Unit Cost | Total | Total, incl. O&P |
| 3310-700-3900 | Structural concrete, placing, pile caps, pumped, 6 C.Y. to 10 C.Y., includes vibrating, excludes material | 562.73 | 200 | 0.32 | C.Y. | $0.00 | $7.10 | $3.76 | $10.86 | $9,031.82 |
| 3310-240-4050 | Structural concrete, in place, foundation mat, over 20 C.Y., includes forms(4 uses), reinforcing steel, and finishing | 2614 | 56.5 | 1.986 | C.Y. | $144.00 | $50.00 | $0.42 | $194.42 | $637,816.00 |
| 3310-220-0300 | Structural concrete, ready mix, normal weight, 4000 PSI, includes material only | 3186 | | | C.Y. | $84.00 | $0.00 | $0.00 | $84.00 | $294,705.00 |
| | Pile Installation | | | | | | | | | $1,250,000.00 |
| **Totals** | | | | | | **$228.00** | **$57.10** | **$4.18** | **$289.28** | **$941,552.82** |



| FOUNDATION CONCRETE COSTS- PROPOSED MAT SLAB | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CSI Code | Description | Qty. | Daily Output | Labor Hrs | Unit | Materials Unit Cost | Labor Unit Cost | Equipment Unit Cost | Total | Total, incl. O&P |
| 3310-240-4050 | Structural concrete, in place, foundation mat, over 20 C.Y., includes forms(4 uses), reinforcing steel, and finishing | 5381 | 56.5 | 1.986 | C.Y. | $144.00 | $100.00 | $0.42 | $244.42 | $1,582,014.00 |
| | Geopier Installation | 916 | | | Ea. | | | | $675.00 | $618,300.00 |
| 3310-220-0300 | Structural concrete, ready mix, normal weight, 4000 PSI, includes material only | 5381 | | | C.Y. | $84.00 | $0.00 | $0.00 | $84.00 | $497,742.50 |
| **Totals** | | | | | | **$228.00** | **$100.00** | **$0.42** | **$1,003.42** | **$2,698,056.50** |

**Assume: Two crews working on mat slab pour = 2x labor costs**
**Geopier cost/element based on rough estimate provided by Geopier professional**
**Pile Installation based on contract value provided by Gilbane**