Foundation Repairs
When Do You Elevate An Existing Slab On Grade?
Full Lift Underpin

PIERS
Engineered Repair Plan

Total Number Of Piers = 50
History of Full Lift Underpinning

- Started in North Texas 1998-1999
  (popular in Houston before)

- From 1998-Present over 2,500 in North Texas
  over 10,000 in all of Texas
Analysis Of Suspended Slab
Typical Loading

LL = 16 PSF
DL = 15 PSF

LL = 40 PSF
DL = 15 PSF

LL = 40 PSF
DL = 100 PSF
TOTAL
LL = 96 PSF
DL = 130 PSF

WALL/BRECK = 45 PSF x 20' = 900 PLF
TOTAL PERIMETER LOAD WALL + FLOOR = 1500 PLF
Two Way Action

Full support on each side

½ (D.L. & L.L.)

M⁻ = 0.46 kip·ft
M+ = 0.23 kip·ft

Two Way Action

Full support on each side

M⁻ = -0.37 kip·ft
M+ = 0.19 kip·ft
### Method 3—Table 4—Ratio of Load \( w \) in \( A \) and Shear in Slab and Load on Support

<table>
<thead>
<tr>
<th>Ratio ( m = \frac{A}{B} )</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
<th>Case 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 ( W_A )</td>
<td>0.50</td>
<td>0.50</td>
<td>0.17</td>
<td>0.50</td>
<td>0.83</td>
<td>0.71</td>
</tr>
<tr>
<td>( W_B )</td>
<td>0.50</td>
<td>0.50</td>
<td>0.83</td>
<td>0.50</td>
<td>0.17</td>
<td>0.29</td>
</tr>
<tr>
<td>0.95 ( W_A )</td>
<td>0.55</td>
<td>0.55</td>
<td>0.20</td>
<td>0.55</td>
<td>0.86</td>
<td>0.75</td>
</tr>
<tr>
<td>( W_B )</td>
<td>0.45</td>
<td>0.45</td>
<td>0.80</td>
<td>0.45</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td>0.90 ( W_A )</td>
<td>0.60</td>
<td>0.60</td>
<td>0.23</td>
<td>0.60</td>
<td>0.88</td>
<td>0.79</td>
</tr>
<tr>
<td>( W_B )</td>
<td>0.40</td>
<td>0.40</td>
<td>0.77</td>
<td>0.40</td>
<td>0.12</td>
<td>0.21</td>
</tr>
</tbody>
</table>
DESIGN

T = 4"

SPAN

f'_c = 3,000 psi

ACTUAL

T = 4.5" TO 5"

SPAN

f'_c ≈ 2,500 - 4,000 psi
### Design Method

#### PT Slab Analysis

<table>
<thead>
<tr>
<th>Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab</td>
<td>2500 mm</td>
</tr>
<tr>
<td>Beam</td>
<td>150 mm</td>
</tr>
</tbody>
</table>

### Calculate Slab Working Stress

- **Longest Span (L)**: 12.0 m
- **Allowable Stress (s)**: 0.75

#### Slab Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (d)</td>
<td>350 mm</td>
</tr>
<tr>
<td>Span (s)</td>
<td>2500 mm</td>
</tr>
<tr>
<td>Beam Depth (d)</td>
<td>150 mm</td>
</tr>
</tbody>
</table>

#### Beam Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (d)</td>
<td>350 mm</td>
</tr>
<tr>
<td>Span (s)</td>
<td>2500 mm</td>
</tr>
</tbody>
</table>

### Effective Section Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (A)</td>
<td>93400</td>
</tr>
<tr>
<td>Moment of Inertia (Iy)</td>
<td>38600</td>
</tr>
<tr>
<td>Second Moment of Area (Iy)</td>
<td>83600</td>
</tr>
</tbody>
</table>

### Calculate Flexural Capacity (SFM)

- **Effective Depth (d)**: 350 mm
- **Effective Span (s)**: 2500 mm

### Slab Moment | Slab Span | Ultimate
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment (M)</td>
<td>2440 kNm</td>
<td>1600 kNm</td>
</tr>
<tr>
<td>Worked</td>
<td>1600 kNm</td>
<td>1600 kNm</td>
</tr>
<tr>
<td>Ultimate</td>
<td>1600 kNm</td>
<td>1600 kNm</td>
</tr>
</tbody>
</table>

### Total Tension (T) | Short Span | Long Span
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1250 kN</td>
<td>1250 kN</td>
</tr>
</tbody>
</table>

This calculation assumes the slab is in the OK condition.
Hilburn Project
Capacity Analysis of Existing Post-Tensioned Slab
Prepared on February 27, 2013

3D physical model of slab showing raised slab, beams and push piles.
3D Finite Element Analytical Model used to accurately calculate demand on slab and inherent capacity.

All tendons in slab are faithfully modeled: slab and beam tendons.
Hilburn Project
Service Sustained Load - Uniform Load
FIN GRADE

REPLACE & COMPACT NATIVE SOIL

STEEL SHIM OVER CONCRETE CYLINDER

BACK FILL & COMPACT NATIVE SOIL TO CREATE A 4" MIN VOID AT BOTTOM OF BEAM AND AT PIER LOCATIONS, TO PROVIDE DRAINAGE PATH FOR WATER (1/8"/FT-MIN SLOPE)

CONCRETE OR STEEL PUSH PILE

NEw EXTERIOR PIER

NEW INTERIOR PIER AT BEAM INTERSECTION SEE PLAN FOR LOCATIONS

ACCESS AREA AS REQ'd

ACCESS AREA AS REQ'd

CONCRETE CAP

CHIP BOTTOM OF BEAM SMOOTH FOR UNIFORM BEARING SURFACE TYP
TYPICAL EXTERIOR PILING
TYPICAL INTERIOR PILING
FLAT SLAB REPAIR
TYPICAL TUNNEL
ACI 437

States the engineering analysis should be for strength and not design code compliance. ACI 437 states: “Engineering judgement is critical in the strength evaluation of reinforced concrete buildings. Judgement of qualified structural engineers may take precedence over compliance with code provisions or formulas for analyses that may not be applicable to the case studies.”
Whenever there is a reasonable doubt as to the stability or load-bearing capacity of a completed building, structure or portion thereof for the expected loads, an engineering assessment shall be required. The engineering assessment shall involve either a structural analysis or an in-situ load test, or both. The structural analysis shall be based on actual material properties and other as-built conditions that affect stability or load-bearing capacity, and shall be conducted in accordance with the applicable design standards.
Actual Load Test
Load Test Photos
Load Test Photos
Load Test Photos
# Floor Load Test

**Floor Load Test**

**Floor Load Test at 2124 Gate Point Way, Arlington, Texas**

**Rone Job No. 00-3874**

<table>
<thead>
<tr>
<th>Date</th>
<th>West half load (inches of water)</th>
<th>East half load (inches of water)</th>
<th>Gauge 1 disp (inches)</th>
<th>Gauge 2 disp (inches)</th>
<th>Gauge 3 disp (inches)</th>
<th>Gauge 4 disp (inches)</th>
<th>Gauge 5 disp (inches)</th>
<th>Gauge 6 disp (inches)</th>
<th>Gauge 7 disp (inches)</th>
<th>Gauge 8 disp (inches)</th>
<th>Gauge 9 disp (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/16/2000</td>
<td>0</td>
<td>0</td>
<td>0.006</td>
<td>0.006</td>
<td>0.003</td>
<td>0.006</td>
<td>0.006</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>07/17/2000</td>
<td>5.5</td>
<td>0</td>
<td>0.006</td>
<td>-0.011</td>
<td>-0.001</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.201</td>
</tr>
<tr>
<td>07/17/2000</td>
<td>11</td>
<td>0</td>
<td>0.002</td>
<td>-0.003</td>
<td>-0.001</td>
<td>-0.001</td>
<td>-0.001</td>
<td>-0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.201</td>
</tr>
<tr>
<td>07/16/2000</td>
<td>18.5</td>
<td>0</td>
<td>0.003</td>
<td>-0.006</td>
<td>-0.002</td>
<td>0.006</td>
<td>0.001</td>
<td>-0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.201</td>
</tr>
<tr>
<td>07/20/2000</td>
<td>22</td>
<td>0</td>
<td>0.003</td>
<td>-0.006</td>
<td>-0.002</td>
<td>0.001</td>
<td>0.006</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>07/21/2000</td>
<td>22</td>
<td>5.5</td>
<td>0.001</td>
<td>-0.048</td>
<td>-0.020</td>
<td>0.006</td>
<td>-0.007</td>
<td>-0.004</td>
<td>-0.001</td>
<td>-0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>07/22/2000</td>
<td>22</td>
<td>11</td>
<td>0.009</td>
<td>-0.009</td>
<td>-0.021</td>
<td>0.001</td>
<td>-0.029</td>
<td>-0.006</td>
<td>-0.002</td>
<td>-0.004</td>
<td>0.000</td>
</tr>
<tr>
<td>07/23/2000</td>
<td>22</td>
<td>18.5</td>
<td>0.009</td>
<td>-0.009</td>
<td>-0.011</td>
<td>0.003</td>
<td>-0.027</td>
<td>-0.007</td>
<td>-0.004</td>
<td>-0.007</td>
<td>0.000</td>
</tr>
<tr>
<td>07/24/2000</td>
<td>22</td>
<td>22</td>
<td>0.001</td>
<td>-0.009</td>
<td>-0.021</td>
<td>0.003</td>
<td>-0.027</td>
<td>-0.007</td>
<td>-0.004</td>
<td>-0.007</td>
<td>0.000</td>
</tr>
<tr>
<td>07/25/2000</td>
<td>22</td>
<td>22</td>
<td>0.002</td>
<td>-0.052</td>
<td>-0.030</td>
<td>0.004</td>
<td>-0.038</td>
<td>-0.010</td>
<td>-0.008</td>
<td>-0.012</td>
<td>0.000</td>
</tr>
<tr>
<td>07/26/2000</td>
<td>26</td>
<td>26</td>
<td>0.003</td>
<td>-0.054</td>
<td>-0.040</td>
<td>0.005</td>
<td>-0.040</td>
<td>-0.016</td>
<td>-0.006</td>
<td>-0.012</td>
<td>0.000</td>
</tr>
<tr>
<td>07/27/2000</td>
<td>30</td>
<td>30</td>
<td>0.003</td>
<td>-0.056</td>
<td>-0.042</td>
<td>0.008</td>
<td>-0.041</td>
<td>-0.012</td>
<td>-0.010</td>
<td>-0.012</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Note:**
- **Upward disp**: (+)
- **Downward disp**: (-)
- **Gauge 6 was not functioning properly**

RONE/JOB/2000/380/TS/00-3874/BOOK5.XLS
Questions?
LESSONS LEARNED
Roof Gutters and Downspout Placement
Undrained Bathtub
Over Excavation and Backfill with Select fill “BATH TUB”

OVER EXCAVATE BACKFILL w/ SELECT FILL

UNDRAINED BATH TUB
Over Excavation and Backfill with Select fill “BATH TUB”

OVER EXCAVATE BACKFILL w/ SELECT FILL

OVER EXCAVATE BACKFILL w/ DRAINED FILL
Building Off of Moisture Conditioned Pad
Plumbing Problems and Moisture Problems with Foundation on Void Boxes
Previous Tree Rows and Uneven Soil Moisture Conditions
EXISTING SITE
Incompatible Foundation Systems

PIERS w/ SLAB-ON-GRADE

PIERS w/ SLAB-ON-GRADE
Incompatible Foundation Systems

PIERS w/ SLAB-ON-GRADE
- Metal Building Type: Slab-On-Grade
- P.I. = 20 – 30  
  - 4” S.O.G. Turned Down
- P.V.R. < 1”  
  - Exterior Grade Beam
Movement Where Partition Wall Meets Exterior Wall
Effect of Post-Tensioning

EFFECTS OF PT SHORTINING
Effect of Post-Tensioning cont.
Corner Cracks
Corner Cracks
FOUNDATION MAINTENANCE

Proper foundation maintenance will minimize differential soil movement. Because of heavy rains at certain times of the year, it is impossible to keep moisture away from the foundation. However, good drainage will control excessive moisture, and this is very important. Excessive drying of the soil can be prevented by controlled watering around the foundation during dry seasons. Trees and other large vegetation accelerate the drying process, and careful consideration should be given when planting. Proper landscaping and ground cover will help prevent drying. Some recommended steps for foundation maintenance and care are listed below:

- Maintain positive drainage away from the foundation with a suggested slope of four inches in the first six feet away from the foundation.
- Fill any depressions adjacent to or near the foundation with native soil. Do not use sand or other granular materials.
- Check gutters and downspouts to be sure that water is discharged away from the foundation area.
- Water liberally around the foundation during dry spells. This should be done in a uniform manner around the entire house to prevent uneven soil movement. This will include the areas of the yard where there is no grass or plants. Automatic lawn sprinkling or automatic foundation soaker hose systems may be installed and are very beneficial.
- Plant trees a distance away from the foundation equal to their anticipated height. If existing trees are near the foundation, they will draw added water from the foundation thus requiring more water within this area. Sometimes tree roots that go under the foundation will need to be out and a barrier trench installed to prevent new roots from growing under the foundation.
- Cracks in the soil from drying should not be allowed to form. If they do, gradual watering should be applied adjacent to the cracks so that they will close. Water should not be placed directly into the open cracks.

The object of a proper maintenance program is to attain as constant a moisture content as is possible for the soil under the foundation and the perimeter of the house. Special emphasis must be made in watering programs during dry seasons and the effect that trees have in the removal of soil moisture during these dry seasons.
Questions?