STRUCTURAL CALCULATIONS

For

Post-Tensioned
BEAM AND ONE-WAY SLAB CONSTRUCTION

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Kowloon

August 16, 2009 - revised
OVERVIEW AND SCOPE
This report presents the structural engineering calculations of a post-tensioned floor using parallel beams and one-way slab construction. The design is based on Hong Kong building code HKCOP 2004 and its amendment of June 2007. The general criteria used for the design, such as details of material properties are given in a separate report entitled “Structural Design Criteria.” Features of the geometry and details of loads applicable to the floor slab covered by this report are included herein.

The requirements called for a “Class 3” design. This means that the computed tensile stresses at the extreme fibers are permitted to exceed \(0.36\sqrt{f_{cu}}\). For the specified concrete material of 65 MPa cube strength, this translates to tensile stresses exceeding 2.90 MPa. At the same time, the computed stresses shall not exceed 0.25\(f_{cu}\). For regions, where stresses exceed the first threshold (viewed as onset of cracking), but are below the second threshold (maximum allowable), reinforcement is added to limit the crack width to 0.2 mm.

To meet the design requirements, a low value for post-tensioning had to be specified, in order to induce cracking in the floor system.

The design moment of the slab is modified for each design section to include the twisting moment of the same section (Wood-Armer) approximation. In the general case, the design moments used for the determination of reinforcement are somewhat larger than the actual bending moments generated in the slab when the Wood-Armer approximation of the program is invoked. However, the impact for the floor system reported herein is small, since the one-way system is small.

The design uses the program ADAPT Floor Pro release 2009/2010 featuring the Hong Kong Code.

A review of the design values suggests that a more balanced design option for the subject matter floor slab would be to increase the amount of post-tensioning provided. It is noted that an undue amount of non-prestressed reinforcement is calculated and added in the design to reduce the crack width to the maximum allowable value. For the design reported herein, the amount of non-prestressed reinforcement would be reduced substantially by a moderate increase in post-tensioning. However, the post-tensioning was kept at a low value to achieve a Class 3 design alternative.

LIST OF CONTENTS
- Structural Design Criteria for the Project – (submitted in a separate package)
  - Input data
    - S3 Reflection of program printout of input design criteria
    - S4.1 Structure plan. There may be more than one sheet. This may have to include sections, column and wall dimensions, steps, openings and possibly labels. It should give a fill definition of structure.
    - S4.2 3D line drawing view of the structure
    - S5 loading assumptions and calculation
    - S6 Load plans
    - S7 Tendon plan
  - Analysis and Design Values
    - S15 Finite Element discretization (mesh plan)
    - S20 Long-term deflection due to dead and live load
    - S21 Instantaneous deflection due to live load
    - S22 Support line identification is x-direction (includes label and span length)
    - S23 support line identification in y- direction
    - S24 design strip display in x-direction
    - S25 design strip display in y-direction
S3 - REFLECTION OF PROGRAM PRINTOUT OF INPUT DESIGN CRITERIA

117 MATERIALS

117.20 CONCRETE MATERIAL PROPERTIES

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<th>ID</th>
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<th>Unit Weight</th>
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<th>Ec</th>
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f'c = strength at 28 days
Ec = modulus of elasticity at 28 days

117.40 REINFORCEMENT (NONPRESTRESSED) MATERIAL PROPERTIES

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fy = yield stress of longitudinal reinforcement
fvy = yield stress of one-way shear reinforcement
Es = modulus of elasticity

117.60 PRESTRESSING MATERIAL PROPERTIES

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fpu = ultimate stress
fpy = yield stress
Eps = modulus of elasticity

142 CODES AND ASSUMPTIONS

142.15 TORSIONAL STIFFNESS OF BEAMS ACCOUNTED FOR
142.16 TORSIONAL STIFFNESS OF LOWER COLUMNS ACCOUNTED FOR
142.17 TORSIONAL STIFFNESS OF UPPER COLUMNS ACCOUNTED FOR

142.20 MATERIAL AND STRENGTH REDUCTION FACTORS

For concrete = 1.50
For nonprestressed steel = 1.15
For prestressed steel = 1.15

142.30 COVER TO REINFORCEMENT

Slabs
Prestressing Tendons (CGS)
   At top = 32
   At bottom = 42 mm
Nonprestressing reinforcement (cover)
   At top = 25 mm
   At bottom = 35 mm

Beams
Prestressing Tendons (CGS)
   At top = 50 mm
   At bottom = 54 mm
Nonprestressing reinforcement (cover)
   At top = 25 mm
   At bottom = 35 mm

142.40 MINIMUM BAR LENGTH

Slabs
   Cut off length of minimum steel over support (length/span) = 0.17
   Cut off length of minimum steel in span (length/span) = 0.33

Beams
   Cut off length of minimum steel over support (length/span) = 0.17
   Cut off length of minimum steel in span (length/span) = 0.33

143 DESIGN CRITERIA
SLABS AND BEAMS

Service (final) stresses
Tension stress as multiple of \((f'cu)^{1/2}\)
   At top fibers = 0.57
   At bottom fibers = 0.57
Compression stress as multiple of \(f'c\)
   At top fibers = 0.33
   At bottom fibers = 0.33

Initial (transfer) stresses
Tension stress as multiple of \((f'cu)^{1/2}\)
   At top fibers = 0.36
   At bottom fibers = 0.36
Compression stress as multiple of \(f'c\)
   At top fibers = 0.50
   At bottom fibers = 0.50

146 LOAD CASES AND COMBINATIONS

1 Table 12.2 and 12.3 lead to different values of allowable stress for the slab and the beam due to different member thickness. However, as indicated above, conservatively the lower value of allowable stress applicable to the beam depth is used.
146.20 LOAD CASES
  Dead load
  Live load
  Selfweight
  Prestressing
  Hyperstatic
  Lateral_1

146.40 LOAD COMBINATIONS
  Name: Service
    Evaluation: SERVICEABILITY
    Combination detail: 1.00 x Selfweight + 1.00 x Dead load + 1.00 x Live load + 1.00 x Prestressing
  Name: Strength
    Evaluation: STRENGTH
    Combination detail: 1.40 x Selfweight + 1.40 x Dead load + 1.60 x Live load + 1.00 x Hyperstatic
  Name: Initial
    Evaluation: INITIAL
    Combination detail: 1.00 x Selfweight + 1.15 x Prestressing
  Name: Prestress
    Evaluation: NO CODE CHECK
    Combination detail: 1.00 x Prestressing
  Name: deflection_sustained
    Evaluation: NO CODE CHECK
    Combination detail: 1.00 x Selfweight + 1.00 x Dead load + 0.25 x Live load + 1.00 x Prestressing
  Name: SWGT
    Evaluation: NO CODE CHECK
    Combination detail: 1.00 x Selfweight
  Name: Live
    Evaluation: NO CODE CHECK
    Combination detail: 1.00 x Live load
  Name: Deflection_cracking
    Evaluation: CRACKED DEFLECTION
    Combination detail: 1.00 x Selfweight + 1.00 x Dead load + 0.25 x Live load + 1.00 x Prestressing
S4.1 – STRUCTURE PLAN
The following partial plan shows the general arrangement of the floor system designed.

FIGURE S4.1-1 GENERAL LAYOUT OF THE FLOOR SYSTEM
The geometry of the model generated for the analysis and design is shown below.

**FIGURE S4.1-2 STRUCTURE PLAN SHOWING THE OUTLINE OF THE POST-TENSIONED SLAB, AND ITS GEOMETRY IN THE ANALYSIS MODEL**
(S = Square; slab thickness 200 mm)

**FIGURE S4-2 THREE DIMENSIONAL VIEW OF THE POST-TENSIONED SLAB AND ITS SUPPORT ARRANGEMENT**
The slab and beam connection over the walls at the two ends of the floor system are assume rotationally free with no transfer of shear. The walls provide vertical support only.

S5 – LOADING ASSUMPTIONS AND VALUES

From the design criteria, in addition to the selfweight, the structure is designed for a uniformly distributed superimposed dead load of 5.00 kN/m² and uniformly distributed live load of 10.00 kN/m². The loads generated in the design model are illustrated in following views from the analysis model.

S6 – LOAD PLANS

FIGURE S6-1 SPECIFIED UNIFORM LOAD ON THE POST-TENSIONED FLOOR (NOT INCLUDING SELFWEIGHT) SDL = 5.00 kN/m²; LL= 10.00 kN/m²
S7 - POST-TENSIONING TENDON LAYOUT

FIGURE S7-1 POST-TENSIONING TENDON LAYOUT

FIGURE S7-2 3D VIEW OF POST-TENSIONING TENDON LAYOUT
(exaggerated vertical scale to illustrate the features of tendon profiles)
Figure S7-3 shows the details of tendon layout. Tendons in the slab are spaced fairly uniformly at about 1.8 m spacing. Each tendon has typically 2 strands, except those adjacent to the columns, where tendons are provided with 3 strands each. The beams have four tendons, two with five strands and the remainder with three strands each.

Control point heights shown indicate the distance of soffit from the center of gravity of strands (CGS). The profile of tendons in the slab is generally reversed parabola, with a cantilever down shape at both ends. The beam tendons are modeled with a partial parabola profile.

**FIGURE S7-3** TENDON CONTROL HEIGHTS (CGS – center of gravity) AND NUMBER OF STRANDS (S=2 means two strands in the tendon)
FIGURE S7-4  ENLARGED VIEW OF TENDON CGS

FIGURE S7-5  ELEVATION OF A TYPICAL BEAM TENDON  
(exaggerated vertical scale)

FIGURE S7-6  ELEVATION OF A TYPICAL SLAB TENDON  
(exaggerated vertical scale)
FIGURE S7-7  PERCENTAGE OF TRIBUTARY SELFWEIGHT BALANCED BY THE BEAM TENDONS
ANALYSIS AND DESIGN VALUES

S15 – FINITE ELEMENT DISCRETIZATION
The structure is discretized in well proportioned quadrilateral finite element cells for improved analysis results (Fig. S15-1).

FIGURE S15-1 VIEW OF FINITE ELEMENT MESH USED FOR ANALYSIS

S20 –DEFLECTIONS – CHARACTERISTIC AND LONG-TERM
The deflection profiles of the floor system under different scenarios of loading are given below
**FIGURE S20-1 IMMEDIATE DEFLECTION BASED ON GROSS CROSS-SECTION (UNCRAKED) DUE TO CHARACTERISTIC LOAD COMBINATION (1.0DL + 1.0LL + 1.0PT).**

Maximum deflection at the tip of overhangs is 30.1mm. Typical interior slab deflection is about 9mm.

**FIGURE S20-2 IMMEDIATE DEFLECTION BASED ON CRACKED SECTION DUE TO CHARACTERISTIC LOAD COMBINATION (1.0DL + 1.0LL + 1.0PT).**

Maximum deflection is 47.7mm.
Note that cracking has increased the deflection by about 50%

The maximum loss of stiffness is at the connection of the overhang to the beam, where the negative moments have reduced the slab stiffness to 63% of its uncracked value.

The design did not lead to cracking due to moments about X-X direction.

**LONG-TERM DEFLECTION**

The long-term deflection is determined from the cracked deflection under sustained loads adjusted to account for the impact of creep and shrinkage.

Sustained load combination: 1.0DL + 0.25LL + 1.0Prestressing

The maximum instantaneous deflection due to sustained load combination (diagram below) is 17.6mm at the tip of the overhangs. Max cracked deflection for the typical interior slab is 5.6mm. Hence the estimated long term deflection would be:

Estimated long-term deflection  = 17.6 x 3 = 52.8mm

The overhang deflection clearly indicates that the slab thickness selected for the cantilever is not adequate. Also, it is important to note that for code compliance and acceptability of long-term...
deflection, one has to determine the fraction of deflection that takes place subsequent to installation of non-structural elements that are likely to be damaged.\(^2\)

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\(^2\) ADAPT Technical Note TN292 Deflection of Concrete Floors
S22 – SUPPORT LINES IN X-DIRECTION
The identification of the support lines used for design and the span lengths are shown in the following two figures.
S23 – SUPPORT LINES IN Y-DIRECTION

FIGURE S23-1 VIEW OF SUPPORT LINES AND SUPPORT LINE SPACING ALONG Y-DIRECTION

S24 and S25 DESIGN STRIPS IN THE TWO ORTHOGONAL DIRECTIONS

The following two figures show the break down of the floor system into design strips for design purposes,
S26 AND S27 DISTRIBUTION OF DESIGN MOMENTS AND DESIGN STRIP STRESSES

The following two figures show the distribution of design moments (strength combination) for each of the design strips.

FIGURE S24-1 DEIGN STRIPS IN X-DIRECTION

FIGURE S25-1 DEIGN STRIPS IN Y-DIRECTION
FIGURE S26-1 DISTRIBUTION OF DESIGN MOMENTS ALONG X-X DIRECTION

FIGURE S26-2 DISTRIBUTION OF DESIGN STRESSES ALONG X-DIRECTION
(tension positive; compression negative; values in MPa)
FIGURE S27-1 DISTRIBUTION OF DESIGN MOMENTS ALONG Y-DIRECTION

FIGURE S27-2 DISTRIBUTION OF DESIGN STRESSES ALONG Y-DIRECTION
(tension positive; compression negative; values in MPa)
S28 AND S29 STRESS CHECK DIAGRAMS FOR X- AND Y-DIRECTIONS

The following two figures show the outcome of stress checks for each of the design sections. Broken/pink lines, if any, indicate the location where stresses exceed the code allowable values. Details of stress check and stress values for each support line are shown later in the report. Reinforcement is added, where computed tensile stresses exceed the specified threshold.

The following figure for stresses in the slab show broken lines at the base of the cantilever. This indicates stresses exceeding the upper value of the code for class 3. The values of the stresses calculated are shown in Fig. 28-2 for the central support line.

![Stress Check Outcome for Support Lines Along X-Direction](image)

FIGURE S28-1 STRESS CHECK OUTCOME FOR SUPPORT LINES ALONG X-DIRECTION (at dotted line, reinforcement will be provided)

The following diagram shows the values of stresses at the top fiber of the slab. Note that the maximum stress occurs at the connection of the overhang to the beams. Over the beams the stresses drop sharply in value. The lower horizontal line (drawn at 4.64 MPa) is the limit for allowable tensile stress for Class 2 design. The upper horizontal line (drawn at 16.25 MPa) is the upper limit for Class 3 design. The region between the two horizontal lines is the field for which the program adds rebar for crack control. The amount of rebar added can be read off (or reported in a table) under the “service load condition.”

Strictly speaking, post-tensioning should be added over the cantilever region to bring the calculated stress within the two horizontal lines.
FIGURE S28-2 DISTRIBUTION OF TOP FIBER STRESSES IN THE SLAB ALONG X-X DIRECTION FOR SERVICE LOAD COMBINATION (TOTAL) (tension shown positive)

FIGURE S29-1 STRESS CHECK OUTCOME FOR SUPPORT LINES ALONG Y-DIRECTION (All solid lines, OK)
S30 – DESIGN SUMMARY LEGEND

This legend is provided as an aid for the interpretation of the results that follow. In the following, each page reflects the design outcome and summary of one of the support lines. The summary includes stress check, distribution of design moment, and the total reinforcement for each design strip.
S31 – DESIGN SUMMARY OF INDIVIDUAL DESIGN STRIPS

Calculated stress is shown against the background of allowable values. The threshold for Class 3 design is marked with horizontal lines at 4.6 and 16.25 MPa tension. Required rebar is shown by the bar chart at the bottom. The provided rebar is shown by the envelope covering the required values.

DESIGN STRIP 1

(a) Max tension 16.0 N/mm², Allowable 4.6 N/mm²
Max compression -8.6 N/mm², Allowable 21.4 N/mm²

(b) Max tension 6.4 N/mm², Allowable 4.6 N/mm²
Max compression -18.0 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

DESIGN STRIP REINFORCEMENT
REQUIRED AND PROVIDED
DESIGN STRIP 2

Stress Diagrams
Project: General name / Load Case: Service
1.00 x Selfweight + 1.00 x Dead load + 1.00 x Live load + 1.00 x Prestressing
Tensile Stress Positive

Allowable Stresses

Tensile Stress Positive

(a) Max tension 17.4 N/mm², Allowable 4.6 N/mm²
Max compression -8.7 N/mm², Allowable 21.4 N/mm²

(b) Max tension 6.6 N/mm², Allowable 4.6 N/mm²
Max compression -19.5 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

Moment Diagrams
Project: General name / Load Case: Strength
1.40 x Selfweight + 1.40 x Dead load + 1.60 x Live load + 1.00 x Hyperstatic
Moment Drawn on Tension Side

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

Rebar Diagrams
Project: General name / Load Case: Envelope

DESIGN STRIP REINFORCEMENT
REQUIRED AND PROVIDED
DESIGN STRIP 3

Stress Diagrams
Project: General name / Load Case: Service
1.00 x Selfweight + 1.00 x Dead load + 1.00 x Live load + 1.00 x Prestressing
Tensile Stress Positive

Allowable Stresses

Span 1 Span 2 Span 3 Span 4 Span 5

Stress [N/mm²]
-15 -10 -5 0 5

(a) Max tension 16.0 N/mm², Allowable 4.6 N/mm²
Max compression -8.6 N/mm², Allowable 21.4 N/mm²

(b) Max tension 6.4 N/mm², Allowable 4.6 N/mm²
Max compression -18.0 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

Moment Diagrams
Project: General name / Load Case: Strength
1.40 x Selfweight + 1.40 x Dead load + 1.60 x Live load + 1.00 x Hyperstatic
Moment Drawn on Tension Side

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

Rebar Diagrams
Project: General name / Load Case: Envelope
Rebar Required Top
Rebar Provided Top
Rebar Required Bottom
Rebar Provided Bottom

DESIGN STRIP REINFORCEMENT
REQUIRED AND PROVIDED
DESIGN STRIP 4

Stress Diagrams
Project: General name / Load Case: Service
1.00 x Selfweight + 1.00 x Dead load + 1.00 x Live load + 1.00 x Prestressing
Tensile Stress Positive

Allowable Stresses

Span 1 Span 2 Span 3 Span 4

-2.0 -1.5 -1.0 -0.5 0.0 0.5
Stress [N/mm²]

Tensile Stress Positive

Span 1 Span 2 Span 3 Span 4

-2.0 -1.5 -1.0 -0.5 0.0 0.5
Stress [N/mm²]

Allowable Stresses

(a) Max tension 0.0 N/mm², Allowable 4.6 N/mm²
Max compression -1.3 N/mm², Allowable 21.4 N/mm²

(b) Max tension 0.7 N/mm², Allowable 4.6 N/mm²
Max compression -2.0 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

Moment Diagrams
Project: General name / Load Case: Strength
1.40 x Selfweight + 1.40 x Dead load + 1.60 x Live load + 1.00 x Hyperstatic
Moment Drawn on Tension Side

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

Rebar Diagrams
Project: General name / Load Case: Envelope

DESIGN STRIP REINFORCEMENT REQUIRED AND PROVIDED
DESIGN STRIP 5

Stress Diagrams
Project: General name / Load Case: Service
1.00 x Selfweight + 1.00 x Dead load + 1.00 x Live load = 1.00 x Prestressing
Tensile Stress Positive

Allowable Stress in Reinforcement
Allowable Stress

Stress [N/mm²]
Top
Allowable Stresses
Allowable Stresses with Reinforcement

Tensile Stress Positive

(a) Max tension 0.0 N/mm², Allowable 4.6 N/mm²
Max compression -1.3 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

(b) Max tension 0.8 N/mm², Allowable 4.6 N/mm²
Max compression -1.7 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

Moment Diagrams
Project: General name / Load Case: Strength
1.40 x Selfweight + 1.40 x Dead load + 1.60 x Live load = 1.00 x Hyperstatic
Moment Drawn on Tension Side

DESIGN STRIP REINFORCEMENT REQUIRED AND PROVIDED
DESIGN STRIP 6

Stress Diagrams
Project: General name / Load Case: Service
1.00 x Selfweight + 1.00 x Dead load + 1.00 x Live load + 1.00 x Prestressing
Tensile Stress Positive

Allowable Stresses

Top
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Span 1 Span 2 Span 3 Span 4

Span 1 Span 2 Span 3 Span 4

Stress [N/mm²]

Allowable Stresses with Reinforcement

Span 1 Span 2 Span 3 Span 4

(a) Max tension 0.0 N/mm², Allowable 4.6 N/mm²
Max compression -1.3 N/mm², Allowable 21.4 N/mm²
(b) Max tension 0.8 N/mm², Allowable 4.6 N/mm²
Max compression -1.7 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

Moment Diagrams
Project: General name / Load Case: Strength
1.40 x Selfweight + 1.40 x Dead load + 1.60 x Live load + 1.00 x Hyperstatic
Moment Drawn on Tension Side

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

Rebar Diagrams
Project: General name / Load Case: Envelope
Rebar [mm²]
Rebar Required Top
Rebar Required Bottom
Rebar Provided Top
Rebar Provided Bottom

DESIGN STRIP REINFORCEMENT
REQUIRED AND PROVIDED
(a) Max tension 0.0 N/mm², Allowable 4.6 N/mm²
Max compression -1.3 N/mm², Allowable 21.4 N/mm²

(b) Max tension 0.7 N/mm², Allowable 4.6 N/mm²
Max compression -2.0 N/mm², Allowable 21.4 N/mm²

DESIGN STRIP SERVICE COMBINATION STRESSES
(Tension stress positive)

DESIGN STRIP "DESIGN MOMENT (Mu)"
(Moment is drawn on the tension side)

DESIGN STRIP REINFORCEMENT REQUIRED AND PROVIDED
S32 – REINFORCEMENT PLAN FROM COMPUTATION

S32.1 – SLAB REINFORCEMENT

Figure S32-1 shows the reinforcement as reported by the software. This figure forms the basis of the reinforcement shown on the construction drawings. In addition to the reinforcement shown in the figure, the construction drawings include trim bars and simplifications in layout.
No non-prestressed reinforcement was required in the beams, since the post-tensioning provided was more than adequate and the beams were not cracked under service loads (Class 2 design). Also, the post-tensioning provided was in excess of the amount needed for the strength requirements of the code. Hence, the beams will be provided with 1-32mm bar at each corner and 1-16mm bar on each side at mid-depth of the beam.

**FIGURE S32.1 -2 TOP REINFORCEMENT PLAN AS REPORTED BY DESIGN**
S40 – VERTICAL SUPPORTS IDENTIFICATION PLAN
The lower columns are identified in Fig. S40-1.

FIGURE S40-1 IDENTIFICATION OF LOWER COLUMNS

The lower walls are identified in Fig. S40-2.

FIGURE S40-2 IDENTIFICATION OF LOWER WALLS
### Strength

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**170.20 LOWER WALLS**

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**S42 – PUNCHING SHEAR PLAN**

Figure S42-1 shows the stress check (SR) ratios for each of the punching shear locations checked. Where stress ratios exceed 1, punching shear reinforcement will be provided and reported in section S43. Details of stress ratios are shown in Table S42-1. The punching shear stresses calculated are based on the minimum top bar requirements of the code. If based on the calculated reinforcement, the stress ratios will be less. In all instances, the punching shear values meet the code requirements without necessity of additional reinforcement.
### FIGURE S42 - 1 PUNCHING SHEAR STRESS RATIOS

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<th>SR-1</th>
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### 180.40 PUNCHING SHEAR STRESS CHECK RESULTS
### TABLE S44-1 PUNCHING SHEAR DESIGN PARAMETERS

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<th>Axis</th>
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Legend:
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**S43 – PUNCHING SHEAR REINFORCEMENT**
Not reported

**S44 – PUNCHING SHEAR STRESS CHECK PARAMETERS**
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