LECWall Methodology:

Section Properties:

Section properties of multi-wythe composite members are calculated using the modulus of elasticity of the main structural wythe (as designated by the user in the Section Dimensions window). If the modulus of elasticity of the secondary wythe differs from the main wythe, the secondary wythe area and moment of inertia is multiplied by the modular ratio between the two wythes. See the % Composite section for a description of how partially composite properties are determined. Section properties are calculated at 100th points along the member.

Openings & Reveals:

Section properties are automatically modified at opening and reveal locations. Openings are cut all the way through one or both wythes, while Reveals are depressions in either the front or back face of the member. To ensure accurate section properties, openings should not overlap with other openings or reveals, and reveals should not overlap with other reveals or openings. The program will not check for overlaps. That needs to be done manually by examining the plan views provided in the Opening and Reveal design windows (be sure to update the views first by clicking the Update button).

Any strands, bars or WWF that cross through openings are cut and development lengths are adjusted automatically. Click on the Section button in the Capacity Check window to verify the strand, bar or WWF areas at 100th points. The bar or strand areas are reduced accordingly if the reinforcing is not fully developed at the section in question.

Strand Development Length:

The calculated development length can be altered by using a multiplier, if desired. To do this, click on Setup, select Defaults and change the values at the bottom of the screen accordingly. We recommend a value of 1.0 at ends and 2.0 at openings, to account for the differing strains near the opening.

Prestress Losses:

The PCI 6th Edition Handbook is used for calculation of initial and final Prestress Losses in the member (Section 4.7).

Handling Analysis:

Vertical lift lines with two cranes or a spreader beam are assumed to be used for stripping members from the bed. Note: If inclined lines are used for lifting, you need to manually calculate the additional moment generated by the angle of the inclined lines and account for it in the member design. See Handling Check for more information.

The center of gravity of the panel is listed near the top of the Handling window. Use the C.G. to assist in specifying the lift point locations to provide a more equal distribution of lift forces, if desired. Potential panel tilt is also displayed. Tilt can occur when rollers are used for lifting to equalize the left and right reactions.

An ultimate capacity check for handling forces is also provided. Statically calculated unfactored moments are first multiplied by the user-specified handling (or impact) factor, then multiplied again by an ultimate load factor. This ultimate load factor is initially set to 1.4, but can be changed by clicking on the Setup menu item and selecting Defaults. Strain compatibility is used to determine the member's ultimate capacity in the horizontal position.

The 1.2MCr moment is displayed as a green line on the handling Ultimate Capacity diagram (see ACI 318, Section 18.8.2). This ACI code provision is meant for in-place loadings, not temporary handling forces. Therefore, it is up to the engineer's discretion as to whether this criteria needs to be applied for handling loads.

P-Delta Analysis:

The program does an iterative second-order analysis of the member under each of the six specified load cases. The PCI 6th Edition Handbook procedure (Section 4.9.3.1) is used to calculate bow and P-Delta forces. The member is considered to be pinned at both ends for the analysis (a conservative assumption when rigid floor ties are used).

If stresses exceed the modulus of rupture (user specified as the "Cracking stress coefficient") at any point along the member, the section is assumed to be cracked and the analysis is repeated using cracked section properties. Cracked I is conservatively calculated using an approximate procedure developed by Antoine Naaman for partially prestressed members ("Prestressed Concrete Analysis and Design Fundamentals", McGraw-Hill, 1982; also page 98 of the May-June 1989 issue of the PCI Journal). Click on the Show Stresses button to check for cracking anywhere along the length for a specific load case. As a general rule, cracking should be avoided under service load cases for prestressed members.
Forces and deflections due to eccentric gravity loads, earth pressure and wind are calculated using the slope-deflection method. The force in the optional floor tie is the total of effects from the eccentric gravity load moment, earth pressure, wind forces and restraint of predicted thermal bow. The floor connection is considered to be a first floor, at grade connection. Wind loads are applied above the floor connection only (a conservative assumption), therefore it would not be valid to use the floor connection for an upper floor (above grade). Floor tie forces can be somewhat unpredictable (they have been known to pull out

occasionally). Therefore, a ductile design for the floor ties is recommended to avoid a brittle failure if overstressed.

Calculation of Bow:

Member bow is calculated based on differential temperature strains, wind load deflection and member bow due to applied gravity and earth pressure loads. Bow due to non-concentric prestress force is included.

Compression members are usually stressed so as to minimize bow. Such bow is hard to predict accurately in real life situations due to other factors such as humidity, storage methods, etc. The Bow & Temperature section of the Capacity form allows manual input of the predicted initial bow, based on the designer's experience.

Ultimate Capacity Interaction Curves:

The member ultimate capacity is calculated at a point along the member length selected by the engineer. The strain compatibility method is used to plot the points along the interaction curves. The equations used are from the PCI 6th Ed. Handbook, Fig. 4.9.1.1. A straight line is plotted from the transition point of PhiPn = 0.10f'cAg, where Phi = 0.7, to PhiPn =0, where Phi = .9. Alternately, if the "Use Canadian material resistance factors" option is checked (see Defaults), the program will use factors specified by the Canadian code, CSA A23.3. For composite members (with two wythes), only one wythe is used for the compression block.

1.0 times the theoretical cracking moment can also be displayed, per ACI 318, Section 14.8.2.4. It shows up as a small red circle on the Interaction Curve diagram. By keeping the member capacity greater than 1.0MCr, additional capacity will be present after cracking, which should provide a "warning" deflection before failure occurs. According to ACI, if member flexural strength is at least twice the applied factored load, then the ultimate capacity can be less than 1.0MCr. Note that this criteria only applies at the point where the member is likely to crack first, not along the entire length.

Partially composite capacity is found by first computing the capacity at 0% composite and again at 100% composite, then finding a ratio based on the percent composite specified (see % Composite). The 0% and 100% capacity curves are plotted along with the partially composite curve for comparison purposes..

LECPres II Methodology:

Ultimate strength design and load factors are based on ACI 318-99, ACI 318-05 or CSA Standard A23.3-94, as appropriate. All shear, moment, stress and deflection values are calculated at 40 equally spaced points along the member span.

Beam analysis for shear and moment at 40th points:

The internal forces are determined by an approximate procedure. An equilibrium check is performed at 40 points along the span.

Shear and Torsion Capacity:

Shear strength is calculated according to ACI 318-05 Section 11.4. Shear reinforcement requirements are based on Section 11.5 and torsion is based on Section 11.6.

Moment Capacity:

Moment strength is based on strain compatibility and ACI 318-05 Section 18.7. The compression block can extend into the topping gap, the beam flange, the beam flange-to-web sloped portion and the beam web. Prestressing strand development length is based on Section 12.9.

Stresses:

End release stresses are calculated at the point of prestress transfer equal to 50 strand diameters from the end of the member. Allowable release and service load stresses are based on ACI 318-05 Section 18.4, with the exception of allowable service load tension stress, which is input by the user. Prestress losses are calculated using Section 4.7 of the PCI Design Handbook, Sixth Edition.

Deflections:

The moment-area method is used to calculate flexural displacements. When the bottom tension stress exceeds 7.5 * SQRT(F'c) bi-linear behavior is assumed, based on the PCI Handbook Section 4.8.3.

References:

Building Code Requirements for Structural Concrete (ACI 318-05), American Concrete Institute, Detroit, MI, 2005.
PCI Design Handbook, Sixth Edition, Precast/Prestressed Concrete Institute, Chicago, IL, 2004