DESIGNING A TILT-UP PANEL FOR LIFTING CONDITIONS

8.1. *Design Analysis Overview*

The structural design of the tilt-up panels is the primary responsibility of the structural engineer. From a construction management point of view, one of the most important aspects of the tilt-up process is the lifting activity. Having a basic working knowledge of the lifting process and basic lift design will help prevent costly errors and potential schedule loss due to poor planning. Additionally, a quick analysis of the lifting inserts can facilitate the prevention of lifting hardware failure potentially resulting in injured personnel, damaged equipment or damaged in-place work.

8.2. *Lifting Tilt-Up Panels*

PRIOR TO LIFTING

Lifting preparation is a very important aspect of the lifting process. Prior to lifting there are several precautions that should take place prior to lifting panels into place. Prior to lifting any of the panels, each tilt-up panel should be checked for the following:

- Overall panel dimensions
- Locations of panel openings
- Proper concrete strength
- Inspect panels for surface defects (cracks, spalling, exposed rebar, ect.)
- Accessibility and location of embedded objects such as lifting anchors
- Test lifting hardware for minimum lifting capacity
- Verification of final panel positioning
- Crane path requirements (underground utilities, clear travel path, ect.)
- Required foundations are installed

The list above is some of the major inspection requirements that should be checked before and after the casting of the panels in addition to checking them prior to setting the panels.

A suspended tilt-up panel is essentially a large sail when exposed to wind, so the weather conditions are extremely important during the tilt-up process. Panels can be erected during a light breeze but should be avoided when windy conditions exist. Checking the weather conditions prior to setting the panels is a necessity.

DURING THE LIFT

During the lift, safety is the main concern. The rigging and setting crews are the only personnel allowed in the lift and swing area. It is necessary that management personnel hold safety meetings on the mornings that lifts will be taking place in order to make other contractors aware of the lifting areas.

AFTER THE LIFT

Once the panels are set into place, it is necessary to properly brace the panels prior to releasing the crane. Bracing holds the panel in place and keeps the panel from blowing down until the supporting structure is in place. The industry standard for bracing factor of safety is 1.5 times the applied wind and seismic load. Typically inner costal regions of the mid-Atlantic require a minimum of two braces to be installed. After the panels are properly braced, a crew follows behind grouting the panel between the foundation surface and the bottom of the panel. Once the panel is fully supported by the structure, the bracing can be removed and the panel is completed with the exception of installing the closure strip and applying the desired finish.

8.3. Lifting Hardware & Rigging

LIFTING HARDWARE

Lifting hardware is an essential part of tilt-up panel design. Tilt-up panels are constructed in a numerous variety of configurations and specifying effective and efficient lifting hardware is vital to the overall costs of a tilt-up system. Lifting hardware ranges from a few dollars per insert to over seventy five dollars per insert. See appendix J for several different types of lifting inserts and their respective structural attributes and configuration information.

PANEL RIGGING CONFIGURATIONS

Designers should have a basic knowledge of the typical rigging configurations in order to try to reduce the number of different lifting configurations on the project. Changing rigging configurations during lifting sequences reduced the efficiency of the crane and labor utilization ultimately resulting in increased costs. The illustration to the right shows the use of various spreader bars and sheaves used to maintain equal load on each of the lift points. It is extremely necessary that he center of gravity is maintained in the horizontal direction in order to eliminate the panel's tendency to roll to the left or right during the lifting process. The number of inserts required to lift the panel depends upon the weight and size of the panel as well as the strength of the concrete.

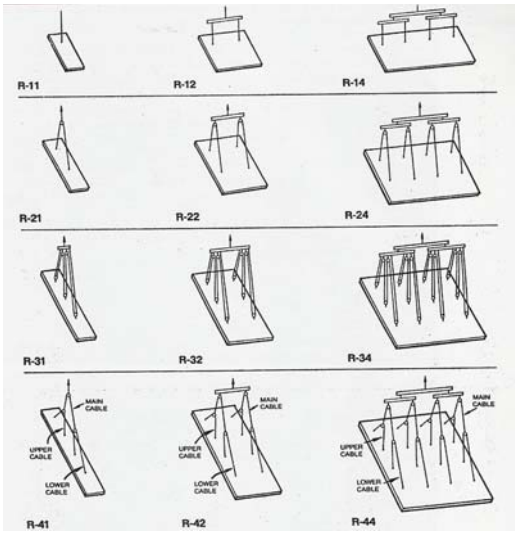

Figure 16: Panel Rigging Configurations

8.4. *General Crane Requirements*

Selecting the right crane for the job is essential for a quick and efficient setting process. An experienced project team will involve the crane operator during pre-planning and panel layout. Typically the minimum factor of safety for lifting tilt-up panels is 2.0 times the heaviest panel, but experienced tilt-up contractors will use evaluate the lifting capacity as well as the working radius of the crane in order to maximize efficiency.

8.5. *Panel Design Analysis for Lifting Condition*

BASIC PANEL PARAMETERS

Panel Height	32' – 6"
Panel Width	25' – 6"
Overall Panel Thickness	0' – 7 1/2"
Insulation Thickness	0' – 1 ½"
Net Concrete Thickness	0 – 6"
Reinforced Concrete Weight	150 psf

DESIGN CALCULATIONS

Gross Panel Area	832.0 sq ft
Void Area	144.0 sq ft
Net Panel Area	688.0 sq ft
Weight of Panel	51,600 lbs

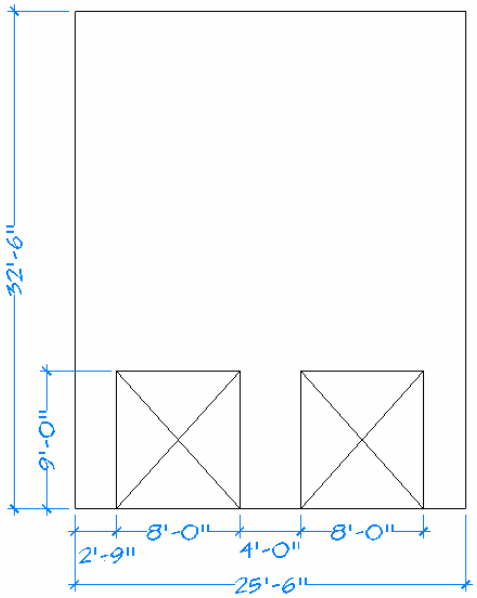

Figure 18: Initial Design Sketch

# of Lift Points = Panel Weight * Suction Factor of 1.3 / Insert Lifting Capacity

# of Lifting Points = 51,600 lb (1.3) / 8,333 lb = 8.05 , Use 8 inserts

Specified lift inserts are ductile ferrule inserts, part number NCFF158, designed for increased load carrying capacity. The factor of safety has been modified from 4:1 to 3:1 and the Universal Form Clamp Company allows for the modification upon confirmation with UFC.

Moment Capacity

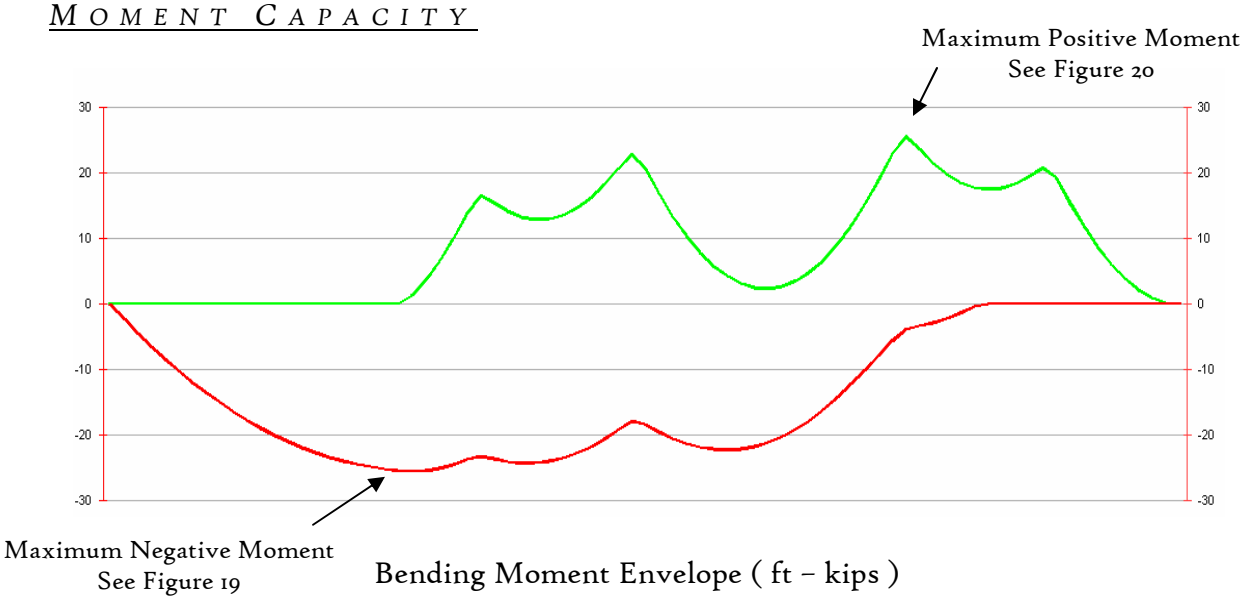

Figure 17: Tilt-Up Panel Moment Diagram

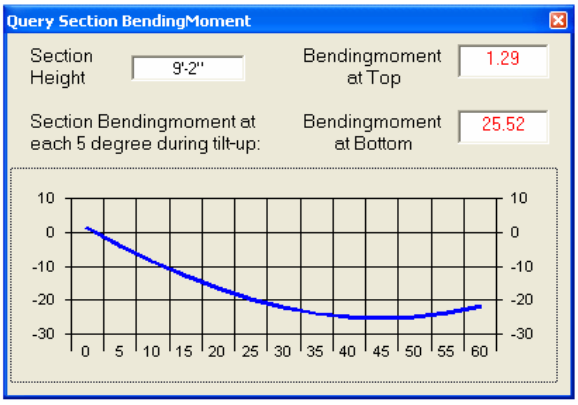

Figure 19: Maximum Negative Bending Moment during Erection

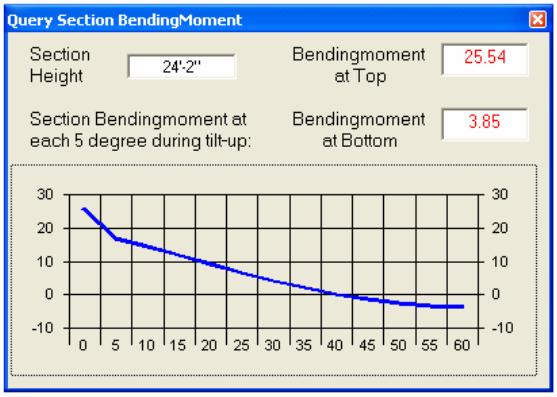

Figure 20: Maximum Positive Bending Moment during Erection

Allowable Bending Stress = $6\sqrt{f'c} = 6\sqrt{3{,}000} = 328$ psi

Maximum Bending Stress Imposed = Maximum Moment / Section Modulus

= 25.54 ft-kip (12 in/ft) (1000 lb/kip) / 2609 in^4

= 117.5 psi < 328 psi ∴OK

PANEL DESIGN SUMMARY

Point	X	Y
CG	12' – 9"	18' – 11 ½"
LP 1	5' – 3"	28' – 6"
LP 2	20' – 3"	28' – 6"
LP 3	5' – 3"	21' – 1"
LP 4	20' – 3"	21' – 1"
LP 5	5' – 3"	15' – 11"
LP 6	20' – 3"	15' – 11"
LP 7	5' – 3"	11' – 2"
LP 8	20' – 3"	11' – 2"

**All points are measured from the bottom left corner of the panel.

Figure 21: Center of Gravity and Lift Point Locations for Local City Tilt-Up Panel

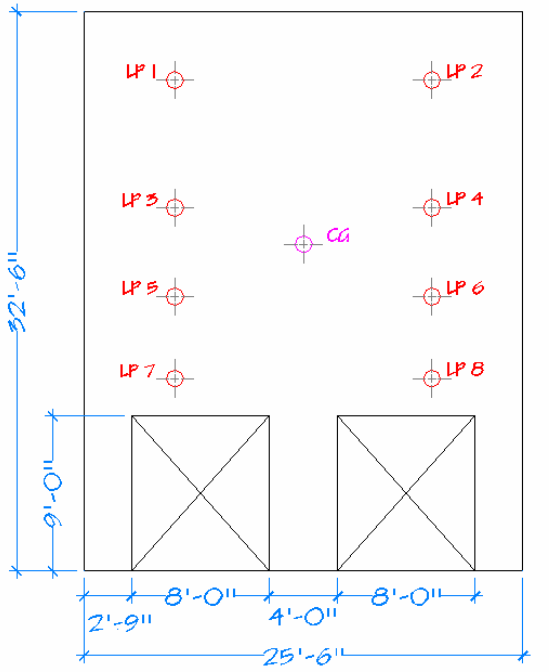

Figure 22: Local City Tilt-Up Panel Design along F & N Line