



*PRE-ENGINEERED
STEEL STRUCTURE
VS
TILT-UP CONCRETE
CONSTRUCTION*



7.1. *Analysis Overview*

During the initial planning phases of a project, the owner, architect and various engineers have to develop the design parameters of the facility. One of the major decisions is determining the appropriate structural system. The structural system chosen for the building is a pre-engineered steel system with a metal wall panel exterior facade. The key determinants for choosing this type of system were the minimal costs of the structure and the overall speed of erection.

7.2. *Pre-Engineered Wall System Overview*

Pre-engineered building systems use standardized metal components which are designed to maximize the structural properties of the material. The system has been designed for maximum efficiency resulting in minimized material.

STRUCTURAL MEMBERS

The existing structural system is pre-engineered steel structure. The system is primarily composed of W 12 x 26, W 14 x 43, W 14 x 61, and W 14 x 90 columns spaced along the exterior wall for the Local City, Corridor and Transition areas. Throughout Loadwings A & B the structural steel has been designed as a brace frame to counteract the large horizontal forces generated by wind. All steel members shall conform to ASTM A570 or A572 and all connections utilize A325 high strength, torsion control bolts.

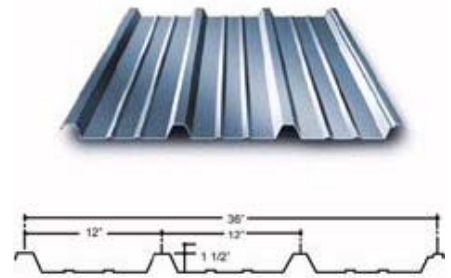
WALL FRAMING

The lateral bracing for the exterior wall panels is comprised of purlins or “Z” girts at various elevations in order to act as connecting points for the exterior wall panels. The “Z” girts conform to ASTM A570 at a minimum of 55 ksi.



W A L L P A N E L S

The exterior wall panels are precision roll-formed Butlerib® II panels. The panels are 26 gage galvanized panels which conform to ASTM A525. The insulating layer is a 2” semi-rigid insulation. Insulation is a commercially odorless glass fiber blanket which shall have a flame spread rating of 25.



I N T E R I O R W A L L S Y S T E M

The interior wall system consists of 8’ tall liner panels comprised of 3/4” CDX fire retardant treated plywood. The plywood will be primed on both sides and 2 coats of paint will be applied to the exposed face.

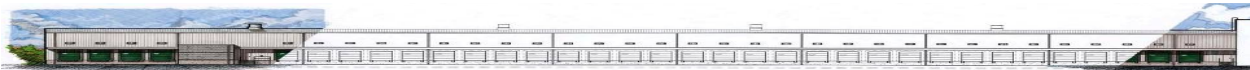
R O O F S Y S T E M

The roof system is a MR-24® Standing Seam Roof System designed and installed by Butler Manufacturing and Butler Construction. All insulation shall be blanket fiberglass insulation with a minimum thickness of 2” for MR-24® roofing applications.



A D V A N T A G E S O F P R E - E N G I N E E R E D B U I L D I N G S

The metal wall system is a very quick and efficient system to put in place. The simplicity of the system makes it very versatile, requiring no specialized labor to properly install the system. Pre-engineered buildings reduce the need for on-site labor by performing as much of the cutting and welding operations in a factory environment. Because most of the work is completed in a factory, weather interruptions and delays are reduced. Expanding a metal building performed easily and quickly. If designed properly, it is as simple as removing wall panels adding new framework and connecting into the existing wall and roof panels.



Pre-engineered structural systems are very cost efficient because the design of the structure takes advantage of the material properties of the elements. This type of design reduces the extra costs by minimizing waste and excess materials. Pre-engineered buildings have lower initial costs. Reducing design costs is a predominant feature of pre-engineered buildings because previous structures are easily modifiable which leads to the owner's ability to see the building prior to beginning construction.

DISADVANTAGES OF PRE-ENGINEERED BUILDINGS

Pre-engineered metal buildings have many disadvantages. The typical life-cycle of metal building is approximately 20-30 years according to steel manufacturers, but the building's paint fades quickly and the building easily becomes damaged and dented. Because of the wear on the interior and exterior facades, the future value of the building is greatly decreased. Also, the aesthetic appearance decreases quickly. In order to maintain the building, continuous monitoring and a regularly scheduled maintenance is necessity.

7.3. *Tilt-Up Wall System Overview*

Developing a structural estimate for the proposed systems will be very useful. Initially, several assumptions need to be as well as descriptions of the systems that will be incorporated into the tilt-up system.



FOUNDATION SYSTEM

The foundation system was not altered during the analysis of the tilt-up system. Tilt-up panels are non-load bearing, so the current wall footings will be utilized as structural components carrying the additional weight of the tilt-up panels. The foundation walls and piers will be maintained due to the use of structural steel along the exterior facades to carry the roof loads for the distribution facility. These structural members will also act as connection points for the lateral support system. The panels will rest directly on the foundation walls and will be structurally tied into the foundation wall system and columns.



TILT - UP PANELS

For this system estimate an 8” insulated panel will be used. The 8” panel thickness is needed to structurally support its own weight while maintaining the current R-value. This is the minimum thickness of panel required to span a distances of approximately 32’. Currently a tilt-up panel of this type will cost approximately \$15 per square foot installed. This cost includes all labor and equipment costs needed to form, set, grout, and brace the panels.

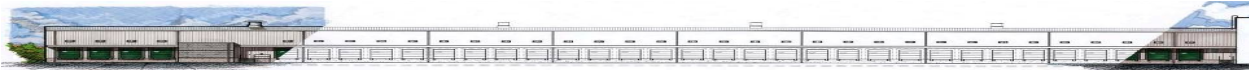
ROOF ADAPTATION

The existing Butler MR-24® Standing Seam Roof System was designed to be compatible with both the pre-engineered system and a tilt-up wall system. So, the existing roof can be used but there will need to be alterations to the exterior edges of the roof structure. The roof-to-wall connections will need to be adapted to the tilt-up panel system.

ADVANTAGES OF TILT - UP

Constructing a building of tilt-up panels is advantageous only when the given locale and project conditions favor it. Many of the advantages of tilt-up make this type of construction very competitive in the construction industry. The cost advantages of tilt-up construction spawn from the minimized use of formwork required to construct the panels. Building maintenance costs over the lifetime of a building can be very demanding, but tilt-up has very low maintenance costs when compared to other types of construction. Typical building maintenance consists of applying a new coat of paint every 6 to 8 years. When tilt-up buildings are coupled with an EPDM membrane roof held in place with ballast rock, the overall heating and cooling costs are greatly reduced. Tilt-up concrete walls offer increased fire resistance over other types of construction which in turn can potentially lower insurance costs.





Tilt-Up panels can be designed as load bearing or non load bearing structures. Load bearing capabilities can support long-span roof members and intermediate floor levels. When used in conjunction with pre-cast concrete structures, long, clear spans of up to 110' are obtainable. Tilt-up panels provide a smooth, durable finish that reduces the amount of damaged caused by trucks, forklifts, and other heavy equipment. They are easily cleanable ensuing in a cleaner, healthier work environment. Tilt-up provides an increased level of security over metal buildings by restricting forced entry to door and window openings.

DISADVANTAGES OF TILT-UP

In the construction industry there are many ways to enclose a building. Tilt-up has many appealing advantages, but there are also disadvantages to this type of construction. The site can very easily limit or restrict the use of tilt-up. Project sites located in remote areas with limited resources can have a negative effect on the productivity of tilt-up. Tilt-up construction yields higher up front costs and these costs are incurred because of the increased number of construction activities which must be completed prior to the casting of the panels. Typically, the management staff should have experience with this type of construction in order to make it beneficial. Fixing minor mistakes can be very time consuming and costly. Planning is critical in order for this type of construction to be beneficial. The building size is typically restricted to low-rise buildings less than 50' tall. There are exceptions to the limitations, but they can quickly increase costs. Tilt-up does not adapt well to unusual building designs and is very susceptible to weather delays.

7.4. Cost Analysis

PRE-ENGINEERED WALL SYSTEM COST ESTIMATE

Initially, Pre-engineered steel structure is the cheapest method of enclosing a structure. Pre-engineered wall systems cost approximately \$6.00 per square foot installed. This cost includes all miscellaneous hardware, insulation, framing members and equipment required to properly install the wall sheets. The FedEx Ground Distribution center contains approximately 104,500 sq. ft. of exterior façade which will be covered by the wall sheeting system. The structural steel estimate was based on weight. The amount of steel was developed for the exterior walls only. The current approximate industry standard for steel installed is \$1600 per ton of material taking into account for minor fluctuations in steel prices. Figure 14 below illustrates the cost breakdown by area and component for the wall system. All costs are approximate in place costs and include procuring all materials, shipping costs, wasted materials and installation labor.

Activity Description	Area								Total
	Local City / Unload (4-10 / E-N)	Corridor (10-15 / E-N)	Loading A & Trans (15-34 / H.6-K.2)	Loading B (12-34 / A-E)	Loading Restrooms	Admin. Office	HUB Ops	Switchgear / Pump Room	
Concrete Footings	359.5	228.5	214.3	208.7	6.3	8.9	23.1	5.2	1,054.4
Concrete Foundation Walls / Piers	304.0	166.4	223.5	190.2	24.0	28.6	24.0	10.6	971.3
Structural Steel	69.4	23.0	82.9	55.0					230.3
Wall Sheeting System	217.7	44.2	207.8	152.6					622.3
Plywood Liner Panels	10.9	9.7	10.9	10.9					42.4
CMU Walls & Masonry Veneer					61.5	91.1	61.5	63.4	277.4
Total	961.5	471.8	739.4	617.3	91.7	128.6	108.6	79.1	3,198.0

* All costs are in thousands of dollars

Figure 14: Metal Wall Panel System Cost Estimate

TILT-UP WALL SYSTEM COST ESTIMATE

The use of tilt-up concrete enclosure system will have increased costs due to the basic components that make up the system. The wall system will utilize the existing spread footings, wall footings and piers. The use of non-load bearing panels will also require the need for structural steel around the perimeter. The recommended wall panel will be an 8” insulated system. Estimated panel costs as of February 2005 are approximately \$15 per square foot installed. This cost estimate includes all lifting hardware, connecting embeds, formwork, labor, equipment, and a basic finish required to completely install the system. Figure 15 depicts the approximate cost of the tilt-up system for the FedEx Ground distribution facility. The costs are divided by area and system and include all material, labor, and equipment costs required to install each system.

Activity Description	Area								Total
	Local City / Unload (4-10 / E-N)	Corridor (10-15 / E-N)	Loading A & Trans A (15-34 / H.6-K.2)	Loading B (12-34 / A-E)	Loading Restrooms	Admin. Office	HUB Ops	Switchgear / Pump Room	
Concrete Footings	359.5	228.5	214.3	208.7	6.3	8.9	23.1	5.2	1,054.4
Concrete Foundation Walls / Piers	304.0	166.4	223.5	190.2	24.0	28.6	24.0	10.6	971.3
Tilt-Up Panels	544.3	110.7	519.3	381.5	54.9	63.5	68.8	44.7	1,787.7
Structural Steel	69.4	23.0	82.9	55.0					230.3
Wall Sheeting System									
Plywood Liner Panels									
Total	1,277.2	528.6	1,040.0	835.4	85.2	101.0	115.9	60.5	4,043.7

* All costs are in thousands of dollars

Figure 15: Tilt-Up Exterior Wall System Cost Estimate



7.5. Cost Comparison

The existing pre-engineered system costs approximately \$3,198,000 and the tilt-up enclosure system costs approximately \$4,043,700. When comparing these two systems, the tilt-up system is an overall increase of 26.4% over the current wall system. The difference between the two systems results in an increased enclosure cost of approximately \$845,700. Both of the estimated system costs are in-place costs resulting in a viable cost comparison.

7.6. Construction Schedule Analysis

P R E - E N G I N E E R E D W A L L S Y S T E M E S T I M A T E

The initial construction schedule was redeveloped utilizing the original activity durations in order to have an appropriate schedule for comparison. The schedule has been simplified for a structural system analysis. The schedule was developed by the project management team which conformed to the milestone dates set forth by FedEx Ground. These milestone dates are in place to ensure the project schedule will be maintained. Appendix G is the simplified schedule for the pre-engineered structural system.

T I L T - U P W A L L S Y S T E M E S T I M A T E

The initial schedule developed for the pre-engineered was modified for the proposed tilt-up wall system. The major activities were adapted to a tilt-up construction process. The actual durations were maintained for the foundations, backfill, underslab rough-ins, and roof installation. The structural steel durations were developed to install the non-required pieces and subtracted from the construction schedule. The total tilt-up construction process takes approximately 45 days per panel and an average forming crew can form, reinforce and pour 8-12 panels per day. It was assumed that a panel forming crew could form 10 panels per day. Also, it was assumed that multiple erection crews were installing the tilt-up panels and all activities could be overlapped in order to fast-track the schedule to meet the milestone dates. Appendix H is the simplified construction schedule for the tilt-up structural system.



7.7. *Schedule Comparison*

Both of the schedules conform to the milestone dates that were developed by FedEx Ground. The proposed wall system will take longer to completely enclose the facility. This is attributed to the time required to form, reinforce and cure the panels.

7.8. *Conclusion & Recommendation*

The proposed tilt-up wall system costs approximately \$4,043,700 which is substantially higher than the current pre-engineered wall system by \$845,700. This difference is minimal when compared to the overall project cost in excess of \$100 million. Also, the construction schedule of the tilt-up wall system will be able to conform to the milestone dates previously set by FedEx Ground. As a recommendation, tilt-up exterior wall system is more valuable than the pre-engineered wall system the durability and aesthetic advantages concrete structures.