Breadth 1 Structural Analysis: Cast-In-Place Vs. Pre-Cast Floor System

A. Executive Summary

In the structural analysis performed in this section a change in the floor system for the Cardiac Elevator Addition is proposed. The designed floor system consists of cast-in-place concrete on composite metal decking and the proposed new system is pre-cast concrete floor planks.

Calculations were performed in the first section of this analysis to determine what size pre-cast concrete floor plank would be required to replace the 3 1/2" thick 4000psi lightweight concrete slab on 2"-20Ga. composite metal deck. The pre-cast floor plank selected based on load and span capacities was a (T6-E23) 6" x 24" pre-cast concrete plank with 2" leveling top coat.

A supplier for pre-cast concrete floor planks was identified and availability was checked in the second section of this analysis. A possible supplier for the pre-cast concrete floor planks is Strescon Industries, Inc. located in Langhorne, PA. Langhorne, PA is located northeast of Philadelphia with an estimated travel time from Langhorne to Lancaster of 2 hours.

A detailed cost analysis was performed to determine what cost savings if any would be possible with the switch to the proposed system. The design system costs approximately $10,530.00 with the proposed system coming in approximately $1,612.00 more expensive at $12,142.00.

A schedule reduction analysis was then performed to determine any schedule savings with the proposed system. The estimated schedule savings is 2 days with the use of the proposed system.

The next section of this analysis contains a constructability review for the Cardiac Elevator Addition project. There are several site characteristics that make this a complicated site. These items are identified and accommodations are described in this section.

B. Overview

The focus of this section is the analysis of the structural system in place for the Cardiac Elevator Addition at Lancaster General Hospital, specifically looking at the benefits and restriction of switching from a cast-in-place concrete on composite metal decking to pre-cast concrete planks for the elevator lobbies. While structural analyses will be completed in this section a cost analysis and schedule reduction will be the main contributing factors to the final recommendation. Also included in this section will be a brief constructability review to address the extremely condensed site for the elevator addition and to address the air intake vents for the hospital that are located directly adjacent to the site.

In order to analyze the switch in structural system from cast-in-place concrete on composite metal decking to pre-cast concrete planks several items will need to be addressed. These items include

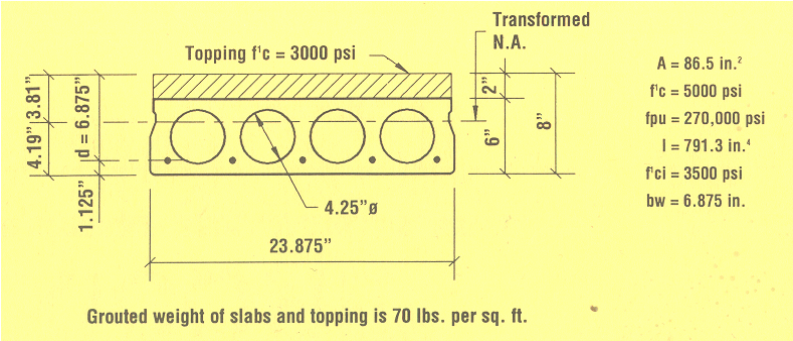
1. Calculations to verify design requirements for the proposed pre cast members
2. Determining a supplier and availability of pre-cast members
3. Cost comparison between the two systems
4. Identification of possible reduction in schedule with the proposed new system.
5. Constructability Review
6. Conclusions

C. Calculations

The span of the pre-cast concrete plank would be 14’ for all applications. By evaluating the load chart included below for the (T6-E23) 6” x 24” pre-cast concrete plank with 2” leveling top coat we can see that the allowable load is 294 lbs. per square foot. Using the standard live load of 150lbs. per

Standard Designation	7-Wire P/S Strand Combination	P/S Strand Area Sq. In.	Ultimate Bending Moment, ø Mn in Kip. Ft. per Unit	SIMPLE SPAN IN FEET																	ø Vcw in Kips per Unit
				12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
T6-E35	3-7/16	.345	41.7						282	246	214	188	165	145	128	113	100	88	77	68	12.43
T6-E31	2-1/2	.306	37.7					289	249	216	188	164	144	126	110	96	84	74	64	56	11.88
T6-E23	2-7/16	.230	29.3			294	249	211	181	155	133	115	99	85	73	62	53	44			11.60
T6-E17	2-3/8	.170	22.2		251	209	174	146	123	103	87	73	61	50							11.38

* INCLUDES THE LIVE LOAD PLUS ANY DEAD LOAD THAT IS ADDITIONAL TO THE WEIGHT OF THE BARE GROUTED SLABS & TOPPING



square foot designated for hospital use it is determined that this member is acceptable.

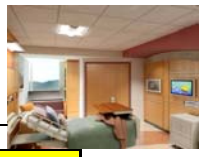
Several assumptions were made in order to complete this analysis. The first assumption is that the originally designed structural steel frame is capable of supporting the weight of cast-in-place system as approximately 145lbs. per sq. ft. as the weight of the pre-cast concrete hollow deck planks is lighter at 70lbs. per sq. ft. For the purposes of this analysis any possible reductions in structural steel frame were not determined due to the assumption that the weight and bracing requirements for the elevator equipment controlled design. Other assumptions include the camber and deflection of the pre-cast concrete hollow core deck planks are within the allowable limit.

D. Supplier/Availability

A possible supplier for pre cast concrete planks is Strescon Industries, Inc. located in Langhorne, PA. Langhorne, PA is located northeast of Philadelphia with an estimated travel time from Langhorne to Lancaster of 2 hours. They feature a Flexicore pre cast concrete plank that will adequately replace the cast in place concrete slab. Availability of these planks as in all pre-cast concrete members is something that needs to be evaluated as they present a longer lead time than cast-in-place lead time as time for design and fabrication in an off-site plant is required. Since the selected member is a standard size and design availability will not be an issue for this application.

E. Cost Analysis

In order to complete the cost comparison between the two structural systems the cost for the cast-in-place concrete system must be broken out of the original estimate. This was completed by using project cost data as well as RSMeans construction cost data to fill in any of the amounts that were included in subcontractor costs for the project. A worksheet of this information has been prepared and is included below. From this worksheet we can see that the total cost for the cast-in-place concrete system on floors 5-8 is $10,530.00. The detailed cost break down can be found on ***page 63***.



Construction Cost for Cast-in-Place Concrete on Composit Metal Deck				
Reinforcing Wire Mesh				
Description	Quantity	Labor $	Material $	Total $
6x6-6/6 w1.4	270 sqft	$47.00	$60.00	$107.00
6x6-6/6 w1.4	270 sqft	$47.00	$60.00	$107.00
6x6-6/6 w1.4	270 sqft	$47.00	$60.00	$107.00
6x6-6/6 w1.4	270 sqft	$47.00	$60.00	$107.00
SOD Wire Mesh	1080 sqft	$188.00	$240.00	$428.00
Slab on Deck Accessories				
Description	Quantity	Labor $	Material $	Total $
Drilled Dowels				
24" #4 epoxy filled	9 each	$119.00	$80.00	$199.00
24" #4 epoxy filled	9 each	$119.00	$80.00	$199.00
24" #4 epoxy filled	9 each	$119.00	$80.00	$199.00
24" #4 epoxy filled	9 each	$119.00	$80.00	$199.00
SOD Accessories	36	$476.00	$320.00	$796.00
Cast in Place Concrete				
Description	Quantity	Labor $	Material $	Total $
4000psi litewt conc	3.75 cuyd	$0.00	$453.00	$453.00
4000psi litewt conc	3.75 cuyd	$0.00	$453.00	$453.00
4000psi litewt conc	3.75 cuyd	$0.00	$453.00	$453.00
4000psi litewt conc	3.75 cuyd	$0.00	$453.00	$453.00
Slab on Deck	15 cuyd	$0.00	$1,812.00	$1,812.00
Place/Finish Slab on Deck				
Description	Quantity	Labor $	Material $	Total $
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Conc. Boom Pump	1 day	$0.00	$0.00	$1,850.00
Slab on Deck		$1,676.00	$0.00	$3,526.00
Composite Metal Decking				
Description	Quantity	Labor $	Material $	Total $
2" 20ga.	270 sqft	$92.00	$540.00	$632.00
2" 20ga.	270 sqft	$92.00	$540.00	$632.00
2" 20ga.	270 sqft	$92.00	$540.00	$632.00
2" 20ga.	270 sqft	$92.00	$540.00	$632.00
Metal Decking	1080 sqft	$368.00	$2,160.00	$2,528.00
Structural Steel Beam				
Description	Quantity	Labor $	Material $	Total $
W12 x 16	16 lf.	$43.00	$317.00	$360.00
W12 x 16	16 lf.	$43.00	$317.00	$360.00
W12 x 16	16 lf.	$43.00	$317.00	$360.00
W12 x 16	16 lf.	$43.00	$317.00	$360.00
Beam	64 lf.	$172.00	$1,268.00	$1,440.00
Total Cost for Cast-in-Place Concrete slabs floors 5-8				**$10,530.00**

The next step is to formulate a worksheet for the cost of the pre-cast concrete plank system. This was complete by using project cost data as well as RSMeans construction cost data to fill in any of the amounts that were included in subcontractor costs for the project. There are several items that are no longer required for this system that were included in the cost for the cast-in-place system. These items include the reinforcing wire mesh, slab on deck accessories, composite metal decking and structural steel beam. The structural steel beam was used to support the cast-in-place system but is no longer needed for the pre-cast system. There is still a need for cast-in-place concrete to be used with the pre-cast system in order to provide the 2" topping slab over the pre-cast planks. This will also cause the placement and finishing costs to be included with the pre-cast system. Even with the reduction of several items from the cast-in-place system the pre-cast system still comes in more expensive at $12,142.00. This represents an increase in cost of $1,612.00 which is not a large increase and would not make a substantial impact on the outcome of the project; however, it does not indicate the desired reduction in cost that would justify a switch in structural systems from the cast-in-place concrete system to the proposed pre-cast concrete system. The detailed cost break down can be found on ***page 65***.

Construction Cost for Pre-Cast Concrete Planks				
Pre-Cast Planks				
Description	Quantity	Labor $	Material $	Total $
T6-E23	270 sqft	$261.00	$1,693.00	$1,954.00
T6-E24	270 sqft	$261.00	$1,693.00	$1,954.00
T6-E25	270 sqft	$261.00	$1,693.00	$1,954.00
T6-E26	270 sqft	$261.00	$1,693.00	$1,954.00
Pre-Cast Planks	1080 sqft	$1,044.00	$6,772.00	$7,816.00
Cast in Place Concrete				
Description	Quantity	Labor $	Material $	Total $
4000psi litewt conc	1.67 cuyd	$0.00	$200.00	$200.00
4000psi litewt conc	1.67 cuyd	$0.00	$200.00	$200.00
4000psi litewt conc	1.67 cuyd	$0.00	$200.00	$200.00
4000psi litewt conc	1.67 cuyd	$0.00	$200.00	$200.00
Slab on Deck	7 cuyd	$0.00	$800.00	$800.00
Place/Finish Topping Slab				
Description	Quantity	Labor $	Material $	Total $
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Place/Finish	270 sqft	$419.00	$0.00	$419.00
Conc. Boom Pump	1 day	$0.00	$0.00	$1,850.00
Topping Slab		$1,676.00	$0.00	$3,526.00
Total Cost for Pre-Cast Concrete Planks floors 5-8				**$12,142.00**

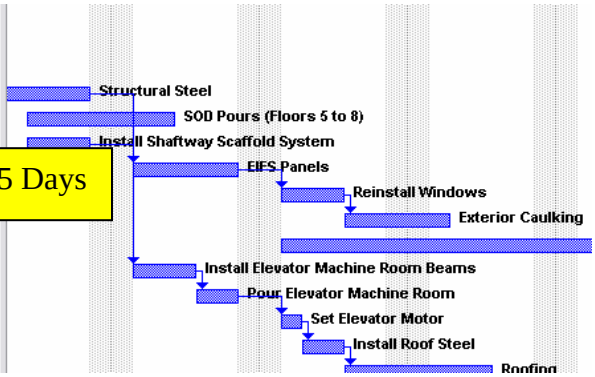
F. Schedule Reduction

Schedule reduction will not be a large contributing factor in this analysis due to the relatively small quantity of concrete being replaced. The on-site tower crane will be used for the setting of the pre cast concrete planks in substitution for the concrete boom pump application of the cast-in-place slabs. The setting of the pre-cast planks will take approximately the same amount of time as placing the wet concrete, however, any delays in placement due to weather or need of the helicopter landing pad adjacent to the site requiring the crane to shut down for a period of time will not lead to spoils of material as would occur if shut downs were required during placement of cast in place concrete. These occurrences are few but often come with little warning and as there are no accessible areas to dump large quantities of waste concrete could cause a serious problem.

The original schedule shown below indicates 5 days for the slab-on-deck concrete pours for floors 5 to 8 which are the slabs proposed to be replaced by pre-cast concrete planks in this section. These 5 days include the placement of 2" – 20Ga. composite steel deck that is used as the support and bottom formwork for the cast-in-place concrete.

12		Remove Scaffold Platform	2 days	Mon 10/16/06	Tue 10/17/06	11
13		Foundation Work	5 days	Mon 10/16/06	Fri 10/20/06	
14		Concrete Structure	8 days	Thu 10/19/06	Mon 10/30/06	
15		Structural Steel	19 days	Tue 10/31/06	Fri 11/24/06	14
16		SOD Pours (Floors 5 to 8)	5 days	Wed 11/22/06	Tue 11/28/06	
17		Install Shaftway Scaffold System	3 days	Wed 11/22/06	Fri 11/24/06	
18		EIFS Panels				
19		Reinstall Windows				
20		Exterior Caulking				
21		Drywall Shaftwalls	15 days	Mon 12/4/06	Fri 12/22/06	
22		Install Elevator Machine Room Beams	3 days	Mon 11/27/06	Wed 11/29/06	15
23		Pour Elevator Machine Room	2 days	Thu 11/30/06	Fri 12/1/06	22
24		Set Elevator Motor	1 day	Mon 12/4/06	Mon 12/4/06	23
25		Install Roof Steel	2 days	Tue 12/5/06	Wed 12/6/06	24
26		Roofing	5 days	Thu 12/7/06	Wed 12/13/06	25

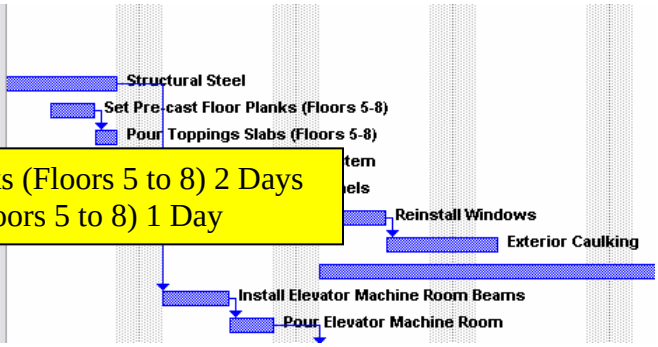
SOD Pours (Floors 5 to 8) 5 Days



A negligible reduction in the 19 day structural steel erection will be applicable due to the elimination of the W12x16 steel beam on each of the 4 floors. The schedule for the concrete placement on floors 5 to 8 was reduced by 2 days with the proposed new system. This does not represent a large

savings in the scale of the project and therefore is not a justifiable proponent to switch to the new pre-cast concrete plank system.

13	Foundation Work	5 days	Mon 10/16/06	Fri 10/20/06	
14	Concrete Structure	8 days	Thu 10/19/06	Mon 10/30/06	
15	Structural Steel	19 days	Tue 10/31/06	Fri 11/24/06	14
16	Set Pre-cast Floor Planks (Floors 5-8)	2 days	Wed 11/22/06	Thu 11/23/06	
17	Pour Toppings Slabs (Floors 5-8)	1 day	Fri 11/24/06	Fri 11/24/06	16
18	Install Shaftway Scaffold System				
19	EIFS Panels				
20	Reinstall Windows				
21	Exterior Caulking				
22	Drywall Shaftwalls	15 days	Mon 12/4/06	Fri 12/22/06	
23	Install Elevator Machine Room Beams	3 days	Mon 11/27/06	Wed 11/29/06	15
24	Pour Elevator Machine Room	2 days	Thu 11/30/06	Fri 12/1/06	23



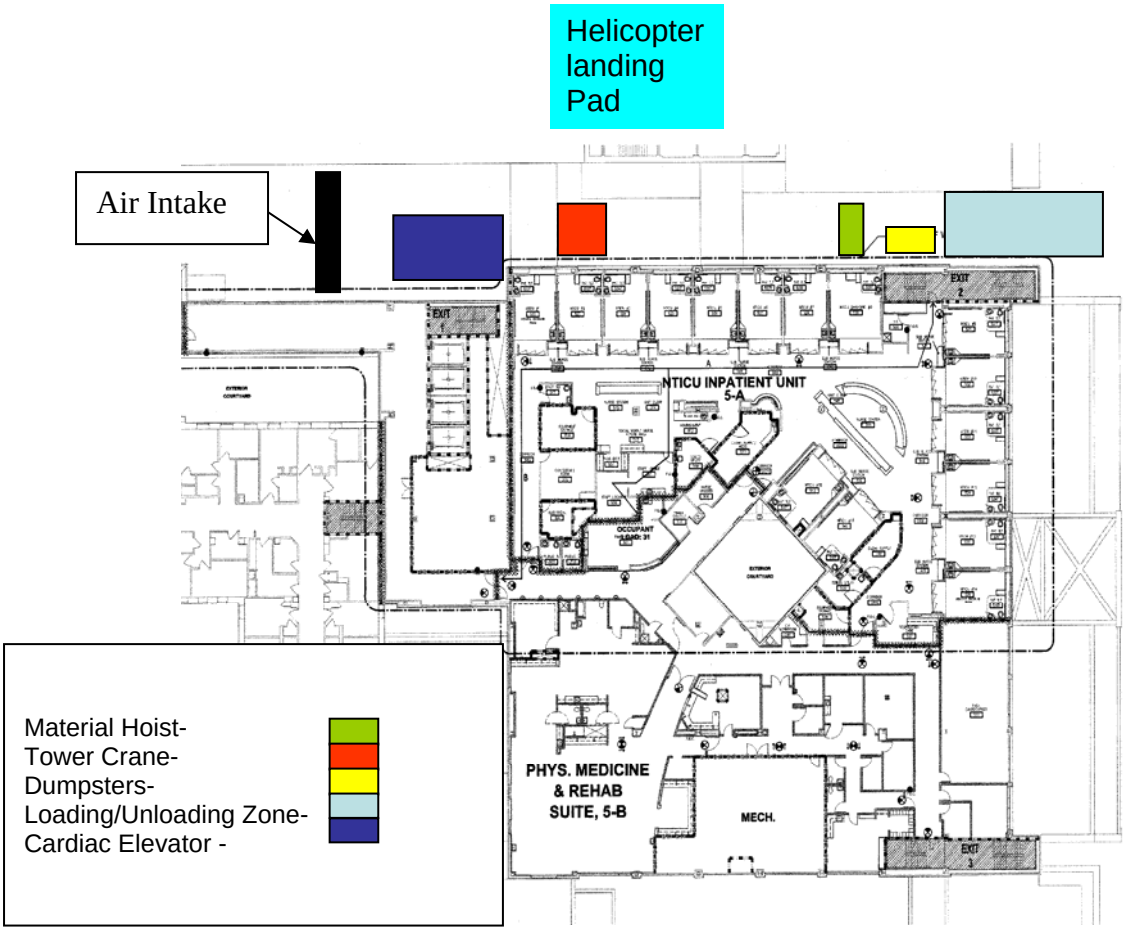
Set Pre-cast Floor Planks (Floors 5 to 8) 2 Days
Pour Topping Slabs (Floors 5 to 8) 1 Day

G. Constructability Review

There are several issues with the site that the Cardiac Elevator Addition is located on. These include very limited access to the actual location of the Elevator, small work area within the site, very limited material and equipment storage, and the main air intakes for the hospital being located on the wall directly adjacent to the site. Other complications include the helicopter landing pad for the hospital being located on the roof of the building directly adjacent to the site.

a. Site Plan-

The site for this project is extremely constricted. The items that must be located on this site include a tower crane, material hoist, loading/unloading zone, loading dock, dumpsters, material and equipment storage, and portable toilets. These items are places as depicted in the site plan below.



b. Site Access-

Site access to the cardiac elevator addition site is limited to the opening pictured below from the parking lot located under the Lime Street Building of the hospital. All materials and equipment had to either come through this opening or be lifted into the site by the tower crane. This meant that any items that were not to be lifted into the site by the tower crane had to be unloaded from trucks in the loading/unloading zone and carried into the site through the garage. This can become a tiring and tedious process but there are limited options for this site.

Figure 14 - Access to Elevator Site

c. Material & Equipment Storage-

There is a small amount of space for storage of materials and equipment around the base of the tower crane as well as a small fenced off area in the parking lot located under the Lime Street Building adjacent to the elevator site. The lack of storage and lay-down area on this project leads to the implementation of just-in-time delivery methods. However, even this method proves challenging due to the small loading and unloading zone with room for just one truck to unload at a time located off lime street which is a one way street with limited parking on either side. All equipment that cannot be fit into these small spaces must be stored off site when not in use.

Figure 15 – Material Storage

d. Air Intakes-

The air intakes for the hospital are located directly adjacent to the site for the construction site for the cardiac elevator addition. These air intakes had to be protected throughout the duration of the project. In order to help alleviate any exhaust or dust from entering the vents during construction shafts were constructed and placed around the intakes with an opening at the top so that all air drawn into the intakes came from well about the construction taking place. Along with this shaft there was also construction filters placed on the intakes in order to filter out any dust that made its way into the intakes. These filters were changed upon completion of the project.

Figure 16 – Air Intake (1)

Figure 17 – Air Intake (2)

E. Helicopter Landing Pad-

The helicopter landing pad is used for the transport of patients that are in critical condition in and out of the hospital. On average the landing pad is used 2-3 times per week. Whenever the landing pad is in use the tower crane must be shut down and swung out of the way since the swing of the crane travels over top of the pad, this is coordinated via radio with the communications center in the hospital. Little warning is often given for shut downs which can cause a problem when the crane is in use and a precise plan must be put into place for these instances.

H. Conclusions

After completing this analysis it is evident that the proposed system did not provide the desired cost and schedule savings that were hoped for. The proposed system was determined to be more expensive than the designed system making it undesirable as far as cost savings is concerned and a schedule savings of only 2 days which is not enough to justify the additional cost. However, if this were a larger project that was schedule driven the proposed pre-cast system may have been a better fit. Another factor is if the crane that was located on site would have only been required for the construction of the elevator structure and could have been removed after the placement of concrete there may have been enough savings recouped from the crane rental costs to justify the switch in floor systems.

Based on the data provided above in this analysis it is recommended that the originally designed cast-in-place concrete floor system be utilized for the Lancaster General Hospital Cardiac Elevator Addition.