Comparison between Post Tension and Hollow Core Slabs systems (Case Study) - Commercial Building in Amman

Ali Alsheikh. Civil Engineering. aliwasef@yahoo.com

ABSTRACT:

This case study is a Pro-Con structural study, which analyze and compares alternate floor for commercial building. Research was performed in to two alternate systems.

The 3– story commercial building located in Amman, is a typical concrete structure. Typical interior columns with different sections are continues on each floor.

For this report, the floor systems that were analyzed as possible alternatives were:

- Prestressed Hollow- Core Precast Slabs (HCS) supported on PT & RC beams
- Prestressed Post- Tensioned Slab (PT) supported on PT & RC beams

Using current standard, design for each system were determined and then advantages and disadvantages for each system were analyzed. Two systems were then compared to determine which system would most benefit the construction and design of the Commercial Building. From this comparison, it was concluded that while two systems achieve Safety in Design & Construction; The Post Tension Slab outstands in Constructability**,** Floor Clear Height and Layout Flexibility however Hollow Core Slabs outstands in Building Weight and Lead Time. Cost is variable and almost equal for both systems

1. INTRODUCTION:

The aim of this report is to give a summary of the study carried out to select the most viable floor slab.

The study has been carried out considering all the requirements of the local building authorities, Amman Municipality and governing relevant codes as listed later in this report.

Our value engineering study focus on changing the floor slab system, vertical elements and foundations were kept as original design.

2. SLAB SYSTEM:

In the view of the type of the structure and the general trend of construction the possible alternatives for the floor slab system are as follows:

- Hollow Core Pre cast slab supported on PT & RC beams.
- Post-tension cast-in place slab supported on PT & RC beams.

3. DESIGN STANDARD:

Design will be carried out using Jordanian cod modified as necessary to suit Municipality regulations. Following are the list of codes used:

- Jordanian code.((93/5)أ.ب.ك كودة الخرسانة العادية و المسلحة)
- British standard BS 8110:Part1&2&3 concrete design

Where these codes are mute for design of PT slab and so the concrete society technical report no.4 is used as a specialize literature.

3.1. MATERIALS PROPERTIES:

- **Concrete.**
  Structural concrete strength as follows:
  - For HCS & PT slab fcu = 40 MPa
  - For PT & RC beams fcu = 40 MPa
- **Reinforcing steel.**
  High yield deformed pars of yielding strength= 420 MPa
- **Prestressing strands.**
  12.7 mm diameter (0.5'') super grade, low relaxation 270 to be used according to ASTM A416

3.2. DURABILITY AND FIRE REQUIREMENT:

Minimum 2 hour fire rating will be adopted,
so, according to Jordanian code, nominal cover will be

For Slabs, simply supported = 35mm
continuous = 25mm

3.3. DESIGN LOADING:

A. Dead load

- Unit weight of concrete=24 KN/m3
- hall area= 4.0 KN/m2

B. Live load

- hall area = 5.0 KN/m2

4. ALTERNATIVE # 1: POST TENSIONING SLAB SUPPORTED ON PT & RC BEAMS

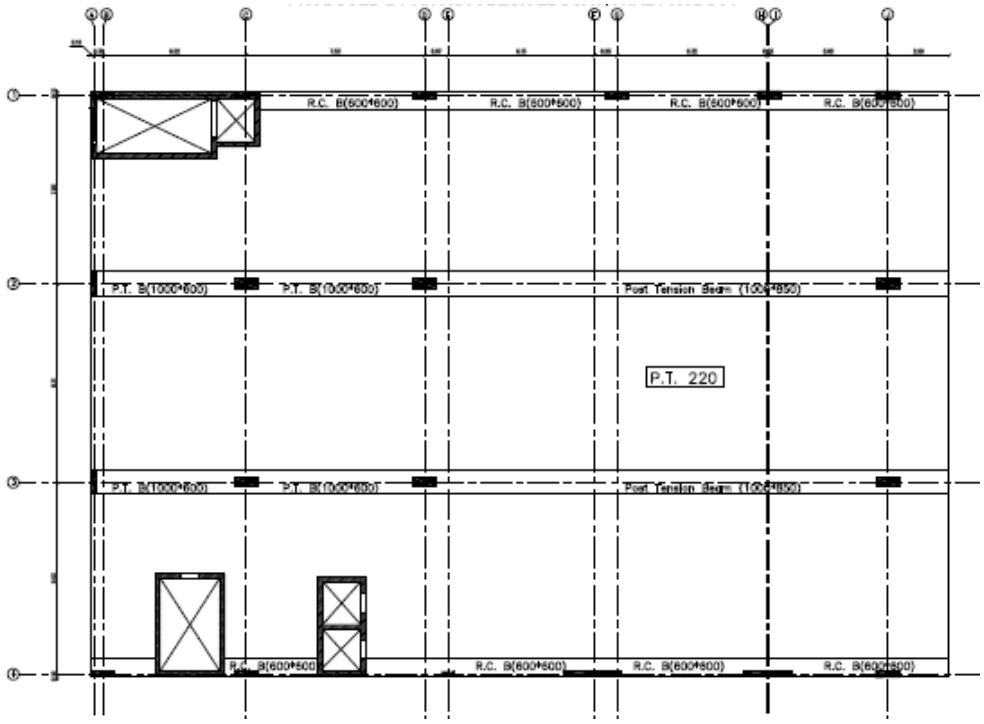

Figure 1: post tension slab plan

4.1. The estimated quantities:

- Equivalent floor slab thickness =220mm
- Estimated typical floor cycle =7 to 10 days

4.2. Advantages of the system:

- Controlled deflection and cracking.
- Allow for thinner slab than other systems.
- The clear height is increased compared to the other alternative, where a lower building height can be translated to considerable saving in mechanical systems and facade costs.
- Flexibility of partitions location and horizontal service distribution.

4.3. Disadvantages of the system:

While this system seems to be advantageous system for Commercial Building, there are several disadvantageous and concerns associated with this system. Most of the negative characteristics related to construction process:

- The tendon laying process extremely labor intensive and lengthy
- The requirement of the formwork and shoring systems.
- It's difficult to cut openings in the floor after the concrete is poured in fear of cutting the stressed tendons located in the slab.

5. **ALTERNATIVE # 2:** HOLLOW CORE PRE CAST SLAB SUPPORTED ON INTERNAL PT & EXTERNAL RC BEAMS.

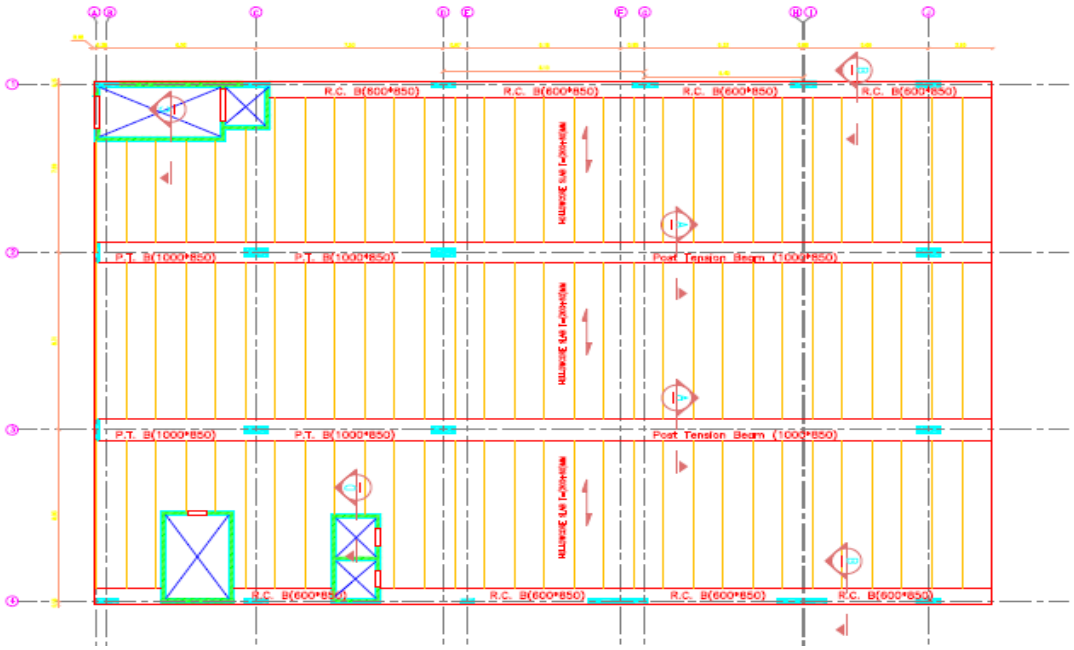

Figure 2: Hollow-core slab plan

5.1. The estimated quantities:

- floor slab thickness =20 cm HCS + 6 cm topping
- Estimated typical floor cycle = 300 to 500 sq m per work shift.

5.2. Advantages of the system:

- The system is extremely durable; High concrete quality.
- The construction is quick and can allow for early completion and the possibility the fast track the project
- No curing is required.
- The need for expensive formwork, shoring, shuttering, scaffolding, machinery and labors is eliminated
- Minimization of maintenance cost.
- Reduction in the self-weight of the floor slab compared with the conventional system that could reach an equivalent to the load of more than 4 additional levels. And reduced loads on vertical elements and foundation
- Its recognized as a LEED rated system
- Very efficient for noise attenuation.

5.3. Disadvantages of the system:

- Its not apprciate for irregular " complicated "shapped system
- Joints between HCS elements should be filled with special materials.

6. COMPARISON OF SYSTEMS:

Criteria for Selection effectiveness in each slab system

- Structure safety and serviceability aspect in additional to flexibility of the system.
- Economic point of view concerning the cost of the materials and process of construction.
- The weight of the slab system which controlling the vertical reaction on foundations and the lateral seismic force.
- Speed of construction.
- Depth of slab, floor to ceiling height

6.1. Weight

The weight of system is one of the most crucial factors because it dictates many others, such as vibration, cost, vertical element and foundation change. It can be seen from the values below the Hollow Core Slab system save more than **30 %** of building weight compared to the other system. The weight of systems; for slabs only (beams were ignored assumed same weight in two systems)

PT slabs system = weight of 22 cm solid slab = 528 kg/m2

HCS Slabs System: Weight of 200mm Precast HCS (230 kg/m2) + Weight of 60 mm topping (144 kg/m2) = 374 kg/m2

6.2. *Depth*

The Post Tension Slab would allow for a thinner slab than the Hollow Core Slab. This would increase the floor-to-ceiling height in the Commercial building.

6.3. Materials Cost

It can be seen from tables below the "Materials Cost" for Hollow Core Slab is close to Post Tension Slab. The major difference related to "Construction Process" Hollow Core Slab eliminated the need for expensive formwork, scaffolding, machinery, labors and plastering.

This is a rough estimation of the cost for each system includes cost of <u>materials only</u>, PT & RC beams were ignored assuming same cost in two alternatives. Prices might be changed based on market

Post- Tension Slab (net PT slab area = 728 m2)			
	Quantities	**Price (JD/m2)**	**Notes**

Post- Tensioning (net area)	728 m2	13.0	for slabs only includes design, supply, apply and any taxes for PT system
CIS Concrete- "22 cm " slab only	161 m3	14.4	assumed concrete cost 65 JD/m3
Reinforcement (55 kg/m3)-slab	8.9 ton	7.3	assumed reinforcement cost 600 JD/ ton
Total Cost (for slabs only)		**34.7**	

Table 1: Post tension slab cost

Hollow Core Slab (net PT slab area = 728 m2)			
	Quantities	**Price (JD/m2)**	**Notes**
Precast HCS, (20 cm) net area	728 m2	26	includes design, supply, apply, craning and any taxes for HCS system
CIS Concrete- 6 cm Topping only	44 m3	4.0	assumed concrete cost 65 JD/m3
Reinforcement - (mesh T10 @200) Topping only	4.5 ton	3.8	assumed reinforcement cost 600 JD/ ton
Total Cost		**33.8**	

Table 2: hollow core slab cost

6.4. Lead Time

For buildings that are fast- tracked, Lead Time is especially important. The HOLLOE CORE SLABS system would has had a significantly greater Lead-Time than other slabs, 300 – 500 m2 erected in one day.

7. CONCLUSION

Using current standard, design for each system were determined and then advantages and disadvantages for each system were analyzed. Two systems were then compared to determine which system would most benefit the construction and design of the Commercial Building. From this comparison, it was concluded that while two systems achieve Safety in Design & Construction; The Post Tension Slab outstands in Constructability**,** Floor Clear Height and Layout Flexibility however Hollow Core Slabs outstands in Building Weight and Lead Time. Cost is variable and almost equal for both systems

REFERENCES

Jordanian code.((93/5)أ.ب.ك المسلحة و العادية الخرسانة كودة)

British standard BS 8110:Part1&2&3 concrete design

PTI technical report no.43