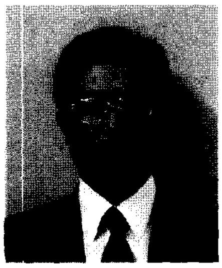
Abu Dhabi Investment Authority New Headquarters Building

김 경 준 / 삼성건설 UAE ADIA 현장소장

1. Introduction



The ADIA New Headquarters building has, nominally, 31 typical floors (levels 2 to 32) and located Abudhabi, UAE. The efficient and economical construction of these floors is critical to the successful completion of the project. Accordingly, the construction method and details of these levels warrants careful study.

During construction, it is important that construction loads do not overload or cause any long-term detrimental effects on the structure being built. In a floor construction cycle there are three critical stages, namely: concrete placement, post-tensioning and formwork removal. This report investigates the loading conditions at each critical stage and proposes construction details that will not have any detrimental effects on the structure.

Figure 1. Site View

2. Typical floor structural design

Structurally, the typical floors of the ADIA New Headquarters building can be categorized into 6 areas: office, filing, plant, reception, lobby and stair.

1) The typical office floor consists of 3 structural elements:
- 125 thick one way slabs spanning between rib beams
- 150 thick one way cantilever edge slabs
- 500 wide by 600 deep rib beams
- 600 wide by 850/1000 deep edge beams.

2) The filing and plant areas are of a similar construction to the office areas, except the 125 thick slab is replaced with a 250 thick slab.

3) The reception area floor consists of a two way 400 or 450 thick slab.

4) The lobby consists of a 300/500 slab with 800 and 500 wide by 600 deep beams and a 400 wide by 2000 deep beam that will probably be constructed as a wall.

5) The stair area, located behind the lift core walls, consists of a two way 500 thick slab.

Each of these areas have been designed to support a different combination of dead and live service loads. The dead load includes the self-weight of the structure and finishes, typically: ceilings, lights, raised floors and services. The live load varies depending on the function of the area under consideration. Live loads for different areas are given in Table 1.

Live load	kN/m2
Partition walls	1.5
Toilets	2.0
Office	2.5
Reception/Corridor/Lift Lobby/Landings	4.0
Plant Rooms	7.5
Filing	7.5

Table 1. In-Service Floor Live Loads

It is a requirement of BS 8110 (BS 1997) that the loading conditions during erection and construction should be considered in the design. This is important because during construction:

- the dead and live loads differ from the service loads
- the concrete in structural elements may not have reached design strength.

Construction dead loads include the self-weights of the structure, construction equipment and stacked materials. The live load from construction operations varies depending on the area under consideration. Table 2 lists the loads specified in BS 59 75 (BS 1995).

Live load	kN/m2
Working Areas	1.5
Access Areas	0.75
Storage Areas	As required but not less than 1.5

Table 2. Construction Live Loads

During construction the structure should not be loaded such that, subsequently, the structure does not meet the design limit state requirements. In the following sections the adequacy of the structure design is verified at several critical stages of construction, namely: concrete placement, post-tensioni ng and formwork removal.

3. Slabs

3.1 Introduction

This section begins with an outline of the scope, structural and construction requirements for the typical floor slabs.

3.2 General requirements

1) Zones

The Reception area slab, in front of the lift core, must be poured with the adjacent area of Wing B. This is necessary because stressing cables running continuously from Wing B across the Reception Areas to live ends adjacent to Wing A.

This is part of the reason, it is proposed that each floor will be constructed in 5 sections or zones, as shown in Figure 2. It is impractical to cast the entire floor area of the building in one shot and dividing the floor into 4 Zones fits well with the proposed 8-day cycle, ie. pour a slab every 2nd day.

2) Structural Areas

For construction purposes, the typical floor slabs can also be divided into different structural areas as follows:

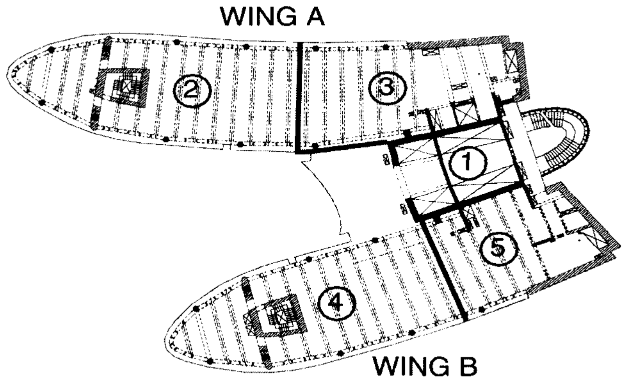


Figure 2. Typical floor zones

(a) Wing Tip - the wing tip area beyond the Stair walls.

(b) Plant and Service - the non-typical area adjacent to the Shear walls

(c) Reception Area - the area in front of the Lift Shaft

(d) Lobby Area - the area within the Lift Shaft wall

(e) Stair C Slab - the area between the Lift Shaft and Stair C

(f) Typical Rib Beams - the balance of the floor It is likely that different construction methods will be required in some Areas (A to F).

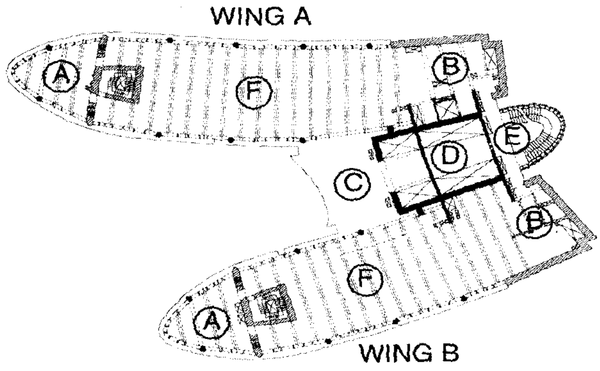


Figure 3. Different structural areas

3.3 Simplification of Rib Beam Layout

1) In order to simplify the design of the formwork and reinforcement, the rib beams in each bay should be parallel. Further, the typical rib beam spacing should be 2400 mm, except for between Grids F and G and Grids N and P where the spacing should be 2700 mm.

2) The proposed changes are compatible with the current structural design, and will result in significant savings during construction.

3) By following the new configuration, all the slabs between the rib beams will span either 1800 or 2100 mm, except the slab along the column Grid lines, which will be trapezoidal on plan. The maximum span of this slab is within the capacity of the slab as designed.

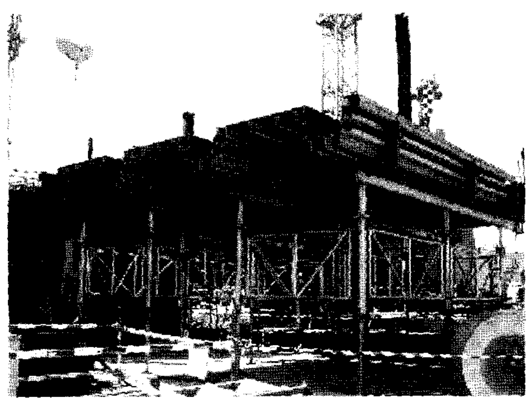


Figure 4. Table Form

3.4 Structural Requirements

The structural design of the building imposes certain limitations and requirements of the construction method. These include: limitations on the maximum shore leg load, number of floors and spacing of backprops, loading effects of post-tensioning and the minimum period before striking.

1) Formwork shore locations

(a) The maximum shore load that can be safely supported at mid-span of the 125 mm thick slab is 10 kN. Formwork shores (including backprops) whose load exceeds 10 kN would need to have a backprop placed directly beneath them or be located closer to the rib, ideally directly over the rib beam.

(b) The formwork design needs to also to take account of the Specification (Happold 2000) that limits the spacing of props to a maximum of 3 metres in both directions.

2) Backpropping

The structural design assumes the construction load of the floor being poured is shared equally between two full strength floors. Consequently, only one floor of formwork and one floor of backprops are required.

3) Post-tensioning

An important consequence of post-tensioning is load transfer. The effect of post-tensioning the rib beams will be to transfer the self-weight of the rib beam and slabs, as well as any construction loads they support, to the perimeter ring beam. Figure 5 shows the effect of load transfer.

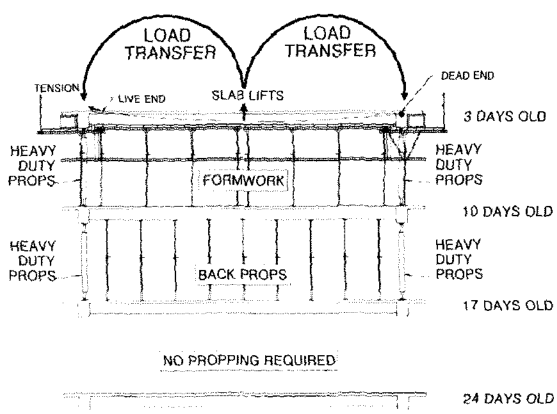


Figure 5. Load transfer after post-tensioning

As the stressing is expected to occur on day 3, before any formwork has been struck, the formwork under the perimeter ring beam must be designed to support this additional transferred load. Assuming a combined self-weight and super-imposed load of 7.5 kN/m2, a load of up 50 kN/m could be expected to be transferred to the ring beam formwork.

Thus, a formwork system must provide supports under the perimeter ring beam that have sufficient strength, not only to carry the ring beam, but also an additional load transferred to the beam during post-tensioning.

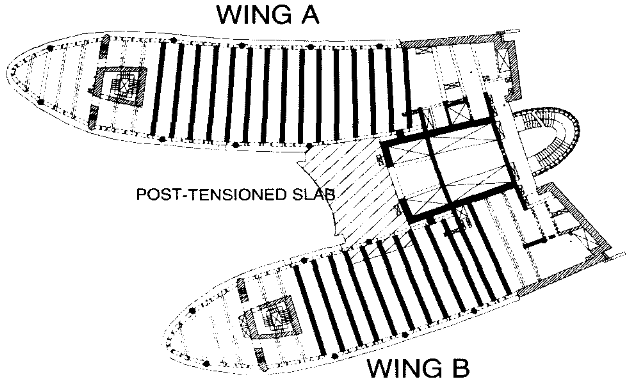


Figure 6. Post-tensioned beams (B1, B2 & B3)

(a) The rib beams and slab highlighted in Figure 6 are post-tensioned.

(b) Post-tensioning can commence once the newly placed concrete has reached a compressive strength of 25 MPa. Accordingly, it is expected that post-tensioning will commence on the morning of the third day after concrete has been placed.

4) Load transfer

(a) A consequence of post-tensioning is load transfer. In the case of the ADIA building, the self-weight of the post-tensioned beams and possibly any concurrent construction load will be transferred to the edge beams at either end of the beam being stressed.

(b) Any falsework under the edge beam at that time must be capable of supporting this additional load. Typically, the transferred load is in the order of 50 kN/m will be transferred to the edge beam. However, along Grid 03 between Grids N and L, the load transferred to the formwork will be as high as 170 kN/m, because this edge beam is the central support of a continuous double span.

5) Striking

(a) Formwork may be removed after the newly placed concrete has reached a compressive strength of 24 MPa and, in the case of the post-tensioned beams, after post-tensioning has been completed.

It is expected that formwork may be removed on Day 3.

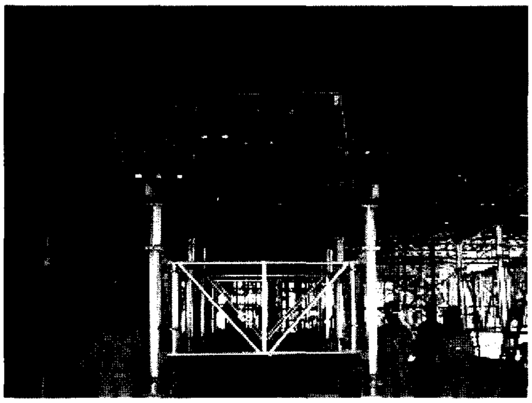


Figure 7. Table Form striking

(b) Assuming the formwork is stripped in one operation, Figure 8 depicts the removal and reuse of formwork and backprops.

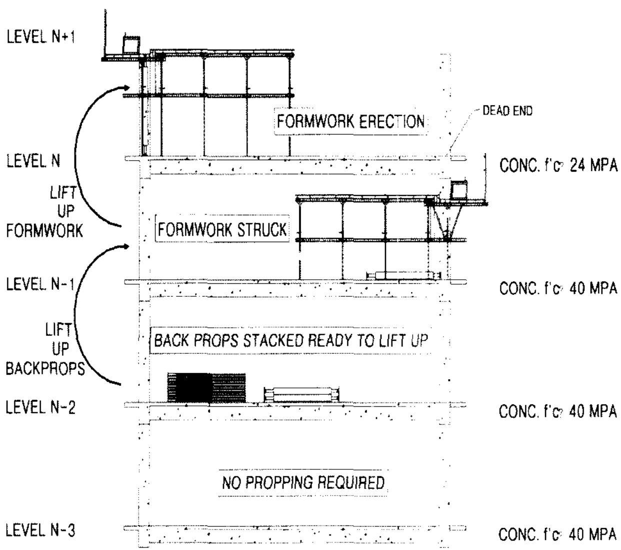


Figure 8. Formwork striking

4. Walls

4.1 General

The building has three types of walls: Wing Tip Stair Walls, Corner Shear Walls and Lift Shaft Core Walls, see Figure 9.

Figure 9. Wing Tip Stair Walls, Corner Shear Walls and Lift Shaft Core Walls.

All wall formwork should be crane handled, because:

(a) According to the preliminary crane analysis, there is sufficient crane time in an 8-day cycle to lift wall formwork. This negates the need to use, or incur the cost of, self-climbing wall formwork. However, the wall formwork design and constru ction techniques should focus on reducing the number and duration of crane lifts.

(b) Handset formwork might delay the floor cycle because of the 4250 mm floor height, ie. two or three lifts of formwork panels would have to be erected working off a scaffold.

All wall formwork should be designed to minimise the number and duration of crane lifts. This means:

(a) Each form to be lifted should be the maximum size that is practical.

(b) The design of each form should allow for lifting from one point.

At the edge of the building, inside shafts and where walls are constructed above the slab, the wall formwork should be mounted on (and be lifted with) working platforms. This type of formwork is commonly called Jumpform. In particular, Jumpform sho uld be used for the Lift Shaft walls, the external face of the Shear walls and internal face of the Stair Shafts, as shown in Figure 10.

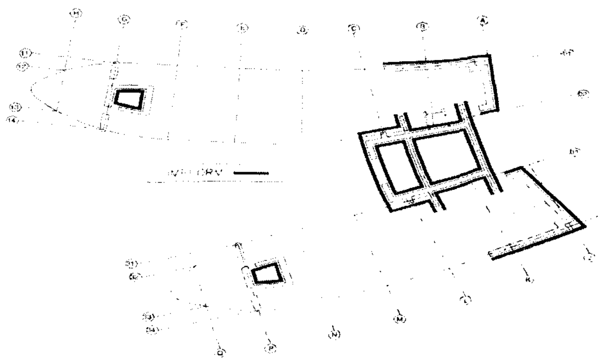


Figure 10. Areas where Jumpform should be used

All Jumpform should be configured with a trailing platform, except where there is a slab beneath, e.g., external lift shaft walls.

The Jumpform should be designed to minimise the number and duration of lifting. This means:

(a) Each form to be lifted will be the maximum size that is practical.

(b) The design of each form will provide for only one lifting point.

(c) The Jumpform anchor points, should allow for an efficient, positive and secure landing, without the need for people to ride the lift.

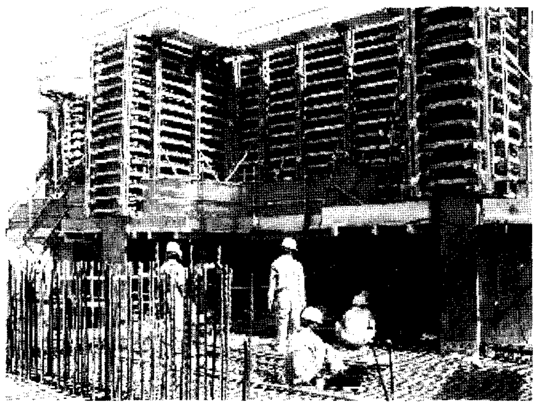


Figure 11. Corewall Jumpform

The edge protection provided with the Jumpform should be sufficiently high (approximately 3000 mm) to protect workers who climb up the high formwork to fix or remove form ties.

Wall formwork shutters that are returned to the ground between use should be stored so that:

(a) Each form can be accessed without multiple handling.

(b) Stored upright in racking or braced to prevent overturning.

Assuming 4100 high walls and a concrete delivery rate of 25 cum/hour the rate of rise for wall forms is expected to be approximately 1.5 m/hr. This translates to approximately 3 hours to pour a wall.

Based on a rate of rise of 1.5m/hr and a discharge height of 4.1 m, the maximum concrete pressure that the wall formwork should resist will be approximately 50 kPa.

The wall between Lower Ground Level and Ground Level (approximately 4750 mm high) should be constructed in 1 lift, using a 500 mm extension on top of the typical shutters.

The wall between Ground Level and Level 1 (approximately 11000 mm high) should be constructed in 3 lifts, which will require a construction joint so the Mezzanine slab can be connected to the wall at a later date.

4.2 Lift Shaft Walls

The lift shaft walls should be constructed two floors above the slabs, as shown in Figure 12. This is necessary because there is insufficient time in an 8-day cycle to form, reinforce and pour the walls without delaying the slab formwork in the same area.

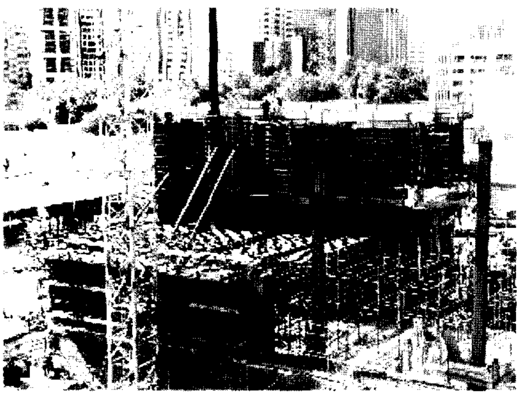


Figure 12. Lift Shaft wall configuration, two floors ahead of slab.

(a) The core might be divided into two pours, with a construction joint through the lobby.
(b) The walls should be poured from underside of floor to underside of floor.
(c) The construction joint between the wall and the slab will require rebates, blockouts, couplers and/or pullout bars.
(d) An access stair scaffold is required to provide access from the highest cast slab to the Jumpform. The access scaffold should be located in a lift shaft to avoid obstructing construction of the slabs.
(e) The Jumpform assemblies should be a large as practical to minimise cranage (22 lifts maximum).

5. Conclusion

This report considers the affect construction loads have on the design of the typical floors of the ADIA New Headquarters building. In particular, the report investigates the loading conditions at three critical stages during construction, namely: concrete placement, post-tensioning and formwork removal. At each stage the construction loading condition is checked to ensure it does not overload or cause any long-term detrimental effects on the structure.

As a result of the checks, it can be concluded that:

(a) The typical floors can be safely constructed using one floor of formwork and one floor of backprops.
(b) Concrete may be placed on the next floor once the concrete in the floor beneath has reached design strength (40N/mm2), assuming that floor is backpropped.
(c) The formwork and backprops under edge beams supporting post-tensioned rib beams must be designed to carry the additional load transferred during stressing.
(d) Formwork under post-tensioned rib beams cannot be removed until they are fully stressed.
(e) Slab and beam formwork and props can be removed providing:
  ① the concrete they support has reached a compressive strength of 24 N/mm2 and
  ② the construction load at the time does not exceed 2.27 kN/m2.

It is proposed that the typical floors of the ADIA New Headquarters building will be constructed in accordance with conclusions of this report.

References

Beeby, A. W. (2000). ECBP Task 4 Report - Early Striking and Backpropping (Report BR 394). BR 394, BRE, London.