CONSTRUCTION PLANNING FOR HIGH-RISE RESIDENTIAL BUILDING

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Abstract: Buildings are becoming higher and higher nowadays in maximizing land use and investment return. Construction of residential developments are considered as focal point of the construction industry in view of its huge labor contents and turnovers evolved due to its own nature of works and investments involved from the investors. Investors tend to build everything possible in a small piece of land to increase their return from their investment in the quickest possible manner. Practitioners in the construction industry are looking for different means and methods in enhancing efficiency and meeting requirements from the statutory bodies and the Clients. The purpose of this paper is to look into the considerations required in nowadays construction planning for construction of high-rise residential building.

INTRODUCTION
A detail construction planning is a pre-requisite element to ensure the project in completing on time, planning and meeting the budget, quality, safety and environmental requirements. This is particular important for success with high-rise residential building construction in view of its repetitiveness and the amount of resources required. The construction of high-rise residential building is in fact a reflection of the set up of a factory, factory production, satisfactory handover the products to the end users and decommissioning, where has provided bread and butter to thousands of family in Hong Kong. Mr. Chris Henrickson has defined construction planning where “involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among different work tasks.”

PLANNING CONSIDERATIONS
The following are some of the basic considerations required during the construction planning process.

- Statutory Obligation
- Contractual Obligation
- Social Obligation
- Site Characteristics

Statutory Obligation
Statutory obligation would include the compliance with Building Regulation / Building Ordinance and Approved Plan. It is the duty of the main contractors to provide continuous Site Supervision and to notify Buildings Department any contravention of regulations that would result from carrying out the works shown in approved drawings. Asides from the above, this would also include the compliance of Chapter 123 Building Ordinance, Practice Notes for Registered Contractor, Authorized Person and Structural Engineer, Construction Site (Safety) Regulations, other rules / regulations from Buildings Department, Labour
Contractual Obligation

Contractual obligation is the commitment between the Contractor and the Employer in delivering the services as accordance to the terms and conditions as laid out in the contract documents. This would also include special terms and conditions required by the Employer together with design assumptions and requirements from the Architects and Engineers.

Social obligation

Social obligation involves the care of workers on site and neighbors or public outside site boundary. For the workers, we have to provide a safe working environment together with all necessary welfare facilities for all workers working on site and to ensure they are getting paid from the respective employers in a timely manner. In taking care of the neighborhood, it has always been the concerns of main contractors in minimizing nuisance and impacts to all nearby residents and pedestrians or road users during the course of construction. Besides the care of workers and neighborhood, sustainability is also one of the upcoming key issues in the construction industry. On the corporate side, it stresses on long-term growth and development. Whilst on the environmental aspect we need to look into new ways and methods in minimizing impact to the environment via noise management, energy management, materials and waste, and look into project life-cycle from design ideas throughout construction, operation and maintenance to decommissioning and renewal.

Site Characteristics

Every projects in Hong Kong are different and having its own characteristics in view of its own geographical location, nature of works, time of construction, people’s knowledge and skill-set. Construction planning is somehow tailor made to suit the site characteristics or constraints and is a one-off exercise, which is not fully applicable to other identical projects although the concept may be the same.

EXPERIENCE SHARING - BELLAGIO PHASE 2

In this paper, I would like to share with you all some of our experience in construction planning for Bellagio Phase 2 development.

The Project

Bellagio Phase 2 is a development by Warf Estate Development Ltd., which is located at 33 Castle Peak Road, Sham Tseng. It is in the close vicinity to the occupied developments, namely, the Bellagio Phase 1 and the Ocean Pointe (Figure 1 refers). The development includes eight levels podium together with four residential towers ranging from 54 to 56 storey and the associated external works. It provides 1,641 residential units, 1,369 car parks, clubhouse facilities and leisure / landscaped nullah decks upon completion. The total building height, from Level 1 to Dome feature at the top roof, is 200.15m.
Four programme milestones have been prescribed in the contract as a control mechanism on performance of main contractor’s progress.

- **Stage 1:** Completion of Podium Structure - 450 days
- **Stage 1A:** Completion of Tower Roof Structure - 500 days
- **Stage 2:** Issuance of Occupation Permit - 760 days
- **Stage 3:** Issuance of Practical Completion Certificate - 850 days

The critical path of the project is to construct eight level podium, a 3m transfer plate and four residential towers, including 52 to 54 storey of typical floors plus 2 refuge floors, in 500 days contract period. Due to the time constraint, 4-day construction cycle has been opted for Towers’ typical floor construction in Bellagio Phase 2.

**High Strength Concrete**

The lowest 10 typical floors of Tower 2, 3 & 5, ranging from 10/F to 20/F, and the lowest 14 typical floors of Tower 1, ranging from 10/F to 25/F, are constructed with Grade 60 high strength concrete. Special attentions have been taken during the planning process and consent application prior the use of High Strength Concrete and these are listed as follows.

- Submission of Quality Assurance Proposal to confirm the reliability and consistency of concrete production.
- Provision of on-site sampling, making, curing and storing facilities for the test cubes.
- Provision of experienced and competent person for full time supervision.
- Provision of HOKLAS accredited laboratory for carrying out on-site and laboratory sampling and testing work.
- Proposal for in-situ core test of finished concrete structure

In addition, on-site trial columns were also required, to demonstrate the quality and workmanship of Grade 60 concrete prior to the issuance of consent.
The period for preparation of the above-mentioned trial columns and documental normally takes 2-3 months before the use of high strength concrete on site. Thus, the lead-in time required for preparation of the submission was reviewed immediately during the pre-construction exercise and at the first instance in the preparation of the construction planning so as not to jeopardize the issuance of the consent and the actual construction works.

**System Formwork for Typical Floors**

Traditional timber formwork is used for the construction of the Podium structure, due to the flexibility to suit the non-typical structure. However, it is more cost effective to use system formwork for the construction of typical floors, due to the repetitive structural form. A Reinforced Polypropylene Compound Plate (PP plate) handset system formwork, which is a composite of aluminium frame with PP plate panel or modified full aluminium handset panel, was adopted. The PP plate handset formworks is a modification from the traditional aluminium handset formworks, with the improvements on the following areas:

1. The panel size is increased, due to reduction in weight, which tremendously reduce the number of panels.
2. Various concrete surface can be formed, both smooth and rough. The rough surface can improve the cohesion of the concrete surface and the cement sand plaster.
3. The PP plate is less likely for disfigurement by hammering than aluminium panel. And in case the PP plate is damaged, it can be repaired easily on site.

Besides, the PP plate aluminium handset formwork system is more environmental friendly as less noise was generated during operation. Lengthy study / review had been conducted prior to the selection of the PP plate handset system formwork, the results are summarized as follows:

<table>
<thead>
<tr>
<th>Comparison Item</th>
<th>Aluminium Panel</th>
<th>PP plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be recycle</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>High</td>
<td>Negligible</td>
</tr>
<tr>
<td>Can form variety of concrete surface finish</td>
<td>No (Only smooth finish)</td>
<td>Yes (Smooth &amp; rough surface can be formed)</td>
</tr>
<tr>
<td>Bonding between concrete surface and plaster</td>
<td>Relatively weak</td>
<td>Good (Due to rough concrete surface)</td>
</tr>
<tr>
<td>Mould oil stain on concrete surface</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Noise generated during operation</td>
<td>Yes</td>
<td>Relatively less</td>
</tr>
<tr>
<td>Disfigurement by scratches and hammering</td>
<td>Yes</td>
<td>Relatively less</td>
</tr>
<tr>
<td>Damaged panel can be repair / replace on site</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Concealed M&amp;E services can be fixed by direct nailing onto the panel (Flexible in construction)</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In planning for the adoption of handset system formwork for high-rise residential building construction, the followings should be allowed:

1. Building design must be frozen at early stage
2. Sufficient time shall be allowed for fabrication, factory pre-assembly and learning period for adopting 4 day cycle
3. Allowance should be made for change from typical floor to non-typical floor, such as refuge floor or plant rooms, and vice versa.

In order to shorten the learning period and smooth flow of works on site, full-scale factory pre-assembly is recommended for each set of system formwork prior to the delivery to site. In addition, an on-site mock-up has also been built to verify the integrity of the system formwork as well as for coordination among different trades.

Due to the adoption of the 4-day construction cycle, it is necessary to strike the beam and slab formwork earlier than the specified period. The approval of such operation should be supported by concrete mix with early strength development. Left-in prop detail of the handset system formwork was developed to cater for striking of formwork without disturbing the propping (Figure 2 refers). In addition, adjustable kicker detail was introduced to absorb the construction tolerance of the concrete flooring.

![Figure 2  Left-in props of Handset System Formwork](image)

**Site Layout**

In planning for the site layout of the Bellagio Phase 2 project, the followings are some of the key important issues needed to review during the pre-construction stage.

1. Site Logistic
2. Site Security
3. Site Plant Set Up

Site logistic includes the arrangement of the storage areas, rebar bending yard, location of stationary concrete pump, construction traffic as well as the workers and materials traffic flow.

Security control points shall be carefully planned and regular reviewed, not only setting up the site entrance hut for workers entrance control but also the surveillance check points for storage area. Site security control should not only focus on the forbidding unauthorized entry into the site, but also to avoid trespass from inside site boundary. Thus, in addition to set up surveillance routing and checkpoints for security guards and supervisory staff, CCTV system has been installed at key locations for monitoring.

Three tower cranes have been deployed for the construction of Bellagio Phase 2, two tower cranes were to serve the towers construction, whereas the other was for podium. The site
plant set up was divided into two stages, which to suit the construction sequence of the Towers and Podium (Figure 3 refers). Upon the completion of the transfer plates for the Towers, and the relocation of the steel bending yards, the site layout will change to stage 2 with the Podium construction to proceed in full speed.

In view of the 270m$^3$ daily concreting volume for the Towers’ typical floors, stationary concrete pump was used for transporting concrete to the casting floor with assistance of mini-placing boom for concreting operation. In view of close proximity to nearby residents, special attentions and precautionary measures are required during incoming and outgoing of waste and materials, access route arrangement for staff and workers, materials uplifting and unloading, concreting, cleaning of external wall finishes, external scaffold erection and dismantle, testing and commissioning of final connection of building services, typhoon season and etc, where full cooperation with Estate Management Office and Owners’ Committee is necessary during the construction period.

**Podium Construction Sequence**

Since the structures of the residential towers is tie-in the critical path of the construction programme, the tower footprint areas of the four towers have been scheduled to commence first, and the rest of the podium was left-out for rebar bending yards and other site facilities until the completion of the towers’ transfer plates. However, the tower footprint area, which lies between the site access road and the Podium, has created a barrier for the site logistic for Podium construction.

The podium construction of the Bellagio Phase 2 was divided into seven areas (Figure 4 refers). The sequence and phasing of the podium construction has taken into consideration on the construction sequence of the whole site, the site logistic as well as the podium plant arrangement, where tower crane and material hoist for podium were located at the late cast Area 7.
The challenge of the Podium construction for Bellagio Phase 2 is not only due to the sequencing works within the site. As the Phase 2 podium for Bellagio development is connected to completed Phase 1 podium, the interfacing works, including structural, architectural and especially the building services, would require detailed coordination and survey prior to the actual site works.

**Aluminium Window Installation**
Aluminium window installation is one of the critical elements in architectural works that require tight supervision and control. Prior to the fabrication, a full-scale window is constructed with performance test to demonstrate the design and structural integrity.

The over-sized window opening for installation is always a major cause for water leakage and use of system formwork for boxing out of window opening has been a big improvement as compared with old days in controlling the completed structural openings within tolerance and allowable limit.

In-situ pullout tests for fixing anchor bolt are conducted after the installation to verify the fixing and quality of works. Lastly, 100% water test was also carried out after the installation of window glazing.

**External Wall Tiles**
The quality and workmanship of external wall finishes are always the key concern for quality control on residential buildings. This is more significant in high-rise residential development, which the building is subject to large extent of deflection due to wind load. In light of this, the quality assurance for external wall tile of the towers is started from the selection of adhesive system. A full adhesive system, which includes adding admixture to spatterdash, cement sand plaster, and bond coat and tile grout is selected. In-situ pull out test had also been carried out prior to the selection of the adhesive system. To avoid error on mixing of adhesive to the cement sand plaster, the adhesive was added to the instant mortar and mixed thoroughly in the truck mixer, prior to deliver to working floor.

The adhesion of the external finishes is much depended on the surface preparation prior to the application of each finishing layers. The cleanliness and soundness of substance should be checked and inspected prior each applications. A “Trade by Trade” handover system is implemented to ensure the quality of the final product and smooth flow of works.
Apart from the routine inspection by the supervisory staff and the client’s site staff, in-situ pull-out tests and tapping survey were also carried out prior to the dismantle of external scaffold to ensure the quality of external wall tiling.

**CONCLUSION**

Land is the most precious resource in Hong Kong. Most residential buildings in Hong Kong increases from 30 - 40 storey to 50 - 70 storey in the recent years to optimize the land use and investment return. Advanced technologies and construction methods, such as modular construction, pre-fabricated kitchen and bathroom, are introduced to facilitate the fast-track construction and to achieve better quality. Legislation on Health, Safety and Environment are become more stringent nowadays in meeting quests from the society and industry.

Building Engineers should frequently review the up-to-date technologies and methods as well as the corresponding legislations, and take into consideration during the planning stage of a building construction project. However, there are other unknown factors, such as inclement weather, regional climate and human mistake or errors that should be allowed during the process of construction planning.

Good construction planning is pre-requisite for a successful project. However, “Plan, Do, Check, Act” process and “partnering” approach should be adopted throughout the whole construction period, to ensure the site management can adapt changes to suite the unforeseen factors and to review from time to time on the effectiveness of measures or facilities that have put in place. The “partnering” approach should apply to all levels including the nearby residents, road users and others, and not just limited to the Clients, Consultants and subcontractors.

“Information is Power” and effective communication is the mean in transferring the information to all stakeholders involved in the project especially for the construction industry in Hong Kong. Communication is critical amongst each contract parties including all the workers working in the project and is the key factor for a successful construction project. The design and built environment are changing throughout the project period and it is important to bring it clear to the whole site team on the requirements from the construction planning, latest development of the project and requirements from the management in having the team to move forward to the right direction.