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Engineering and Construction Features of an Extremely Complicated Redevelopment Project in the Densely Built-up area of Hong Kong

Raymond W M Wong
Lecturer, Div. of Building Science & Technology, City University of Hong Kong, Hong Kong.

Abstract

There is a very eye-catching project, namely the Langham Place, being completed recently in the densely built-up area of Hong Kong. The project was originally an urban renewal project under the former Land Development Council, in which a series of pre-war buildings in poorly maintained conditions were resumed, demolished and redeveloped. The site occupied an area of about 12,000 sq m, with a servicing 1 way 3-lane roadway cutting in between. The final decision was to redevelop the site into a commercial complex which includes a 58-storey office tower, a 16-level shopping mall constructed in structural steel and a 42-storey 5-star hotel building. Other provisions included a 5-level basement used as retail and car-parking purposes, Site condition was extremely unfavorable both for the designers, engineers and the builder particularly when the congested environment of the site was taken into account. This paper tries to highlight the engineering and construction features of the project.

Keywords

Basement construction, Composite structure, Planning for complicated site environment.

1. INTRODUCTION

Mong Kok is one of the most densely populated and aged districts in the metro area of Hong Kong. Some streets within the area have a development history which can date back up to the end of the 19th Century. Being a city under fast development, majority of the old streets and historic buildings were demolished to give way for developments under usual free-market environment. Except for some modern commercial buildings using as office, entertainment or retail purposes, majority of the remaining buildings in the district were constructed after the World War II with averaged age ranging from 30 to 50 years. Due to the insufficiency of space and urban facilities which inherited from outdated city planning, the district is deteriorated in a very fast manner and created a lot of associated social problems. In view of this, through the Land Development Corporation, the government started to resume altogether about 120 blocks of old buildings within an area bounded by 7 streets. After that, the project was developed by a private developer under negotiated contract. The development was known as the Langham Place afterward.

2. Project Background and Coverage

The Langham Place project covers a total area of about 12,000 sq m, which is further sub-divided into two lots of land, separated by a street in the middle. The larger lot (Site A) is a 7,950 m^2 island site, bounded by four busy streets on the side. Site A accommodates a 58-storey office tower block, a 16-storey retail mall, and a 5-level basement uses as retail and carpark that stretches the entire area of the site. The smaller site (Site B, 4,300 m^2) is opened two sides to two streets, and the shorter ends abutted to existing buildings. This site consists a 2-level basement while the upper structure is a 42-storey hotel building with 750 rooms. Except for an entrance foyer for the hotel and a small landscape garden on its side, majority of the area on the ground level is used as a public light bus terminus that formed part of the ground transportation relief strategies for the existing congested neighborhood in downtown Mongkok. The total development of

Langham Place involved a gross floor area (GFA) of 167,400 m_2. Connection provisions in the development have been provided in the design in order to enhance the flow between the two sites and the nearby areas. This includes a 2-way vehicular tunnel to link up the two basements, two pedestrian footbridges on Level 3 and 4 linking the hotel block and the retail mall, and a 90m pedestrian subway linking the subway network of the Mass Transit Railway with the mall.

3. Construction Highlights

The major construction works for the project can be sub-divided into five core portions, that is, the foundations, the construction of the main tower, the basement structure on site A, the retail mall structure, and the hotel block on site B. below are the highlights of these works.

3.1 Foundation in general

The foundation works were carried out at the same time for the both sites at the end of 1999. The contract involved the forming of various cut-off systems in the form of sheet pile wall, diaphragm wall and small diameter pipe-pile wall; as well as the usual bored piles as support for the upper structures. Majority of the bored piles were 2.5m in diameter formed by reversed circulation drilling process and grab-and-chisel method, and seated on bedrock averaged 45m below ground. Connection provision was also allowed at the formation level of the bored piles for the erection of steel stanchions which used as temporary support of the basement structure constructed in top-down. These stanchions would be encased with reinforced concrete afterward to become the permanent columns in future. To facilitate the construction of the basement at convenient stages at a later time, a section of sheet pile wall were also provided.

3.2 The main tower

The tower founded on a 5m RC raft constructed in a bottom-up manner. To facilitate the construction of the raft, a 42m x 42m cofferdam was formed with diaphragm wall lined on 3 sides and sheet pile wall on the other as cut-off provision. The cofferdam pit was laterally supported by a complicated strut and bracing system in structural steel with 7 layers of lateral supporting frame. The support system also provided a work platform at top on which mobile cranes and dumping trucks were stationed during the excavation process. The formation level of the cofferdam was about -28m.p.d. The main structures located inside the cofferdam included the core wall, four composite columns and 6 other minor columns in RC for the support of the upper structure. The basement structure, constructed in in-situ RC and traditional timber formwork, was done in an usual bottom-up manner with the walls and floors cast in carefully sub-divided sections to suit various constraints within the highly congested space within the cofferdam pit.

The core wall and the composite columns continued upwards until they reached Level 5 where a 5m-thick transfer plate located. A falsework system erected in tubular scaffold and universal steel beams was erected to facilitate the casting of the transfer plate. The 13,000 tons transfer plate was cast in 2 layers to relieve the loads acting onto the falsework during the casting process. Upon the completion of the transfer plate, a set of jump form was assembled for the forming of the core wall for the upper tower structure. Column configuration was in 4 composite mega-columns plus 6 in-situ RC side columns for floors below the transfer plate, which was re-configured to 12 in-situ RC columns layout with shorter span arrangement above. The floor system was of usual main/secondary beams design, which was constructed in RC using traditional timber form and connected to the core wall with build-in couplers. Headroom of the typical floors is 3.9m and the average coverage of typical floor is about 1,500 sq m in size. A 4-day cycle was adopted for the construction of typical floor with the core wall constructed using a hydraulic-lifting slip form in an advanced phase of 4 to 5 levels ahead and floor slab in traditional timber formwork that followed. The core wall measured about 15m x 32m on plan. Maximum thickness of wall is 1.2m for the lower floors, and reduced to 600mm when reaching the upper levels.

There are 2 outrigger systems incorporated in the superstructure of the building as a stiffening design. The outriggers was in a simple bracing frame design, with a built-in X-shape steel frame inside the core wall and inclined composite tie members that tied rigidly with the external frame. Instead of a fully-braced belt truss system, a simple truss in the form of an inverted "A" configuration was adopted as the external truss of the outrigger.

3.3 Basement Structure on Site A

The basement under the retail mall at Site A was constructed using a top-down approach. Total volume of excavation involved in the basement was about 170,000 cu m. Majority of the sub-soil is of made-ground with significant amount of marine deposits. The basement structure consists of 5 levels, with the upper 2 levels use mainly as retail, while the remaining as car parking purposes. The basement was joined to the portion under the main tower which was constructed in a bottom-up manner in an advanced stage during the progress of basement construction.

One very spectacular structure in the basement is a 36m diameter vehicular ramp which serves as an access for vehicles into the basement carpark. The ramp was constructed also in a top-down manner and served as an important provision for spoil disposal and material delivery during the peak period of construction. Besides, the escalator voids located inside the basement was also made use of for similar purposes. Due to the large size of the basement and complicated spatial layout within, as well as the employment of top-down method to construct, the basement structure was sub-divided into 7 major portions to construct. The ground floor slab was the structure being cast in the first place which served also as the first lateral supporting structure against the sides before the proceeding of the basement excavation in full scale.

3.4 The Retail Mall

The retail mall is a very complicated structure with the lower portion (from ground to Level 4, the main deck) constructed of in-situ RC, and the upper portion in a structural steel composite. In addition, there is a grand atrium located in between the office block and the mall structure, which provides an averaged 52m high unobstructed space above the main deck at Level 4 that forms the highly impressive entrance to the retail mall.

The grand atrium provides a covered void inside the mall with 77,000 cu m of space. The structure of the grand atrium is a space truss supported by 10 columns on two sides and connected by the roof trusses to form a portal frame. The columns are made of tubular steel trusses in rectangular shape. The height of columns ranges from 51m to 63m. Space between the columns is tied by connecting beams in tubular section and cables girders for the mounting of the glass wall. The steel roof curves slightly upward to provide cover for the remaining portion of the retail mall. The steel roof was constructed of 14 sets of main trusses, with average depth 3.5m each. Besides the grand atrium, there are 2 other atrium provisions placed inside the main structure of the mall in which two fast-track escalator systems are located. There is also a provision for a function area on Level 12 with averaged 15m headroom, and cladded on the sides with glass wall to provide transparency and natural lighting for the area.

3.5 Hotel Block on Site B

The hotel block started its basement construction in August 2001. The basement adopted a rather tradition method to construct, that is, it was done in a bottom up arrangement, with the excavation carried out in layers starting from the ground level, until it reached the formation level where the pile caps located. The averaged depth of excavation was about -14m from street level. Side support was by the use of sheet pile wall with a section of pipe-pile wall at both ends where it abutted to existing buildings. Six layers of strut frame were installed as lateral support, with a 60m x 12m temporary platform erected on top as work station to facilitate the excavation process.

In order to provide a 4-lane public light bus terminus at the ground level of the site, the floor span on the lower levels of the hotel block is maximized by the use of thin composite columns in an approximate 9m and 15m span layout. The arrangement continues upward until it reached Level 11 where the 3.2m-thick transfer plate locates. The structure above Level 11 is used as hotel guestrooms. The hotel structure is comprised of two portions, one is the major core wall system which housed the lift shafts, staircases and other major services; the other is the shear wall block for the typical guestrooms. The averaged 500mm-thick core wall system was constructed in an advanced phase using a crane-lifted gang form, while the averaged 300mm-thick shear walls were constructed using large panel-type steel form. The 3.15m-clearance floor system in this case was constructed using a traditional timber formwork propped with standard tubular scaffold.

4. Special problems encountered during the construction process

The Langham Place project encountered a lot of work difficulties during the construction due to practical reasons. Below show some of these examples.

4.1 Extremely congested environment surrounding the site

The site (Site A and B) was bounded by one main road with 3-lane dual way traffic and 4 busy inner roadways with averaged width below 12m. Usual site activities such as the removal of excavated spoil and the delivery of materials during the basement and superstructure construction, created numerous disturbances and interruption to traffic both within or outside the site boundary, that very careful planning and coordination was required.

4.2 Large work frontage and coverage

The entire project excluding the foundation works took 36 months to complete. The peak period arrived about 15 months after the contract commencement in August 2001. During this period, the excavation work for the substructure was basically completed, while the construction of the main tower began to reach its typical cycle. At the same time on the retail mall portion, the podium structure in RC was completed that followed by the erection of the upper structure. The basement constructed in top-down arrangement was carried out in parallel with the other major work portions. At a result, there were more than 600 workers working in the site with a cash flow of US$16 million per month during the climax period.

4.3 Working at high altitude

Beside the general engineering and technical concerns in the installation of the steel frame building, there was also the problem of working at high altitude especially for the retail mall structure. This was further worsened by the existence of a number of long-span and high-headroom atrium spaces which involved a lot of very heavy pre-assembled components and other temporary supporting falsework.

4.4 Difficult site layout planning to meet the construction operation

The large work frontage and dynamicity of the construction operations within a congested site demands very accurate support in site layout provision and planning. How to locate the required provisions was often a problem especially where the work front was difficult to access, some were located at high altitude, or situated at enclosed areas such as within the top-down basement or inside an atrium space within the enclosed structure on the upper level.

In order to obtain the best result, the contractor of the project had to maintain a very strong team on site to take care all the work items. The role of the team was responsible to take care of matters such as, works coordination, planning and scheduling, temporary work provisions, construction safety and other logistic support. Besides, due to the involvement of large number of external works, the team had to maintain a comprehensive temporary traffic management network with relevant parties and authorities to ensure the thorough running of the nearby traffic during the entire period of construction.

At the same time, some innovative provisions and special equipments were also introduced to improve the efficacy of work. These included the use of an advanced slip form system for the construction of the core wall of the office tower, a climbing work screen which was mounted on temporary guide rail to protect exterior work activities at high level, and the use of several sets of floor-to-floor material hoists with lifting platform driven by hydraulic action. In order to provide a convenient and fast vertical transportation for workers and materials to reach the working floors, a series of jump-lifts were installed. The lifts made use of the permanent lift shaft while it was still under construction. All this provisions and equipments were proved to be contributing obvious result in making the site into a more effective and safe production line.

5. Conclusive Remark

Beside the input of large amount of investment and the significant use of effective means to manage and carry out the construction of the Langham Place, the project also possesses strong urban and social meaning that set a good precedence for similar projects of which they are quite universal worldwide in big cities with huge population and the coexistence of new and old city environment. In Hong Kong there are other districts where situations are very similar. And of course, the development process including the arrival of an agreed procurement scheme and the land requisition negotiation, will be very lengthy and generate countless conflicts between different interests. We are waiting to see what come next.

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