The Research on the Influence of Economic Benefit for High-Rise Buildings Constructed by Different Excavation Method – Taking of Residence Buildings at New Taipei City as Example

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Abstract

The application of engineering technology could influence the cost and progress, and the excavation method for the infrastructure might cause significant difference of construction planning and cost. This research studies the construction time and cost efficiency for various infrastructure excavation methods. Based on the designed case, carry on the evaluation of construction time, construction price, and performance in accordance with different excavation method. It could provide the developer to select the best method at the initial design and planning stage, in order to obtain the highest benefit.

Keywords: Top-down Construction, up-up Construction, the high-rise buildings, the diaphragm wall

1. Introduction

In the metropolis, there is limited land with the overcrowding in Taiwan, so the building land was difficult to get in the downtown. Because of overcrowding, convenient traffic and life function, it caused the expensive land costs [1]. The developer always expected the project could achieve the high benefit and satisfy the parking requirement, which was the trend for high-rise buildings and deeper infrastructure excavation in the metropolis. This paper tried to study the performance of deep excavation method on construction time and cost efficiency.

The construction industry is changed from the constructor into the project administrator gradually, to ensure the execution life cycle of project can be controlled in a predictable range [2]. If the same scale and type of project is implemented by different construction method, there will be a significant difference for the cost efficiency. There is unique property and different management method for various construction projects, so the risk management of construction project are higher than other industries.

From the data of government, this paper first reviews development trend of the domestic real estate in recent ten years as fig.1, in order to understand the prosperous fluctuation situation of construction industry. The prosperity pulse of construction industry is closely to the domestic and international economic boom. This paper uses the excavation methods commonly used for high-rise buildings, as bottom-up, top-down and up-up construction, to evaluate the construction time and cost efficiency. An actual project was studied to assess and compare in order to get the most favorable construction time and cost efficiency to the developer.

2. Literature

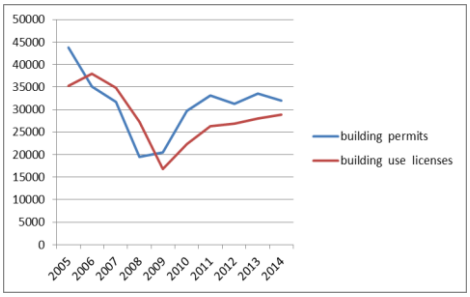
In Taiwan, the r construction industry was integrated the planning, automation, financial administration and risk management instead of the previous labor intensive. The

selection for the method of construction project has close relationship with the cost. The price of material, the different technique, equipment, personnel and schedule might cause direct or indirect influence.

The land developers always follow the market trend and expect to construct the building by faster and economic way. If the infrastructure of high-rise buildings took the tradition excavation and supported it might be increase duration due to the topographical, weather factors or space limited and poor management [3]. For the mention reasons, the innovative research, expert and scholar develop Top-Down Method and Up-Up construction method to overcome the dilemma [4].

The quantities of building permits and building usage licenses showed in Fig.1, issued by Taiwan Government from 2005 to 2015, reveal the information that the constructor could make the investment opportunity by following the wave band peak of house market [5].

Fig. 1 Construction permit and usage permit issued by Taiwan Government



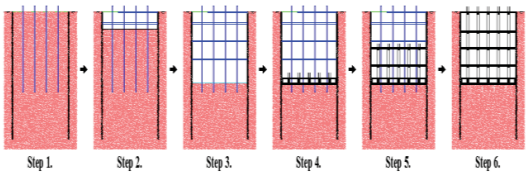
2.1 Excavation Method

Because of the fast development of economy and construction in the 1970s, the high-rise buildings were built gradually at urban area in Taiwan. Most of the excavation of infrastructure used the Bottom-Up construction method. Because of the space limited for working requirement and duration reduce, the contractor used the new technology by the Top-Down construction method. This method could construct both the Superstructure and infrastructure simultaneously after completing the ground floor, which would get the result of shortening construction time. The Up-Up method was even developed subsequently, the various methods were used with different project and building condition.

2.1.1 Bottom-Up Method

The Bottom-Up construction method normally followed the procedure 1. making the diaphragm wall 2. complete piling works 3. king post work 4. excavation 5. horizontal supports. After finishing the mat foundation, the basement structure was constructed from the bottom of the basement to the top floor.. The construction procedures are shown in Fig. 2. 〔7〕

Fig. 2 The construction sequence of Bottom-Up Method

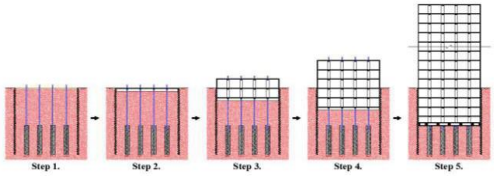


Most of the building project adopted the Bottom-Up construction method, because the construction procedure is simple, suitable for general medium-scale buildings without special construction time requirement etc., all regard this method as the prior choice.

2.1.2 Top-Down Method

First to construct the diaphragm wall and the bore-pile foundation with Steel stanchion place, afterwards completed the ground floor to be transition floor. This method could construct both the Superstructure / infrastructure at the same time after completing the transition floor. During the excavation, the building structure would become the horizontal supports, and the completed bore-pile foundation with steel stanchion place work as the vertical support. Because of the Superstructure / infrastructure could construct simultaneously, which would arrive the target to shorten the construction duration. The infrastructure construction for the building constructed from top to bottom, so the construction method was known as the Top-Down. Its construction procedures are shown in Fig. 3. [7]

Fig.3 The construction sequence of Top-Down Method



The Top-Down method constructed both the Superstructure and infrastructure at the same time, which could effectively shorten construction duration and avoid the neighboring building security during the construction period [6]. This construction method required with complicated technology and might meet more unexpected risk, so this method was suitable for large-scale building with space limited and tight schedule requirements.

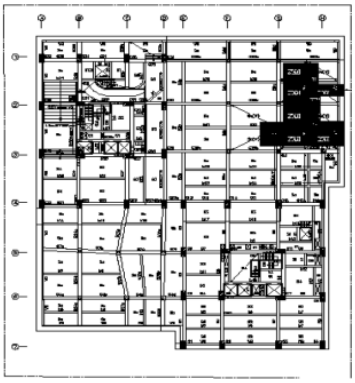
2.1.3 Up-Up Method

For the target to shorten the project duration, the contractor always expected to construct both the Superstructure and infrastructure at the same time. They modified the top-down method and developed the up-up construction method, whose procedure as 1. the diaphragm wall 2. piling work 3. king post work 4. excavation and support 5. Repeat the step 5 and finished the mat foundation 6. construct the Superstructure structure from 1st floor up 7. construct the infrastructure structure from mat foundation up to ground floor. The infrastructure structure excavation and each layer of excavation support and finish, and after finishing in lower structural raft base, can carry on the first floor edition and construct at once. The UP-Up construction method constructed both the Superstructure and infrastructure simultaneously.

3. Case Study

The case was the high-rise building in New Taipei City. Its plane drawing of building is shown in Fig. 4.

Fig. 4 The Plan of the case study building



3.1 Difference Analysis for Excavation Method to Construction Time, Cost

Because the construction complicated, difficult degree and construction condition, the various method were with different duration and construction cost. This case on the initial planning stage, the planner made analysis by the Bottom-Up, Top-Down, and Up-Up construction method to evaluate the benefit on duration and cost. The owner finally adopted the Top-Down Method through the research before the construction.

To consider the geological condition with liquefaction reaction, the building project designed the deep foundation with boring-pile which prevent the effect of liquefaction of soil. All of the three construction method designed in same condition with boring-pile.

The various construction method was exhaustive planned and made analysis, the infrastructure could be completed in 209 days by Top-Down Method. The Bottom-Up method took 380days and the Up-Up method took 254 days relatively. If the Top-Down method acted as a benchmark, the Bottom-Up method took more 171 days and the Up-Up method needs more 45 days. The cost estimations were NT$ 50,142,815, 30,939,065 and 40,706,905 for the Top-Down, the Bottom-Up and the Up-Up method relatively. If the Top-Down method acted as a benchmark, the Bottom-Up method took 1.52 times and the Up-Up method needs 1.23 times.

4. Conclusion

The infrastructure was constructed by the Top-Down Method to get 171 and 45 days less compared with the Bottom-Up and the Up-Up Method respectively. The construction cost of Top-Down Method was 1.52 times of Bottom-Up Method and 1.23 times of Up-Up Method. Although the construction cost of Top-Down Method was most expensive, it created more value and benefit than the other two methods due to the construction duration saved. The overall benefit can be summed up as follows:

1. As for higher construction cost of Top-Down Method, because upon excavating, the steel columns have to be used as the support, the PC has to be used at every floor, the consumption of forms is higher, and the non-shrink cement has to be used at the joint of piles.

The high construction cost can be compensated by the short construction time.

2. As for shorter construction time of Top-Down Method, because after the end of story change, the upper part structure and underpart structure can be constructed at the same time. When the construction time and urban space are limited, the largest benefit can be developed.
3. Only the benefit of construction time and construction cost of the project is studied in this case. The next research goal will focus on the interest effect of construction time and the expedient analysis.

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