Funan Redevelopment – Singapore's Creative Intersection

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Abstract: *This paper summarized the design concepts and construction strategy of Project Funan Redevelopment at North Bridge Road, Singapore Downtown by Woh Hup-Obayashi JV. Major areas discussed in this paper includes (i) full top-down construction methodology which allows superstructure to be completed ahead of ERSS and basement structure; (ii) control demolition of existing basement structure which allows piling work to be carried out concurrently; (iii) hybrid system construction by using precast reinforced concrete columns with steel/composite floor system for superstructure which allows shorter floor cycle duration; (iv) encased composite columns at basement which allows temporary king-posts to be utilised as encased steel sections of permanent columns; (v) Rectangular Pipe Jacking method for Underground Pedestrian Linkway Construction (vi) enhanced construction productivity by adopting Building Information Modelling (BIM) and Visual Design and Construction (VDC) for Tree of Life Structure, Facade Installation and 4D Simulation of overall project timeline. It also provides an overview on the key challenges faced during construction such as underground obstructions, sensitive neighbourhood and tight construction access. In addition to the challenges, greater emphasis is placed on key factors contributing to project success such as through appropriate choice of construction method in early stage, good selection of construction materials and temporary staging works.*
Keywords: *Full Top-Down Construction; ERSS; Control Demolition; Hybrid System; Composite Structure; RTBM, VDC & BIM, 4D.*

1. INTRODUCTION

Funan, one of Singapore's best-known and most enduring retail icons, reopens its doors to shoppers today after three years of redevelopment, starting a new chapter in its storied evolution. Home to a rich variety of more than 190 brands clustered around six passion themes Tech, Craft, Play, Fit, Chic and Taste, the new Funan is set to become the centre of commercial, social and cultural activities in Singapore's Civic District. Injecting vibrancy to Singapore's retail scene, more than 30% of Funan's brands are new-to-market brands, concepts or flagships. As a showcase for local talents, more than 60% of Funan's brands originate from Singapore.

Figure 1. Funan Redevelopment Completion

1.1. Full Top-Down Construction Methodology to meet tight construction timeline

The existing Funan Mall was in good business which brought in strong revenue to the owner – Capital Mall Asia (CMA). As a result, when CMA decided to redevelop Funan into a brand-new mall of creative intersection, the required construction timeline given to contractors during tender was very challenging, a mere 29-month duration including the demolition of the three existing basements (see Figure 2). To overcome this very tight construction timeline, Woh Hup-Obayashi JV proposed a full Top-Down Construction Methodology (see Figure 3), which would allow them to complete the construction within 29 months. Essentially, it would allow superstructure to be constructed concurrently with and even completed ahead of basement structure. It was estimated that if the traditional bottom-up construction method was adopted, it would take 38 months to complete the project due to the complexity of the basement works. The full top-down construction proposal helped Woh Hup-Obayashi JV win the project in January 2017 and subsequently was approved by relevant authorities.

Figure 2. Site condition with existing basement structures during Site Possession

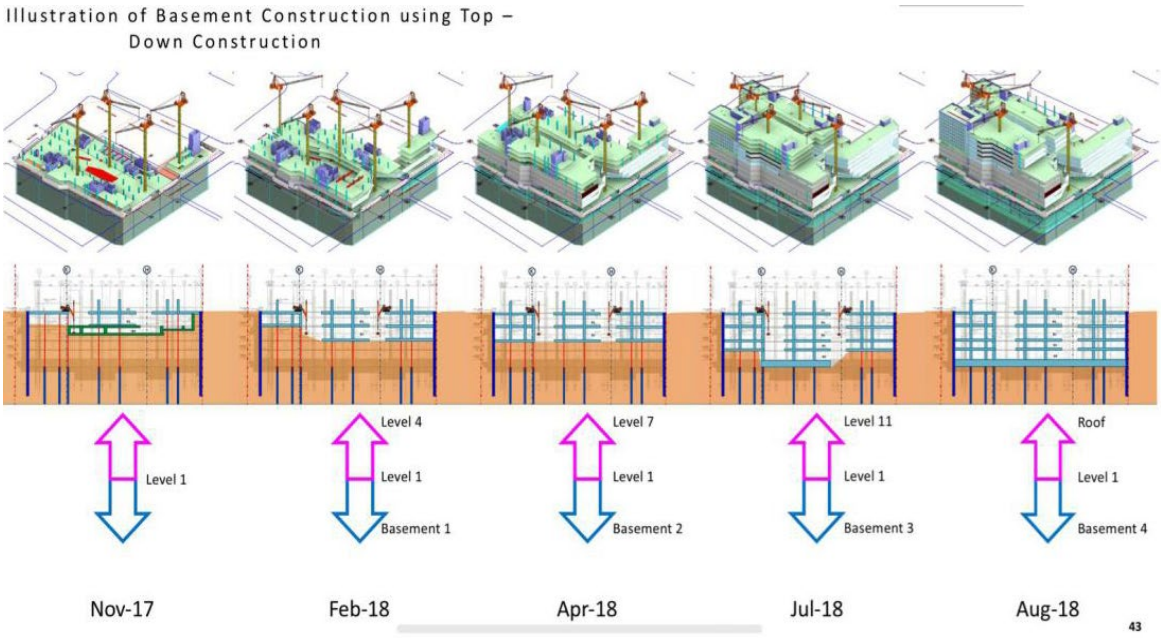


Figure 3. Full Top-Down Construction Methodology

1.2. ERSS System & Control Demolition to protect surrounding sensitive buildings

Funan Mall is located right at centre of the Downtown area of Singapore, surrounded by a number of old and sensitive buildings which are susceptible to soil displacement and vibration. The nearest building Peninsula Hotel which was built in 1974 is only 6 meters away from Funan boundary line. It is therefore crucial to have careful planning and right construction method so as to minimise adverse impacts to these buildings. Woh Hup-Obayashi JV adopted Control Demolition which was planned well with localized hacking of existing basement slab in order for piling works to be carried out concurrently (see Figure 4). On the other hand, the CBP wall and bored piles were adopted for ERSS system and foundation to prevent soil displacement and vibration transferred to neighbouring buildings. In addition, suitable boring machines were adopted for the installation of CBP wall and foundation bored piles in order to generate different frequency with the natural frequencies of the surrounding sensitive buildings (see Figure 5).

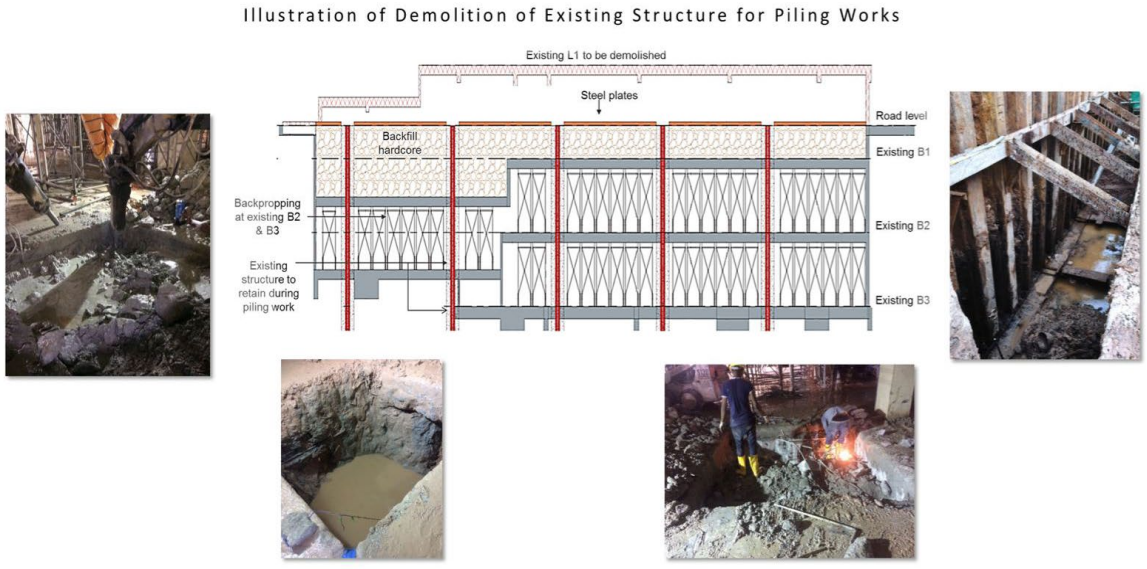


Figure 4. Control Demolition

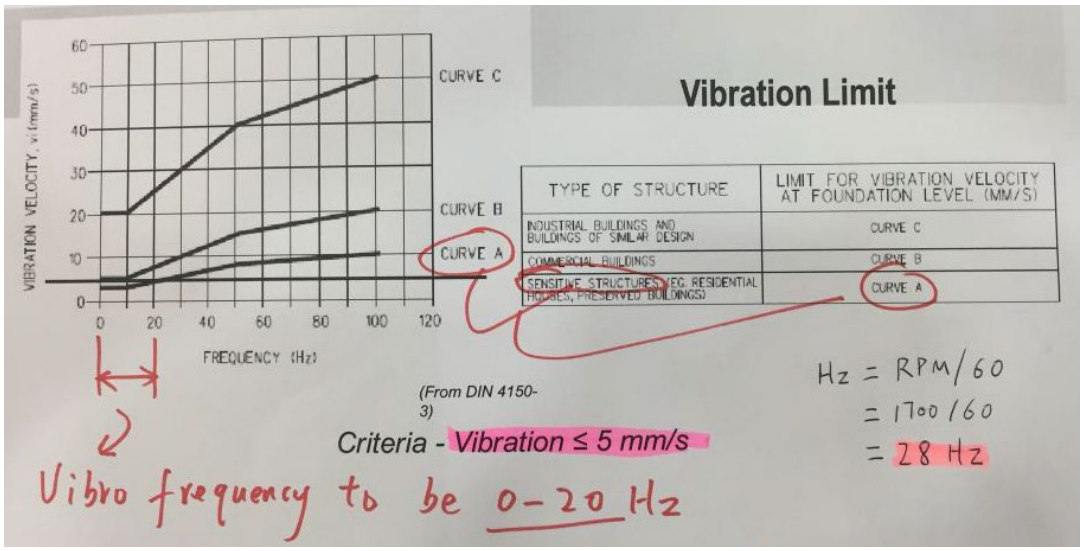


Figure 5. Control of Vibration Frequency

1.3. Hybrid System for Superstructure & Use of Self Compacting Concrete (SCC)

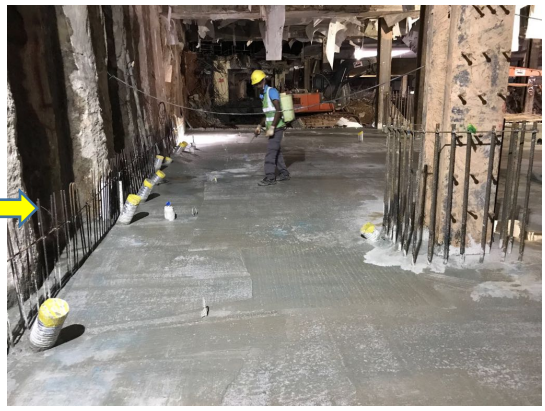
A hybrid system of precast column and steel-composite floor was adopted for the superstructure of the new Funan Mall. The structural elements of the hybrid system including precast columns, steel beams, Bondek slab and BRC mesh were all fabricated offsite thus improving construction productivity on site significantly. Furthermore, the use of SCC eliminated noise and vibration during casting hence allowed the concreting work to be carried out 24 hours to meet the tight timeline. With detailed engineering study using BIM/VDC model, each connection detail was discussed with virtual simulation. This facilitated quick decision from the Qualified Person and approval from the authority. Shop drawings therefore could be generated promptly and sent to factory for production. Through this seamless work flow as Figure 6, Woh Hup-Obayashi JV was able to manage every trade of work to be carried out smoothly through the only single access at site.

Figure 6. Work Flow of the Hybrid System

1.4. Encased Composite Column for Basement Structure

The full top-down construction methodology required good planning and coordination right at tender stage. For Funan project, foundation bored piles were installed with plunge-in columns/king-posts during pouring of concrete. High strength steel grade 460 UC Steel Section was adopted for the king-posts which were designed to support temporary heavy construction loading such as vehicles, tower cranes, and also the basement and superstructure loadings before the raft foundation at level B4 was reached. This would allow basement and superstructure to be carried out without waiting for completion of excavation and substructure, thus shorter the construction duration. On the other hand, most of the king-posts were located accurately at basement column positions which allowed them to be encased with rebar and concrete to form permanent composite columns of higher capacity to resist the full design loads after construction.

(a) Installation of King Post



(b) Construction of Basement Slab

(c) King Post Encased with Concrete to form composite columns

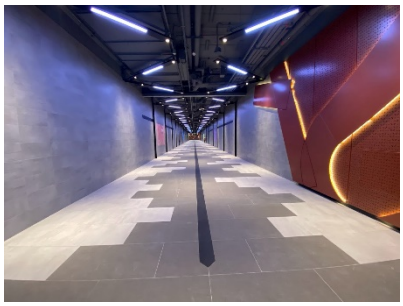
Figure 7. Basement Construction Sequence

1.5 Rectangular Pipe Jacking method for Underground Pedestrian Linkway Construction

The Underground Pedestrian Linkway is constructed below live North Bridge Road, in consideration of the heavy traffic condition and congested underground utilities, we proposed a Rectangular Pipe Jacking Method for the construction of this UPL. The Rectangular Pipe Jacking underpass is constructed using Rectangular Pipe Jacking Method tunnelling a total length of 108 m. The tunnel has a cross section of 7.6 m in width and 6.4 m in height, with an

average overburden of as shallow as 3.6 m from live road. It is the biggest and shallowest known rectangular pipe jacking tunnel in Singapore.

On North Bridge Road, in between Funan and Adelphi, we divert the traffic and construct a launching shaft. In November 2020, the RPJM was launched and bored underneath several major utilities which include the 600 mm diameter gas pipe and 800 mm water main at Coleman Street Junction in December 2020. The minimum clearance from the tunnel crown to the gas pipe and water main was only 880 mm and 730 mm respectively. After Coleman Street Junction, the RPJM continued to jack beneath North Bridge Road and docked outside the CBP wall of Capital Piazza. Due to the space constraint, there was no provision of receiving shaft and the RPJM was dismantled from the completed tunnel while the machine shield was left in the ground. Upon completion of the tunnelling works, the ma-chine shield will also be utilized as part of permanent structure construction of the linkway. With the successful docking and completion of the underpass, we have provided sheltered walkway for general public at convenient.

1.6. Use of VDC / 4D-BIM

At Funan Project, 3D-BIM models were adopted for Design Visualization, Planning, Multi-disciplinary collaboration and Documentation. Together with 3D-BIM, VDC Workflow were adopted to help project team members to manage their multidisciplinary collaboration more effectively in modelling and analysing complex spatial and structural problems (see Figure 8).

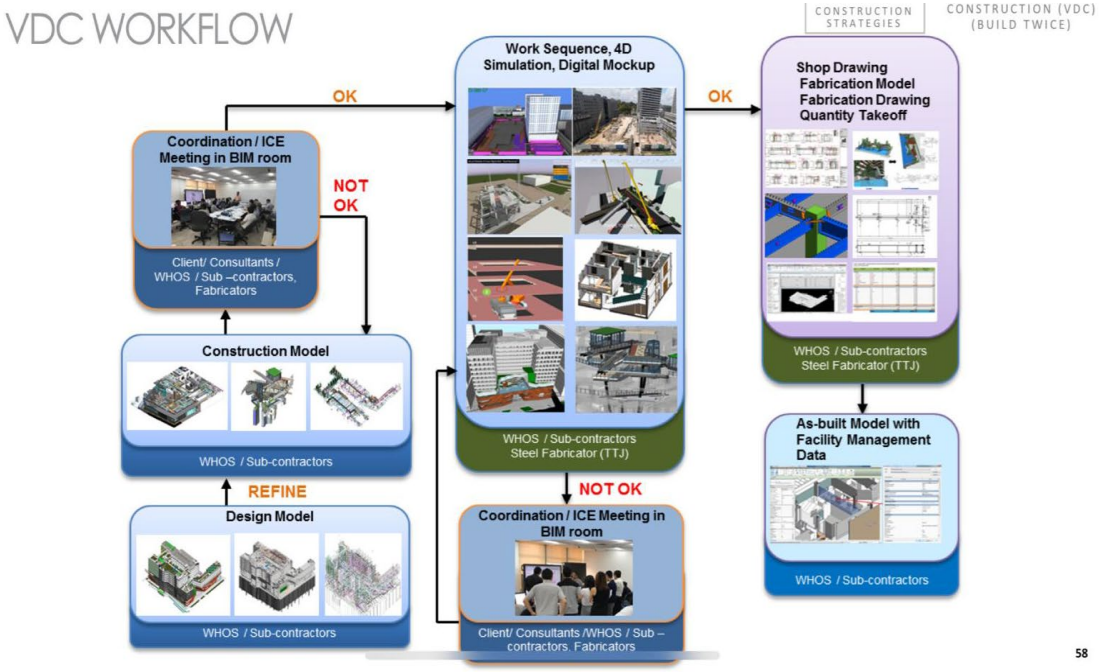


Figure 8. VDC Workflow

Benefits of VDC included:

- Improving visualization of the project and communication of design intent
- Improving multidisciplinary collaboration
- Reducing abortive works

In addition, 4D-BIM was used for construction site planning related activities. It was a 3D model with added information on time or project schedule . It helped to visualize the entire construction process by displaying the progression of activities through the lifetime of the project and a step by step visualisation of the project's development (see Figure 9).

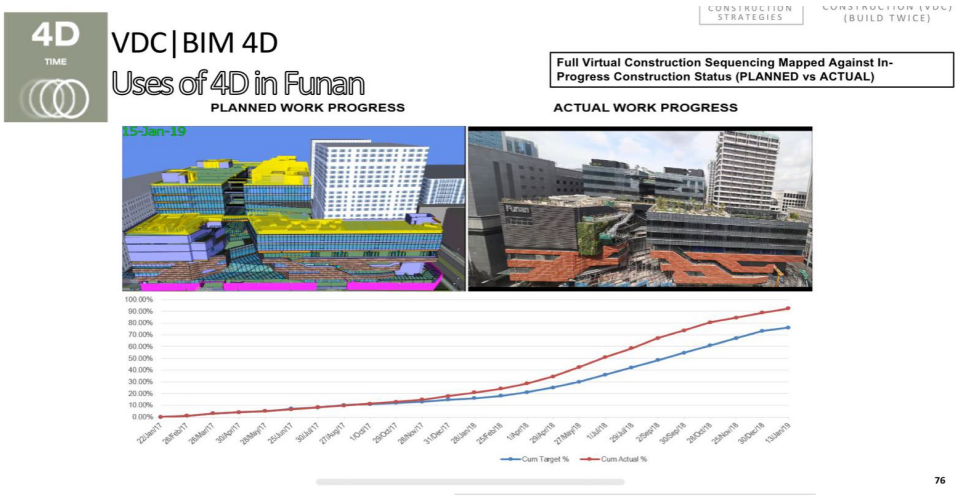


Figure 9. 4D-BIM Progress Planning

Benefits of 4D-BIM included:

- Providing project team with easy planning optimization.
- Helping builders and fabricators prioritise their construction activities and team coordination

2. OTHER FACTORS CONTRIBUTING TO THE SUCESS OF THE PROJECT

2.1. Cooperation and Coordination Among Project Team Members

Numbers of Integrated Concurrent Engineering (ICE) sessions were conducted during the whole project (See Figure 10). Thanks to the cooperative working culture, project team members including client, consultants and main contractor had closed coordination and worked seamlessly as a team to overcome the challenges and achieve the final goal.

Figure 10. 4D-BIM Progress Planning

2.2. Supports from Specialists and Government Agencies

When technical difficulties encountered, Woh Hup-Obayashi JV would bring them up for team discussion and never hesitated to work closely with specialists (e.g. professors from NUS and SIT) and relevant authorities to work out acceptable solutions to get the project moved on quickly.

3. CONCLUSIONS

The construction of the new Funan Mall was amazingly completed 2 months ahead of the tight master schedule due to the adoption of top down composite construction methodology. The project team adopted 3D-BIM models for Design Visualization, Planning, Multi-disciplinary collaboration and Documentation. This helped the project team members to manage their multidisciplinary collaboration more effectively in modelling and analysing complex spatial and structural problems. Great emphasis was placed on collaboration between designers, fabricators and project managers to exploit the advantages of using building information model and 3D visualization technique for work flow integration. The success of this project provides new pointers to design and construction of complex large scale hybrid structures with awareness being placed on public safety and sustainable development. Figure 11 shows the topping out ceremony held on 28 September 2018. This would be a Mission Impossible to complete such a mega project in such a short duration without whole project teams' tireless effort and cooperation.

The Mall and Office Open to public in Jun 2019, The Service Apartment Open to public in Oct 2019, The Underpass open to public in Dec 2021.

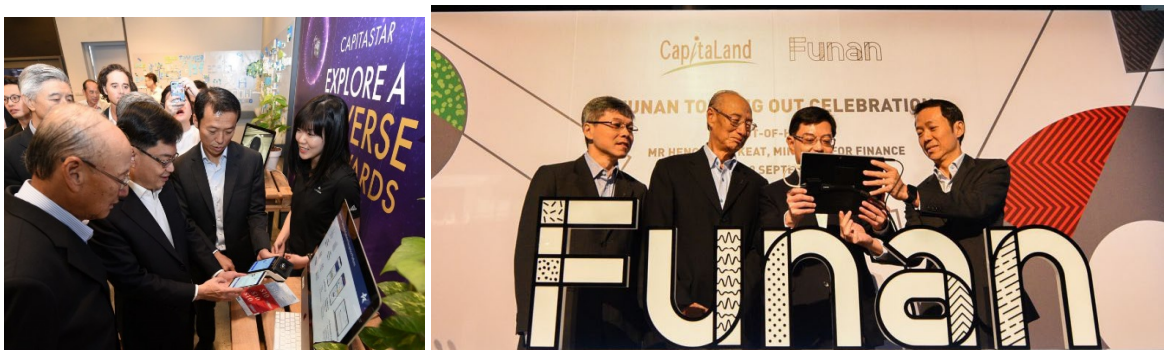


Figure 11. Topping Out Ceremony Held on 28 September 2018

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