Case Study- Excavation Around Heritage Buildings in an Urban Environment

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ABSTRACT

Cultural heritage is what makes Singapore's history tangible and shapes our identity as a nation. Integrating heritage buildings within new developments enables Singapore, a small island nation with limited resources, to optimize land use while preserving its cultural identity. This paper presents Sophia Hills, a residential condominium in an urban setting, as a case study. This development incorporated three conservation buildings, namely the former Nan Hwa Girls School, the former Olson Building and the former Trinity Theological College. The main challenge encountered during construction was the protection of the heritage structures, particularly the former Olson building, where an excavation of 17m depth took place around the structure. Abnormal building movement was observed through instrumentation monitoring during the construction stage. This paper discusses these observations in detail and outlines the mitigation measures implemented to safeguard the conserved building.

Keywords: Sophia Hills, heritage conservation, cultural heritage, excavation impact, building movement

INTRODUCTION

Sophia Hills is a condominium development located at Mount Sophia in Singapore. It consists of 12 building blocks, each up to 7 storeys high and a basement carpark. The project site is surrounded by existing buildings and situated above the North-East Line (NEL) tunnels, which connect the Dhoby Ghaut Station (NE6) and the Little India Station (NE7). Sophia Hills distinguishes itself from the other developments as it consists of three conservation buildings within the site, which require protection and restoration, namely:

- Conservation Building A- Former Nan Hwa Girls School
- Conservation Building B- Former Olson Building
- Conservation Building C- Former Trinity Theological College Chapel

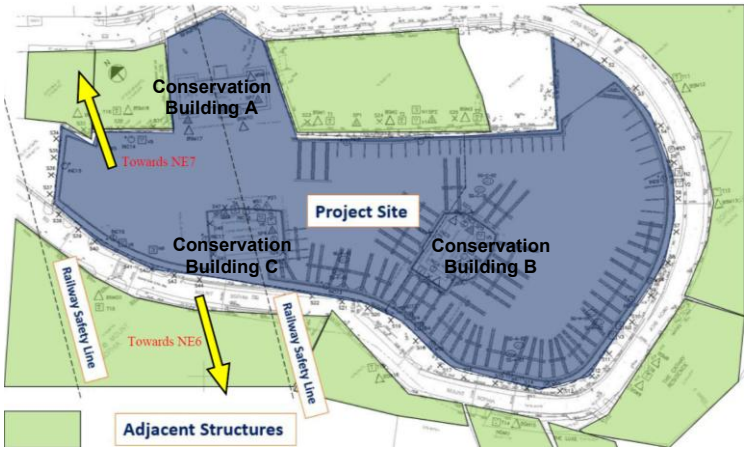

Figure 1. *Site plan*

BACKGROUND OF THE CONSERVATION BUILDINGS

Conservation Building A- Former Nan Hwa Girls School

The former Nan Hwa Girls School is historically significant as it provided education opportunities for girls in Singapore. The school's origins date back to the early 1900s, when Dr Sun Yat-Sen's visited Singapore and encouraged the establishment of public schools while advocating for girls' education. Nan Hwa Girls School was established in 1917 at Coleman Street following fundraising efforts initiated by the principal of Tao Nan School, Mr Xiong Shangfu, in collaboration with local businessmen (Nan Hua High School, 2025). To cater for the increase in student population, the school was relocated to a bigger building at Bencoolen Street in 1921, and a new campus was later built at Adis Road in 1941. During World War 2, the Adis Road campus was forced to close and was turned into the headquarters for the Japanese Imperial Army (Nan Hua High School, 2025). The former Nan Hwa Girls School was gazetted for conservation by the Urban Redevelopment Authority (URA) in August 2011 (National Heritage Board, 2021). As part of the Sophia Hills development, the building was converted into a childcare and kindergarten. Figure 2 shows a historical photograph of the school.

Figure 2. *Former Nan Hwa Girls School at Adis Road (Nan Hua High School, 2025)*

Conservation Building B- Former Olson Building

The two-storey Olson Building, completed in 1928, was part of the former Methodist Girls School campus at Mount Sophia. Among the other structures within the campus, only the Olson building was given the conservation status by the URA in 2012 (Quek, 2012). Architecturally, the building is characterised by its high-pitched tiled roof, stylish corbels, moulded concrete lattices and concrete louvered vents situated beneath the window sills (see Figure 3). These features blend in harmoniously with the building, allowing for cross-ventilation and creating a cooling effect well suited to Singapore's tropical climate (Spykerman & Wee, 2012). The Olson building was integrated into the Sophia Hills development as a clubhouse with terracotta and fair-faced brickwork set reinstated.

Figure 3. *Former Olson Building Photo Taken in 1990s (Urban Redevelopment Authority, n.d.-a)*

Conservation Building C- Former Trinity Theological College Chapel

The Trinity Theological College Chapel, opened in 1948, serves as an institution for training pastors and church workers. The chapel is formed by a simple rectangular pavilion with an asymmetrical shape of roof that represents the Chinese character "人" (ren) or "Man" (Urban Redevelopment Authority, n.d.-b). Its stained glass with geometric abstract compositions allows natural sunlight to enter the building (see Figure 4). As part of the Sophia Hills development, the chapel was repurposed as a restaurant. The mosaic and marble flooring were retained and restored while the "stained glass" feature was replicated with glass due to fire safety requirements (Zaccheus, 2018).

Figure 4. *Former Trinity Theological College Chapel (Urban Redevelopment Authority, n.d.-b)*

SITE GEOLOGY

According to the Singapore Geology published by the Building and Construction Authority (BCA) in 2021, the soil condition at the site is classified as the Kusu Formation (Kusf). This formation, which dates back to the Lower Cretaceous period, comprises of white, quartz-rich sandstone and subordinate conglomerates (Building and Construction Authority, 2021).

An abundance of sandstone boulders of various sizes, some measuring up to 10m in diameter, was observed during excavation (see Figure 6). The boulders were embedded within the hard matrix of sandy silt or sandy clay.

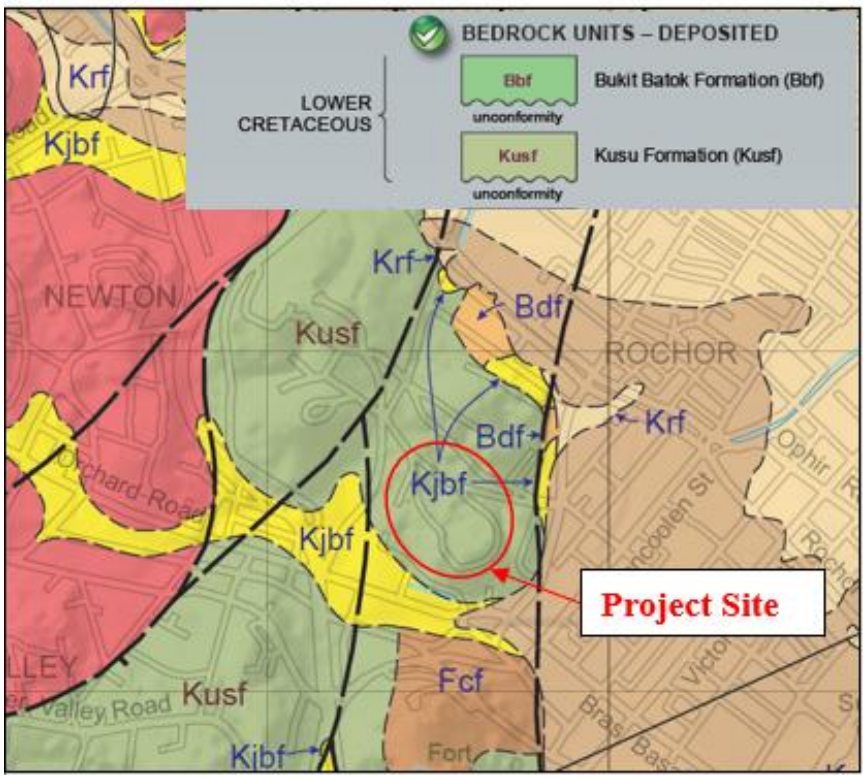

Figure 5. *Singapore geological map covering the site*

Figure 6. *Sandstone boulders of various sizes exposed during excavation*

BASEMENT EXCAVATION AND EARTH RETAINING SYSTEM DESIGN

The former Olson Building is situated at the highest point of the site. The platform level of the development follows the lower road level and a basement carpark was proposed for the development. This resulted in an excavation depth up to 17m, particularly in the vicinity of the former Olson Building. As the site was irregular and the ground level was undulating along the project boundary, secant bored pile (SBP) wall with raker strut system was proposed as the earth retaining and stabilizing system (ERSS).

Figure 7 and Figure 8 present the overall ERSS layout plan and the typical SBP wall with raker strut system respectively.

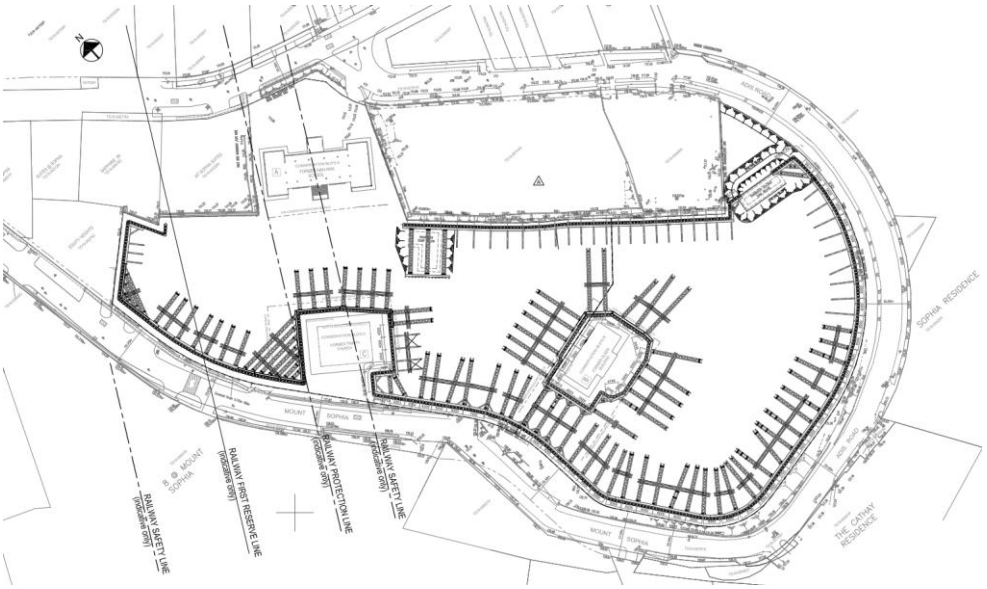

Figure 7. *Overall ERSS layout plan*

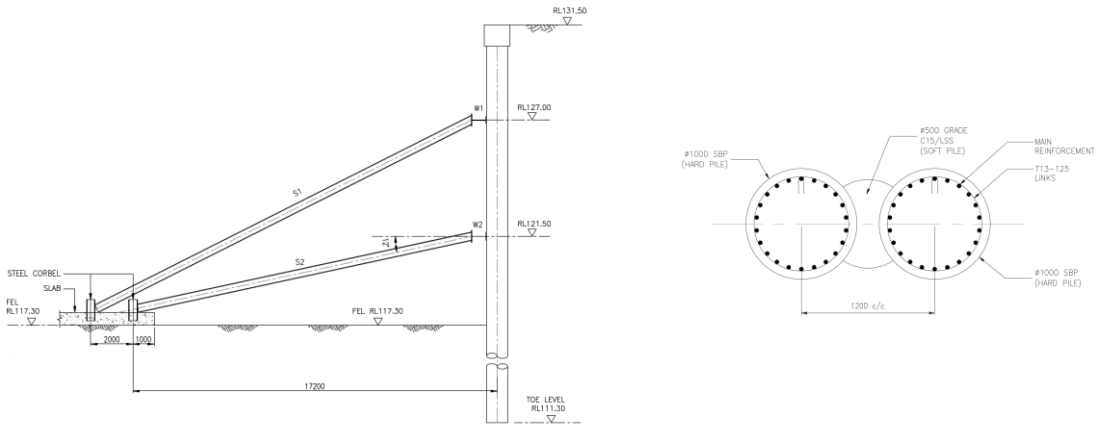

Figure 8. *Typical raker strut system (left). Typical SBP wall arrangement detail (right)*

The general ERSS construction sequence is summarized as follows:

1. Installation of the SBP wall and construction of the capping beam
2. Excavation to the final excavation level with soil berm retained
3. Partial construction of the basement slab
4. Installation of the first layer of waler and raker struts (S1)
5. Removal of soil berm to below the second layer of raker struts (S2)
6. Installation of the second layer of waler and raker struts (S2)
7. Removal of the remaining soil berm
8. Construction of the remaining permanent basement slab and first storey slab
9. Removal of the second layer of raker struts (S2) and waler
10. Removal of the first layer of raker struts (S1) and waler

Before the commencement of engineering works, a detailed structural investigation was carried out on the conservation buildings and it was found that they were supported on reinforced concrete footings. Impact assessments on the conservation buildings were carried out during the design stage to evaluate the potential impacts arising from the excavation works. In addition, instrumentations such as tilt plates, building settlement markers, survey prisms, inclinometers and water standpipes were installed to monitor the performance of the ERSS and the conservation buildings. Figure 9 shows the site condition of the former Olson Building during and after construction.

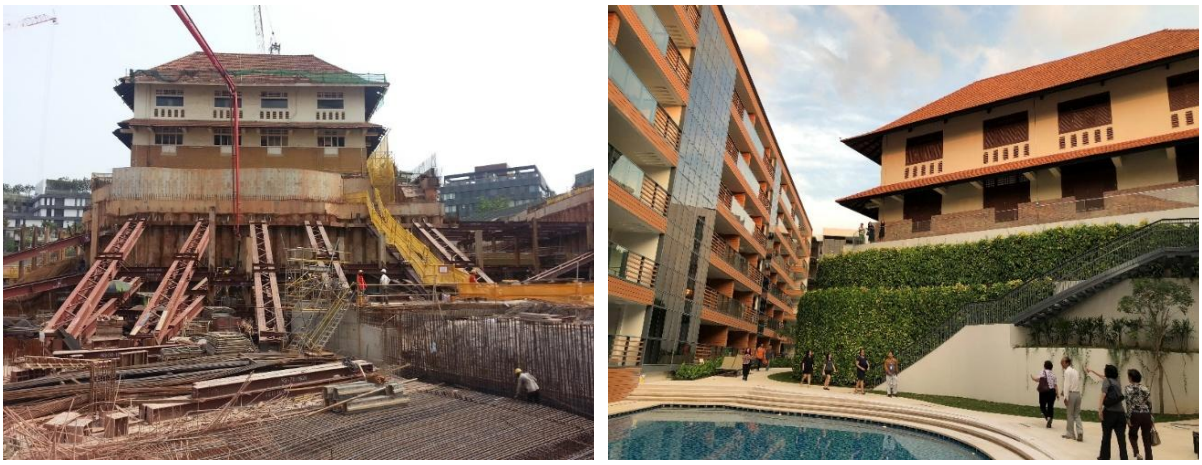

Figure 9. *Site condition of the former Olson Building during construction (left) and after construction (right)*

PERFORMANCE OF THE FORMER OLSON BUILDING DURING EXCAVATION

During the construction stage, the tilt plate (T6) installed on the former Olson Building (refer to Figure 10) recorded a sudden increase in reading from 0.003° to 0.043° within a 10-day period even though no excavation works were being carried out during that time. The positive tilt plate reading indicated that the building was tilting outward from the back of the conservation building. The direction of movement was further verified by the nearby inclinometer (INC5), which showed a consistent ground displacement trend (refer to Figure 11).

An investigation was promptly carried out to assess the relationship between the construction activities and the instrumentation readings. Findings suggested that the tilt of the former Olson Building associated with the ongoing installation of the SBP wall. Due to the closer proximity of the SBP wall to the rear side of the building, greater ground displacement occurred in this area, resulting in differential movement of the building.

To minimize further disturbance to the building, the following mitigation measures were implemented:

1. The capping beam on the SBP wall was cast all around before the excavation works, providing structural continuity
2. Excavation works surrounding the building were carried out sequentially and in stages, progressing level by level to reduce the differential settlement.

During the subsequent excavation works, the former Olson Building recorded an additional backward tilt of about 0.03°, corresponding to a tilt ratio of approximately 1/1900. The total recorded building settlement is 7mm and is within the allowable limit of 10mm for conservation buildings (Building and Construction Authority, 2024). The measured tilt was consistent in direction with the predicted tilt of 1/1100 and was within the allowable limit, indicating that the proposed measures were effective in controlling the differential settlement throughout the excavation process.

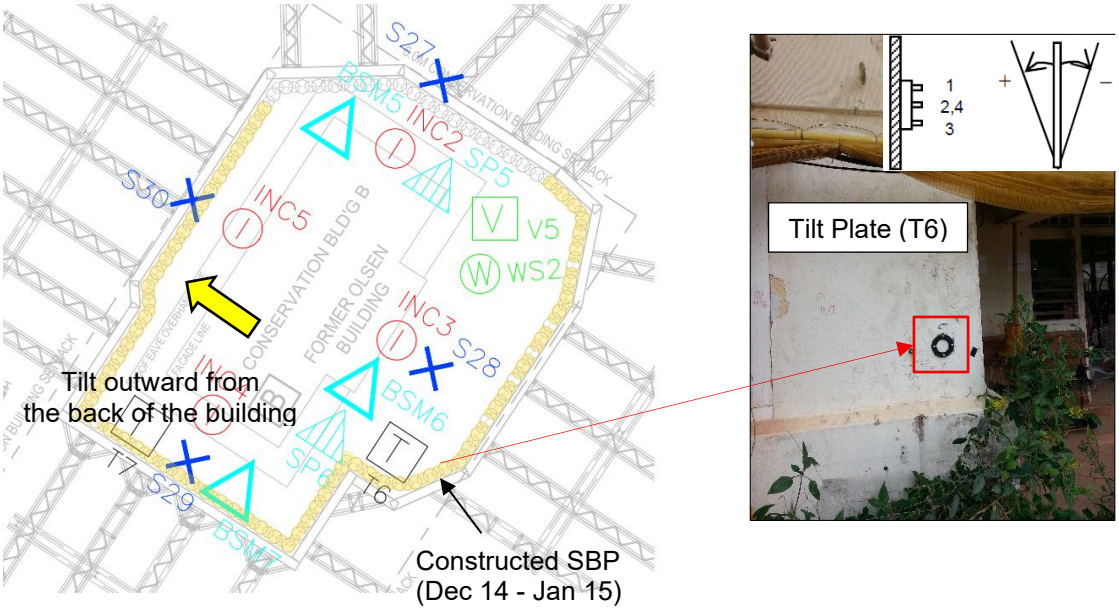

Figure 10. *Instrumentation plan (left). Tilt plate (T6) installed on the former Olson Building (right)*

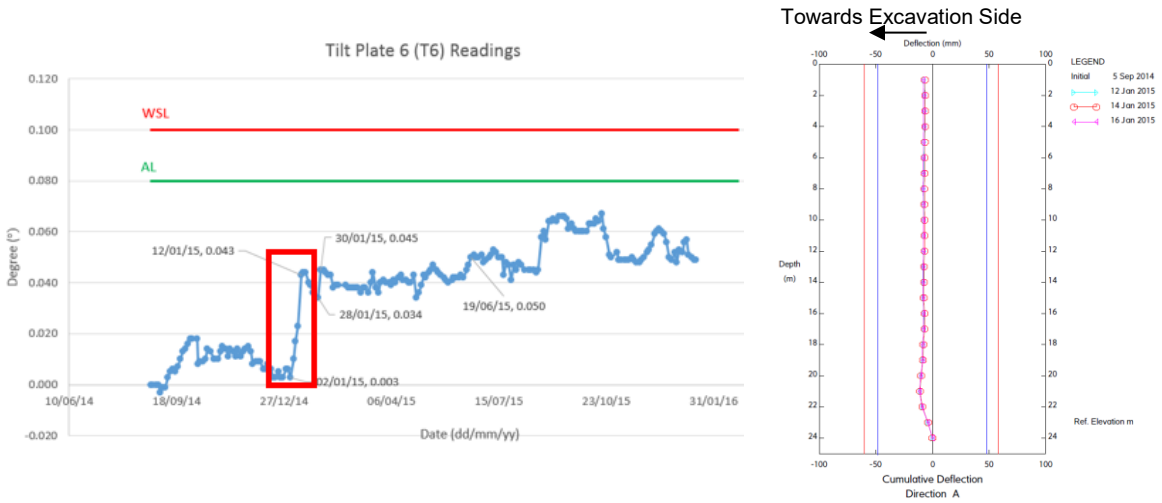

Figure 11. *Tilt plate T6 readings (left). Inclinometer INC5 readings (right)*

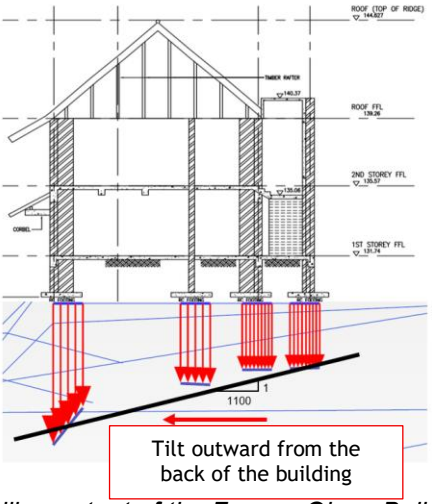

Figure 12. *Finite element modelling output of the Former Olson Building*

CONCLUSIONS

The Sophia Hills development demonstrates the successful integration of conserved buildings within an urban development. Through careful planning, detailed structural investigation and robust ERSS implementation, excavation around the conserved buildings was carried out safely. The proposed instrumentation monitoring effectively captured abnormal building movement, allowing timely mitigation measures that reduced the differential settlement to within an acceptable limit.

This case study highlights the critical role of monitoring and proactive mitigation measures in safeguarding heritage structures during urban development. The lesson learned from Sophia Hills can provide valuable guidance to future conservation projects in Singapore and other similar urban contexts.

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