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A BUILDING CONTROL POINT OF VIEW ON DEMOLITION OF FULL PRECAST CONCRETE BUILDINGS IN HONG KONG

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Abstract
Five 16-storey precast concrete domestic buildings were constructed in 1967 at Ngau Tau Kok of Hong Kong to meet the demand for resettlement. Housing Department (HD) was established in 1973 and these blocks were under its administration which later became Lower Ngau Tau Kok Estate (LNTK). In 2010, HD decided to demolish LNTK for re-development. The demolition plans of the buildings were required to be submitted to the Independent Checking Unit (ICU) of HD for approval and to obtain the consent from ICU before demolition could be commenced. Demolition of full precast concrete high rise buildings had not been carried out in Hong Kong before so vetting of the demolition plans had to be continuously done in order to ensure the demolition work was safe. During the process of the demolition plans, ICU and project team exchanged views on the demolition methods and site trial was arranged. The demolition plans were approved on 3/9/2010 with appropriate precautionary measures introduced. The demolition of five precast concrete domestic blocks took 9 months to complete without accident. It is therefore worthwhile to share the experiences from building control point of view on the demolition of these full precast concrete buildings in Hong Kong.

Keywords: Independent Checking Unit, Full Precast Concrete Buildings, Demolition Sequence, Approval and Consent, Trial Run of Demolition.

1. Introduction

After a major fire broken out on 25 December 1953 in Shek Kip Mei squatter area leaving 53,000 people homeless and meanwhile Hong Kong was facing a surge of immigrant population from mainland China, the then governor Alexander Grantham launched a public housing program to introduce the idea of "multi story building" for the immigrant population. A programme of mass public housing therefore commenced for providing affordable homes for those on low incomes.

Being the first tangible manifestation of the policy, the Shek Kip Mei Estate was completed in 1954 for occupation. But in reality, the extreme shortage of available housing at that time still could not resolve the problem. Thus in that year, the first Housing Authority was formed out of the Urban Council through enactment of the 1954 Housing Ordinance to manage the supply and demand of housing in Hong Kong. Subsequently, the "low-cost housing" scheme was introduced which marked the commencement of Hong Kong's public housing programme.

Lower Ngau Tau Kok Estate (LNTK), among the first group of resettlement estates was built between 1967 and 1970. There were total 14 high rise domestic blocks in the estate. All blocks were 16-floor high structures with provision of lifts to serve between ground floor and 8th & 13th floors. The estate was one of the largest in scale and among the earliest to adopt the concept of overall community development, where primary and secondary schools and street front shops were well provided. LNTK was a milestone in the history of public housing construction in the 1960's as Blocks 8 to 12 were the first resettlement blocks built with prefabricated parts. In 1973, the Hong Kong Housing Authority (HA) and Housing Department (HD) were established and these blocks were then under their administration.

2. Demolition of the Lower Ngau Tau Kok Estate

Having provided accommodation for the residents over 40 years, the estate finally completed its historic mission. HA decided to clear the estate by demolishing all the blocks in 2010 to make way for new developments. For demolition of the blocks, the demolition plans and relevant documents including appraisal report and other records were required to be submitted to the Independent Checking Unit (ICU) of HD for approval. Even though approval of the demolition plans was obtained, the demolition works could not be commenced until the consent was granted by the ICU after all the conditions specified in the approval had been fulfilled and checked in order.

3. Independent Checking Unit of Housing Department

In accordance with Section 41(1)(ba) of the Buildings Ordinance of Hong Kong, any land vested in the HA shall be exempt from the provision of the Ordinance; so construction of housing blocks by HD is not under the control of the Building Authority (BA) who is the Director of the Buildings Department (BD) of Hong Kong through enforcement of the Buildings Ordinance. In order to align with the practices of BD and to enhance quality of the housing development, the ICU of HD was established in 2000. The functions of the ICU is to vet HA's building projects against the Buildings Ordinance, giving approval of plans, granting consent to the commencement of works, carrying out final inspections and issuing occupation permit on completion of the building projects.

4. First Demolition Plan Submission (Traditional Demolition Method)

The proposal for demolition of the 5 precast concrete blocks of LNTK was first submitted to the ICU on 11 May 2009 for approval. The documents included 2 sets of demolition plans providing information and stability report of the precast concrete blocks to substantiate the proposed demolition method.

5. Structural Form of the Precast Concrete Blocks

From the information shown in the submitted demolition plans, Blocks 5 to 12 were built by the then Architectural Office which now known as Architectural Services Department (ASD) in the years 1967 to 1969. According to a technical paper published by ASD, the 5 blocks were constructed mainly with precast wall panels, precast slab panels, precast staircases and precast beams. Except the general floor plans, there were no record drawings or construction photographs could be retrieved regarding the design or as-built details of the buildings.

To substantiate the demolition proposal, the project team conducted investigation on site to get the required information. With the help of the management office of the LNTK, project team entered some vacant flats of Block 11 and public area to carry out investigation. During inspection of the concrete elements, various portions of walls, beams and slabs had been carefully checked to understand structural arrangement of the members. Surfaces of the beam/slab joint, slab/wall joint and beam/wall joint were hacked out to expose the reinforcement bars so as to find out the structural details of the structures.

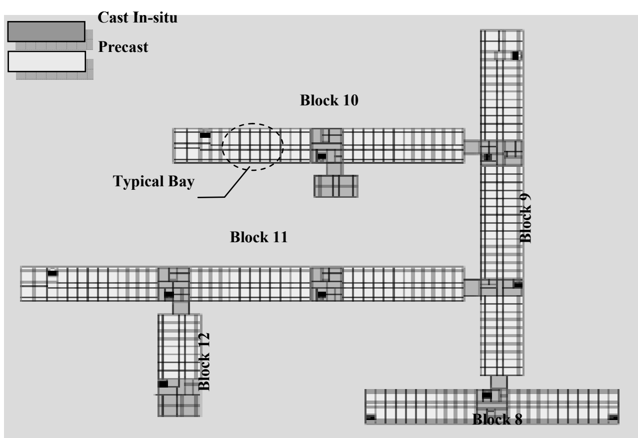

Figure 1 General Floor Plan

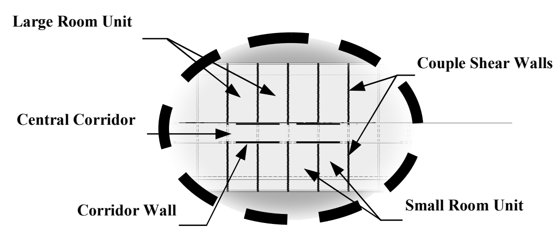

Figure 2 Typical Bay

Referring to the general floor plan in Figure 1, each precast block was linear in shape on plan comprising living units and lift core units. The living and staircase core units were precast elements and they were mainly to take vertical load. The lift core units located in between the precast elements were cast in-situ construction. From structural engineering view point, the cast in-situ lift core units should act as lateral restraints for the building to resist the wind load acting in longitudinal direction. The blocks were able to withstand the transverse wind load by means of the couple wall action formed by pairs of shear walls in the living units and staircase core units.

6. Connection Details of the Structural Elements

6.1 Slab/Wall Joint (Detail A in Figure 3)

Investigation to the interface of the precast slab and precast wall revealed that 3 rectangular shape marks with sizes 400mmx150mm at regular interval along the slab/wall joint were notably filled by concrete filling. After removal of the concrete filling, the marks were actually slots formed in the precast walls and slabs and that one pair of slab reinforcement bars extended into the wall slots and connected with the pair of slab reinforcement bars from next bay of the living units. One pair of reinforcement bars from the lower wall extended up into the wall slots and connected with the pair of reinforcement bars of upper wall. There was no structural connection at other part of the slab/wall joint.

6.2 Wall/Wall Joint (Detail B in Figure 3)

A gap was observed at the vertical joint between the couple shear wall and corridor wall. A thin plate was used to insert into the gap and moved from top to bottom of the walls. There was no obstruction detected throughout the movement. It was therefore concluded that there was no structural connection at wall/wall joint.

6.3 Beam/Wall Joint (Details B & E in Figure 3)

There were 2 groups of beam/wall joints, where the connection details were similar to wall/wall joint. Nevertheless, the difference was that 2 mild steel bars were inserted in the end of the precast beam in advance. Once the precast beam was placed in position, the joint was then filled up with cement/sand substrate.

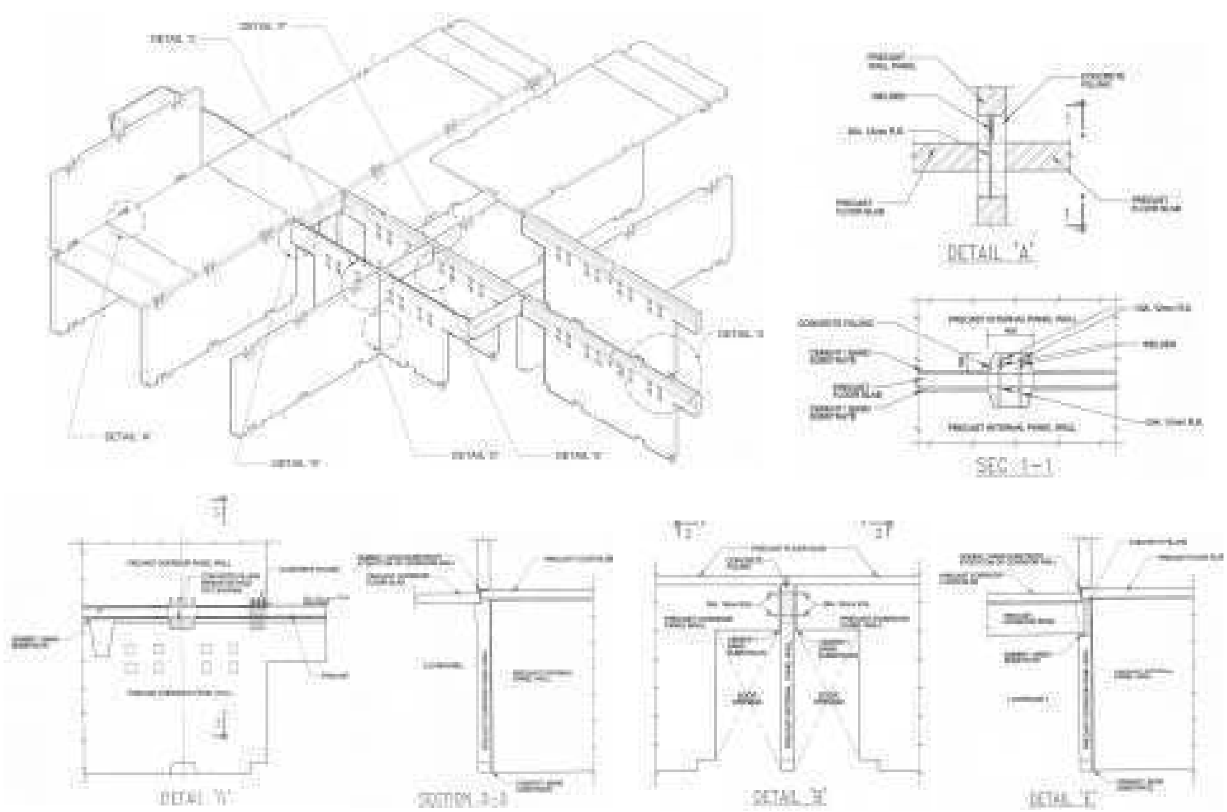

Figure 3 Structural Layout of Precast Block

7. Assessment of the First Demolition Plan Submission (Traditional Demolition Method)

The proposed demolition method was traditional top down method with operation procedures according to the recommendation specified in the Code of Practice for Demolition of Buildings issued by the BD (the Code). Before commencement of demolition works, temporary strengthening to the structures was required to cater for the additional vertical loads due to crushers and debris throughout the operation of demolition. Before demolition of a

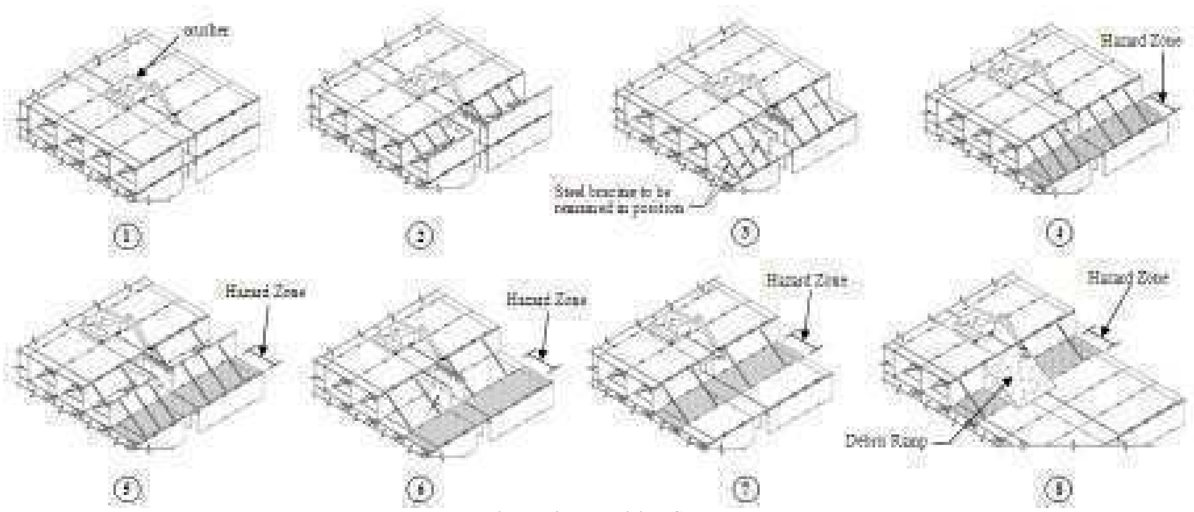

Figure 4 Demolition Sequence

block, a crusher would be lifted up to the roof of it by mobile crane. The area that the crusher would move around to execute the works should be confined and stated in the plan such that sufficient provision of support to the area could be calculated. Movement of the crusher from upper to lower floors would use a debris ramp. The maximum load case would appear when the crusher was moving down the debris ramp.Transient lateral load due to the crushers and dumping of debris should be considered in the design of the temporary works. Precast concrete structures of this kind were structurally weak in lateral stability. To strengthen the precast structures, temporary steel bracings were used to fix the top of precast wall to the slab at each floor in longitudinal direction. This could secure the walls from falling down when the slabs at top of the wall was removed. Logic of the demolition sequence had also to be carefully checked such that the structure under demolition would always be kept in structurally safe condition. Demolition sequence is shown at Figure 4. Other precautionary measures were checked generally acceptable.

8. Approval of the Demolition Plans (Traditional Demolition Method)

Except additional information was required to supplement some steps, the proposed sequence of demolition and corresponding calculation of the temporary support were considered generally in order and complied with the requirements of the Code. An interview was arranged to meet the project team for clarification of the submission. Project team gave a detailed description on the design philosophy of the demolition proposal and both parties had exchanged their view points, particularly in safety, executability and practicability aspects. Some details and notes were finally required to be amended to comply with the requirements of the Code and ICU's relevant Instructions. After the revision of the plans, the demolition plans were approved by the ICU on 10 June 2009.

9. Assessment and Approval of Demolition (Amendment) Plans (Alternative "Cut & Lift" Method)

The amendment submission of the demolition plans was received on 28 July 2010. This proposed method in this submission was in fact a reversed sequence of the precast block construction. The first step was to erect a tower crane beside the block to be demolished with the jib could reach all corners of the block. The demolition would commence from roof level. For the first member to be removed, the grout to conceal welded reinforcement bars and gap between members was removed first. The exposed reinforcement bars would be cut so as to free the member. Then the subject member would be lifted up by the tower crane and delivered to the ground. For the cast in-situ lift core of the block, traditional method as approved before was adopted.

Checking of the demolition plan was focused on the precautionary measures for stability of the blocks during demolition and safety arrangement for the workers and public. The proposal included steel scaffolding frames to be installed inside each unit and corridor to support the slabs. The walls would be strengthened by pairs of raking struts at top of walls and slabs. Calculation to demonstrate the adequacy of the provided temporary strengthening works under different load cases had been checked which were considered acceptable.

9.1 Demolition Sequences

Demolition sequences should base on the structural system of the precast block. To maintain sufficient stability of the structure in longitudinal direction, the lift core should never be lower than the precast portion. The part of lift core higher than the top level of the precast portion had to be taken down first. The first precast member to be removed was the corridor slab at the end of a wing of the block. There were two precast slabs in each unit where the outermost precast slab of the larger unit would be taken out first and followed by the adjacent one. Same step would apply to the smaller unit; then the adjacent bays until all precast slabs were removed. Afterwards, demolition of walls/beams would be ready by going back to the starting end. The external short precast wall at balcony of the larger unit would be taken out then the opposite one in the smaller unit. The pair corridor walls of the two units had to be removed and followed by the pair of precast end walls. The procedure applied to the adjacent units and continued to the other end. The sequence would be same for the other wings. After the precast members of roof were cleared, the lift core higher than the height of current precast part of the block would be brought down to the level of current precast part. The cycle of sequence would be repeated for the next floor until completion of the demolition of the whole block.

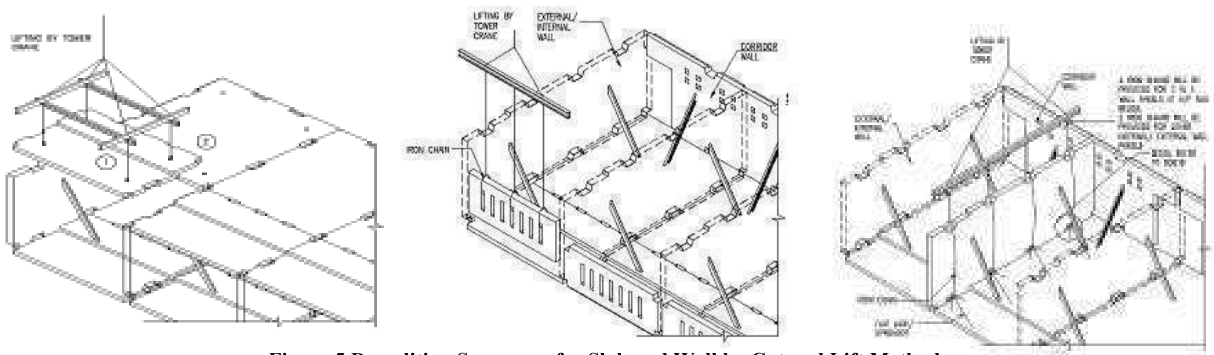

Figure 5 Demolition Sequences for Slab and Wall by Cut and Lift Method

9.2 Precautionary Measures

The demolition sequences were found to be generally feasible from technical view point. However, details of the procedure had to be carefully examined in order not to overlook any hidden danger. The members had been stuffed by grout for over forty years so the cohesion between members would still be large though the grout had been broken away before the action. Lifting up of the members without pre-separation of the members might lead to sudden bounce up of the member and caused excessive vibration to the adjacent members. To prevent wrong steps to be manipulated on site, the sequence of works had to be presented on the plans by clearly labelling the sequence number for each member with annotations so that the workers could easily follow up the steps. Tower crane could not be connected to any part of the precast blocks to avoid unnecessary external force to act on the structures. One salient point had to be considered was that there was no experience to demolish such precast concrete structures before while this proposed method also had not been performed before. To prove whether the proposal could be accepted or not, a trial run of demolition in applying the method should be a solution.

Having grouped and summarised the comments, an interview was arranged to meet the project team for discussion. Project team gave a brief on the new design concept of the proposal and elaborated the demolition sequence shown on the plans. Subsequent discussion was focused on the ICU’s comments on the proposal. Project team appreciated ICU’s concerns and would revise the plans accordingly to address all ICU’s comments. On 3

September 2010, the re-submitted demolition plan was approved by the ICU and an additional condition for conducting a trial run of the demolition at the roof of one precast concrete block before granting consent to other parts of the block was imposed in the approval letter.

10. Trial Run of the Demolition

Figure 6 Trial Run of Demolition

On 11 October 2010, ICU was invited by the project team to witness the trial run to be conducted at roof of Block 10. Before lifting up the first precast slab, the existing grout around the gap and in the slots of the slab had been removed. The exposed reinforcement bars were then cut. Below the subject precast slab, the jaws of four special ordered hydraulic wedge spreaders were inserted into the slots. The precast slab was connected to a prefabricated steel frame by four chains which in turn hanged from the tower crane by lifting wire. The lifting wire would then be gradually retracted and stopped when a very small force of 0.5kN had been induced. This was to avoid the precast slab from falling down suddenly as well as to assist for slackening off the precast slab from its position. Upward force was then applied through the four hydraulic wedge spreaders. The precast slab slowly moved up without bouncing up. Before the next step to proceed, ICU inspected the subject precast slab to check the integrity of the precast slab and surrounding supports. Minor cracks were found appearing on sides of the precast slab. Uneven rising up of the precast slab at four sides was also noted. The observed defects were immediately conveyed to the project team for investigation. The project team soon reported that the cracks were due to the incomplete removal of the existing grout at one slot. This rendered one set of the reinforcement bars had not been cut. As a consequence, uneven rising up of the precast slab was observed. After knowing the reason, the affected portion was rectified at once. The precast slab was then lifted up and lowered down to the ground.

Demonstration for precast wall demolition was subsequently followed. The precast wall was first tightened and fixed by four chains from bottom to top and around the wall element to ensure the stability from falling sideway. The chains were connected to the lifting wire of the lift tower through a steel section. The lifting wire was then gradually retracted and stopped when the chains had just got “straightened”. The grout of the pre-formed openings had been broken in advance. The exposed reinforcement bars were cut and the bracings for the precast wall were also released. Two hydraulic jacks were installed at locations close to two ends near bottom of the precast wall to slightly move it up. Before lifting up of the precast wall, inspection was conducted to check its integrity. No anomaly was found on the precast wall so it could be moved away by the tower crane.

From building control point of view, the demolition procedure and sequence demonstrated in the trial run were considered acceptable. However, the problems noted during removal of the precast slab might cause accident which needed to be addressed before the consent could be granted. Project team responded that in order to ensure the precast slab has been completely disconnected from other members, a minimum up-rise of 10mm at all four sides of the precast slab had to be confirmed before it could be lifted up. ICU accepted the proposed solution.

11. Consent Application to Commencement of Demolition Works

On 19 October 2010, ICU received the first consent application for the demolition of Blocks 10 and 11. As the trial run before consent application had been conducted and the result was acceptable, the consent to commencement of works was granted on 27 October 2010.

12. Site monitoring and Completion of the Demolition Works

In receiving project team's formal notification of the commencement of works, ICU would carry out regular visits to site without advance notice to carry out audit check of the site works. The result of the site audit check showed that the demolition works were carried out according to the approved demolition plans and the provided level of site supervision also met the standard. Following Blocks 10 and 11, consents were granted to Block 8, 12 and 9 on 22 February 2011, 10 March 2011 and 4 May 2011 respectively. The last precast concrete block was completed on 2 September 2011 where no accident had been reported throughout the demolition period.

13. Conclusion

From the experiences gained in vetting the demolition proposal for precast concrete block, careful study and vetting of the plans is required before approval and consent for demolition could be given. It is advised to conduct trial demolition at selected part of the structure to prove whether the proposed demolition method and sequences are feasible and safe before the works can be commenced. The trial run can also serve as reference for the workers to follow. Demolition works are far more dangerous than other site works in the construction industry. Preparation of demolition proposal would normally focus on technical issues but overlook the need to take into account the health and safety aspect. ICU's control of demolition under the Ordinances and Regulations is to safeguard the standard of the design and works for demolition to avoid any tragedy to happen.

References

Buildings Ordinance, Chapter 123. Hong Kong Special Administrative Region.

Building (Administration) Regulations. Hong Kong Special Administrative Region.

Buildings Department. Code of Practice for Demolition of Buildings, Year 2004.