



## Quiet Construction: State-of-the-Art Methods and Mitigation Measures

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### ABSTRACT

Alongside with the economic growth, construction activities to cope with the intense demand for infrastructural developments and housing in Hong Kong are at high time in recent years. However, noise from these activities is often a concern to the local communities and it is necessary to strike a balance between the need for meeting tight construction timeframes and the quest for quieter living environment. Typical ways to control noise from construction activities include applying standards for controlling noise at source; site boundaries; and at the receiver such as a residence. No matter which approach is adopted, the use of quieter construction methods, equipment, and effective noise mitigation measures is essential to, both comply with the control requirements and, to certain extent, meet the rising public expectation. This paper will describe the findings from a review on the available state-of-the-art quieter construction methods, equipment and innovative noise mitigation measures. Assessment and analysis of their applicability to Hong Kong situation will be discussed. This paper will also address the issue on promoting wider adoption of these quieter means and enhancing noise awareness through partnership programmes established with the construction trade.

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### 1. INTRODUCTION

Hong Kong is one of the most densely populated metropolitan cities in the world. It has a total area of 1,104 square kilometers of which 25% are developed lands and the rest are countryside with hilly landscape. Over 7 million inhabitants are housed in the developed lands, and majority of the buildings therein are of high-rise nature.

Alongside with the economic growth in recent years, a number of mega-sized infrastructural projects such as the Mass Transit Rail West Island Line, South Island Line, Shatin to Central Link, Kwun Tong Line Extension, Guangzhou-Shenzhen-Hong Kong Express Rail Link, and the West Kowloon Cultural District Development, etc. are under construction. In parallel, many residential developments and urban renewal projects are underway to meet the intense housing demand in the territory. It is not uncommon that these projects are executed next to high-rise residential towers and subject to very tight timeframes. As a result, construction noise is often the concern of the local communities given some of the activities may have to be proceeded in a round-the-clock manner, and that typical mitigation measures such as vertical barriers are only effective for protecting residences at lower floors.

With the implementation of the Noise Control Ordinance (NCO) [1] in 1989 and the Environmental Impact Assessment Ordinance (EIAO) [2] in 1998 respectively, legislative frameworks are in place to

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protect residents from exposing to excessive construction noise in both night and day hours. Despite these frameworks having, to a certain extent, offered protection against construction noise impact, there is also a need to address community's growing aspiration for a better living quality in terms of noise environment.

Against this background, the Environmental Protection Department (EPD) of the Government of the Hong Kong Special Administrative Region (Government) has adopted a partnership approach with the construction trade since 1999 to comply with environmental laws and improve the city's environmental performance. Another objective of this approach is to promote and keep abreast of environmentally friendly construction technology for use in Hong Kong. With the concerted efforts from all stakeholders, a number of viable quieter alternatives have been introduced in place of conventional noisier methods to further minimize noise at source for various construction works such as demolition of buildings/concrete columns/slabs, site formation and excavation, etc.

To support the partnership, the EPD has also conducted reviews on the available state-of-the-art quieter construction methods, equipment and innovative noise mitigation measures with a view to identifying and assessing their applicability to Hong Kong's situation.

## 2. QUIET CONSTRUCTION

### 2.1 Partnership with the Construction Trade

As part of the partnership programme, seminars, talks and workshops related to the technical and practical aspects of the identified quieter alternatives were jointly conducted to provide the latest technological information to the contractors. The EPD has also launched a green construction website [3] as a platform for promoting the use of the latest quieter alternatives and practical noise mitigation measures. Relevant technical specifications were gathered through real applications in the territory, and made available via the website for reference of contractors. The ensuing paragraphs will summarize the quieter construction methods that have been promoted to and adopted by the contractors in Hong Kong.

### 2.2 Adoption of More Environmentally Friendly Equipment

Since 2005, an administrative Quality Powered Mechanical Equipment (QPME) [4] system has been introduced by the EPD to promote the adoption of more environmentally friendly PME. Equipment complying with the relevant noise emission standards stipulated in the European Union Directive 2000/14/EC or the equivalent Japanese requirements are qualified for obtaining QPME labels from the EPD. Equipment fitted with QPME label facilitates and speeds up the process of the permit application for working during the restricted hours (i.e. 7 pm to 7 am on normal weekdays and at any time on a general holiday) because they no longer need to resort to on-site measurements and the EPD could readily assess the application based on the recognized noise emission performance.

In the same year, the Government also issued a technical circular [5] requiring contractors engaged in government's works contracts to propose and implement Environmental Management Plan in their construction sites. Specific precautionary measures like using non-percussive pile driving methods such as the vibratory or hydraulic jacking for installing or extracting sheet piles; using non-percussive equipment such as hydraulic crusher, sawing, coring machines, etc. for demolition and concrete breaking works; requiring hand-held noisy percussive breakers to be fitted with mufflers or silencers and damping layers with steel collars; mounting damping pads for refuse chutes; and carrying out on-site noise monitoring are needed to be considered and implemented as appropriate.

### 2.3 Adoption of Quiet Construction Methods

Typically, noise from construction works ranging from demolition of buildings, site formation and excavation to erection of superstructures can be as high as 80 to 90 dB(A) at the nearby Noise Sensitive Receivers (NSRs) in Hong Kong. The adoption of quieter construction methods or equipment enables the reduction of noise at source, and hence it is effective in enhancing compliance with the legal and contractual requirements. The following examples illustrate some quieter construction methods adopted for various types of construction works in Hong Kong:

**Demolition of buildings:** Conventionally, excavator-mounted hydraulic percussive breakers were employed in most building demolition projects as shown in **Figure 1**. The impact sound generated by

these percussive breakers could be as high as 90 dB(A) at the nearby NSRs and caused serious noise disturbance. In the early 2000s, the Government had implemented a trial for adoption of hydraulic crushers for demolition of public housing blocks as shown in **Figure 2**. The findings revealed that hydraulic crushers did not seriously compromise the construction progress as compared with the conventional hydraulic percussive breakers, while on the other hand, they had achieved a significant noise reduction of more than 20 dB(A) at the nearby NSRs. Following the trial, the use of hydraulic crushers became a standard specification in subsequent government contracts for demolition of public housing sites in urban areas. Guidelines [6] were also made available via the internet for further promulgating the use of hydraulic crushers for demolition among the construction trade and private developers.

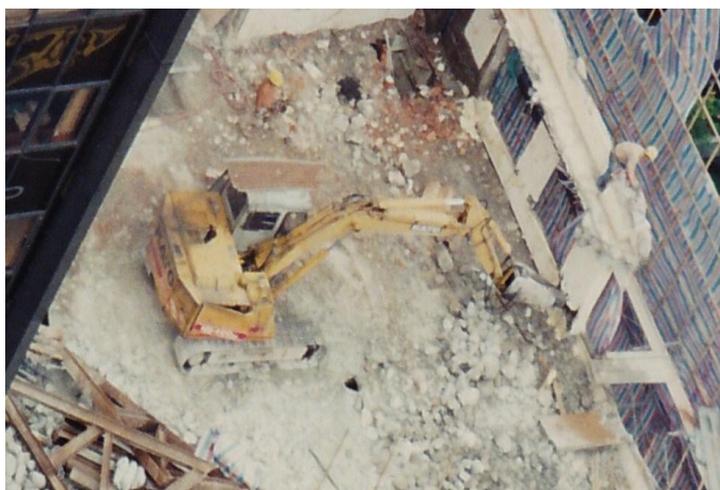


Figure 1 – Conventional excavator-mounted percussive breaker



Figure 2 – Hydraulic crushers for demolition works

**Demolition of concrete columns/slabs:** Typically, hydraulic percussive breakers were used for demolition of concrete columns/slabs in buildings. In the early 1990s, technologies such as coring, wire or blade sawing became more common in Hong Kong. These technologies enable on-site cutting of the concrete columns/slabs into manageable pieces which can then be disposed of or further broken down off-site in order to minimize the duration of disturbance to the locality. It can achieve a noise reduction of more than 10 dB(A) at the nearby NSRs. The technologies had been adopted in a number of demolition projects in Hong Kong as shown in **Figures 3, 4, and 5**.



Figure 3 – Blade Sawing of Concrete Slab



Figure 4 – Hydro Blade Sawing of Concrete Slab



Figure 5 – Wire Sawing of Concrete Floor Slab

**Site formation and excavation:** The ground of Hong Kong is geo-technically complex with volcanic and granitic rocks as dominant rock types. Before the foundation works of most projects, site formation is often required and involves rock breaking and excavation activities. Currently, the use of excavator-mounted hydraulic percussive breakers is still the practical norm of the construction trade as the viable quieter alternatives are very limited. As rock excavation is a rather lengthy task during the normal construction cycle, noise from which often causes serious disturbance to the nearby NSRs.

However, in some situations where sufficient space is available, the use of pre-drilling and expandable chemical agents and/or hydraulic splitters could be deployed for rock breaking activities as shown in **Figure 6**. These quieter technologies have been introduced in Hong Kong since the mid 1990s, and can help perform breaking up rocks silently.



Figure 6 – Employment of Expandable Chemical Agents and Resultant Cracked Rocks

In the early 2000s, the hydraulic press-in-method also became popular in Hong Kong as an alternative for conventional percussive hammers for driving sheet piles before the soil excavation. Noise from percussive piling is very intrusive, although it has already been subject to the control via a permit system, and is often limited to 3 hours of daily operation in urban areas. Therefore, the hydraulic press-in-method provides an incentive to the contractors for achieving a quieter environment while having the benefit of longer operation hours. Typically, the hydraulic press-in-method can achieve a noise reduction of around 20 dB(A) at the nearby NSRs, and it has been employed in a number of railway projects as shown in **Figure 7**.



Figure 7 - Hydraulic Press-in Method

**Pipe replacement and installation:** Conventional method to replace aged water pipes or utilities pipes was by laying new pipes through trench opening method (also called open-cut method). As this method involves road opening and soil excavation for the whole section of the pipe, construction noise would be the concern of nearby residents. In the early 2000s, pipe jacking method, or “minimum dig”, or trenchless replacement techniques became popular in Hong Kong. This method involves pre-drilling of a suitable-sized hole and jacking of a pipe sleeve along the pre-drilled hole from the launching pit using a hydraulic jacking machine to the receiving pit, as shown in **Figure 8**. The soil inside the pipe sleeve is removed and then a new pipeline is inserted into the pipe sleeve. Upon making connections in the two ends of the newly inserted pipe, the existing pipe can be abandoned. As there is minimum dig, and most of the works are conducted under the pit, construction noise to the nearby sensitive can be largely reduced.



Figure 8 – Pipe jacking method (Source: Water Supplies Department, HKSAR Government)

**Building repairs:** High-rise multi-flat public housing has a long history in Hong Kong. Frequent repairs of concrete surfaces inside domestic flats, shops, and in common areas are necessary to maintain the building conditions. Currently, the use of percussive breakers to remove concrete defects often causes noise and vibration disturbances at the nearby households. The Government is, therefore, exploring the feasibility of using hydro-scarification as shown in **Figure 9** as a quieter alternative. The use of high-pressure water jets enables selective removal of concrete defects without causing damages to the rebar and concrete that are still in good conditions. Findings reveal that such a quieter alternative is much less annoying as compared with the intrusive impact sound from conventional percussive breakers.



Figure 9 – Removing Concrete by Hydro-scarification (Source: Housing Department, HKSAR Government)

**Road maintenance:** Many roads in Hong Kong are heavily trafficked, and unavoidably some road resurfacing or repair works have to be done at the less busy night hours. Where circumstances allow, the much quieter infra-red heating device as shown in **Figure 10** will be adopted in place of conventional hand-held percussive breakers for removal / repaving of asphalt during maintenance of road surfaces.



Figure 10 – Removal/Repaving of Asphalt by Infra-red Heating Device

#### 2.4 Adoption of Innovative Noise Mitigation Measures

It is unique that the urban settings in Hong Kong are highly compact and majority of the NSRs are high-rise buildings. For situations where no conventional quieter alternatives are available, the EPD will endeavor to liaise with the contractors to explore innovative and practical noise mitigation measures to protect the nearby NSRs against the construction noise impact. As shown in **Figure 11**, a substantial acoustic enclosure capable of providing a noise reduction of over 40 dB(A) was erected to protect the adjacent high-rise NSRs against noise impact from the round-the-clock construction inside the enclosure. In many situations, innovative measures are required to overcome the prevailing site constraints. Some examples of these innovative on-site mitigation measures are mobile /inflatable noise screens / enclosures as illustrated in **Figures 12, 13, and 14**.

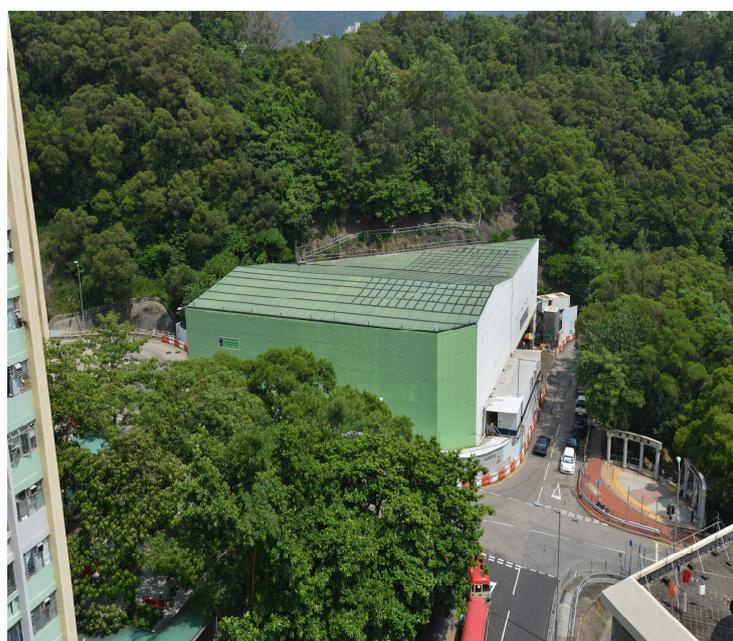


Figure 11 – Purposely-built Substantial Acoustic Enclosure



Figure 12 – Movable Enclosure with Internal Sound Absorption Lining



Figure 13 – Movable Noise Barrier



Figure 14 – Inflatable Noise Screen

## 2.5 Findings from Review of the Available Quieter Alternatives

The EPD has also been keeping abreast of the latest development of quiet technologies. A recent review has identified the quieter construction methods, namely “Hat-down” method for demolition of buildings and “Gyropress” method for driving piles that possess their potential to be adopted in Hong Kong’s highly compact urban as well as geo-technically complex situations.

The “Hat-down” method was originated in Japan and uses a movable partial noise enclosure built on the top of the high-rise building like a “hat”, and all demolition activities are carried out inside the noise enclosure. During the building demolition, the “hat” is gradually jacked down. Japanese experience indicated that the hat-down method can achieve a noise reduction of around 25 dB(A) at the nearby NSRs and has been proved to be practicable in Japan. As shown in **Figure 15**, a hotel building is under demolition by the “hat-down” method. It is worth more detailed analysis and evaluation on its practicality for demolition projects in urban areas of Hong Kong where the building under demolition is often in close proximity and surrounded by high-rise Noise Sensitive Receivers.



Figure 15 – Hat-down Demolition of Grand Prince Hotel Akasaka (Japan)

The “Gyropress” method, as shown in **Figure 16**, is one kind of hard-ground press-in silent piling methods. This method combines the auger head as well as the water jet together with the basic hydraulic press-in method. Japanese experience indicated that the noise is at least 20 dB(A) lower than typical piling methods by vibratory means. This improved hydraulic press-in-method is versatile for driving sheet piles and possesses high potential in overcoming the geo-technically complex conditions in Hong Kong.



Figure 16 – Gyropress Hard-ground Press-in Method in Operation (Japan)

Through the partnership programme, it is anticipated that the above quieter construction methods would be introduced to the construction trade in Hong Kong, and their applicability and cost implication can be further evaluated via real applications in local situations.

### 3. FINAL REMARKS

While joint efforts from the Government and the construction trade has led to the successful introduction and adoption of certain quieter construction methods and noise mitigation measures, the collaboration needs progress further, as more and more quieter technologies emerge with their benefits and applicability progressively demonstrated. The EPD will continue to review the available quieter means and innovative mitigation measures in order to strengthen the partnership in protecting the noise environment, while allowing fast-tracked construction be proceeded in a densely populated and vibrant metropolitan city like Hong Kong.

[The opinions in this paper are those of the authors and do not necessarily reflect the views or policies of the Government of the Hong Kong Special Administrative Region of the People's Republic of China.]

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