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Review

The evolution of prefabricated residential building systems in Hong Kong: A review of the public and the private sector

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ABSTRACT

Prefabricated building components have been adopted in Hong Kong for over two decades for high-rise buildings. In the public sector, prefabrication together with standard modular design was introduced in the Housing Authority's public housing projects in the mid-1980s. Over the years, precasting techniques have significantly evolved in public housing projects. In contrast, prefabrication has only recently been adopted in the private sector. The aim of this paper is to examine the evolution of precasting technology in high-rise residential developments in Hong Kong, and then explore the technological influences in both sectors. A database of 179 prefabricated residential buildings was developed and detailed case studies of five residential developments were conducted. The findings revealed that a greater extent of prefabrication use over the years, in terms of precasting percentage by volume and types of precast elements utilised. Major prefabrication innovations, in both sectors, influenced the technological advancement in prefabrication in Hong Kong.

Contents

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1. Introduction

1.1. Prefabrication

Prefabrication is a manufacturing process, generally conducted at a specialized facility, in which various materials are joined to form a component part of the final installation [1]. The manufacturing process may be undertaken in a factory environment (factory prefabrication) or under the open sky at the site (site-prefabrication) [2]. The term off-site fabrication is used when both prefabrication and pre-assembly are integrated [3]. Gibb [3] identified three categories of off-site fabrication such as, non-volumetric, volumetric and modular building, but argued that the line dividing each type is flexible. Prefabrication has been identified as the first degree of industrialisation, followed by mechanisation, automation, robotics and reproduction [4]. Prefabrication techniques have been progressively adopted in the construction industry in various countries. In Hong Kong, it was introduced with the outstanding development of the public housing programme [5]. This move constitutes one of the most extensive applications of prefabricated high-rise buildings in the world, and reflects a unique experience on the use of prefabrication strategy in dense urban environments.

1.2. Development and application of prefabrication in buildings

Prefabrication was made feasible with the advancement of production techniques and equipment for transportation and erection [6]. After the World War II, comprehensive prefabricated building systems including prefabricated slabs, vertical structural elements, façades, partitions, stairs and sanitary units were developed with the support of public authorities to cope with the pressing and increasing demand for housing. The demand was at its peak in the 1950s, 1960s and the early 1970s in Eastern and Western Europe for the construction of new towns, suburbs, and large scale public housing developments [6]. During this period, various precast concrete building systems were created. In the early 1970s, the US government also explored several prefabricated building systems.

Worldwide, the highest precast levels in 1996 were located in Denmark (43%), the Netherlands (40%), Sweden and Germany (31%) [7]. In fact, Denmark established a modular coordination legislation in the 1960s [7], thus facilitating the use of prefabrication. In Asia, the precast levels in Japan and Singapore were about 15% and 8%, respectively [7]. In Singapore, precast concrete was introduced in the early 1980s [8]. Several prefabricated systems, including fully and semi-prefabricated systems, were developed by local and overseas contractors. Recently, the use of prefabrication is further encouraged in Singapore to increase productivity and buildability [9,10].

In most countries, prefabrication is applied in building construction to enhance productivity, improve quality, and cope with a shortage of skilled labour [3,6–8,11]. Numerous studies have investigated the feasible uses of prefabrication and its potential [12–15].

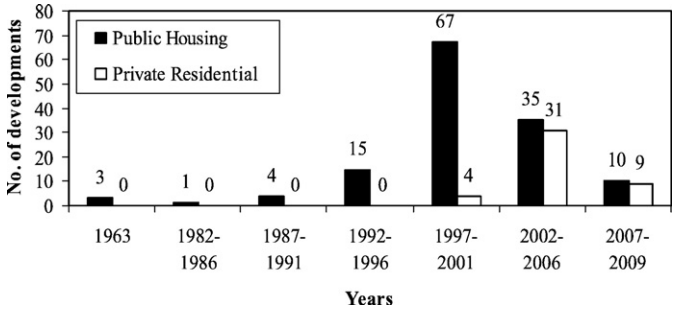

Fig. 1. Number of new residential developments, by sector, adopting prefabrication construction since 1963.

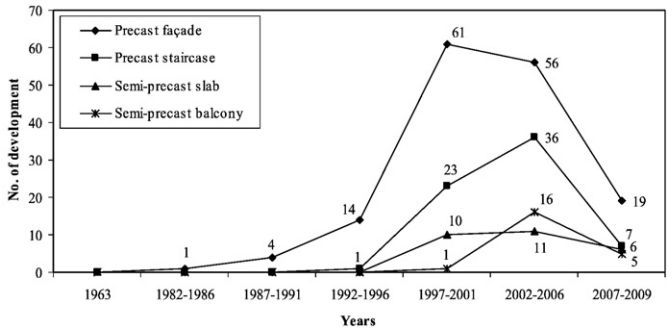

Fig. 2. Number of residential developments, from the public and the private sectors, adopting precast façade, precast staircase, semi-precast slab and semi-precast balcony, during 1982–2007.

However, only few studies covered the use of precast concrete in high-rise buildings [16,17]. Indeed the use of prefabrication in a dense urban environment such as Hong Kong has rarely been examined.

1.3. Hong Kong experience in prefabricated buildings

1.3.1. The use of prefabrication in the public sector

Over the past 50 years, Hong Kong has experienced a huge increase in housing demand in a very short period of time, requiring a massive production of residential buildings. An extensive public housing programme was initiated in the 1950s, and is now housing about half of the Hong Kong population [18]. In the mid-1980s, prefabrication, combined with standard modular design, was introduced in public housing projects [19]. Since then, the Hong Kong Housing Authority (HKHA) has recommended the usage of precast units and reusable formwork in all public housing contracts. In 2002, prefabricated elements accounted for about 17% of the concrete volume used in public housing projects [20]. Major precast elements used are façades; staircases; parapet; partition walls (dry wall); and semi-precast slabs. A recently completed pilot project has extended the use of precasting to 65% comprising precast volumetric kitchen and bathroom, and structural walls [21]. With over two decades of experience in the use of prefabrication, the HKHA was a pioneer in adopting precasting techniques and contributed to major precasting innovations in the industry. Consequently, the majority of past studies are confined to the innovations and performances of public housing projects [5,19–24], while the private sector has taken a backseat.

1.3.2. The use of prefabrication in the private sector

In fact the private sector still heavily relies on cast in-situ conventional construction method involving the use of timber formwork, in-situ concreting, substantial amount of wet trades and bamboo scaffolding. Construction activities in the private sector in Hong Kong are, therefore, considered as labour intensive, dangerous and polluting, and the built products are rarely without imperfection

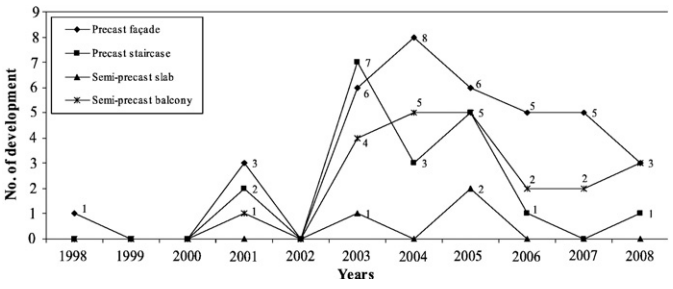

Fig. 3. Number of private residential developments adopting precast façade, precast staircase, semi-precast slab and semi-precast balcony in the last decade.