Title Page

DEVELOPMENT OF ULTRA HIGH PERFORMANCE SELF COMPACTING CONCRETE (UHP-SCC) FOR SUPER HIGH RISE BUILDING

By

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Thesis Submitted in Fulfillment as the Requirement for the Doctor of Philosophy in Civil Engineering by Research Degree in the Faculty of Engineering and Technology Infrastructure

I U K L

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Declaration

I declare that thesis titled “Development of Ultra High Performance Self Compacting Concrete (UHP-SCC) for Super High Rise Building” is a result of my own work except where cited in references.

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Abstract

The establishment of the super high-rise buildings (over 400m high) represents both the fast local economic development and the highest level of the current building -related designs, construction and materials. As the new landmark of Guangzhou, China, the West Tower Project of Guangzhou International Financial Center (West Tower Project for short) has a height of 441m high and 108 floors in total. The complicated tube-in-tube structure brings great challenge to the constructors.

This study is focused on the mass application of the C70~C90 concrete in the West Tower Project and the engineering requirements of the ultrahigh pumping height. Based on the conventional raw materials and production equipment, it develops, exploits produces and applies the UHPC of C100 and UHP-SCC, and carries out the ultrahigh pumping as high as 411m (first in China and the world). The self-compacting concrete, especially UHP-SCC, usually needs thickening agents to make concrete mixture have sufficient cohesion and sand and rubble are evenly distributed in mortar to let its mixture pass through the retainer together. The lignin is used as thickening agents at home and abroad and it can influence concrete strength and increase cost. This research use ultrafine natural zeolite as thickening agents to resolve the coordination among viscosity，fluidity and self-compacting. In addition, with high SiO_2 content, the zeolite powders can make the concrete thickened and enhanced. UHP-SCC in this research, not only can attain self-compacting in factory, but also can attain self-compacting (The test of filling height of U-shaped device is more than 30cm)after it is ultra-highly pumped to 411m height. The reason is that a patent self-made produce (special additive) is used to keep fluidity for more than 3 hours.

As for the physical and mechanical properties, the compressive strength of the 28d in the C100UHP-SCC reaches over 110MPa,and its splitting tensile strength is 7.92MPa, flexural strength is 11.3MPa, axial compressive strength is 113.2MPa and the elasticity modulus is 48400MPa,which indicates that the studied C100UHP-SCC has excellent physical and mechanical properties. In terms of the durability, this research especially studies the durability projects like C100UHPC resistance to the chlorion permeability (the electric flux of 56d is 87c), sulfate corrosion resistance (expansion rate in 15 weeks is 0.083%), freezing resistance (quality loss after 300 times freeze thawing cycle is 0.10%, and the relative dynamic modulus of elasticity is 95.8%), alkali-reactivity of aggregate, sample alkali aggregate reaction of the engineering concrete, and long-term shrink. It turns out that the C100UHP-SCC meets the need of the durability of 100 years. Through micro XRD experiment, the Ca $(OH)_2$ in the hydration products is effectively reduced since the hydration products of the studied UHPC and UHP-SCC using the mineral admixtures like zeolite powder. Through the observation of SEM experiment, the micro-crack caused by the self-constriction inside the UHPC-SCC is evidently decreased because of the zeolite powder's features of multi-hole and water retention, and the density of the UHP-SCC. According to the UHPC and UHP-SCC's requirement of ultrahigh pumping technology, Zoomlion researches and produces the pump with ultrahigh pump pressure (the exit pressure of the concrete reaches 40MPa). It also meets the requirements of the high-performance concrete's ultrahigh pumping technology through advanced techniques like reasonable piping design and layout.

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Chapter 1:Introduction

This chapter introduces the development and application of self-compacting concrete (SCC), and describes the background, aims and scope of this project. In addition, significance of the research is also described.

One of the main features of the thesis is the pumping of HSC and UHP-SCC to high elevation. This is because, as more buildings in the cities are being built to meet the increasing demands of the growing population, they are required to achieve greater height exceeding 400m in some cases. The design and development of this type of concrete buildings requires special consideration in many aspects, including selection of raw materials, design criteria, material characterization, engineering properties of fresh and hardened concrete and the application in high rise building.

A much detailed review of previous works on the performance of SCC and HS-SCC, and the pumping technology of the concrete at high elevation is given in Chapter 2.

1.1 Development and Application of SCC

Self-compacting Concrete (SCC) represents a milestone in concrete research. SCC is a highly flow-able, non-segregating concrete that can spread in to the inside parts of the places, fill the formwork and encapsulate the reinforcement without any mechanical vibration for consolidation. SCC was originally developed by Prof. Okamura and his team in 1986, from University of Tokyo (Japan), to improve the quality of construction

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