UNIVERSITI PUTRA MALAYSIA

STANDARDISATION OF PRECAST CONCRETE MEMBERS FOR LOW-RISE RESIDENTIAL FRAMED BUILDING

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By

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October 2002

Chairman: **Professor Dr. D.N. Trikha**

Faculty: **Faculty of Engineering**

Precast concrete technology has become an emerging trend in Malaysian Construction Industry. Hence, there is a niche in developing a set of standardised and optimised precast concrete elements as well as connections for a speedy, affordably and better quality residential building.

By studying the preferred sizes of the structural members in the existing and combined with the standards of Modular Coordination System; the standardization of precast concrete elements for skeletal framing type of structure can be achieved.

This thesis had also covered the economy part of the elements by comparing the costs of producing these elements for different sets of dimension and

reinforcement combinations until deriving to a most cost effective section with the respective span.

Nearly 300 types of precast concrete elements and connections that have been standardised and optimised through the above mentioned process for skeletal framing residential structures. This is to streamline the precast concrete industry towards proper metrication and cost efficiency in planning, design, construction, assembly and manufacturing of these elements and joints.

Case study on application of standardised precast elements and connections of a residential building – Putra Apartment has proven the practicability of these elements and connections in the building.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

KESERAGAMAN ELEMEN-ELEMEN KONKRIT PASANG SIAP UNTUK BANGUNAN KEDIAMAN BERTINGKAT RENDAH

Oleh

HENG CHIANG CHEW

Oktober 2002

Pengerusi : **Profesor Dr. D.N. Trikha**

Fakulti: **Fakulti Kejuruteraan**

Teknologi pembinaan jenis pasang siap telahpun menimbul sebagai satu trend pembinaan baru di Malaysia. Oleh itu, adalah perlunya untuk membangunkan satu set elemen dan sambungan konkrit pasang siap yang berseragam dan beroptimum demi menwujudkan bangunan residensial yang cepat dibina, bersanggupan dan berkualiti.

Dengan menyelidik segala size-size elemen yang biasa digunakan dalam pasaran bangunan kediaman bersama Standard Sistem Kordinate Modular Malaysia; penyeragaman elemen konkrit jenis pembinaan pasang siap untuk struktur berangka skeletal boleh dicapai.

Selain daripada itu, tesis ini juga meliputi pengajian kos pembuatan elemen-elemen jenis pasang siap demi memperolehi size yang paling ekonomi dalam siri eleman yang ditetapkan.

Hampir 300 jenis elemen dan sambungan telahpun diseragamkan dalam tesis ini dengan cara yang disebut dan merupakan satu cara untuk menyalurkan cara pembinaan konkrit pasang siap ke arah metrikasi dan kos efektif dalam peringkat perancangan, pembinaan, pemasangan dan pembuatan.

Kes pembelajaran juga dikemukakan untuk menguji kesesuaian elemen dan sambungan konkrit berseragam dalam pembinaan sebuah rumah kediaman – Putra Housing. Dan ia telahpun menujukkan tahap kesesuaian yang tinggi elemen-elemen dan sambunagan ini dalam bangunan tersebut.

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I certify that an Examination Committee met on 11th October 2002 to conduct the final examination of Heng Chiang Chew on his Master of Science thesis entitled "Standardisation of Precast Concrete Members for Low-Rise Residential Framed Building"in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

HENG CHIANG CHEW

Date: 31/10/2002

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ϕ - Diameter of the steel bar

ζ - Bursting force coefficient

ε - Strain at the end of the parabolic part of stress diagram

α_e – Modulus Ratio

α_e – Modulus Ratio

μ_f - Effective shear friction coefficient at the crack surface

γ_m – Partial safety factor for strength of material

Σp – Total perimeter of the steel section

μ_s - Static friction coefficient

δ - Ratio of joint width to joint thickness, t/v

η_o - Reduction factor reflecting the trapped air content

σ_c - Compressive stress of mortar

τ_{max} - Maximum shear stress.

a_d - Center to center distance between bars perpendicular to the steel

A_{burst} – Confinement reinforcement to prevent bursting

As – Flexural Reinforcement for Beating Conenctions

Asn – Axial Tension reinforcement

A_{sv} – Area of shear reinforcement

b_v - Breath of the section

c – Distance between the centers of bolts and column

C_c - Compression force in concrete

C_s - Compression force in steel

d - Effective depth of the section

E_c - Modulus of elasticity of the concrete

E_s – Modulus of elasticity of the steel

F_b – Design perimeter bond stress per unit length of steel

F_{bt} – Tensile force due to ultimate loads in the bar

F_{burst} – Outward bursting force

f_{cu} - Weaker concrete compressive strength of either the joint mortar or the concrete

f_{cw} - Compressive strength of mortar

f_{cw}/f_{cu} - Concrete compressive strength of mortar and precast

f_y – Characteristics strength of steel reinforcement

f_{yb} – Ultimate strength for the bolts

H_a – Horizontal reaction force at the bottom wall in base connection

L_b – Base plate overhang beyond the column face

precast concrete components adjacent to the joint.

p_y – yield strength of steel plate (table 6, Part I, BS5950)

r - Radius of steel bar bend

T - Tension force in steel

V - Designed shear force due to the ultimate load

V_h – Horizontal shear force

x – Neutral axis of section

CHAPTER 1

INTRODUCTION

1.1 General

Providing Malaysians with affordable, durable and energy efficient housing probably has become an important issue presently. Affordability means being affordable to groups of different income levels by optimizing the structural design and/or consuming the local raw material, durability and energy efficiency can be achieved by using proper design of building elements. In the Seven Malaysian Plan (RM7)(1996-2000), out of the 800,000 units of targeted housing demand, 235,000 units are needed to meet the demand of low-cost houses, 350,000 for medium-cost houses and the remaining 85,000 units for high cost houses. Although the figures are not yet available, a severe shortfall in construction is expected. Since the demand for low and medium cost housing has further increased tremendously, precast concrete technology in construction is needed to meet the targets within the scheduled period of time.

It is well recognized that economy can also be achieved through the use of precast concrete elements in buildings, with added advantage of overcoming shortage of skilled labour as well as providing quality in the final product from the user group. Prefabricated structures actually have been used in much simpler forms far back during the ancient Romania Empire, but prefabrication has become more popular and being widely used in engineered building construction in European countries for the past fifty years especially after the unparalleled destruction of the second world war, the sudden increase of population had fuelled the demand of accommodation in those European countries. For them the industrialization techniques were their only solution and hope and the prefabrication for concrete products became very essential in this precast system of construction.

Nowadays the precast concrete structural members are excellent for its high quality with regard to strength, stiffness and durability. Also architectural precast concrete has found its place as one of the best technologies for high quality facades with unlimited variety of shapes, colours, surface textures and finishes, fast erection time and competitive price.

Precast concrete technology can be found today in almost every part of the building. But it has been more commonly adopted for the sub-structure member such as precast concrete piles as compare to the superstructure members such as columns, stability cores, floors, stair flights and parapets in Malaysian residential buildings. This is mainly due to the comparatively high manufacturing, transporting and erecting cost for these members as compared to cast the elements on site by using conventional ways. However, the speedy erection of the precast concrete structural members and high repetitive in design can actually reduce the cost and increase the feasibility of using precast concrete technology. Also the new trend of changing organisation of the building process has impacted on the increasing-use of the precast concrete. This explains why more and more general contractors are shifting their activities from general contracting such as masonry, carpentry, and steel fabricating to construction management, with only a minimum manpower on the payroll while having the same amount of profit margin. Manpower needed only for good organization of the construction process, while the other necessary trades is subcontracted elsewhere. This seems to be a paradigm swift for the global construction industry in giving a new generation of general contractors more flexibility necessary in the competitive market and create at the same time bigger demand for the precast building members that are made somewhere else and which do not require extensive input of labour from the general contractor.

In Malaysia context, the niche of having precast concrete has became more appearing after the labour crisis in August 2002, when Malaysian government has enforcing the Immigration Act to overcome serious social problems created by the illegal foreign workers. This has created a sudden "vacuum" of labour force in the market and incurred extra time as well as cost in resuming the work force.

1.2 Types of Precast Concrete

There are many ways of grouping precast concrete system in the market, but in this dissertation, the author standardises the systems into three major category; namely the skeletal framing system, load bearing wall system and modular cell system.