SPLICE SYSTEM IN EXTENDING THE PRECAST PRESTRESSED CONCRETE BEAM SPAN

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"This study is especially dedicated to my beloved Mommy and Daddy
Brothers, Friends,
for everlasting love, care, and supports….."

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ABSTRACT

This project focuses on the use of splicing precast concrete beams to extend their span length. Precast prestressed concrete beams are economical solutions for many bridges, due to various restrictions such as weight and hauling length they are rarely used for spans greater than 40 m. This project was initiated by collecting the information from internet and technical reports of some bridge projects that have used spliced beam system. The experimental work has been carried out on three beams of 2.5 m span with different location of splice loaded to fail. The type of splice beam system used consisted of precast pretensioned beam joint together by post-tensioned method. The experimental results show the development at shear failures inclined the depth opposed with initial prediction to fail in flexure. Both spliced beam has achieved the ultimate load capacity. On the other hand, the actual load capacity for controlled beam was twice times higher than calculated. From this research, base on ultimate load failure, the spliced system applied for double spliced beam has succeeded to perform as calculated nominal beam. However, since the actual controlled beam perform better, and the splice beam fail unexpectedly in shear, the future research should focusing on the materials, location and type of splice section to improve the present research.

ABSTRAK

Projek ini menfokuskan kepada penggunaan sistem sambungan kepada rasuk konkrit prategasan untuk memanjangkan rentangnya. Ketika rasuk prategasan menjadi penyelesaian ekonomikal untuk pelbagai projek jambatan, namun kerana halangan seperti had berat dan panjang maksima di atas jalan raya, sistem ini menghadapi masalah untuk rentang melebihi 40 m. Projek ini berasaskan kepada pengumpulan maklumat dari internet dan laporan teknikal beberapa projek jambatan yang menggunakan sistem sambungan. Eksperimen telah dijalankan ke atas tiga rasuk 2.5 m dengan berbeza bilangan bahagian sambungan yang dikenakan beban secara berkala sehingga gagal. Jenis sambungan yang diaplikasi pada spesimen rasuk dalam ujian makmal adalah sistem pratuang prategasan yang dicantumkan dengan kaedah tegangan. Keputusan eksperimen menunjukkan kegagalan ricih lebih ketara pada garisan sambungan bertentangan dengan jangkaan awal agar ia gagal dalam lenturan. Rasuk yang mempunyai dua sambungan melepasi kapasiti beban maksima. Pada masa yang sama, rasuk yang dikawal gagal pada nilai dua kali ganda daripada nilai jangkaan. Berdasarkan kiraan kegagalan beban maksima, adalah didapati, rasuk yang mengaplikasi sistem sambungan ini berjaya bertindak seperti rasuk monolitik biasa. Namun, memandangkan rasuk kawalan sebenar bertindak jauh lebih baik daripada segi nilai kegagalan dan rasuk bersambungan gagal pada jenis ricih, kajian pada masa depan perlu menumpukan pada bahan, lokasi dan jenis sambungan yang lebih baik berbanding kajian sedia ada.

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α	-	Coefficient of short term losses.
β	-	Coefficient of long term losses.
A_{ps}	-	Area prestressing tendon (mm^2)
A_s	-	Area of strands (mm^2)
b_v	-	Breadth of the member (mm)
d	-	Effective depth (mm)
d_n	-	Depth to the centroid of compression zone (mm)
e	-	Eccentricity of the prestressing steel (mm)
f_{ci}	-	Concrete strength at transfer (N/mm^2)
f_{cu}	-	Concrete strength at service (N/mm^2)
f_{ct}	-	Flexural compressive stresses (N/mm^2)
f_{tt}	-	Flexural tensile stresses (N/mm^2)
f_{cp}	-	Design compressive stress at the centroidal axis due to prestress (N/mm^2)
f_{pu}	-	Tensile strength of strand (N/mm^2)
f_t	-	Maximum design principal tensile stress (N/mm^2)
f_{cp}	-	Design compressive stress at the centroidal axis due to prestress (N/mm^2)
f_{pe}	-	Design effective prestress in the tendons after losses (N/mm^2)
F_{bst}	-	Bursting force (kN)
h	-	Height of section (mm)
h_f	-	Height of flange section (mm)
I	-	Moment of inertia of the section (mm^4)

L	-	Length (m)
M_o	-	Moment necessary to produce zero stress in the concrete at the extreme tension fibre. (kNm)
Mu	-	Ultimate moment (kNm)
n	-	Number of strand
P	-	Prestressing force (kN)
V_c	-	Shear resistance of the concrete (N/mm^2)
V_{cr}	-	Shear resistance of a section cracked in flexure (N/mm^2)
y_o	-	Half side of the end block (mm)
y_{po}	-	Half side of the loaded area (mm)
z_1	-	Section modulus of top fibre (mm^3)
z_2	-	Section modulus of bottom fibre (mm^3)

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A prestressed concrete structure has many advantages, such as delaying cracks, saving materials, reducing deflection, and has been widely or increasingly used in long span structures (Lin and Burns, 1982). However, these beams are still used infrequently for spans in excess of 40 meters. This upper limit of practical application exists for several reasons, including material limitations, structural considerations, size and weight limitations on beam shipping and handling and a general lack of information and design aids necessary to design longer spans using concrete beams.

Some designers, fabricators and contractors, however have successfully collaborated to extend span lengths for precast prestressed concrete beams to distances greater than 40 meters and expand their use to other applications not normally associated with precast prestressed concrete beam construction. Unfortunately, the methods used only for specific job, and the knowledge gained has not made widely available to use in similar projects.

1.2 Problem Statements

Among the issues faced by the engineers on design stages such as the needs to eliminate piers for safety, reducing the number of substructure unit to avoid certain unstable soil foundation, improve the aesthetics and minimize the structure depth

During construction, there are various issues especially for long span beam and involving large full-span beam. These will resulting problems in fabrication and handling, transportation, erection, access to the site, fabricator`s facility and contractor`s equipment.

Economical issues are priority in all construction. The issues on reduction of construction costs, reduction of fabrication time and also cost for temporary support system on the nominal structures are among the challenges for the engineers.

Figure 1.1: Length and weight limits on precast beams lead to splicing for longer spans

1.3 Objectives

The main focus of this research was to address issues related to the design and construction of spliced precast prestressed concrete beam. The products of this research project include the following:

a) To investigate the options used for extending span ranges of precast prestressed concrete beam current projects and data.

b) To demonstrate the effectiveness of spliced beam method through the smaller scale laboratory work.

c) To examine the cracking type and failure occur in spliced beam system.

1.4 Research Scopes

The literature review and information address the full spectrum of possible approaches for extending the span ranges of precast prestressed concrete beams. Although this wide focus was retained for portions of the research, it was determined that narrowing the focus of the study would provide the greatest benefit. This decision was based on the following findings from the early stages of the research:

a) Most of the techniques and approaches for extending span ranges involve incremental changes in conventional design methods and materials. These changes generally result in relatively small increases in the span range for precast prestressed concrete beams. Information required to implement these techniques is generally available in the literature or from commercial sources.

b) One technique, the splicing of beams, was found to allow significantly increased span ranges for precast prestressed concrete beams bridges. This technique involves the fabrication of the beams in segments that are then assembled into the final structure. Although many spliced beam bridges have been constructed, the use of this technique is not widespread. Use of this technology also requires consideration of various issues with which the designer of conventional precast prestressed concrete beams typically is not familiar. Furthermore, the information available in the literature regarding the implementation of spliced beam construction is limited.

c) The laboratory work consist smaller scale precast prestressed concrete beams with a splice section.

d) The issues regarding this research were from Public Work Department (PWD), fabricator and main player of precast prestressed concrete industry, Hume Engineering Sdn. Bhd and ACPI Sdn. Bhd.

Based on these findings, it was determined that the main focus of this study would be to address issues related to splicing method in extending span for prestressed concrete beam.