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STRUCTURAL BEHAVIOUR OF A SINGLE TENDON END BLOCK

MARIA BINTI NUID

A report submitted in partial fulfilment of the
requirement for the award of the degree of
Master of Engineering (Civil – Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

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Buat insan-insan yang dikasihi…….

Mak, Rusmidi Linggam, Abah, Nuid Hj Soh dan juga
Adik-adik(Nuh, Surena, Kamariah, Sarizan, Nazeer, Sabastian,
Alfierahmie, Suhaimi, Mashita, Shahfuan)

Dan buat yang teristimewa;
Abdah Bin Hj Norbek

Segala pengorbanan, kasih sayang dan dorongan yang diberikan
Tidak ternilai harganya akan ku kenang buat selamaya
Semoga kalian dilindungi Allah S.W.T dan berbahagia di samping orang-orang tersayang………

ACKNOWLEDGEMENT

Firslty, grateful to Allah s.w.t after a yaer of move violently and hard work, with his will, this thesis is completed. Thanks to Allah s.w.t for giving me strength to complete this project and the strength to keep on living.

To my supervisor, Assoc. Prof. Baderul Hisham bin Ahmad, thanks a lot for the guidance you gave in completing this thesis. All advises and help you gave during this thesis progress, academically or non-academically, are really helpful and will never be forgotten.

My special thanks must be extended to technical staff members at the structural laboratory at UTM for their collaboration and assistance while carrying out my laboratory work.

Special thanks to my mother, my father, to all my siblings and my other half thanks for all the support and contribution that you gave to me. Thank you for staying with me through thick and thin and thanks for believing in me. I will never be here, if you have never been there for me. You'll never be forgotten.

Million word of thanks for fellow friends who showed their concern and support all the way. Their views and tips are usefull and indeed. Unfortunately, it is not possible to list.

ABSTRACT

There are many proprietry design for end blocks with cable of multiple tendons available in the market. However, in this study tests have been carried out on end block with single tendon specifically design for laboratory work. This study investigate the effect of different types of bursting reinforcement, number of bearing plate and size of end block for a single tendon cable. A total number of 18 end blocks have been tested until failure using a compression testing machine. Failure load were than compared with those obtained from design using BS 8110: 1997 and CIRIA guide 1 (1976). Test results show that spiral bursting reinforcement failed with higher failure load than orthogonal bursting reinforcement. Is has been noticed that end block using two bearing plate separately can accommodate a higher failure load compared with using only a single bearing plate. The overall failure loads for all the specimens are closer to that design by BS 8110: 1997 and thus it can be concluded that it is a more conservative design than CIRIA guide 1 (1976).

ABSTRAK

Rekabentuk blok hujung yang menggunakan berbilang tendon banyak terdapat di pasaran. Namun, bagi tujuan ujian ini blok hujung hanya menggunakan satu tendon sahaja untuk kerja-kerja yang perlu dilakukan di dalam makmal. Kajian ini meneliti kesan daripada pelbagai jenis tetulang, jumlah plat galas dan pelbagai saiz blok hujung yang menggunakan tendon tunggal. Sebanyak 18 sampel blok hujung yang disediakan dan diuji menggunakan mesin mampatan sehingga gagal. Kegagalan beban dibandingkan dengan kod amalan yang berbeza iaitu BS 8110: 1997 dan Manual CIRIA 1 (1976). Daripada experiment yang telah dijalankan menunjukkan bahawa tetulang jenis pilin mampu menampung kegagalan beban yang tinggi jika dibandingkan dengan tetulang jenis ortogon. Selain itu, specimen yang menggunakan dua plat galas yang berasingan dapat menampung beban kegagalan yang lebih tinggi jika dibandingkan dengan specimen yang hanya menggunakan satu plat galas. Kegagalan beban keseluruhan untuk semua specimen adalah menghampiri kepada BS 8110:1997 dan dapat disimpulkan bahawa rekabentuk adalah lebih konservatif apabila menggunakan Manual CIRIA 1 (1976).

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T_{burst}	=	the bursting force
d_{burst}	=	the distance of bursting force from bearing plate
f_{ca}	=	the compressive stress at distance equal to ahead of the bearing plate
P_u	=	the factored tendon force
a	=	the side length of the bearing plate in the long direction of the rectangular cross section
b	=	the side length of the bearing plate in the thin direction of the rectangular cross section
t	=	the thickness of the cross section
e	=	the eccentricity of the tendon force with respect to the centroid of the rectangular cross section
h	=	the larger side length of the rectangular cross section
α	=	the angle of inclination of the tendon force
A	=	the area of concrete surrounding the anchorage device with a similar shape, representing the confinement provided by surrounding concrete.
A_b	=	the area of the anchorage device.
PT	=	the time of stressing of the tendons.
SL	=	service loads.
f'_{ci}	=	the concrete strength at stressing, but not more than $f'_{c.}$
f'_{cu}	=	the concrete cube strength at stressing.
f'_{ck}	=	the characteristic concrete cube.
K	=	1.0 for isolated anchors, 1.5 for anchors distributed in one direction and 2.0 for anchors distributed in two directions.

P	=	the tendon force.
a_1	=	the dimension of the anchorage device.
a_2	=	the lateral dimension of the member.
c	=	given in function of a_1/a_2
b	=	the width of the section in the plane of potential bursting cracks.
d	=	the effective depth of the end block, where the stresses become linear. Generally taken as the depth of the section.
e	=	the eccentricity of the post-tensioning force measured from the centroid of the section.
h	=	the depth of the section.
A_{st}	=	the amount of end zone reinforcement in each direction.
F_{bst}	=	the bursting force.
f_s	=	the stress in the transverse reinforcement
P_k	=	prestress in the tendon
y_{po}	=	length of a side of bearing plate
y_o	=	transverse dimension of the end zone.
f_{br}	=	prestress in the tendon with one bearing plate.
P_k	=	punching area.
A_{pun}	=	area of contact of bearing plate.
$f_{br,all}$	=	allowable bearing stress.
f_{ci}	=	cube strength at transfer.
A_{br}	=	bearing area or maximum transverse area of end block that is geometrically similar and concentric with punching area.
P_{fail}	=	the value that can bear the burden of the specimen before failure at end block.
$P_{jacking\ foce}$	=	initial force in tendons.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Over the last few decades prestressed structures have found wide applications in Europe, North and South American continents, and South Africa, whereas to a lesser extent in Asia and other parts of the world. The applications of prestressing were considered to obtain optimum structural performance of steel with ecomomy in construction of new as well as to reinforce and strengthen existing structures. Method for prestressing concrete divide into two main categories namely are pre-tensioning and post-tensioning. For pre-tensioning method the tendon is applied to the tendons before casting of the concrete. The pre-compression is transmitted from steel to concrete through bond over the transmission length near the ends. Different with the post-tensioning the tension is applied to the tendons (located in a duct) after hardening of the concrete. Whereas the pre-compression is transmitted from the steel to concrete by the anchorage device.

Post-tensionsed concrete presents several advantages over concrete reinforced with non-prestressed reinforcement only. The deflections under service loads are better controlled and cracks in the concrete are largely eliminated by compressive stresses induced by the post-tensioning force. Economically, the combination of high strength steel in tension with high strength concrete in compression leads to an optimal utilization of both materials and allows for smaller cross sections (Burdet, 1990).

One of the most critical aspects of post-tensioned construction and one necessary for the success of the system is the anchorage zone (Young, 2004; Sanders, 1990). The anchorage zone is where the concentrated post-tensioning force of the tendons is applied to the structure. Anchorage zone is the most commonly used term to designate the length wherein the stress transformation from one stage to another takes place and the part of the member within this zone is known as anchor block or the end block (Saadoun, 1980). Burdet however, has given this zone an alternative name of Lead-in-zone.

1.2 Problem Background And Motivation

A large number of studies of end block behaviour and design have been conducted over more than 40 years, yet this abundance of information seems to have contributed to the confusion rather than alleviating it. While research has focused on a narrow range of special and often much idealized problems the versatility of post-tensioned concrete requires a general and systematic procedure for end block design.

Several instances of the failures of the anchor blocks, some from the construction of a few major structures, have been reported. Due to the complexity of the stress distribution system associated with the end block as well as because of a large number of commonly interactive parameters present in the design situation, codes of practices on structural prestressed concrete in most of the countries, even to this day, either do not include any recommendations or at best make some general comments or suggest some empirical formulae which have little relevance to this problem.

There are many standard end block detail produced by prestressed specialist company such as VSL and PCI. A single tendon end block for post-tensioned beam is not common in practice but more relevant to laboratory work required special investigation. There is to need to study the behaviour of a single tendon end block and produce standard detailing for researcher.

1.3 Objectives Of Study

The objectives of the study are;

i. To compare the effectiveness of spiral and orthogonal bursting reinforcement at maximum load.

ii. To compare the factor of safety of failure load against various percentage of ultimate tensile strength of jacking force.

iii. To compare results from design method proposed by BS 8110, CIRIA Guide 1 (1976), with that obtained from experimental work.

1.4 Scope Of Study

The scope of the research is limited to certain things as follow:

i. Single tendon end block.

ii. End block comprise of single plate and two plates

iii. Effect of incline angle of tendon is neglected.

iv. Jacking force simulated by applying compressive force to bearing plate through the prestressed barrel.

1.5 Importance Of Study

In a prestressed post-tensioned concrete member, the pre-stressing force is applied to the concrete through relatively small anchorages causing high-local stresses which reduce as the force spreads out over the cross-section of the member. The region in which this spread occurs is known as the anchorage zone and that part of the member within this zone is known as the anchor block. Failure of anchorage zone is perhaps the most common cause of problems arising during construction. Such failures are difficult and expensive to repair and might require replacement of the entire member. Anchorage zones failure due to uncontrolled cracking or splitting of the concrete from insufficient transverse reinforcement. Bearing failures immediately behind the anchorage plate are also common and may be caused by inadequate dimensions of bearing plates or poor quality of concrete.

The stress pattern in the anchor block is quite different from that in the main body of the member. Thus the design of the anchorage zone must be given special consideration. Local thickening of the concrete is often required to accommodate the anchors and to allow sufficient space for applying the prestress, and this also has an influence on the distribution of stress.

1.6 Thesis Organisation

The thesis consists of six chapters. Chapter I consist of the problem background, research objectives, scope and important of the study. Chapter II covers the literature review which discusses the domain of the study, related works and fundamental review of end block. Chapter III shows the methodology for the design of end block which includes the design using BS 8110 and CIRIA Guide 1 (1976). Chapter IV presents the analysis results to be obtained through experiments conducted in the laboratory and then presents a table relating to the objectives of the study. Finally Chapter V covers detailed discussion and future works. This organization can be map via organization chart (Figure1.1).

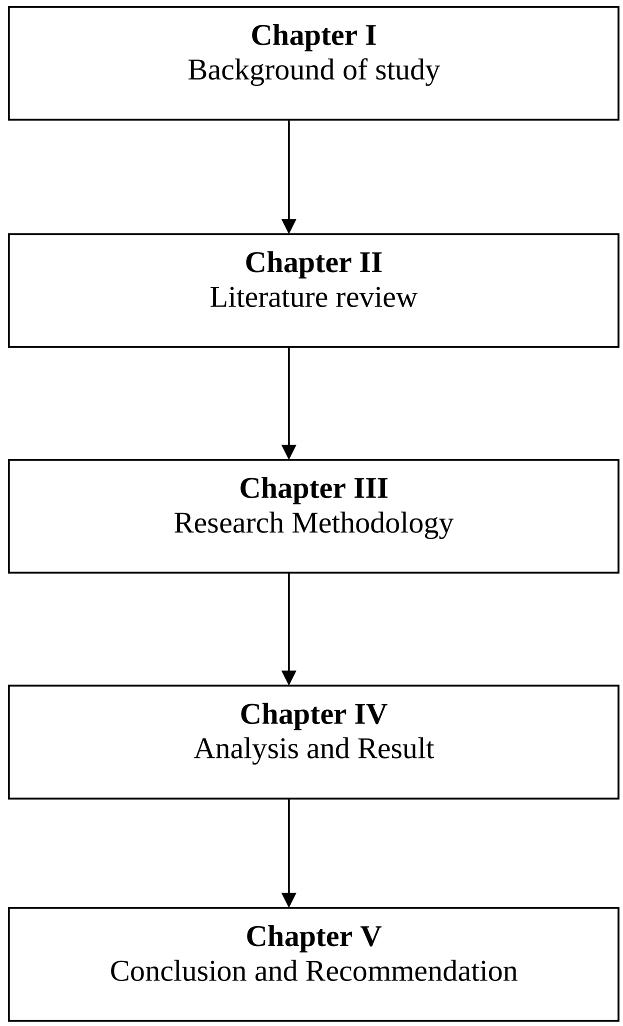

Figure 1.1: Chart of Study Organisations