COMPARISON BETWEEN BS 5950: PART 1: 2000 & EUROCODE 3 FOR THE DESIGN OF MULTI-STOREY BRACED STEEL FRAME

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ABSTRACT

Reference to standard code is essential in the structural design of steel structures. The contents of the standard code generally cover comprehensive details of a design. These details include the basis and concept of design, specifications to be followed, design methods, safety factors, loading values and etc. The Steel Construction Institute (SCI) claimed that a steel structural design by using Eurocode 3 is 6 – 8% more cost-saving than using BS 5950: Part 1: 2000. This study intends to testify the claim. This paper presents comparisons of findings on a series of two-bay, four-storey braced steel frames with spans of 6m and 9m and with steel grade S275 (Fe 460) and S355 (Fe 510) by designed using BS 5950: Part 1: 2000 and Eurocode 3. Design worksheets are created for the design of structural beam and column. The design method by Eurocode 3 has reduced beam shear capacity by up to 4.06% and moment capacity by up to 6.43%. Meanwhile, structural column designed by Eurocode 3 has compression capacity of between 5.27% and 9.34% less than BS 5950: Part 1:2000 design. Eurocode 3 also reduced the deflection value due to unfactored imposed load of up to 3.63% in comparison with BS 5950: Part 1: 2000. However, serviceability limit states check governs the design of Eurocode 3 as permanent loads have to be considered in deflection check. Therefore, Eurocode 3 produced braced steel frames which consume 1.60% to 17.96% more steel weight than the ones designed with BS 5950: Part 1: 2000. However, with the application of partial strength connections, the percentage of difference had been reduced to the range of 0.11% to 10.95%.

ABSTRAK

Dalam rekabentuk struktur keluli, rujukan kepada kod piawai adalah penting. Kandungan dalam kod piawai secara amnya mengandungi butiran rekabentuk yang komprehensif. Butiran-butiran ini mengandungi asas dan konsep rekabentuk, spesifikasi yang perlu diikuti, cara rekabentuk, factor keselamatan, nilai beban, dan sebagainya. Institut Pembinaan Keluli (SCI) berpendapat bahawa rekabentuk struktur keluli menggunakan Eurocode 3 adalah 6 – 8% lebih menjimatkan daripada menggunakan BS 5950: Part 1: 2000. Kajian ini bertujuan menguji pendapat ini. Kertas ini menunjukkan perbandingan keputusan kajian ke atas satu siri kerangka besi terembat 2 bay, 4 tingkat yang terdiri daripada rentang rasuk 6m dan 9m serta gred keluli S275 (Fe 430) dan S355 (Fe 510). Kertas kerja komputer ditulis untuk merekabentuk rasuk dan tiang keluli. Rekebentuk menggunakan Eurocode 3 telah mengurangkan keupayaan ricih rasuk sehingga 4.06% dan keupayaan momen rasuk sebanyak 6.43%. Selain itu, tiang keluli yang direkebentuk oleh Eurocode 3 mempunyai keupayaan mampatan 5.27% – 9.34% kurang daripada rekabentuk menggunakan BS 5950: Part 1: 2000. Eurocode 3 juga mengurangkan nilai pesongan yang disebabkan oleh beban kenaan tanpa faktor sehingga 3.63% berbanding BS 5950: Part 1: 2000. Namun begitu, didapati bahawa keadaan had kebolehkhidmatan mengawal rekabentuk Eurocode 3 disebabkan beban mati tanpa faktor yang perlu diambilkira dalam pemeriksaan pesongan. Justeru, Eurocode 3 menghasilkan kerangka keluli dirembat yang menggunakan berat besi 1.60% – 17.96% lebih banyak daripada kerangka yang direkabentuk oleh BS 5950: Part 1: 2000. Namun begitu, penggunaan sambungan kekuatan separa telah berjaya mengurangkan lingkungan berat besi kepada 0.11% – 10.95%.

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	BS 5950: PART 1: 2000	EUROCODE 3
Axial load	F	N_{Sd}
Shear force	F_v	V_{Sd}
Bending moment	M	M_{Sd}
Partial safety factor	γ	γ_{M0}
		γ_{M1}
Radius of gyration		
- Major axis	r_x	i_y
- Minor axis	r_y	i_z
Depth between fillets	d	d
Compressive strength	p_c	f_c
Flexural strength	p_b	f_b
Design strength	p_y	f_y
Slenderness	λ	λ
Web crippling resistance	P_{crip}	$R_{a.Rd}$
Web buckling resistance	P_w	$R_{b.Rd}$
Web crushing resistance	-	$R_{y.Rd}$
Buckling moment resistance	M_{bx}	$M_{b.y.Rd}$
Moment resistance at major axis	M_{cx}	$M_{c.y.Rd}$
		$M_{pl.y.Rd}$
Shear resistance	P_v	$V_{pl.y.Rd}$
Depth	D	h
Section area	A_g	A
Effective section area	A_{eff}	A_{eff}
Shear area	A_v	A_v

Plastic modulus		
- Major axis	S_x	$W_{pl.y}$
- Minor axis	S_y	$W_{pl.z}$
Elastic modulus		
- Major axis	Z_x	$W_{el.y}$
- Minor axis	Z_y	$W_{el.z}$
Flange	b/T	c/t_f
Web	d/t	d/t_w
Width of section	B	b
Effective length	L_{E}	l
Flange thickness	T	t_f
Web thickness	t	t_w

CHAPTER I

INTRODUCTION

1.1 Introduction

Structural design is a process of selecting the material type and conducting in-depth calculation of a structure to fulfill its construction requirements. The main purpose of structural design is to produce a safe, economic and functional building. Structural design should also be an integration of art and science. It is a process of converting an architectural perspective into a practical and reasonable entity at construction site.

In the structural design of steel structures, reference to standard code is essential. A standard code serves as a reference document with important guidance. The contents of the standard code generally cover comprehensive details of a design. These details include the basis and concept of design, specifications to be followed, design methods, safety factors, loading values and etc.

In present days, many countries have published their own standard codes. These codes were a product of constant research and development, and past experiences of experts at respective fields. Meanwhile, countries or nations that do not publish their own standard codes will adopt a set of readily available code as the national reference. Several factors govern the type of code to be adopted, namely suitability of application of the code set in a country with respect to its culture, climate and national preferences; as well as the trading volume and diplomatic ties between these countries.

Like most of the other structural Eurocodes, Eurocode 3 has developed in stages. The earliest documents seeking to harmonize design rules between European countries were the various recommendations published by the European Convention for Constructional Steelwork, ECCS. From these, the initial draft Eurocode 3, published by the European Commission, were developed. This was followed by the various parts of a pre-standard code, ENV1993 (ENV stands for EuroNorm Vornorm) issued by Comité Européen de Normalisation (CEN) – the European standardisation committee. These preliminary standards of ENV will be revised, amended in the light of any comments arising out of its use before being reissued as the EuroNorm standards (EN). As with other Europeans standards, Eurocodes will be used in public procurement specifications and to assess products for ‘CE’ (Conformité Européen) mark.

The establishment of Eurocode 3 will provide a common understanding regarding the structural steel design between owners, operators and users, designers, contractors and manufacturers of construction products among the European member countries. It is believed that Eurocode 3 is more comprehensive and better developed compared to national codes. Standardization of design code for structural steel in Malaysia is primarily based on the practice in Britain. Therefore, the move to withdraw BS 5950 and replace with Eurocode 3 will be taking place in the country as soon as all the preparation has completed.

Codes of practice provide detailed guidance and recommendations on design of structural elements. Buckling resistance and shear resistance are two major elements of structural steel design. Therefore, provision for these topics is covered in certain sections of the codes. The study on Eurocode 3 in this project will focus on the subject of moment and shear design.

1.2 Background of Project

The arrival of Eurocode 3 calls for reconsideration of the approach to design. Design can be complex, for those who pursue economy of material, but it can be simplified for those pursuing speed and clarity. Many designers feel depressed when new codes are introduced (Charles, 2005). There are new formulae and new complications to master, even though there seems to be no benefit to the designer for the majority of his regular workload.

The increasing complexity of codes arises due to several reasons; namely earlier design over-estimated strength in a few particular circumstances, causing safety issues; earlier design practice under-estimated strength in various circumstances affecting economy; and new forms of structure evolve and codes are expanded to include them.

However, simple design is possible if a scope of application is defined to avoid the circumstances and the forms of construction in which strength is over-estimated by simple procedures. Besides, this can be achieved if the designer is not too greedy in the pursuit of the least steel weight from the strength calculations. Finally, simple design is possible if the code requirements are presented in an easy-to-use format, such as the tables of buckling stresses in existing BS codes.

The Steel Construction Institute (SCI), in its publication of “eurocodesnews” magazine has claimed that a steel structural design by using Eurocode 3 is 6 – 8% more cost-saving than using BS 5950. Lacking analytical and calculative proof, this project is intended to testify the claim.

1.3 Objectives

The objectives of this project are:

1) To compare the difference in the concept of the design using BS 5950: Part 1: 2000 and Eurocode 3.

2) To study on the effect of changing the steel grade from S275 to S355 in Eurocode 3.

3) To compare the economy aspect between the designs of both BS 5950: Part 1: 2000 and Eurocode 3.

1.4 Scope of Project

The project focuses mainly on the moment and shear design on structural steel members of a series four-storey, 2 bay braced frames. This structure is intended to serve as an office building. All the beam-column connections are to be assumed simple. The standard code used here will be Eurocode 3, hereafter referred to as EC3. A study on the basis and design concept of EC3 will be carried out. Comparison to other steel structural design code is made. The comparison will be made between the EC3 with BS 5950: Part 1: 2000, hereafter referred to as BS 5950.

The multi-storey steel frame will be first analyzed by using *Microsoft Excel* worksheets to obtain the shear and moment values. Next, design spreadsheets will be created to calculate and design the structural members.

1.5 Report Layout

The report will be divided into five main chapters.

Chapter I presents an introduction to the study. Chapter II presents the literature review that discusses the design procedures and recommendations for steel frame design of the codes EC3 and BS 5950. Chapter III will be a summary of research methodology. Results and discussions are presented in Chapter IV. Meanwhile, conclusions and recommendations are presented in Chapter V.

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