

EXPERIMENTAL AND ANALYTICAL INVESTIGATION
TORSIONAL BEHAVIOR OF SIGMA PROFILE

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This report is submitted with the
purpose to fulfill the program requirement of awarding
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SUPERVISOR DECLARATION

‘I hereby declare that I had read this project report entitled “Experimental and Analytical Investigation Torsional Behavior of Sigma Profile” and in my opinion, this project is sufficient in term of scope and quality for the purpose of awarding Bachelor in Mechanical Engineering (Structure and Materials)’

Signature :

Name :

Date :

DECLARATION

I hereby declare that the work in this report is my own except for summaries and quotation which have been duly acknowledged

Signature :

Name :

Date :

Specially for my
Dear Mum and Dad

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I would like to express unlimited thankful to my supervisor, Dr. Hady Efendy upon giving me his precious opinion and unlimited support and his willingness to spend his time to guide me in this project throughout my final year.

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ABSTRACT

Structural stability has been the most important factor to be concern during constructing no matter in civil or mechanical aspect. One of the major study subset from the structural stability is the buckling. This project is meant to study the buckling mode of the sigma profile which obtained from company SSI Schaefer. This project will discuss the behavior and characteristic of sigma profile based on finite element analysis and detect the buckling mode that exist on the sigma profile. Upon completion of this project, buckling mode, characteristic and behavior of sigma profile will be known.

ABSTRAK

Kestabilan struktur selalunya merupakan faktor yang dipermentingkan dalam konstuktur tidak kira di aspek civil atau mekanikal. Salah satu subset kajian utama dari kestabilan struktur lengkakan. Projek ini bertujuan untuk mengkaji mod lengkakan Profil Sigma yang diperolehi daripada syarikat SSI Schaefer. Projek ini akan membincangkan tingkah laku dan ciri-ciri Profil Sigma berdasarkan analisis unsur terhingga dan mengesan mod lengkakan yang wujud pada profil sigma. Semasa kehabisan projek ini, lengkakan mod, ciri-ciri dan tingkah laku Profil Sigma akan diketahui.

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LIST OF ABBREVIATIONS

ABBREV	NAME
CAD	Computer Aided Design
EN	Eurocode
FEA	Finite Element Analysis
FEM	Federation Europeene De La Manutention Standard
SSI	Schaefer Systems International
VNA	Very Narrow Aisle
FKM	Faculty of Engineering Mechanical

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CHAPTER 1

INTRODUCTION

1.1 Background

Sigma Profile is the steel structure currently widely used in the industry of logistic and warehouse system and act as upright structure to withstand and distribute the load that transferred to it.

Sigma profile is manufactured through cold-forming manufacturing process of a flat steel sheet is rolled to become an open cross sectional profile structure as shown in the picture below:

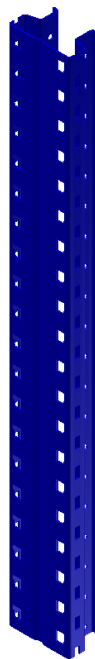


Figure 1. 1: Sigma Profile Post 115

The existences of the holes on the Sigma profile are used to mount or fit with the relative component such as beam, bracing, screw and etc. Some connection on the Sigma Profile is using the End Connector as well. The continuous of holes on the profile provided a great flexibility in the construction of warehouse and logistic systems. The picture below explains the uses of the holes on the Sigma Profile:

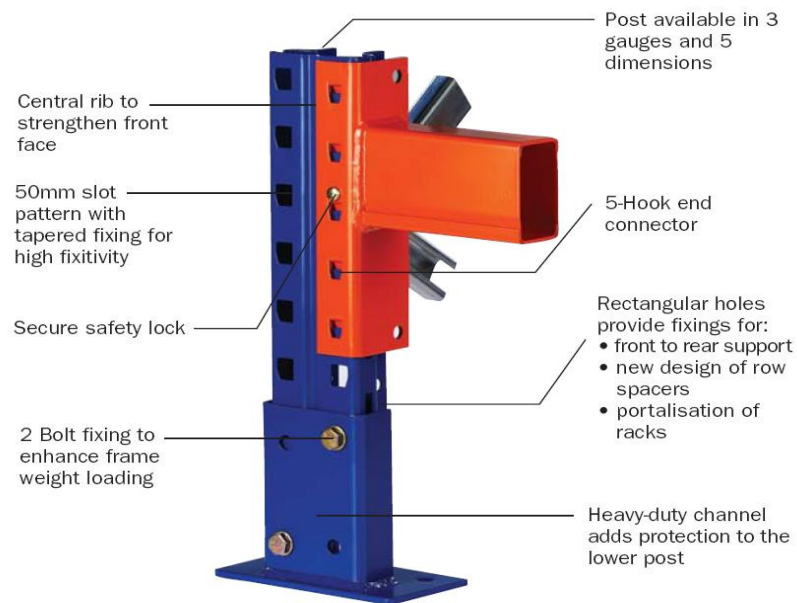


Figure 1. 2: Application of Interlock Cache on the Sigma-Profile.[1]

Due to the high flexibility and durability of the Sigma Profile, Sigma Profile is widely used in constructing high bay storage system. In SSI Schaefer, various kinds of storage systems are developed together with the Sigma Profile as the main upright of the storage system. The picture below shows several example types of storage system from SSI Schaefer.



Figure 1. 3:Very Narrow Aisle (VNA) Pallet Racking System at Agility, Indonesia[1]



Figure 1. 4: Drive-In Pallet Racking System[1]

1.2 Problem Statement

Since the Sigma Profile is the thin-walled profile which manufactured through cold forming process, the thin-walled structures with open cross sectional area are cost effective manufacturing. However, the cold-rolled thin-walled profile will normally rise up the impact on the structure stability.

In the actual industry application, Sigma Profile which is the upright of the structure, widespread in order to construct high-bay warehouse system plays a relative important role in the whole system. The major concern of every structure or building that builds is the stability of the structure.

The determination of stability in this project will be using the failure mode fundamentally refer through the regulation technique from Eurocode, EN 1993-1-3 and FEM (Federation Europeenne De La Manutention) for cold formed thin-walled structure to be examined and investigate. In the industry applications, it is often found out that the Sigma-Profile occur flexural torsion failure before the static failure occur. The further information is to be investigating throughout this project.

1.3 Objective

This project is mainly about the studies of failure mode of Sigma-Profile throughout the investigation and analysis. The main objectives of this project are:

- i. To investigate the behavior and the capability of sustainability of Sigma Profile.
- ii. To find out the characteristic of Sigma Profile.
- iii. To investigate the flexural torsion failure of the Sigma Profile
- iv. To develop ways to reduce or postponed the flexural torsion failure.

1.4 Scope

The project will be conducting the analysis with using the Finite Element Method software. Beside, actual testing of several examples will be conduct to compare with the computational analysis. Sigma-Profile is going to obtain from company Schaefer System International Sdn. Bhd. to run through a series of testing to investigate and analysis the behavior of the profile. The stability of the Sigma-Profile against the torsion flexural failure is made to be prior in the investigation. The overall analysis will be referring to the standard EN or FEM for developing the relevant equation to combine with the experimental or computational results. Alternatively, at the ending of this project, ideas will be develop to reduce or postpone the torsion flexural on the Sigma-Profile and achieve the objective of the project.

CHAPTER II

LITERATURE REVIEW

This chapter starts with the review of process manufacturing of Sigma profile which is the cold-forming process, buckling behavior of cold-formed thin-walled structure.

2.1 Cold-Formed Thin-Walled Steel Structure

Cold formed thin-walled steel members are relative widely used in all kind of construction including building construction, drainage facilities, steel structure construction, car bodies, floor joists, roof construction and various type of structural product. The thickness of the cold-formed thin walled steel structure is often range from 0.378 mm to 6.35 mm.

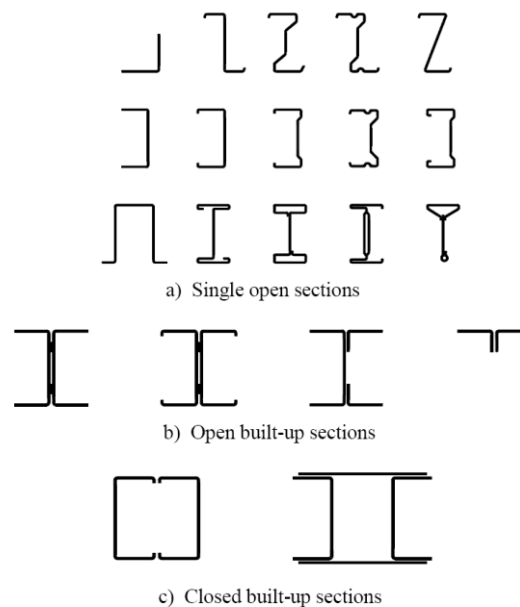


Figure 2. 1: Typical sectional members formed by cold-forming [2]

The huge application on cold-formed thin-walled steel members in steel construction industry compare to timber and concrete application is because of the several advantages that offered by the cold-formed thin-walled steel members as following:

- i. Lightness
- ii. Strength and Stiffness
- iii. Flexibility
- iv. Ease of fabrications
- v. Ease of mass production
- vi. Economy and etc.

The major function of most of the cold-formed thin-walled steel members is to carry or transfer the load in order to maintain the global stability of the structure. Thus, structural strength and stiffness of the members are normally being the main consideration during constructing the design. Since the member steel facing various types of joints in order to hook up the connection of the structure, design of the structure tends to be critical part of study for overall safety of the structure.

Rolling manufacturing is one of the process cold-forming of the thin-walled steel member which major applied by the industry. The process of rolling divided to

cold-rolled and hot-rolled section in which the hot-rolled is the process of rolling in elevated temperature but the cold-rolled is in the room temperature (without elevated temperature condition). The process of rolling employed numbers of pairs of roller and further allow the metal strip passed through and formed to be the final forms of profile. [3]

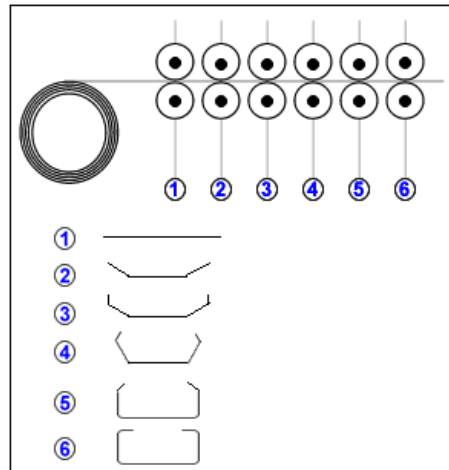


Figure 2. 2: Rolling, Cold Forming To Formed The Steel Profile[3]

Cold-rolled enable the metal sheet to formed desirable structural shape. The advantages of the cold-roll process are good dimensional accuracy, smooth surface finish, formable of complex shape and etc.

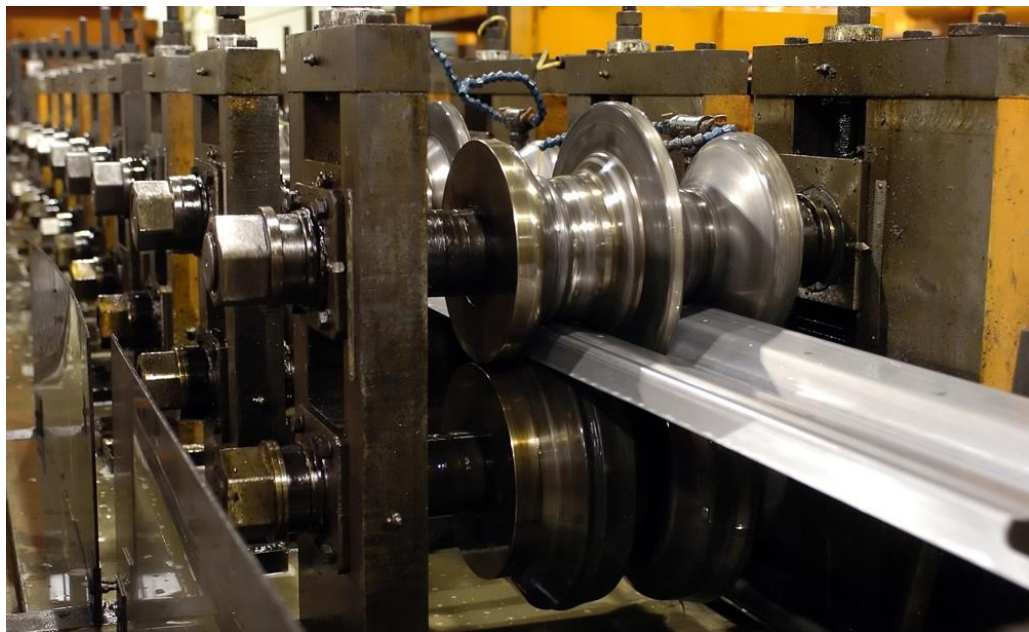


Figure 2. 3: Cold-Formed Rolling Process[4]

However, the cold forming product do bring along the cons effect on the thin-walled steel structure where the disadvantages of cold-forming are:

- i. Easy to get impart on its directional properties
- ii. Reduce the ductility of the metal
- iii. Potential of residual stress occur

2.2 Buckling

Cold-formed thin-walled steel structure is quite popular among the world steel structure industry due to its flexibility, high strength, reliability, durability and light profile section. This is due to the capability of increasing use of high strength steel with further small thickness of the section. Nowadays, most of the cold-formed structure is customize with relative low thickness. When thin-walled cold-formed member subjected to compressive stress over cross sectional area, the stability of the structure always questioned. The thickness that reduced arise the structural problem in which buckling is the common problem that formed in the cold-formed thin-walled structure.