CHAPTER ONE
INTRODUCTION

1.1 General

The cold formed steel sections are special sections which have high strength to weight ratio. The cold-formed steel C- and Z-sections are the most common sections used in building construction. These sections can be used as secondary beams (purlins) to support the light weight roof covering systems, also can be used as side girt, cassettes…etc. The design of such sections requires many calculations and checks. In the first step the designer should account for the moment capacity and deflection of the beams. In the second step, the webs of the beams should be checked for shear, web crippling, combined bending and shear and combined bending and web crippling.

In more details, the flexural capacity of the cold-formed steel beam in general is limited either by the effective section capacity or the lateral buckling capacity, especially when supported laterally at large intervals. On the other hand, the web crippling of such beams is a function of the cross section parameters (web slenderness ratio, web thickness and inside bend radius to thickness ratio) in addition to the design yield stress and the bearing length to web thickness ratio. Although, the webs of such sections have high depth to thickness ratio, using stiffeners under the concentrated loads is not practical in this type of construction. Therefore, the web crippling is a very critical problem that may control the design.

The theoretical study of web crippling was considered very complicated because many factors should be considered. These factors are the non-uniform stress distribution under the applied load, the local yielding at the loaded area, the bending due to eccentric loading, elastic and inelastic behavior of the web element, the different web flange restraint and the initial imperfections of the web element, Yu [37,38]. That is why most of researches on web crippling and combined bending and web crippling are experimental.

Nowadays, with the progress achieved in the field of computer programming, the numerical analysis using an approved finite element tool is a good alternative to the experimental work.

1.1 Objectives of The Research

The main objective of this research was to gain thorough understanding of the web crippling behavior of cold formed steel channels (C-sections) under interior one flange (IOF) loading case. Another objective was to evaluate the web crippling strength of cold formed steel channels with geometrical properties range common in practice but beyond the current design codes limit of application.

Introducing the main geometrical properties affecting the web crippling strength of C-sections under IOF loading was also set as an object. Comparing the web crippling strengths obtained from different design specifications and determining which are conservative in design and which are not. Derivation of new web crippling coefficients to improve the web crippling prediction of unconservative specifications as possible was also an objective.

The interaction between bending and web crippling is common behavior in cold formed steel construction and needs to be studied carefully in light of the continuous modifications of web crippling strength prediction. Modifying the interaction design equations of the current North American Specification (NAS-2007) in light of derivation of new web crippling coefficients was an object too.

1.2 Scope of The Research

This research was focused on the behavior of cold formed steel C-sections (Figure 1.1) subjected to web crippling under interior one flange loading (Figure 1.2) and interaction of bending and web crippling.

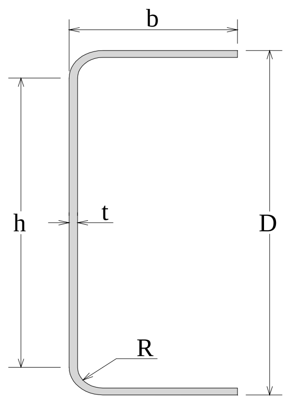

Fig. 1.1 Typical cross section of the studied C-sections

The parameters range of the studied channel dimensions are: web heights (D = 100, 150, 200 and 250 mm); web thicknesses (t = 2 and 3 mm); inside bend radiuses (R = 6 and 9 mm) and constant flange width (b = 50 mm). On the other hand, the bearing load lengths are (N = 25, 50 and 75 mm) in addition to using two different steel yield stresses (F_y = 240 and 360 N/mm^2).

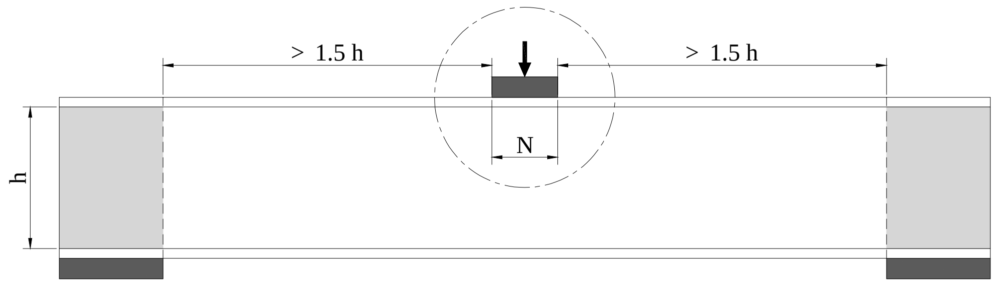

Fig. 1.2 Interior One Flange loading conditions (IOF)

Where:

h = Flat web depth

In addition to the above mentioned parameters range, two different span lengths are used (L = 1000 and 2000 mms) for studying the interaction of bending and web crippling strengths.

In this study four different design specifications are included in comparisons, the Australian/New Zealand Standard (AS/NZS-4600), British Standard (BS:5950-5), Egyptian Code of Practice (ECP-LRFD) and North American Specification (NAS).

1.3 Outline of The Research

In Chapter 2, an introduction to the web crippling of cold formed steel sections was presented. Reviews on experimental researches and numerical investigations on web crippling and interaction of bending and web crippling were covered. The web crippling and interaction design equations of Australian / New Zealand Standard AS/NZS 4600, British Standard BS 5950-5, Egyptian Code ECP-LRFD and North American Specification NAS are detailed.

Chapter 3 discussed the analysis methodology and tools used in this research. The model arrangement, element types and mesh, material properties, load application and boundary conditions were discussed in details. Finite element models were verified against experimental work and comparisons of finite element results with experimental results for both web crippling and combined bending and web crippling were conducted. The parameter ranges and material properties of extensive models were presented by the end of Chapter 3.

In Chapter 4, the results of the finite element analysis models were tabulated and compared with the design codes for web crippling and interaction of bending and web crippling. New modified coefficients for the predicted web crippling strength according to ECP and NAS were derived and calibrated. Also modified interaction equations were proposed.

Finally, the summary, conclusions and design recommendations were presented in Chapter 5.