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COLLABORATIVE RESEARCH ON THIN-WALLED STRUCTURES BY THE UNIVERSITY OF STRATHCLYDE AND THE TECHNICAL UNIVERSITY OF LODZ

J. Rhodes

Department of Mechanical and Aerospace Engineering, University of Strathclyde,
Glasgow, Scotland

J. Zaras, M. Kotelko

Department of Strength of Materials and Structures, Technical University of Lodz
Stefanowskiego 1/15, 90-924 Łódź, Poland

M. Macdonald

Department of Mechanical, Electrical and Environmental Engineering, Glasgow
Caledonian University, Glasgow, Scotland

This paper describes the collaborative research carried out into various aspects of the behaviour of thin-walled structures at the University of Strathclyde and the Technical University of Lodz over the past 40 years or so. The two Universities have had links over the past 45 years, and collaboration has been carried out in many disciplines. The collaboration between the Department of Mechanical Engineering at Strathclyde and the Department of Strength of Materials at Lodz has been largely concentrated on thin-walled structures, and some aspects of this collaboration are outlined in this paper.

1. INTRODUCTION

The link between the University of Strathclyde and the Technical University of Łódź was initiated in 1967 when Sir Samuel Curran, the Principal of the University of Strathclyde and Professor Jerzy Werner, the Rector of the Technical University of Łódź signed an official agreement establishing the academic co-operation between these Universities.

The forty five years of the co-operation with the University of Strathclyde has also played a unique role in the history of the relations between the Technical University of Łódź and other foreign universities. There was a justified opinion that could very well be the best working academic co-operation between any British and Polish university.

For a number of years the main components of the co-operation were the collaboration and exchange of staff members between the universities which has involved approximately 60 university study units and 300 members of staff since its inception. Joint PhD projects have also been carried out, involving 34 participants from Lodz. A number of special 5x5 and 3x3 seminars have been carried out over the years, in which teams of 5 or 3 members from one university visit and give lectures at the other university. A number of common Symposia and Conferences have been organized as part

of the collaboration. The collaboration has also lead to the establishment of English language courses for the Technical University of Łódź staff members.

It is perhaps true to say, however, that a very large component of the collaboration has been the establishment of joint scientific and industrial research, which has lead to the production of joint publications (papers, monographs, books, PhD Theses, industrial reports).

2. COLLABORATION ON THIN-WALLED STRUCTURES RESEARCH

Collaboration between the Strathclyde University Department of Mechanical and Aerospace Engineering, (formerly the Department of Mechanical Engineering) and the Technical University of Lodz Department of Strength of Materials and Structures (formerly Institute of Applied Mechanics) has been largely focused on the joint activity in the area of Thin-Walled Structures, considering various aspects of the behaviour of these structures depending on the form and geometry of structures, their materials and manufacturing , types of loading, expected time of service etc.

The aim of this paper is to present the effects of this joint activity of both collaborating units in the area of Thin-Walled Structures including their Stability, Post-buckling behaviour, Load-carrying capacity, Impact-crushing behaviour etc.

3. AREAS OF COLLABORATION

There have been various areas of collaboration in the thin-walled structures field. The initial contact between the two departments arose when Prof A. S. Tooth, from Strathclyde, visited Lodz in 1971, and inaugurated collaboration between the two units in the area of pressure vessels. This collaboration continued for a number of years, and resulted in the evolution of a number of visits between the units, and the organisation of seminars for Polish engineers and researchers: “Modern design of pressure vessels” - in the years 1988 and 1995. It became obvious from the interests of the early visits from the Lodz researchers that the thin-walled structures field was a common interest for both units, and this field became the presiding interest. Particular areas within this field are as follows:-

3.1. BUCKLING AND POST-BUCKLING BEHAVIOUR OF PLATES

It became obvious that the behaviour of thin plates was of interest to both units, and early seminars at Strathclyde given by visitors from Lodz showed this to be true. The first joint project carried out in this area was the joint PhD project carried out by Dr J Zaras from 1980-1983 [1] on rectangular plates under linearly varying compression and shear, and subsequently reported in the literature [2], [3].

3.2. BEHAVIOUR OF THIN-WALLED COLD-FORMED MEMBERS

A substantial number of collaborative projects have been carried out in this area, with experimental and theoretical research being undertaken into beams, columns and beam-columns.

The Lady Curran Endowment Fund set up by the wife of Strathclyde's first Principal, granted its first scholarship to Dr J. Zaráš to continue research at Strathclyde jointly with the first author in the academic years 1985-86 and 1991-92 in co-operation with the Faculty Research Committee. This led to a number of publications in the area of compression members [5], beams [6] and purlin systems [7]

The examination of members under combined bending and compression has been the subject of a number of publications carried out jointly by several of the authors of this paper. A typical diagrammatic set-up for the application of eccentric loading to a compression member used in these investigations is shown in Figure 1 and a number of investigations of various aspects of behaviour in carbon steel and stainless steel columns are reported in Refs [8] - [15].

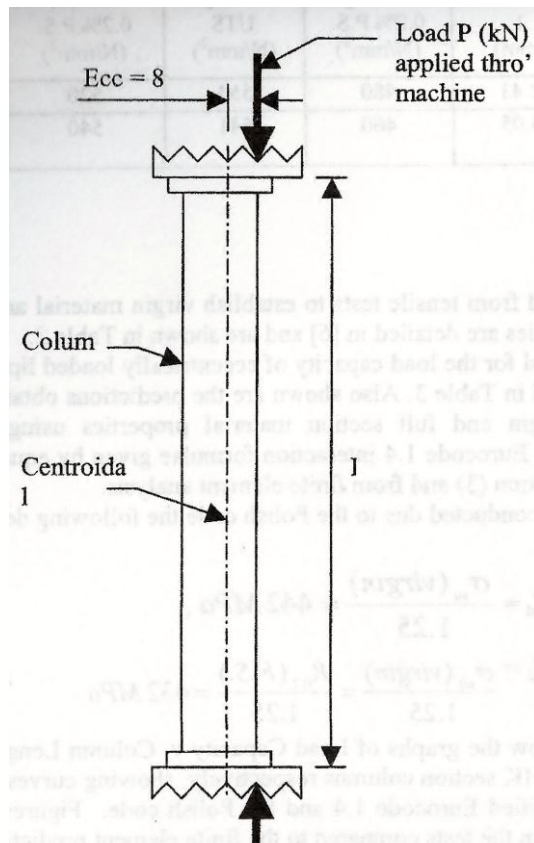


Fig. 1. Application of eccentric compressive load to cause bending and compression

3.3. PLASTIC BEHAVIOUR, PLASTIC MECHANISMS AND CRUSHING

The behaviour of plates, light gauge steel members and structures in the elasto-plastic and plastic range has been of interest to researchers in both departments for some time. There has been substantial research in each department individually, but there have also been collaborative ventures in his area. Among these ventures is that related in Ref

[16]. This examined the behaviour of closed hat-sections under crushing. Figure 2 shows a typical hat section before and after crushing.

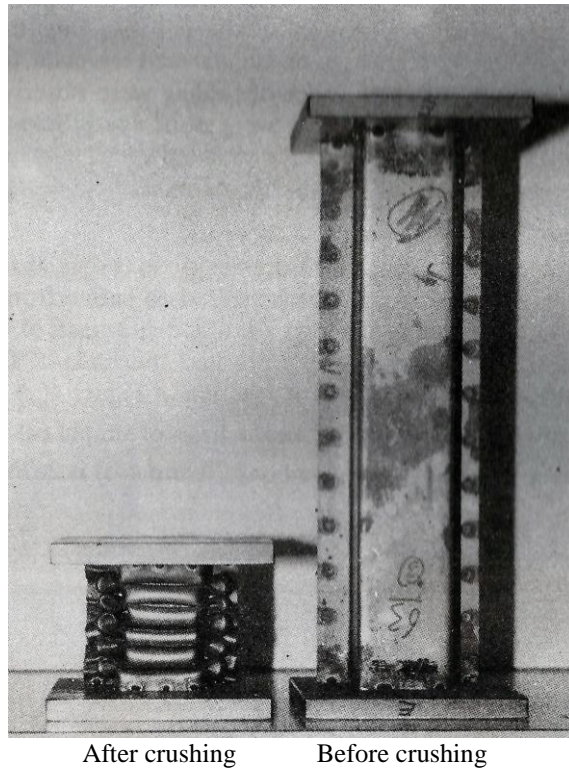


Fig. 2. Closed hat-section before and after crushing

The very large degree of compression involved in the crushing of such members causes progressive buckling and failure of individual sections occurring progressively, and the behaviour can be adequately predicted by relatively simple plastic mechanism analysis.

A number of collaborative projects have been carried out on the application of plastic mechanism analysis to evaluate the capacity of thin-walled members, for example [17], [18], [19], [20]

3.4. WEB CRIPPLING IN LIGHT GAUGE STEEL BEAMS

In recent years substantial efforts have been applied to the examination of web crippling in thin-walled beams subject to local loads and support reactions. Traditionally web crippling has been considered in design specifications using empirical formulae derived purely on the basis of testing. This has the fundamental limitation that the formulae so derived are only directly applicable to the cases tested, and more generally applicable approaches would be desired.

Collaborative efforts to examine web crippling under various conditions have been carried out using different approaches together with experiment, for example plastic mechanism analysis [20], finite element analysis combined with experimentation [21], [22], [23], [24]. Figure 3 shows the type of mesh used in the early finite element examinations of web crippling behaviour. The models used have been improved and enhanced to improve the accuracy with which the finite element models portray the actual web crippling behaviour obtained experimentally and to include the effects of holes in the region of the localized loads etc.

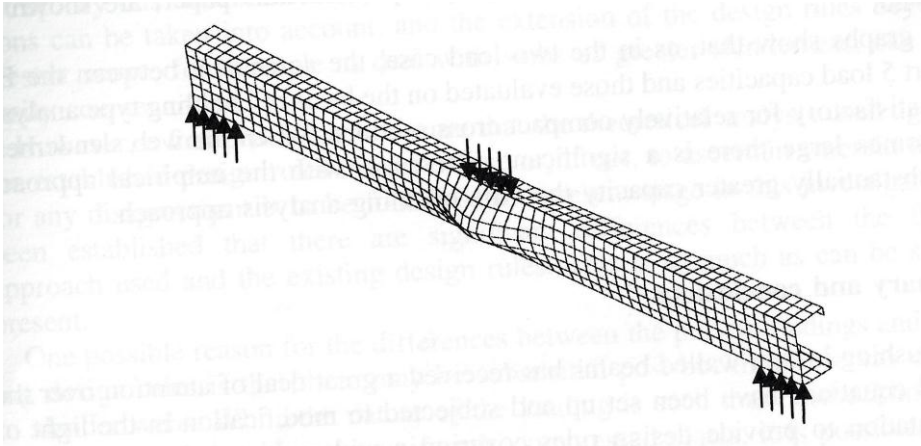


Fig. 3. Early finite element reproduction of beam subject to web crippling

4. OTHER ASPECTS OF THE COLLABORATION

Some joint publications not mentioned previously include Refs [25] – [30] In addition to the specialist areas mentioned, researchers from both institutions have collaborated in a variety of different ways.

There have been 5x5 seminars between the two units held at both organizations. A course for Polish engineers on “Analysis, design and application of thin-walled cold-formed sections” was jointly produced in Lodz in 1990. A substantial number of research programs on thin-walled structures carried out at the University of Strathclyde have been highly dependent on the input of researchers from the Technical University of Lodz, and researchers from that organization have been active over a long period of time in Research and Development projects for industry carried out at the University of Strathclyde.

The collaboration is also reflected in the membership of the Editorial Board of the Journal “Thin-Walled Structures”, which was originated at the University of Strathclyde. The first author is Founder-Editor of this Journal, and the three other authors are members of the Journal Editorial Board. It is also worth of note that the Editor of this Journal for the past 14 years, Prof J Loughlan, who is also a member of the Scientific Committee of this conference, carried out his initial research in this field at the University of Strathclyde, where he obtained his doctorate.

A number of conferences have also had the assistance of the collaboration between the University of Strathclyde and the Technical University of Lodz. In Glasgow, the Conference Applied Solid Mechanics – 2, 1987, had significant participation from the Technical University of Lodz, as had the Thin-Walled Structures (1) Conference, in 1996. The latter conference was the first in the ICTWS series of conferences, and the third conference in this series was held in Cracow, in 2001 and was organized by the Technical University of Lodz, jointly with the University of Strathclyde and Cranfield University UK.

The present conference, ‘Stability of Structures’ has had representation from the University of Strathclyde in attendance since the third conference in the series, and in the Scientific Committee since the 7th in the series. In the present, and the previous conference on the series there have been three representatives from the UK on the Scientific Committee, and all three have strong links to the University of Strathclyde where they received their introduction to the field of Thin-Walled Structures.

As may be inferred from the references, the research collaboration at the present time also includes researchers from Glasgow Caledonian University.

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