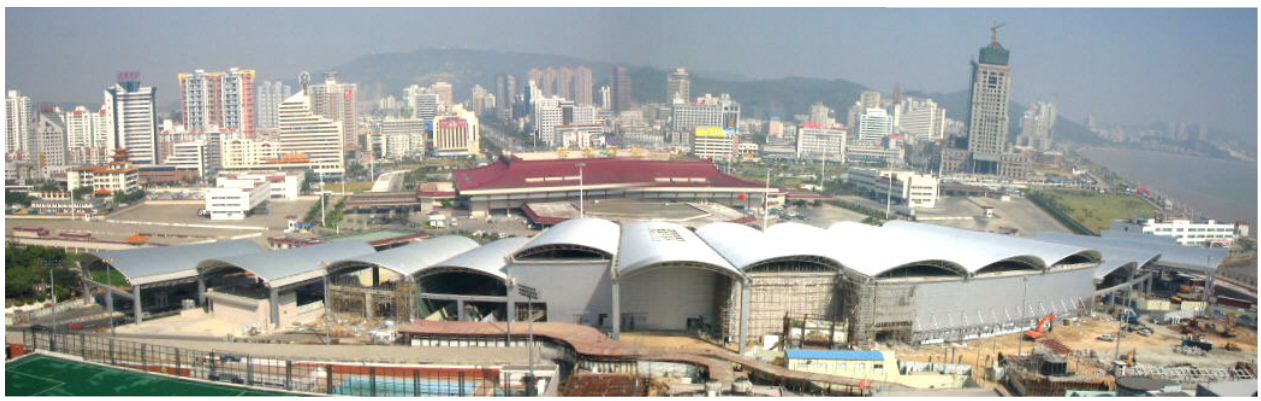
INTERNATIONAL SYMPOSIUM on

COLD-FORMED METAL STRUCTURES



10 December 2004
Hong Kong

edited by

K. F. CHUNG

THE HONG KONG POLYTECHNIC UNIVERSITY

RCATISE

The Research Centre for Advanced Technology in Structural Engineering (**RCATISE**) of the Hong Kong Polytechnic University was established in 1999 under the general management of the Department of Civil and Structural Engineering.

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b) To facilitate the transfer of these technologies to the construction industry through specialist consultancies, technical and professional publications, conferences and seminars, and continuing professional development training courses.

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香港
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Hong Kong Institute of Steel Construction

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The HKISC serves the steel construction industry in Hong Kong and the region with the following missions:

a) Channeling of technology transfer between academic and industry for improved quality in design, analysis and construction ;

b) Organizing seminars for local and overseas experts for dissemination of their latest technological know-how ;

c) Organizing international conferences for sharing of expertise between local and overseas researchers and engineers ;

d) Steering university researches to be more practical and useful for practitioners ;

e) Disseminating new technology worldwide among members ; and

f) Developing and fostering friendship among members.

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Printed by The Hong Kong Polytechnic University

ISBN: 988-97679-4-5

PREFACE

Cold-formed metal sections and profiles are widely used in the construction industry due to their excellent structural performance, versatility in application, and high buildability during construction. There are growing interests globally in the scientific research and technological developments of cold-formed metal structures including new materials, advanced analysis and design methods, innovative applications and product developments.

With the strong support of the local construction industry in Hong Kong, the *International Symposium on Cold-formed Metal Structures* is organized to provide a forum for dissemination of recent scientific advances and technological developments in cold-formed metal construction technology. It aims to facilitate the up-grading of the technical capability of numerous building products manufacturers in the Pan-Pearl River Delta Region. A total of 8 renowned overseas and local academics, researchers, and engineers are invited to share the findings of their research work to over 125 engineers from various government departments, consultant firms and construction companies in Hong Kong and Southern China.

We are thankful to the supports from a number of organizations, in particular, the Hong Kong Institute of Steel Construction, and the sponsorships of various companies to this Symposium as well as their contributions in promoting cold-formed metal construction in Hong Kong and Southern China.

Dr K F Chung
Chairman
Organizing Committee
The International Symposium on Cold-formed Metal Structures

THE HONG KONG POLYTECHNIC UNIVERSITY

RCATISE

香港鋼結構學會

Hong Kong Institute of Steel Construction

International Symposium on Cold-formed Metal Structures

Organized by
Department of Civil and Structural Engineering, The Hong Kong Polytechnic University

Supported by
The Hong Kong Institute of Steel Construction

Friday 10 December 2004

Senate Room (Room M1603), Li Ka Shing Tower, The Hong Kong Polytechnic University, Hung Hom, Kowloon

Time	Program	
8:30 am	Registration	
9:00 am	Welcoming Speech **Ir Professor Fred S H Ng** *IStructE Hong Kong Representative, Adjunct Professor of HKU and HKPolyU*	
9:10 am **Lecture 1**	***Development of the new Australian / New Zealand standard for cold-formed steel structures AS/NZS 4600*** **Professor Gregory J Hancock** *University of Sydney, Australia*	**Ir K K Choy** *Chief Structural Engineer* *Buildings Department*
9:50 am **Lecture 2**	***Novel deployable spatial structures*** **Professor J Y Richard Liew** *National University of Singapore, Singapore*	
10:30 am	**Tea / Coffee Break**	
10:50 am **Lecture 3**	***Investigations into cold-formed steel structures with bolted moment connections*** **Professor K F Chung** *The Hong Kong Polytechnic University*	**Ir P C Wong** *Chief Engineer* *Highways Department*
11:30 am **Lecture 4**	***Development of cold-formed steel section portal frames*** **Professor Young Bong Kwon** *Yeungnam University, Korea*	
12:10 pm	**Lunch Break**	
2:00 pm **Lecture 5**	***Light steel and modular construction in residential buildings*** **Professor R Mark Lawson** *University of Surrey, United Kingdom*	**Ir P S Tam** *Assistant Director* *Housing Department*
2:40 pm **Lecture 6**	***Design of scaffolds of cold-formed steel tubes by second-order analysis to pr-Eurocode-3*** **Professor S L Chan** *The Hong Kong Polytechnic University*	
3:20 pm	**Tea / Coffee Break**	
3:40 pm **Lecture 7**	***Development of a new cold-formed steel building system*** **Professor Mahen Mahendran** *Queensland University of Technology, Australia*	**Ir M K Tong** *Chief Structural Engineer* *Architectural Services Department*
4:20 pm **Lecture 8**	***Effects of elevated temperatures on the mechanical properties of cold-formed steel*** **Professor Ben Young** *The Hong Kong University of Science and Technology*	
5:00 pm	Closing Remarks **Ir Y W Mak** *Chairman, Joint Structural Division, HKIE & IStructE*	
5:10 pm	End of Day	

CONTENTS

DEVELOPMENT OF THE NEW AUSTRALIAN/ NEW ZEALAND STANDARD FOR COLD-FORMED STEEL STRUCTURES AS/NZS 4600

G. J. Hancock

Dean, Faculty of Engineering
University of Sydney, NSW, Australia, 2006

ABSTRACT

The paper describes the new developments in the Australian/ New Zealand standard AS/NZS 4600. The developments are based mainly on research in Australia and the USA. They include new rules for high strength steel, the new Direct Strength Method of design as an alternative to the Effective Width Method and many other detailed changes including design of unstiffened compression elements under stress gradient. The standard is based mainly on the North American Specification published in 2001 with a 2004 Supplement but with special rules for high strength steels as produced in Australia including rules for distortional buckling and welding of high strength steel.

NOVEL DEPLOYABLE SPATIAL STRUCTURES

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ABSTRACT

Two families of deploy and stabilize structures; the cable-strut system and the cable SLE (Scissor Like Element) system are proposed in this paper. These structural systems combine the structural efficiency of cable-strut systems with the foldability of deployable structures. The structural geometry of most deployable structures is dictated by kinematic requirements often at the expense of structural efficiency. The de-linking of structural and kinematic requirements, made possible by the proposed deploy and stabilize strategy, gives greater freedom in structural design enabling structural optimization. This innovation leads to the invention of a wide variety of ornamental forms which are structural safe and stable for application to spatial construction. Experimental investigation was carried out on two prototypes of cable strut grids to study their ultimate strength behaviour. The suitability of using novel joints for modular construction and high-tensile rods for tension resistance is demonstrated. Prototype of a new form of deployable structures is described. The proposed cable-strut system, when fully deployed, shows promise to have lower weight-to-strength ratio than the conventional space truss systems for spatial applications.

INVESTIGATIONS INTO COLD-FORMED STEEL STRUCTURES WITH BOLTED MOMENT CONNECTIONS

K. F. Chung

Department of Civil and Structural Engineering,
The Hong Kong Polytechnic University, Hung Hum, Hong Kong SAR, China.

ABSTRACT

This paper presents a number of experimental and theoretical investigations into the structural behaviour of typical bolted moment connections in cold-formed steel structures as follows:

a) Lap shear tests between cold-formed steel strips with single bolted fastenings
b) Beam-to-beam connections for single Z sections with overlaps
c) Column base connections for double C sections back-to-back with inverted T sections
d) Beam-to-column connections for double C sections back-to-back with gusset plates

The basic deformation characteristics of bolted fastenings between cold-formed steel strips in lap shear tests is described, and the proposed normalized bearing deformation curve suitable for general application is presented. Moreover, for each of the connection types, the experimental investigation including both the test program and the test results is reported while the theoretical investigation such as design development and finite element modelling is also presented.

The presentation aims to provide structural understandings, and practical as well as advanced analysis and design methods to structural engineers, enabling them to design and build cold-formed steel structures rationally with improved structural performance.

DEVELOPMENT OF COLD-FORMED STEEL SECTION PORTAL FRAMES

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[2] Steel Structure Division, Yehwa Construction Co., Ltd., Seoul, 123-111, Korea
[3] Steel Structure Technology Division, Research Institute of Industrial Science and Technology, Hwasung, 445-810, Korea

ABSTRACT

A series of column, beam, and connection tests for portal frames, which consisted of closed cold-formed steel columns and rafters, were carried out to develop a new portal frame system. First, the compressive and flexural strength of the sections were investigated and second, the structural behavior of the connections including the moment-rotation relation, the yield and ultimate moment capacity of the connections were studied. The connection test specimens consisted of column-base, column-rafter, and rafter-rafter connections. The main factors of the connection test were the thickness and the shape of mild steel connecting elements, which were important for the unique attachment system of wall panels. The connection test results were compared with those achieved by using advanced analysis procedures. The semi-rigid connection concept was considered for the analysis of the portal frame using the secant stiffness of the connections, which were estimated from the moment-rotation curve of the connections tested. Simple formulas for the ultimate shear strength of the screw fastener connections were also proposed and compared with the test results.

LIGHT STEEL AND MODULAR CONSTRUCTION IN RESIDENTIAL BUILDINGS

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[1]SCI Professor of Construction Systems, University of Surrey, Department of Engineering, Guildford, Surrey GU2 7XH, UK
[2]School of Architecture, Oxford Brookes University, Gipsy Lane, Headington, Oxford OX3 8JR, UK

ABSTRACT

The use of light steel framing as a method of house construction has increased significantly throughout Europe in recent years. The steel industry has supported an intensive technical development, and housing systems are now available from several European companies. For example, in the UK, the market share for steel has reached approximately 5% of current house and apartment building. This paper describes the general forms of construction that have been adopted, and the levels of performance that are achieved. Recent developments associated with the use of light steel modules and steel frames in medium-rise residential buildings are also presented.

DESIGN OF SCAFFOLDS OF COLD-FORMED STEEL TUBES BY SECOND-ORDER ANALYSIS TO PR-EUROCODE-3

S.L. Chan[1] , S.W. Yuen[2] and B.H.M. Chan[2]

[1] Department of Civil and Structural Engineering, The Hong Kong Polytechnic University
[2] RED Façade Consultant Limited

ABSTRACT

A computer procedure for the second-order structural design of scaffolds made of cold-formed tubes is proposed. The semi-analytical stability function is used for the determination of buckling resistance of scaffolding units. The approach is based on the rigorous second-order analysis allowing for the P-δ and P-Δ effects and the uncertain assumption of effective length is not required. For simulation of imperfection, the present method uses an elastic buckling mode with 0.5 % scaffold height as system imperfection and buckling curve "c" for cold-formed sections in member imperfection. The method has been applied to design of hundreds of steel and bamboo scaffolds successfully and it is observed that properly engineered scaffolding systems with proposed design and acceptable standard of site workmanship are of adequate safety margin. It is expected that a proper design and fabrication procedure will reduce the high scaffold rate of collapse in different parts of the world, as reflected in Taiwanese experience in a considerable reduction of scaffold collapse since its introduction of rigorous design and fabrication procedure 3 years ago.

DEVELOPMENT OF A NEW COLD-FORMED STEEL BUILDING SYSTEM

Greg Darcy and Mahen Mahendran

School of Civil Engineering, Queensland University of Technology, Brisbane, Australia.

ABSTRACT

This paper presents a new innovative cold-formed steel building system that has no conventional frames, purlins or girts. As this building uses a new structural system, the load paths and structural behaviour are unknown. Therefore a series of full scale tests of a 5.4 m x 5.4 m steel building was conducted under simulated wind uplift and racking loads. The test results showed that in its present state, this new building system needs to be modified for its intended purpose. The structural behaviour of the test building was also investigated using finite element analysis. This paper presents the details of the new cold-formed steel building system, full scale tests, finite element analyses, the results, and finally the details of an improved building system.

EFFECTS OF ELEVATED TEMPERATURES ON THE MECHANICAL PROPERTIES OF COLD-FORMED STEEL

Ju Chen [1] and Ben Young [2]

[1] Research Student, Department of Civil Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong
[2] Assistant Professor, Department of Civil Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong.

ABSTRACT

This paper describes the development of an expression for the complete stress-strain curve of cold-formed carbon steel at elevated temperatures that covers the full strain range. The stress-strain relationship of cold-formed steel material at elevated temperatures is necessary in the analysis and simulation of cold-formed steel structures under fire. However, most stress-strain curve models are based on hot-rolled steel and very few stress-strain curve models based on cold-formed steel have been reported. Therefore, a stress-strain curve model of cold-formed carbon steel material at elevated temperatures is developed. The cold-formed steel grade G550 and G500 with thicknesses of 1.0 and 1.9mm, respectively, have been investigated. The stress-strain curves at elevated temperatures predicted by the European Code and other researchers were compared with test results. It is shown that the predicted stress-strain curves do not compare well with the cold-formed steel test results. Hence, a full strain range expression up to the ultimate tensile strain for the stress-strain curves of cold-formed carbon steel at elevated temperatures is proposed in this paper.

ACKNOWLEDGEMENTS

The Organizing Committee would like to express heartfelt thanks to the following sponsors for their generous support to the Symposium:

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