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Issue Editor : ***Dr. Austin D.E. Pan***, P.E.
Department of Civil Engineering,
The University of Hong Kong

HKISC has been registered as a non-profit making organization with its members coming from universities, consultants, developers, contractors and laboratories in Hong Kong. HKISC serves the construction industry in Hong Kong and the neighbouring region and carries the following specific objectives.

Objectives

- Channeling of technology transfer between academics and industry for improved quality in design, analysis and construction;
- Making university research more practical and useful for practitioners;
- Informing and sharing of new technology worldwide among members ;
- Organizing seminars for local and overseas experts for dissemination of their technological know-how ;
- Developing and fostering friendship among members for exchange of opinions on complex problems ;
- Sponsoring international conferences on steel structures in order to allow sharing of expertise between local and overseas researchers and engineers and
- Publication of bulletin for news and new technology developed by local or overseas universities

A few words from the issue editor, Dr. Austin D.E. Pan of The University of Hong Kong

I am pleased to serve as the issue editor of the HKISC bulletin. In this issue Dr. K.F. Chung presents the latest design and construction practice of composite slabs with profiled steel decking in compliance with BS5950. Prof. S.L. Chan compares the new BS5950 (2000) steel code against the old BS5950 (1990). These articles are informative and practical oriented. Perhaps the next question is on whether engineers in Hong Kong should adopt the latest version of the BS5950 steel code.

The main objective of the bulletin is for members to communicate and share information. In that regard, we invite and encourage all HKISC members to submit articles. The bulletin is here to serve you. You may like to share certain experiences from your projects or express an opinion on some aspect of steel design or construction.

For this issue we are very pleased to receive the following message from Professor W.F. Chen of the University of Hawaii. Professor Chen is an internationally renowned scholar and expert in steel construction. He has authored some 500 publications, including many books. Currently he holds membership on the editorial boards of a number of international journals. Included among his many honours and awards are: Member, US National Academy of Engineering; Academia Sinica; Honorary Member, American Society of Civil Engineers; T.R. Higgins Lectureship Award, American Institute of Steel Construction; Honorary Fellow, Singapore Structural Steel Society; Honorary President, Fritz Engineering Research Society, Lehigh University

Message from Professor W.F. Chen

It is a great pleasure and honor for me to write a message to you, the members of the newly established Hong Kong Institute of Steel Construction. The Institute is a focal point for students, researchers or practitioners, novices and experts alike, to profit much from sharing up-to-date information on specific topics of steel construction, fostering friendship among members of different background, and keeping in touch with overseas counterparts to facilitate and promote economic and safe design of steel structures.

Looking back to the formation of the Structural Stability Research Council established in 1944 by the Engineering Foundation in the US with goals similar to that of HKISC, the Council has made major contributions to the various stages of progress of the American Institute of Steel Construction's Specifications for Steel Construction, that can be attributed to the major advances made by the SSRC activities in structural stability research. Some of the recent major changes in the US steel building code include such innovative ideas as "structural fuse concept"-- designed to controlled failure at pre-selected locations, "performance-based design"-- designed for different levels of performance of structural components, and a new definition of "expected yield stress" of materials -- in the revision of the 1997 LRFD code, among others.

Looking forward to the future direction of advances in steel construction, two areas of great importance come to mind immediately: computing and material. When I first began to work in structural steel design over 35 years ago, evaluation of the first-order elastic response of a structural system was a significant problem. The advance in computing technology today has made second-order inelastic analysis (commonly called advanced analysis) of complicated structural system having hundreds of thousands of degree of freedom rather routine. Research works are currently in full swing to develop nonlinear methods and software for their use in design office. The AISC specification committee has established a working group to make this state-of-the-art method work in engineering practice.

Material properties had an important role in the cause of moment connection damages in buildings during the 1994 Northridge earthquake in California. Steel is usually considered to be an isotropic, homogeneous, and ductile material. But none of these properties are true near and around the connecting joints. The development of innovative test methods and models for making accurate, reliable predictions of its inelastic properties and weld ability becomes increasingly important for its success in some specific structural applications.

As a life member of the SSRC and an executive committee member of that Council, I wish the newly established Hong Kong Institute of Steel Construction great success and I trust that the Institute will follow the footsteps of that Council's success by providing support and technical counsel for technology transfer between academia and industry, by holding regular meetings to report on research activities, and by offering definite guidance to specification writers and practicing engineers on these new developments.

Professor W. F. Chen
Dean, College of Engineering
University of Hawaii at Manoa
Honolulu, Hawaii 96822
USA

Research and Technology Forum

Opinions expressed in this column do not represent that of the HKISC nor the affiliated organization(s) of the author(s). Further details can be sought directly from the author(s)

Composite Slabs with Profiled Steel Decking

Dr. K. F. CHUNG
Department of Civil and Structural Engineering
Hong Kong Polytechnic University
E-mail: cekchung@polyu.edu.hk

Composite slabs have been very popular in building construction in many parts of the world for more than 30 years, and it is becoming more and more popular in Hong Kong in recent years. This article aims to present the latest design and construction practice of composite slabs with profiled steel decking in compliance with BS5950.

Introduction

Composite slabs with profiled steel decking have been very popular in building construction in many parts of the world for more than 30 years, in particular, in high-rise steel framed buildings. In the recent years, it is becoming more and more popular in Hong Kong not only in commercial high-rise buildings but also in low to medium-rise offices, long span footbridges and building envelopes. The structural behaviour of composite slabs with profiled steel decking is covered by various parts of the British steel code BS5950 [1-3]. One of the major advantages of profiled steel decking [4] in the construction of floor slabs is that neither timber formwork nor temporary support is required as in conventional construction of reinforced concrete slabs. Moreover, the profiled steel decking provides safe working platforms and effective protection to workers.

The term composite member is generally applied to member having a steel-concrete section, in which the two materials behave compositely as an integral. This action is possible because of inter-connection between the two materials, either continuously or at discrete points, along the length of the member. In composite slabs with profiled steel decking, inter-connection is achieved by chemical bond and mechanical interlocking acting on the interfaces between the concrete and the profiled steel decking.

Typical applications

Modern profiled steel deckings are in the range of 45 to 80 mm in height and 150 to 300 mm trough spacing. Two well-known types are shown in Figure 1: trapezoidal decks and re-entrant decks. Galvanized steel sheet for this application is typically 0.75 to 1.5 mm thick with design yield strength at 280, 350 and 550 N/mm2. The thickness of galvanizing is specified as G275 (275 g/m2) which is equivalent to approximately 0.02 mm for each face. The most efficient use of composite slabs is for spans between 2.7 and 4.5 m. The typical span to depth (steel deck) ratio of the steel decking is 50 for simply supported slabs and 60 for continuous slabs. Typical usage of the profiled steel decking is described below.

Permanent formwork

Profiled steel decking may be used as permanent formwork to facilitate the construction of reinforced concrete slabs where timber formwork and temporary supports are difficult to be provided. The profiled steel decking should be able to support the self-weight of the wet concrete and the construction loads together with any other storage loadings as appropriate. The design of profiled steel decking is covered in BS5950: Parts 4 and 6 where the loading requirements during the construction stage [1] and the section capacities of the profiled steel decking [2] are given respectively. Moreover, the deflection limit of the profiled steel decking is normally taken at L/180, where L is the span of the slab. This limit may be relaxed to L/130 when the ponding effect of wet concrete is being considered during concreting as recommended in Clause 5.3 of BS5950: Part 4.

In general, both 'positive' and 'negative' reinforcements should be provided in the slabs according to normal design of reinforced concrete slabs for the in-service stage. No specific requirement on profiled steel decking against fire resistance is thus required as the profiled steel decking is considered to be 'inactive' after construction, and the fire resistance of the reinforced concrete slabs depends on the provision of suitable concrete cover.

Composite slabs

In general, the profiled steel decking may be utilized as positive reinforcement in floor slabs in the in-service stage provided that there are strong chemical bond and effective mechanical interlocking at the interfaces between the concrete and the profiled steel decking, i.e., composite slabs with the concrete in compression and the profiled steel decking in tension. The composite slabs are usually designed as simply supported irrespective of the continuity of the profiled steel decking over supports. Nominal reinforcement for crack control may be provided over the supports in accordance with Clauses 6.7, 6.8 and 6.9 of BS5950: Part 4.

The composite slabs should be able to support the dead and the imposed loads of the floors at ultimate limit state, and deflection is unlikely to be critical. The design of composite slabs with profiled steel decking is covered in BS5950: Part 4 [1]. They are usually designed against slippage between the profiled steel decking and the concrete before the plastic moment resistance of the composite section is reached. This is known as 'shear bond' failure, and it is required to execute physical tests in accordance with Section 8 of BS5950: Part 4 to confirm the structural behaviour of the composite slabs, as shown in Figure 2. The slabs are first subject to 10,000 cycles of loading variation between 50% and 150% of the desired working load in order to identify any inherent fragility in the concrete-profiled steel decking interfaces during the in-service stage. The slabs are then loaded statically to failure in order to evaluate the shear bond parameters, mr and kr, to design against shear bond failure at ultimate limit state. Figure 3 plots the load-deflection characteristics of a typical composite slab with profiled steel decking undergoing shear bond failure.

In general, the load carrying capacities of composite slabs are significantly larger than the loading requirements in typical applications, and thus, the design of continuous composite slabs is usually controlled by strength check of the profiled steel decking during the construction stage.

It is common practice [4] to confirm the structural performance of composite slabs with profiled steel decking in fire through standard fire tests. In general, simply-supported composite slabs with nominal reinforcement rarely exceed a fire resistance period of 30 minutes whereas tests on continuous slabs with the same reinforcement can achieve over 60 minutes. Since the release of BS5950: Part 8 [3], it has been widely accepted [5,6] to use the fire engineering approach to assess the load carrying capacities of composite slabs at elevated temperatures, and then to check against the loading requirements with appropriate partial safety factors in fire limit state. In general, the design of composite slabs is controlled by strength consideration in the normal or 'cool' design rather than the fire resistance requirement.

For typical composite slabs with practical dimensions and applications, simplified rules for the fire resistance of composite slabs with normal weight concrete are presented in Table 1 [4].

Product development

With the availability of modern design recommendations on the structural performance of composite slabs with profiled steel decking in both the construction and the in-service stages, it is possible to develop project-specific profiled steel deckings with required structural and architectural features. Moreover, both the material specification and the geometrical dimensions of new profiled steel decking may be optimized with the help of computer software for improved structural behaviour at reduced material cost.

Conclusions

Engineers are encouraged to capitalize on the advantages offered by composite construction to build long spanning structures with reduced self-weight. Moreover, composite slabs with profiled steel decking are considered to be one of the most promising fast-track construction methods in Hong Kong with proven performance, and they are likely to be widely accepted by clients, architects, engineers and contractors owing to their buildability.

References

1 British Standards Institution BS5950 Structural use of steelwork in building, Part 4, Code of practice for design of composite slabs with profiled sheeting, BSI, London, 1994.

2 British Standards Institution BS5950 Structural use of steelwork in building, Part 6, Code of practice for design of light gauge profiled steel sheeting, BSI, London, 1995.

3 British Standards Institution BS5950: Structural use of steelwork in building, Part 8: Code of practice for fire resistant design, BSI, 1990.

4 Steel Designers' Manual, fifth edition, edited by Owens GW and Knowles PR, the Steel Construction Institute, published by Blackwell Scientific Publication, 1994.

5 The fire resistance of composite floors with steel decking, The Steel Construction Institute, SCI-P056, second edition, 1991.

6 Fire resistant design of steel structures - A handbook to BS5950: Part 8. The Steel Construction Institute, SCI-P080, 1990.

Table 1a Trapezoidal decks with depth not exceeding 60 mm

Maximum span (m)	Fire resistance period (h)	Minimum sheet thickness (mm)	Minimum slab thickness (mm)	Fire reinforcement (mm^2/m)
2.7	1.0	0.8	130	142
3.0	1.0	0.9	130	142
	1.5	0.9	140	142
3.6	1.0	1.0	130	193
	1.5	1.0	140	193

Table 1b Re-entrant decks with depth not exceeding 50 mm

Maximum span (m)	Fire resistance period (h)	Minimum sheet thickness (mm)	Minimum slab thickness (mm)	Fire reinforcement (mm^2/m)
2.5	1.0	0.8	100	142
3.0	1.0	0.9	120	142
	1.5	0.9	130	142
3.6	1.0	1.0	125	193
	1.5	1.2	135	193

Figure 1 Common shapes of profiled steel decking

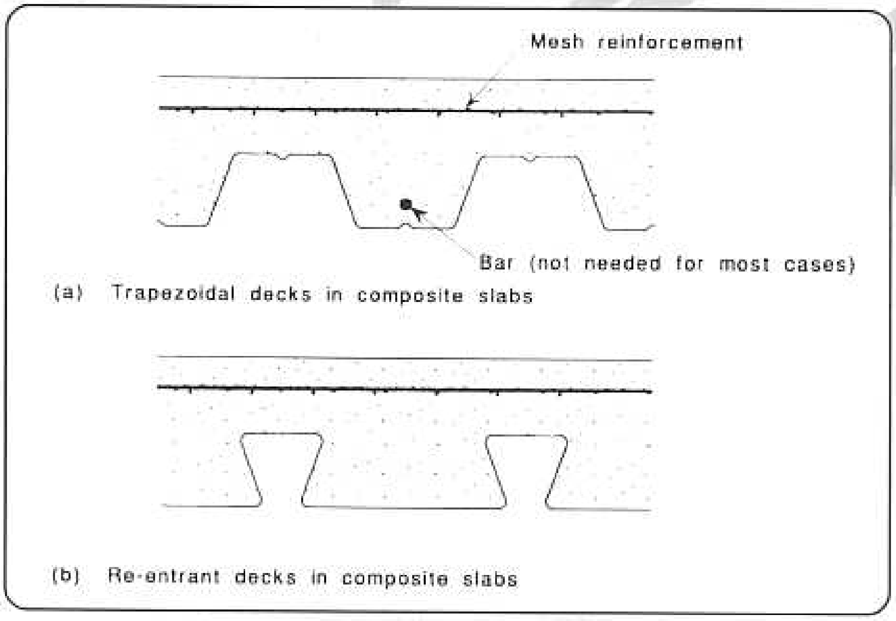


Figure 2 Typical set-up of performance test of composite slab with profiled steel decking

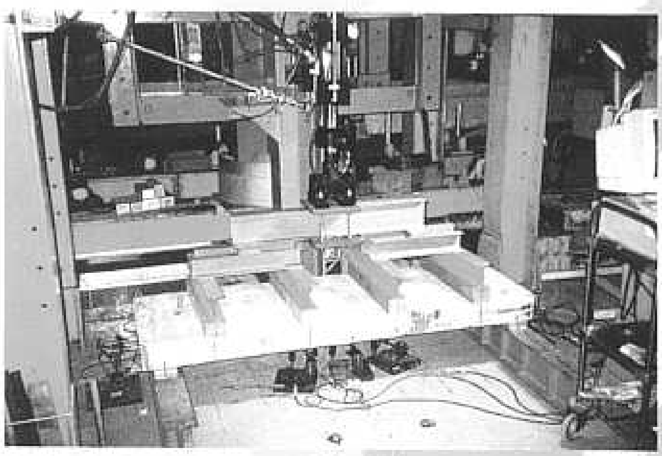
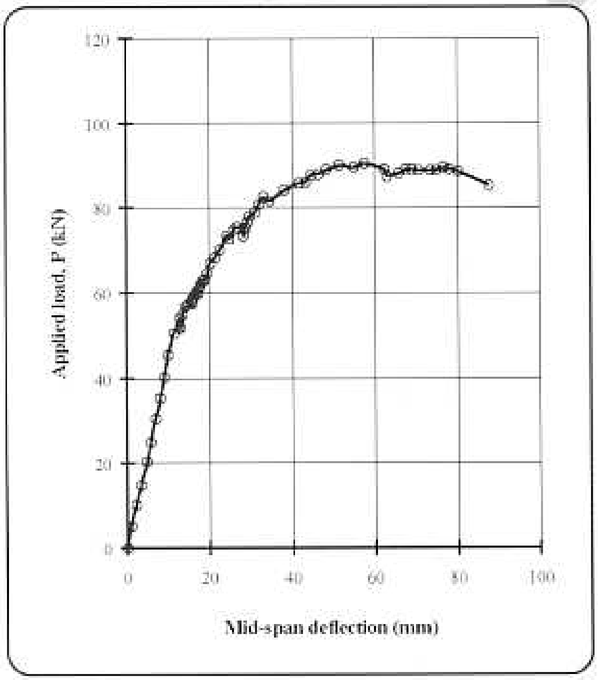
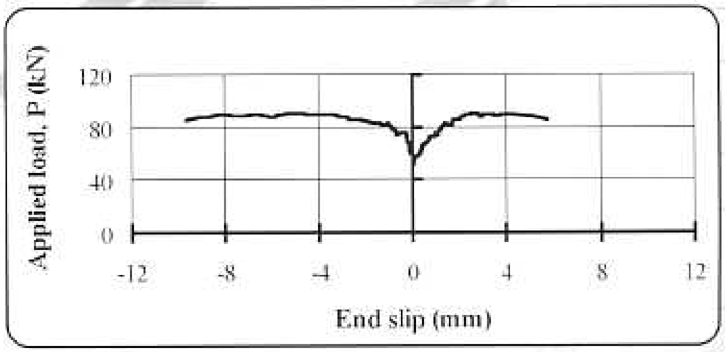


Figure 3 Typical load-deflection characteristics of composite slabs with profiled steel decking





Opinions

New BS5950(2000) against old BS5950 (1990)

By Professor S.L. CHAN
Department of Civil and Structural Engineering
Hong Kong Polytechnic University
E-mail: ceslchan@polyu.edu.hk

The new BS5950: Part 1, was published in May 2001 and was formally used on 15 August 2001 in U.K. It involves quite a number of changes when compared with the last version. To keep abreast of the newest development in structural design and consistent use of overseas products manufactured to the new standard etc, engineers in Hong Kong are interested in understanding the differences between the new and the old BS5950 for steel buildings. Below is a summary of the feature and changes in the new code.

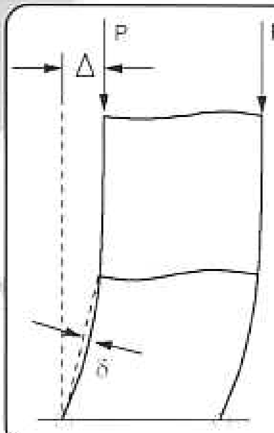
A brief history

Being possibly the most popular steel design code in Hong Kong and many other places like Singapore, BS5950 was first introduced in 1985, re-issued in 1990 and amended in 1992, re-reissued again in December 2000 before the publication of the present version in May 2001.

Changes in the new BS5950(2000)

There are many changes in the new BS5950. The followings are some of the major changes:

- ➪ Steel grades are S275, S355, and S460 in place of Grade 43, 50 and 55.
- ➪ Bolt grades are changed to 4.6, 8.8, and 10.9 (BS EN24017/8) and electrode grades for welding to 35, 42, and 50 (BS EN440). Higher strength transverse fillet welds are recognized.
- ➪ Full strength of bolts can be used, provided that the prying action is allowed for.
- ➪ Classification of structural sections to Classes 1, 2, 3 and 4, in addition to plastic, compact, semi-compact, and slender sections. Also, the method of classification is different. For slender sections where reduction in section capacity is required, the old method of reducing the design strength is replaced by the use of effective modulus or area.
- ➪ Method of calculating effective area for angle and tee sections in tension is revised.
- ➪ More elaboration is given on the aspect of fracture failure by limiting the thickness under various ranges of low temperature. This appears to be less applicable in Hong Kong, except for cold storage purposes.
- ➪ Base plate design is changed. The permissible bearing strength is increased from 0.4 to 0.6 of concrete cube strength and the effective area method is used.
- ➪ Design method of lateral-torsional buckling in beams is revised. No more "n" factor is used.
- ➪ Stability is more rigorously checked because of the availability and wide use of high-grade steel. All frames are required to be checked by more sophisticated methods if they are prone to P-Δ effects. The use of a notional force equal to 0.5% of the vertical load is required to be imposed to roof and floors of a structure to ensure the structure is robust.
- ➪ Clauses for checking against progressive collapse is imposed more rigorously.
- ➪ Frame stability checks are applied to both braced or moment resistant frames. A new method is included in the appendix for determination of effective length by a buckling load factor λ_{cr}. This indicates the importance of making a correct estimation of effective length which affects significantly the buckling strength of a compressive member.



P-Δ effect is considered in BS5950 via the use of λ_{cr} in various clauses like 2.4.2.

P-δ effect is considered through buckling curves a, b, c, and d in Table 23, BS5950(2000).

Conclusions

Steel material is indispensable in modern construction. Its wider use as architectural structures as roofs, stadia, high-rise buildings, space frames with glass and cladding etc. is expected. The new BS5950 code provides a more comprehensive and detailed checking of steel structures against ultimate and serviceability limit states. The buckling check using the load factor, λ_{cr}, is more common in the new code. With the exception of some regular and simple structures without inclined moment resisting members, λ_{cr} can only be determined by computer analysis. It appears that engineers are required to get used to the more frequent uses of computer buckling analysis. A series of courses and seminars are planned by HKISC to introduce the new code to engineers. Also, a more comprehensive M.Sc. module on stability of structures is offered at the Hong Kong Polytechnic University. Finally, a computer software, NIDA, for second-order and advanced analysis and design WITHOUT the need of artificial and uncertain assumption of an effective length is developed by the author and his former students.

This design method is indeed mentioned by Professor W. F. Chen in the message to HKISC on p.2 in this issue as one of the important advances in structural engineering drawing the effort of the AISC specification committee to have established a working group to make this state-of-the-art method work more widely in engineering practice. The method is more economical and safer than the conventional method since some members have been over-designed whilst others are under designed. Interested readers can visit the web-site "http://www.cse.polyu.edu.hk/~freda/nida/main.htm" for more information.

Report on the last seminar

The last seminar on Advances in Façade and Cladding Technology, 27 October 2001 was well received. The structural, environmental and serviceability aspects of curtain wall and façade technology were discussed. The concepts of pressure equalization system and the rain-screen principle for water-resistance design were described. Method of inspection for spontaneous breakage due to impurities of nickel sulfide was illustrated by photographs. After the lecture, we believed the audience had a much better grasp of the properties and behaviour of façade, glass structures and curtain walls.

We would like to thank again all those involved in the seminar: the Chairmen, Ir. Paul Pang and Ir. S.M. Pang, the speakers Mr. R. G.Kloepper, Dr. A. Lee, Mr. H. Schepers, Dr. A. So and Mr. B. Wymond. Also, the support of the audience was much appreciated.

A shot during tea break of the seminar

Call for articles

HKISC bulletin is circulated among engineers, architects, building and construction professionals. If you wish to express an opinion or submit an article of interest, please send to HKISC for review.

Call for membership

HKISC is a registered non-profit making organisation to promote the healthy development and the quality and competitiveness of steel related structures. Anyone interested in steel construction are welcome to join HKISC. Members will receive information on local and overseas technologies, conferences and seminars.

Please download the membership application form from the institute's web-site.

http://www.geocities.com/hongkongsteel/

Membership fee

Fellow member HK$400 per year
Corporate member HK$200 per year
Associate member HK$100 per year
Further information can be obtained from Professor S.L. Chan,
Department of Civil and Structural Engineering, the Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong.

email : ceslchan@polyu.edu.hk Tel : 27666047 Fax : 23346389

Coming seminars

Many interesting topics are coming, such as fire engineering, design of scaffolding, discussion of the new BS5950(2000) by Professor Nethercot of Imperial College, U.K., recent developments of large span steel structures in China by Professor Lan, Beijing, China .... Please refer to the updated seminar programme on the institute's web-site.

CALL FOR PAPERS AND CALENDAR

Please consider submitting papers about your interesting projects or research studies to the following conference

Calendar for conferences and meetings related to steel construction in Hong Kong

3rd International Conference on Advances in Steel Structures (ICASS'02),
9-11 December 2002, Hong Kong.
organised by the
Department of Civil and Structural Engineering,
Hong Kong Polytechnic University,
Hung Hom, Kowloon, Hong Kong.
sponsored by
The Hong Kong Institution of Engineers,
The Hong Kong Institute of Steel Construction
http://www.cse.polyu.edu.hk/seminar/icass02.htm

SHORT COURSES

DESIGN OF STEEL STRUCTURES TO BS5950

by Professors D.A. Nethercot (I.C., U.K.) and S.L. Chan (HKPolyU), Drs. C. Gibbons (Arup) and K.F. Chung (HKPolyU)

17-19 January 2002, organised by Department of Civil and Structural Engineering, Hong Kong Polytechnic University

DESIGN OF SPACE FRAMES -

WORLD PRACTICE AND THE CHINESE CODE

by Professor T. T. Lan,
Institute of Building Structures,
Chinese Academy of Building Research, Beijing and
Professor S.L. Chan,
Department of Civil and Structural Engineering
The Hong Kong Polytechnic University

Please refer to Institute the HKISC web-site for more information on conferences and seminars

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