

EVALUATION FOR SOME ASPECTS OF EGYPTIAN STANDARD
SPECIFICATIONS FOR METALLIC STRUCTURES AND BRIDGES
AND THE STUDIES REQUIRED FOR THE SUGGESTED
ALTERATIONS

Thesis Submitted to Ain Shams University for The Master
of Science Degree in Structural Engineering

By
Khaled Mohamed Youssef
B. Sc.



2074/5

Supervised By
Prof. Dr. Adel H. Salem
Dean of Faculty of Engineering,
Ain Shams University.

323/252
K.M

Prof. Dr. Mohamed N. El-Atrouzy
Professor of Structural Engineering,
Ain Shams University.



Ain Shams University
1986

To my father



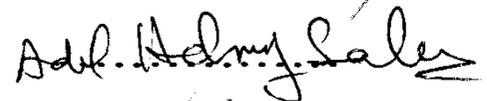
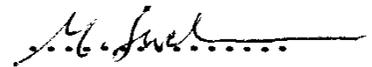
Approved by:

Prof. Dr. Mostafa A. Swelem

Prof. Dr. Kamal Hassan

Prof. Dr. Adel Helmy Salem

Prof. Dr. Mohamed Nabil El-Atrouzy



Committee in Charge

ACKNOWLEDGEMENT

I would like to express my deep appreciation and gratitude to Professor A.H. Salem, Dean of Faculty of Engineering, Ain Shams University, for his invaluable supervision, helpful guidance throughout this work, and for his unfailing support, discussions and suggestions during the course of this study.

I am also deeply indebted to Prof. M.N. El-Atrouzy, Professor of Structural Engineering, for his useful advice, great help, continuous interest, and constructive criticism throughout every step of this work. He did not save any effort in his supervision and direction.

I am deeply obliged to my wife, for her patience and encouragement, without which this work would not have been completed.

ABSTRACT

This thesis aims at revealing aspects of deficiency in some items of the Egyptian specifications for steel structures and bridges (ESS) through comparison with their universal specifications counterparts, such as the American specifications (AISC), the German (DIN), the French (CM 66), the Swiss (SIA), the European (ECCS), Japanese (AIJ), and British (B.S. 449).

The seventies of this century witnessed the introduction of many suggestions which resulted in substantial amendments on some of the items of these specifications. The present work comprises a discussion of some of these suggestions each in its place.

Chapter (1) provides a concise introduction to the subject, while chapter (2) treats the tension members design requirements and comprises a discussion which proved that the (ESS) conforms with some of the universal specifications, except that the allowable stresses should be specified in terms of the yield stress.

Chapter (3) comprises a detailed comparative study between the (ESS) and those of other universal specifications. The study revealed that the (ESS), as well as many other codes which apply the bifurcation theory, are far from proper considerations. Thus, the curves suggested here were based on limit states design, which gives the same safety margin for various

compression members. It has been shown also that the theory on which the local buckling provisions of the (ESS) were based, is still under dispute. Therefore, other simple and more safe provisions are here proposed. Suggestions and amendments to the specifications of the built-up columns, are also made.

Chapter (4) shows that the (ESS) do not give any recommendations concerning the design of laterally unsupported beams. Thus a comparative study of the recommendations of other codes was made, which proved that specifications which apply the bifurcation theory provide inappropriate equations. Therefore, here also suggestions on limit states design are made. Provisions against web crippling of rolled beams are also introduced, since they are missing in the (ESS). Also a definition of beams which can achieve full plastic moment (compact sections) is outlined.

Chapter (5) shows that the linear buckling theory of plates which is the basis of the (ESS) plate girder design, is inadequate. The Cardiff method which is based on the ultimate analysis was found appropriate in this respect. However, the (AIJ) recommendations which though based on the linear buckling theory, are recommended.

Chapter (6) comprises a comparative study of the universal manual procedures for the evaluation of the effective column lengths in continuous frames. In view of this comparison, it is suggested to apply the

(AISC) nomographs. It is found that the (ESS) beams-columns design is inadequate and thus the (AISC) procedure is recommended.

Chapter (7) is a synthesis of all the suggested recommendations for a new Egyptian specifications. It also includes a conclusion of the whole work.



CONTENTS

	Page
Abstract	i
List of Figures	viii
List of Tables	xx
CHAPTER ONE: Introduction	1
CHAPTER TWO: Tension members	4
2.1. General	4
2.2. ESS Recommendations for Tension members	5
3.3. Comparative Study	6
CHAPTER THREE: Compression Members	15
3.1 General	15
3.2. ESS Recommendations for Axial compression Members	16
3.3 Comparative Study	22
3.3.1. Basic Column curves used in some universal codes	22
3.3.1.1. First design approach (classical bifurcation theory)	24
3.3.1.2. Second design approach (assumed unaccuracies as a basis of column design)	30
3.3.1.3. The new approach of column design (ECCS column curves)	40
3.3.1.4. Observations and conclusions	52
3.3.2. Universal specifications provisions for local buckling	59
3.3.2.1. The basic concept	59
3.3.2.2. AISC concept	63
3.3.2.3. SIA concept	66
3.3.2.4. AIJ concept	67
3.3.2.5. The equivalent slenderness ratio method as a base of German DIN 4114, French CM 66, and Egyptian ESS, local buckling provisions	68

	Page
3.3.2.6 Observations and conclusions	69
3.3.3. Built-up compression members	71
3.3.3.1. Specifications recommendations for shearing force in built-up columns	77
3.3.3.2. Effect of shearing force on the critical column load	80
3.3.3.3. Observations and conclusions	86
CHAPTER FOUR: Beams	88
4.1. General	88
4.2. ESS Recommendations for Beams Design	89
4.3. Comparative Study	91
4.3.1. Local buckling provisions	91
4.3.2. Maximum bending capacity for laterally supported beams	92
4.3.2.1. Specifications apply (working stresses design method)	96
4.3.2.2. Specifications apply the ultimate limit design method	100
4.3.3. Specifications provisions for lateral torsional buckling	103
4.3.3.1 AISC concept	104
4.3.3.2. AIJ concept	109
4.3.3.3. CM 66 concept	110
4.3.3.5. DIN 4114 concept	116
4.3.3.6. ECCS concept	119
4.3.3.7. SIA concept	120
4.3.3.8. Practical example	122
4.3.3.9. Observations and conclusions	127
4.3.3.10. Proposal for a new Egyptian code	131
4.3.4. Web crippling provisions	133

	Page
CHAPTER FIVE: Plate Girders	140
5.1. General	140
5.2. Stability of Web Plates According to the Egyptian Specifications	142
5.3. Comparative Study	145
5.3.1. The classical approach (linear buckling theory)	147
5.3.1.1. West German specification DIN 4114	148
5.3.1.2. Japanese specifications AIJ	153
5.3.1.3. Comparison between DIN 4114 & AIJ recommendations	162
5.3.1.4. French code CM 66	167
5.3.1.5. British Code B.S. 449	171
5.3.1.6. Evaluation of the Egyptian EES and British B.S. 449 specifications	174
5.3.1.7. Criticism of the safety philosophy in the classical approach (linear buckling theory)	176
5.3.2. Ultimate strength theory of plate girders	177
5.3.2.1. AISC provisions	179
5.3.2.2. Swiss SIA specifications	198
5.3.2.3. Comparison between the AISC and SIA specifications for the design of girders	204
5.3.3. Proposals for new codes	210
5.3.3.1. Gardiff method	210
5.3.3.2. Stockholm method	217
CHAPTER SIX: Members Subject to Bending and Axial Stresses	223
6.1. General	223
6.2. ESS Recommendations for Members Subjected to Bending Moment and Axial loads	223

	Page
6.3. Operative Study	226
6.3.1. Evaluation of effective column length according to some universal codes	226
6.3.1.1. AISC procedure	226
6.3.1.2. French code CM 66 procedure	230
6.3.1.3. West German DIN 4114 procedure	234
6.3.1.4. ECCS procedure	238
6.3.1.5. Comparison between the discussed procedures	241
6.3.1.6. Practical examples	242
6.3.1.7. Reasons behind the results variation	251
6.3.2. Specifications design procedures for members subjected to combined bending and axial force	258
6.3.2.1 Beam-columns design procedures according to some universal codes	260
CHAPTER SEVEN: General Conclusion and Recommendation	273
7.1 General Conclusion	273
7.2. Recommendations	274
7.2.1. Safety factor	274
7.2.2. Tension members design requirements	275
7.2.3. Calculation of the net area	276
7.2.4. Width-to-thickness ratio of plate elements	278
7.2.5. Compact sections requirements	279
7.2.6. Maximum carrying capacity of laterally supported beams	281
7.2.7. Allowable bending stresses for laterally unsupported beams	282
7.2.8. Web crippling provisions	283
7.2.9. Plate girders design requirement	284
7.2.10. Effective buckling length of columns in continuous frames	284
7.2.11. Beam-columns	285
APPENDICES	286
REFERENCES	304

LIST OF FIGURES

Fig. No.		Page
2.1	Ex. 2.1	10
2.2	Ex. 2.2	11
2.3	Eccentrically loaded members	13
3.1	Range of column strength vs. slenderness ratio	16
3.2	ESS local buckling provisions for elements under uniform compression	18
3.3	ESS typical built-up columns	20
3.4	General behaviour of ideal straight column with residual stresses (bifurcation theory)	24
3.5	Typical residual stresses distribution on I-shape section according to SSRC	25
3.6	AISC basic allowable column curves for steel with $F_y = 2400, 2800$ and 3600 kg/cm^2	27
3.7	Variation of the critical slenderness ratio C_c according to AISC, AIJ and ESS	29
3.8	The transition between the elastic and inelastic ranges according to AISC, AIJ and ESS	31
3.9	Behaviour of column with initial bow	32

Fig. No.		Page
3.10	Column curves to be used for usual sections (Swiss SIA)	36
3.11	Comparison among the column curves used in B.S. 449, CM 66 and SIA, ($F_y = 3600 \text{ kg/cm}^2$)	37
3.12	Stress-strain curve of eccentrically loaded column that shows the determination of the ultimate load according to DIN 4114	39
3.13	Typical section which the analysis of DIN 4114 column curve is based on it	39
3.14	Comparison between the DIN and B.S 449 allowable column curves	41
3.15	Tangent and reduced modulus theories of Engesser	42
3.16	Bending stress distribution along the depth of column at onset of buckling due to reduced modulus theory	42
3.17	Critical column stresses due to tangent and reduced modulus theories, $F_y = 3600 \text{ kg/cm}^2$	44
3.18	Shanley's concept	45

Fig. No.		Page
3.19a	Ramberg-Osgood determination of yield stress	48
3.19b	Dimensionless representation of stress-strain curve with respect to the characteristic value n	49
3.20	ECCS multiple column curves in dimensionless representation, (see appendix 1, for sections corresponded to each curve)	50
3.21	Typical residual stresses distribution on I-rolled section according to Young [Ref. 44]	51
3.22	Comparison of the Egyptian and AISC allowable column curves with those of the ECCS (a safety factor of 1.67 is applied to the ECCS curves)	54
3.23	Shows how the SIA gave its design curves with the ECCS curves, ($F_y = 3600 \text{ kg/cm}^2$)	56
3.24	The use of Perry formula to fit the ECCS column curves (as a proposal for new specifications in the U.K, Ref. [18], and also Ref. [13])	57
3.25	Comparison between the ECCS and the new SSRC (U.S.A), [Ref. 39] multiple curves	58