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Design of Concrete Structures

Dr. Ramchandra
Virendra Gehlot

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DESIGN OF
CONCRETE STRUCTURES

(In S.I. System of Units as per Code IS: 456-2000)

[S.I. UNITS]

3rd Revised and Enlarged Edition

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LIST OF THE PAPERS PUBLISHED BY

Prof. Dr. Ram Chandra and Virendra Gehlot***

I. PAPERS PUBLISHED IN INTERNATIONAL JOURNALS

*1. "Non-Linear Analysis of Steel Space Structures," Journals of American Society of Civil Engineers, Volume 116, No. 4, April, 1990, Paper no. 24525 (pp. 898-909) New York.

*2. "Elastic-Plastic Analysis of Steel Space Structures", Journal of American Society of Civil Engineers, Volume 116, No. 4, April, 1990 Paper no. 24528 (pp. 939-955) New York.

II. PAPERS PUBLISHED IN NATIONAL JOURNALS, CONFERENCES & SEMINARS

*3. "Non-Linear Elastic-Plastic Analysis of Skeletal Steel Plane Frames Hinged at supports", proceedings of the seminar on Modern trend in structural analysis and design, 25-26 February, 1984, Department of Civil Engineering, Banara Hindu University, Varanasi (U.P.)

*4. "Non-Linear Elastic Plastic Analysis of Skeletal Plane Steel Frame", International conference on computer applications in Civil Engineering, October 23-25, 1979, University of Roorkee, Roorkee.

*5. "Stub Column Tests on Indian Standard H-Beams", Journal of the Institution of Engineers (India), Volume 51, No. 11, C.I. 6, July, 1971.

*6. "Kani's Iteration Method I-Analysis of Continuous Beams" The Indian Engineer, Volume XIV, No. 6 June, 1970.

*7. "Kani's Iteration Method II Analysis of Frames", The Indian Engineer", Volume XIV, No. 8 August, 1970.

*8. Hinge Formation in Plane Frames Considering Finite Deformations All India Conference on "Tall Buildings" The Institution of Engineers (1) Roorkee Local Centre, March 1-3, 1993.

**9. "Design, Construction and Behaviour Aspects of Concrete and Steel Structures' Recent Trends in Civil Engineering National Seminar, Jodhpur, February 22-23, 2002, Department of Civil Engineering MBM Engineering College, Faculty of Engineering, JN Vyas University, Jodhpur pp 229.

**10. 'Corrosion of Reinforcing Steel Bars in Concrete' Futuristic Construction Materials and Technique (FCMT-2004, Feb. 21-22, 2005) Department of Structural Engineering Faculty of Engineering, JN Vyas University Jodhpur.

**11. 'Stresses in Reinforcing Steel Bars, HYSD of Grade Fe 415' Futuristic Construction Materials and Technique (FCMT 2004, Feb. 21-22, 2005) Department of Structural Engineering Faculty of Engineering, JN Vyas University, Jodhpur.

ACKNOWLEDGEMENT

The author highly acknowledges Bureaue of the Indian Standards for reproducing in this book some of the 'Tables and Clauses' from the Indian Standard Specifications.

It is desirable that for complete detail, reference be made to the latest versions of the Standards which are available from Indian Standards Institution, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi-1, or from its branch offices at Bombay, Calcutta, Kanpur and Madras.

SYSTEM INTERNATIONAL d' UNITES (SI-System of Units)

In order to avoid the conversion of results obtained by engineers working with the foot-pound second system (gravitational) of units in terms of centimetre-gram second absolute system of units used by the scientists, a need of common system of units was realised. The General Conference on Weights and Measures held at Paris is 1960 finalised the System International *d'* Unites (SI). It is an absolute system of units. The mass is considered as fundamental unit and not the force. ISI has included a comment of transition in IS 3616-1966. 'Recommendation on the International System (SI) Units' that this system has begun to replace older systems of units in several branches of science and technology. The SI is a universal system of units and it has been adopted in France as a legal system and it is likely to become common in many countries. SI Units have the following six basic units.

Units of length (metre, m)

The length equal to 1,650,763.73 wave lengths, in vacuum, of the radiation corresponding to the transition between $2p^{19}$ and $5d^5$ levels of the krypton n atom of mass 86 is known as *one metre*.

Linear distances are expressed in metres and multiples or division of 10^3 of metres (i.e., one kilo-meter (km) = 10^3 m, one metre (m) = 1m, and one millimetre (mm) = 10^{-3} m.

Unit of mass (kilogram, kg)

The mass of planium-iridium cylinder deposited at the International Bureau of Weights and Measures and declared as the international prototype of the kilogram by the First General Conference of Weights and Measures is called as *one kilogram*.

Units of time (second, s)

1131, 566, 925, 974.7 of the length of the tropical year for 1900, the year commending at 1200 hours universal time on the first day of January, 1900 is termed as *one second*.

Units of electric current (Ampere, A)

The constant current which flows in two parallel straight conductors of infinite length of negligible circular cross-section and placed at a distance of one metre from each other in vacuum producing a force 2 x 10^{-7} Newtons per metre length between the conductors is defined as *one ampere*.

Unit of thermo-dynamic temperature (degree Kelvin, °K)

The degree interval of the thermo-dynamic scale on which the temperature of triple point of water is 273.16 degrees, is known as *one degree Kelvin*.

For temperatures, conventional degrees centigrade (°C) may be used, since, temperature changes are concerned rather than absolute temperatures.

Units of luminous intensity (candela, cd)

One sixtieth of luminous intensity normally emitted by one centimetre square of integral radiator (black body) at the temperature of solidification of platinum is called as *one candela*.

Following are the derived units (derived from the basic SI units and these are relevant for the study of design of steel structures).

Force	Newton (N)	$kg.m.sec^{-2}$
Work, energy	Joule (J)	$kg.m^2, sec^{-2} = (N - m)$
Power	Watt (W)	$kg.m^2 . sec^{-3} = (J . s^{-1})$
Frequency	Hertz (Hz)	Cycles /sec.

Accerelation due to gravity used is 9.81 ms^{-2}.

The force is a derived quantity and physical law connecting the quantity of the fundamental quantities or previously obtained derived quantities is force = mass x acceleration. It is defined as that force which produces unit acceleration (i.e., 1 m per sec^2) in a unit mass of 1 kg. Its unit is Newton (N). Though, the Newton is a small unit, a still larger unit kN may be used. The intensity of force (viz., stress) due to 1 Newton over a unit area of one metre square is known as one *pascal*. It is denoted by symbol, Pa (1 Pa = 1 N/m^2 and 10^6. Pa = 1 N/mm^2, viz., 1 MPa = 1 N/mm^2).

The unit of force, (the Newton N), is the force required to develop unit acceleration (m s^{-2}) to unit mass (1 kg). In terms of Newtons, the common force units in the foot-pound-second system (with g = 9.81 m s^{-2}) are

1 lb-wt = 4.45 Newtons (N)

1 ton-wt = 9.96 x 10^{-3} Newtons (N)

1 ton-wt = 9.96 kN

The unit of force, the Newton (N) is used for the external loads and the internal forces, such as the shear force. Torque and bending moments are expressed as Newton-metres (N-m).

Another important unit is stress. In the foot-pound-second system the stresses are commonly expressed in lb-wt/in^2 and tons/in^2. In the SI system of units, these are taken as

1 lb. wt/in^2 = 6.89 x 103 N/mm^2 6.89 kN/m^2

1 ton. wt/in^2 = 15.42 x 10-6 N/mm^2 = 15.42 MN/m^2

Yield stresses of the common metallic materials are in the range [200 MN/m^2 to 750 MN/m^2]. Young's modules for steel,

$E_{STEEL} = 30 \times 10^6$ lbs. wt/in^2 = 207×10^5 N/mm^2 = 207 GN/m^2

The SI units make the use of multiples and sub-multiples 1000 times or 1/1000 times the unit quantity and in powers of 10^3 *(kilo)* or 10^{-3} *(milli)* in respect of still larger and smaller quantities respectively. The lengths are measured usually in kilometre (1 km = 1000 m). metre and millimetre (1 mm = 10^{-3} m). The symbols of units are not to be suffixed with `s' for plural.

[(kilo k 10^{+3}), (mega M 10^{+6}), (giga G 10^{+9})].

SI system of units have many advantages. The units are very handy. The burden of non-decimal coefficients in foot-pound second system is avoided. It has relatively large main units in contrast to centimetre-gram-second system. At the same time, it is closely related to centimetre-gram-second system of units. In practice, it results in perfectly reasonable number when the value of g = 10 m/sec^2 is used instead of 9.806 m/sec^2.

References

1. Professor V.S. Mokashi, Visvesvaraya Regional College of Engineering, Nagpur in his paper titled as International System (SI) Units and their Application to Engineering, Published in Journal of Institution of Engineers, India, Vol. 19, March 1970 has highlighted the advantages and discussed SI units. A reference has been made to this paper.
2. John, Case and A.H. Chilver, `Strength of Materials and Structures' Second Edition (ELBS)/Edward Arnold, 1986, Printed of the Bath Press, Avon, Great Britain.

PREFACE (Thirteenth Edition)

This book `Design of Concrete Structures' in S.I. Units is based on working stress method as per code IS: 456-2000.

All the chapters of the book have been revised and re-arranged in eight parts (32 thirty two chapters) separate aspects of design of one structrual member have been described in different subsequent chapters.

In addition to above (i) the service life of concrete structures, (ii) Non-destructive tests/ Evaluation of strength (NDT/NDE) of materials and (iii) futuristic construction materials and Technique (FCMT) likely to be used for the concrete are new topics. Text for these topics (rarely, available in current books by other authors) have been first time given to familiarize the readers.

Authors are thankful to their colleagues and friends for their liking and sending useful suggestions. Authors express their thanks to the publishers of this book, M/s Scientific Publishers (India), Jodhpur for preparing make-up and printing this book in the latest technology and bring-out the same in a nice-getup.

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Suggestions from the students and affectionate teachers of various Institutions shall be highly appreciated.

12 February, 2010

Ramchandra
Virendra Gehlot

PREFACE (First Edition)

In this book, the author with his long teaching experience in the subject has made an attempt to present the subject mater of `Design of Concrete Structures' in a way which lays emphasis on the fundamentals, keeping in view, the difficulties experienced by the students. Every basic principle, method, equation or theory has been presented in a simplified manner. The text has been described in a sequence most naturally desired and appealed to the student. SI system of units has been used throughout the text. Indian Standard Specifications (specially, IS: 456-1978) have been used. The symbols and notations used in the text match with those of present code of practice. The book is intended for Degree, Diploma and AMIE students in various branches of engineering. The book deals with design of structural members.

The complete text in this book has been divided in **eight parts** [Part I: Introduction, Part II: Loads and Stresses, Part III: Design of Beams, Part IV: Design of Slabs, Part V: Design of Columns, Part VI: Design of Footings, Part VII: Design of Other Concrete Structures, and Part VIII: Design of Concrete Mix and Laboratory Tests] and **twenty-one** chapters (detailed as in contents).

A number of design problems has been solved to illustratre the theory and practice. The chapters have been so arranged that it facilitates self-understanding of the subject during study. In spite of careful scrutiny of the manuscript, it is possible that some typographical and computational errors are still left. The author shall be highly obliged to all those who will bring these errors in his notice.

The author is thankful to his colleagues for their suggestions. The author is also thankful to the publishers M/s Standard Book House for bringing the book in a nice get up and in a short time. Suggestions from the students and affectionate teachers of various Institutions shall be highly appreciated.

January 1, 1990 **RAM CHANDRA**
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