# Limit State Design of **Steel Structures**

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# LIMIT STATE DESIGN OF
# STEEL STRUCTURES-1

**(Based on IS: 800-2007 in S.I. Units)**
**for Under graduate and post-graduate students (LSD: SS)**


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*Dedicated*
*to*
*our teachers*

## ROLE OF STEEL STRUCTRUES IN SERVICE FOR THE SOCIETY (Chat-magni aur Patt-byah)

Role of Steel Structures is useful, significant and important inservice for the society due to following advantages of steel inconstruction Steel is strong and these structures have extremely highload-bearing capacity.

1. These may be fabricated in the work-shops quickly.
2. The construction of the structures is also quick.
3. These structures may be furbished (made new again) strengthened and remodelled, if necessary. These may be expanded or relocated.
4. These structures have long life-span.
5. These structures need few columns to stand-on, minimizing waste of space.
6. Steel is recyclable.
7. Steel is more environment friendly.
8. If necessary, steel structures are easy to dismentle.
9. These structures can withstand earthquakes to much significant degree.

Authors fully support the views of R.K.P. Singh, Director General, Institution of Steel Development and Growth (INSDAG).

**Reference:** Times of India, dated 14.05.2007, page 12, dated 22.5.2007 page 1.

# ACKNOWLEDGEMENT

Tables and clauses from the Indian Standard Specifications have been produced in the book with the kind permission of the Indian Standards Institution.

It is desirable that for complete detail, reference be made to the latest versions of the Standards Institution, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi -I, or from its branch offices at Mumbai, Kolkata Kanpur and Chennai.

## SYSTEM INTERNATIONAL d' UNITS (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 in 1960 finalised the System International d' Units (SI). It is an absolute system of units. The mass is considered as fundamental unit and not the force. BIS 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 system 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.

### Unit 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 η atom of mass 86 is known as one metre.

### Unit of mass (kilogram, kg)

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

### Unit of time (second, s)

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

**Unit 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 of $2 \times 10^{-7}$ 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.

**Units of luminous intensity (candela, cd)**

One sixtieth part of luminous intensity normally emited by one hundred millimetre 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. $s^{-2}$

Work-energy Joule (J) kg.$m^2$ . $S^{-2}$=(N − m)

Power Watt (W) kg.$m^2$ . $s^{-3}$=(J . $s^{-1}$)

Frequency Hertz (Hz) Cycles/sec.

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

**The force** is a derived quantity and physical law connecting the quantity to 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 quare 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 (kg). In terms of Newtons, the common force units in the foot-pound second system (with g = 9.81 $ms^{-2}$) 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/in2 and tons/in2. In the SI system of units, these are taken as

$$1 \text{ lb. wt/in}^2 = 6.89 \times 10^3 \text{ N/mm}^2 \; 6.89 \text{ kN/m}^2$$

$$1 \text{ ton. wt/in}^2 = 15.42 \times 10^6 \text{ N/mm}^2 = 15.42 \text{ MN/m}^2$$

Yield stress of the common metallic materials are in the range 200 MN/m2 to 750 MN/$m^2$. Yound modulus of elasticity, E for steel

$$E_{steel} = 30 \times 10^6 \text{ lbs.wt/in}^2 = 2.07 \times 10^5 \text{N/mm}^2 = 207 \text{ GN/m}^2$$

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 nn-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 sytem 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

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# LIST OF THE PAPERS PUBLISHED

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

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# PREFACE

METHOD OF LIMIT STATE (Ultimate Limi State, (ULS) and Serviceability Limit State (SLS) present an improved design philosophy and makes allowance for the short-compings of working stress method (conventional and long time used in practice). This method provides basic framework, within which the performance of the steel structures may be assessed against various limiting conditions and involves some concept of probability.

Object of limit design method is to get steel structure that will remain fit for use during its life with acceptable target reliability. The probability of a limit state being reached during its life time is kept very small.

This method has been broadly adopted in many developed countries.

In our country, `Limit State Method of Design of Concrete Structures (LSD : CS) was intoduced in IS 456-1978. It was natural for Bureau of Indian Standards, to introduce this method (LSD : SS) for **Steel Structures** in its recommendations in IS : 800-2007 (Third Revised Edition).

Authors have made efforts to present the matter to understand the subject easily and conveniently. This book has been covered in eight parts in twenty six chapters and four appendices as listed in contents. Appendix A and B have been given for `shear centre for the thin walled cross-sections' and `unsymmatrical bending' being important topics for many points of view for the interest of the students.

The expressions given in IS : 800-2007 for the determination of the strengths of te structural members in bending and shear have been derived by first principle of strength of materials and / structural stability.

Inspite of careful scrutiny of the manuscript, it is possible that some typographical and computational errors are still left. Authors shall feel highly obliged to those, who bring these errors to their notice.

Authors acknowledge Shri R.K. Singhal, Shri Sher Singh Gehlot and Shri Suresh Sankhla of Department of Structural Engineering, Faculty of Engineering, Jodhpur for their encouragement and time to time consultations.

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**Dr. Ramchandra**
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