# The Study of Design of Industrial Factory Steel Shed and Foundation and Compare with Reinforced Concrete Portal Frame Structure

**Er. Annu Sharma, Er. Rahul Sikka, Er. Bhavana Arora, Dr. Arvind Dewangan**

***Abstract*— the object of project is to typify at national level the common forms of industrial structures used in light and medium engineering industries, warehouses, workshops and process industries, and to obtain economical designs under-these conditions. Even if an industrial complex is classified as heavy industry, it need not necessarily mean that all the industrial structures coming within the complex should be heavy industrial structures and that many structures could be from the typified design. The main objective of typification of industrial structures is to reduce the variety to the minimum and provide standard prefabricated designs so that the structures Could be easily mass produced and made available to the user almost off the shelf.in doing so, there will be tremendous saving in time in putting up an industry into production and hence increased production.**

***Index Terms*— Loads, Trusses, Pitch, Spans**
**Sub Area : Construction Technology & Management**
**Broad Area :Civil Engineering**

## I. INTRODUCTION

In a developing country like India, the capital outlay under each five-year plan towards setting up of industries and consequently construction of industrial Buildings is very high. It is therefore, necessary that the various parameters of industrial buildings be standardized on broad norms so that it will be feasible to easily adopt prefabricated members, particularly where repetitive structures could be used. The standardization of parameters for industries by itself will be, no doubt, a difficult task as it will not be possible to specify the requirements of each industry. The layout including height will vary from industry to industry, for it depends on The process of manufacture and end products. However, a little more detailed analysis of the requirements indicates that the problem may not be as difficult as it appears. Although it would not be possible to specify any constraint on the parameters, a broad norm can be given within which most industries could be accommodated.

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**Er. Annu Sharma**, M.Tech.(CTM- Civil Engineering) Scholar – Roll No.17162418, HCTM Technical Campus, Kaithal 136027(Haryana)

**Er. Rahul Sikka** – Asstt. Professor Department of Civil Engineering, Haryana College of Technology & Management, HCTM Technical Campus, Kaithal (Haryana) INDIA

**Er. Bhavana Arora**– Asstt. Professor (HOD)Department of Civil Engineering, Haryana College of Technology & Management, HCTM Technical Campus, Kaithal (Haryana) INDIA

**Dr. Arvind Dewangan** – Director, Yogananda College of Engineering & Technology, Jammu (Former-Professor & H.O.D., CED HCTM Technical Campus, Kaithal (Haryana) - INDIA

***EXPANSION JOINT***

These joints, as the name implies, provide for expansion and contraction of the concrete floor due to temperature variations. They are provided at about 30m center and may coincide with similar joints in the super-structure, if any. The purpose is to provide for linear expansion of the concrete floor due to temperature stresses. Conventionally, theses joints are provided by form work during construction stage itself. A normal width of 12mm to 25mm is provided for full depth of the concrete floor. In practice, very seldom does the need occur for providing expansion joints in industrial factory floors since the temperature differentials required for expansion of a concrete panel to close a joint of say 12mm will never happen. On the contrary, shrinkage and creep phenomenon continue to occur for several years after construction which continuously shorten the concrete panel in both directions, thereby counteraction any expansion, if at all any. Also, present —day high- strength cements are also high shrinkage type and will contribute to more linear shrinkage than expansion. The author has investigated and examined several old factory floors constructed over 20 to 30 years back and have found that the width of the expansion joints have almost doubled from the originally constructed specifications. This phenomenon leads to failure of edges due to traffic movement and subsequent deterioration of the floor. Hence, it is the opinion of the author, that expansion joints need not be provided at all in all covered factory floors.

## II. REVIEW OF LITERATURE

Various is codes and handbooks, bis publications, insdab publications are referred to study the topic. For design of industrial structure, the general guideline given in “reinforced concrete designers handbook” by C. E. Reynolds & stidman” are followed & the same logic is used in analysis & design of structure in staad platform. As the main plant building houses the various machinery & the chemical design unit i steam dryers etc. It is designed in reinforced cement concrete with more cover to reinforcement to meet requirement. The provision of is 456-2000 (table 16) are studied for this purpose & cover is provided accordingly.
The load on structure i.e. Live load on floor, floor finish load, dead load of various material, wind load on trusses & structure are taken as per is 875-1987 part 1, 2 &3(code of practice for design loads — other than earthquake).
For calculation of design wind speed & design wind pressure a structure & truss the various provision of is 875-1987 are used.

1) The roof truss part is studied form textbook of “design of steel structure” by arya & ajmani. The various

guideline & clauses of IS 800 (code of practice for general construction in steel) are followed for design of roof trusses.

2) Sp : 6 (i) 1964 — 181 handbook for structural engineers —structural steel sections is used for dimension & properties like sectional area, moment of inertia, radius of gyration, section modulus, centre of gravity of angle sections used in trusses.
3) Is 456 — 2000 (code of practice for plain & reinforcement concrete) is referred for general & special design requirement for structural members & systems & also for limit state method of design.
4) The various provisions of is 456 — 2000 studied are - Section 3
   - CI. 18.2 — method of design.
   - Cl. 19.2 — dead loads
   - Cl. 19.3 — imposed & wind loads
   - Cl. 20.1 — overturning
   - Cl. 21.1 — fire resistanc
   - Cl. 26 — requirement governing reinforcement & detailing
   - Table 16 & 16 a — nominal cover requirement
5) Section 4 - cl. 28.1 — design requirement for concrete corbels
6) Section 5 — design by limit state method
   - Cl. 35.3 - limit state of serviceability
   - Cl. 37.1 — analysis of structure
   - Cl. 39.6 — column design for biaxial body
   - Cl. 40.1 — shear reinforcement

## III. TYPES OF TRUSSES

Steel roof trusses are one of the cheapest and most convenient roofing systems for various types of buildings. These are most commonly used for industrial buildings, workshop buildings, storage god own, and warehouses. School buildings, offices and residential buildings which have to be constructed quickly arid temporarily at less cost also necessitate use of roof trusses one of the reasons for the economy of roof truss is that its depth at the mid span is greatest and building moment at this point is maximum, so maximum advantage is taken of the available greatest section at the center.

The truss is a frame work in which the members are connected at their ends. to cover a certain area, a series of trusses are placed on wall or two parallel lines of columns. the trusses support the purlins on their principal rafters and the purlins support the roof covering either directly or through common rafters and battens. loads acting on the joints cause only direct stresses in the members. therefore the truss is mainly composed of ties and struts. members of roof trusses are designed as axially loaded tension or compression members if they are slender and their resistance to bending is neglected. sometimes purlins are not placed at the nodes but have to be located in between panel points because of glazing requirements, large panel length etc. in that case the principal rafters are subjected to bending moments and shear forces as well , in addition to direct thrust and should be designed as such. thus the section becomes heavier and this arrangement should be adopted only when the increase in the cost of rafters will be more than balanced by the savings in the sheeting etc. or when it is essentially required from functional requirement of glazing etc.

The lower chord of the trusses may be left straight or may be cambered. Cambering is done for the sake of appearance so that in a large room a series of trusses, one behind the other, may not appear to sag. Cambered trusses work out costlier than straight chord trusses. a sag tie is used to reduce the moment due to self-weight in the long middle tie member and to reduce the resulting deflection of this member.it also carries load due to weight of the ceiling hung from the bottom chord, any.

## IV. PITCH OF TRUSS

Various types of trusses along with the spans for which they can be applied are as below:based on slope or pitch the trusses can be divided into three categories

1) Large pitch - depth is more than one fifth of the span, use fine. Roof truss.
2) Medium pitch - span to depth ratio is between 5 to 12, use Pratt truss
3) Small pitch - span to depth ratio is more than 12, use warren

Truss.Pratt, howe and compound fink trusses are used up to maximum span of 30 meters.pitch requirement:
The pitch of roof is determined by the following criteria:

A) Climate conditions of place as wind, rains and heavy snow.
B) The nature of covering material and overlap.
C) Aesthetic conditions.

## V. METHODOLOGY

*SPACING OF TRUSS AND PURLINS*

Usual spacing of trusses varies from 5 to tom. The range of economical spacing of trusses varies from one fifth to one third of the span. For larger spans smaller spacing to span ratio should be used and vice versa. Where the roof is subjected to only wind loads, larger spacing of trusses would be economical. Quite often spacing of houses is kept at 4m. Spacings 3m to 4.5m for spans upto 15m and 4.5 m to 6m for span 15 to 30 meter are suitable. For larger spans , say 45m and above, it will be more economical to space the trusses 12m to 15m and use longitudinal trusses in place of purlins. The spacing of purlins depends largely on the maximum safe span of the roof covering, glazing sheets etc. Naturally it should be less than or equal to their safe spans when they are directly placed on the purlins. But if the covering is supported through battens and common rafters, the spacing of purlins may be kept at will, preferably located at the panel points of the truss, by varying the spacing and size of battens and common rafters.

*ROOF COVERING*

The most common covering materials for roofs are:

1. Slates.
2. Tiles.
3. lead sheets
4. Zinc sheets.
5. Glass
6. Galvanized iron (corrugated) sheets (G.I Sheets).
7. Asbestos cement sheets (A.C Sheets).
8. Corrugated aluminum sheets.

Out of these the last three are also used for side covering of sheds and godowns. However, the most important roofing materials are still the G.I And A.C Sheets.

## VI. ANALYSIS

All the portal frames are analyzed according to the principles of elastic theory for dead load, live load and wind load as described in ‘2.1. For simplifying the analysis, the loads are assumed to act at four intermediate points on the rafter andat one intermediate point on the column. It is assumed that the frames are supported on an isolated footing. In the case of isolated footing, the idealized support condition for the column can be fixed end condition or hinged end condition depending on the soil strata. If the isolated footing is vresting on hard rock, it can be assumed as a fiied base because the rock will not deform much to allow the rotation of the foundation, and if it is resting on normal soil, it can be assumed as hinged because due to the compressibility of the soil, the foundation can undergo a rotation relieving off the moment. In the case of the columns supported by a pile foundation, the base of the column should be assumed as fixed. Analysis has been carried put for both cases of support conditions, that is, fured and hinged. The portal frames have been analyzed using a plane frame computer programme which is based on stiffness method of analysis. Three degrees of freedom are assumed at each node. In this method, the structure coordinates are specified at all the nodal points including the supports. The number of forces at each node is equal to the possible degrees of freedom per node that are inputted. Then, the stiffness matrix of the structure is assembled and the boundary conditions are incorporated. The resulting simultaneous equations are solved for displacements, using which the member end actions are finallyobtained.

## VII. CALCULATION

Load Combinations for Design of Portal Frames and Column

LOAD COMB 501 0.75X(DL+LL + WL+ZP)
1 0.75 2 0.75 4 0.75
LOAD COMB 502 0.75X(DL+LL + WL-ZP)
1 0.75 2 0.75 5 0.75
LOAD COMB 503 0.75X(DL+LL + WL+XP)
1 0.75 2 0.75 6 0.75
LOAD COMB 504 0.75X(DL+LL + WL-XP)
1 0.75 2 0.75 7 0.75
LOAD COMB 505 0.75X(DL+LL + WL+ZS)
1 0.75 2 0.75 8 0.75
LOAD COMB 506 0.75X(DL+LL + WL-ZS)
1 0.75 2 0.75 9 0.75
LOAD COMB 507 0.75X(DL+LL + WL+XS)
1 0.75 2 0.75 10 0.75
LOAD COMB 508 0.75X(DL+LL + WL-XS)
1 0.75 2 0.75 11 0.75
*
LOAD COMB 509 0.75X(0.9DL+WL+ZP)
1 0.675 4 0.75
LOAD COMB 510 0.75X(0.9DL+WL-ZP)
1 0.675 5 0.75
LOAD COMB 511 0.75X(0.9DL+WL+XP)
1 0.675 6 0.75
LOAD COMB 512 0.75X(0.9DL+WL-XP)
1 0.675 7 0.75
LOAD COMB 513 0.75X(0.9DL+WL+ZS)
1 0.675 8 0.75
LOAD COMB 514 0.75X(0.9DL+WL-ZS)
1 0.675 9 0.75
LOAD COMB 515 0.75X(0.9DL+WL+XS)
1 0.675 10 0.7
LOAD COMB 516 0.75X(0.9DL+WL-XS)
1 0.675 11 0.75
**
LOAD COMB 517 0.75X(DL+LL+SLX)
1 0.75 2 0.75 12 0.75
LOAD COMB 518 0.75X(DL+LL-SLX)
1 0.75 2 0.75 12 -0.75
LOAD COMB 519 0.75X(DL+LL+SLZ)
1 0.75 2 0.75 13 0.75
LOAD COMB 520 0.75X(DL+LL-SLZ)
1 0.75 2 0.75 13 -0.75
*
LOAD COMB 521 0.75X(0.9DL+SLX)
1 0.675 12 0.75
LOAD COMB 522 0.75X(0.9DL-SLX)
1 0.675 12 -0.75
LOAD COMB 523 0.75X(0.9DL+SLZ)
1 0.675 13 0.75
LOAD COMB 524 0.75X(0.9DL-SLZ)
1 0.675 13 -0.75

## VIII. DESIGN OF COLUMN

The design forces at various critical sections of c-c Grid middle column are taken from stead

AT SECTION B:

FACTORED MOMENT, $M_U$ = 893 KN.M

FACTORED AXIAL FORCE = 446 KN

COLUMN HEIGHT (H) =5.5 M ABOVE THE FOUNDATION

SLENDERNESS RATIO ALONG MAJOR AXIS = ( 1.5 X H ) / D

= ( 1.5 X 5.5) /1.0

= 8.25

SLENDERNESS RATIO ALONG MINOR AXIS = ( 0.75 X H ) / D

= ( 0.75 X 5.5) / 0.3
12.19 = 12

HENCE, THE COLUMN IS DESIGNED AS A SHORT COLUMN.
MINIMUM ECCENTRICITY ALONG THE MINOR AXIS ACCORD-
ING TO 25.1.2 OF 18:456-2000

(UNSUPPORTED LENGTH / 500) + ( D / 30)

= (5500 / 500) + ( 1000 / 30)

= 44.33 SAY 45MM

FACTORED BENDING MOMENT ALONG THE MINOR AXIS
= 893 X 0.045 = 38.835 KN.M

## IX. RESULTS OF PORTAL FRAMES ANALYSIS AND DESIGN

The results of the extensive analysis and design work carried out for the large number of portal frame configurations as described in the earlier clauses are presented in the form of detailed design drawings and tables. Whereas the detailed design drawings prepared can be straight away adopted for fabrication and erection, they are naturally strictly valid only for the definite set of assumptions like the material properties,section dimensions and other relevant data chosen as the basis for design. Although one should try to have a joint with sufficient moment resisting capacity, it is always an advantage to have the joints at the point of contraflexure or at least in a zone with very small bending moments. Gives the information about the recommended points at which joints and lifting hooks can be provided in the rafters and in the columns for all . The main reinforcement in the precast column and rafter members need not undergo any change from what has been given in As they are found to be adequate to withstand possible handling stresses also.

## CONCLUSITION

- Analysis and design of steel structure (single bay, without cranes) have been presented for 20m spans, five same spacings, $5.16^0$ roof slopes, same column heights, there different basic wind pressures and different earthquake zones.
- It has been found that the forces in members even due to the lowest basic wind pressure of $1kn/m^2$ are more than that due to the most severe earthquake zone forces.in addition to analysis and design forces, foundation forces have also been given in tables for use in the design of foundations.

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