

Design of an Industrial Shed Using Prestressed Concrete

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ABSTRACT: This project deals with the design of a three bay industrial shed. In our country, a majority of the industrial structures are made of structural steel work. Use of prestressed concrete in industrial structures has not yet gained popularity in our country but there is no doubt that it provides a great challenge to the civil engineers. The advantage and disadvantages of using steel and prestressed concrete are numerous. Maintenance costs are negligible in the case of industrial structures made of prestressed concrete. Prestressed concrete in addition has properties like increased fire resistance, greater fatigue strength, larger impact resistance etc. Which add to its assets? At the same time increased dead weight of the structure and increase in cost of construction are its chief liabilities. There is no doubt that the latter cost can be greatly reduced by repeated use of form work. By diligently manipulating the methods of construction and the resources available it can be seen that a strong case exists for the use of prestressed concrete in industrial structures. There already exist a number of structures which consist of reinforced concrete elements, but when spans become larger prestressing has to be resorted to for obtaining satisfactory sections. Cost of materials is increasing rapidly day by day. But the rate at which the cost of steel is increasing is very high as compared to concrete. Of course, prestressing also involves usage of steel but this amount is not much.

KEYWORDS: Reinforced concrete, prestressed concrete, Fatigue strength, Impact resistance.

I. INTRODUCTION

By diligently manipulating the methods of construction and the resources available it can be seen that a strong case exists for the use of prestressed concrete in industrial structures. There already exist a number of structures which consist of reinforced concrete elements, but when spans become larger prestressing has to be resorted to for obtaining satisfactory sections.

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II. PRESTRESSED CONCRETE

2.1 General:

The prestressing is commonly introduced by tensioning the steel reinforcement. There are some confusion about what is prestressed concrete and the difference between prestressed concrete and reinforced concrete. In prestressed concrete, high tensile steel is used which will have to be elongated a great deal before its strength is fully utilized. Compressive stresses and strains in concrete and tensile set eases and strains in steel. This combined action permits the safe and economical utilization of the two materials which cannot be achieved by simply burying steel in concrete as is done for ordinary reinforced concrete. Therefore, prestressed concrete is nothing but an extension of the applications of the reinforced concrete to include steels of high tensile strength.

2.2 Types of Prestressing Used in Concrete:

Prestressed concrete structure can be classified in number of ways depending upon their features of design and construction as:

- Externally or internally prestressing
- Circular and linear prestressing
- Pre tensioning and Post tensioning
- Partial or full Prestressing

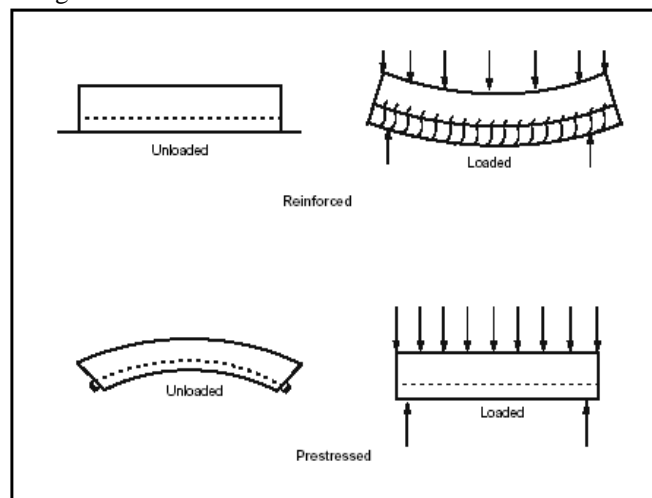


Fig: 1 Reinforced Concrete V/S Prestressed

2.3 Advantages of Prestressed Concrete:

1. It is more durable than reinforced concrete.
2. The section of prestressed concrete member is less compared to RCC member as it utilizes the maximum tension and compression of concrete, so it reduces the cost.
3. Prestressed concrete can be used in long spans as the section of member can be reduced.
4. Shear resistance can be increased using curved tendons.

2.4 Disadvantages of Prestressed Concrete:

1. The major problem with prestressed concrete is that it needs specialized construction machineries like jacks anchorage etc.
2. Advanced technical knowledge and strict supervision is very important.
3. Highly skilled labor is needed for prestressed concrete constructions.

III. ANALYSIS AND DESIGN OF SHED

3.1 Codal Provisions:

All the designs were carried out in accordance with the Draft Indian Standard Code of Practice for Prestressed Concrete (First revision of IS: 1343). Relevant sections of the code have been reproduced below.

3.1.1 Limit State of Collapse (Flexure):

Assumptions: Design for the limit state of collapse in flexure shall be based on the assumptions given below:

- Plane sections normal to the axis remain plane after bending.
- The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.
- For design purposes, the compressive strength of concrete in the structure shall be 0.47 times the characteristic strength.
- The partial safety factor $\gamma_m = 1.5$ shall be applied in addition to this.

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- Area of stress block = $0.36 f_{ck} .Xu$
- Depth of centre of compressive force from the extreme fibre in compression = $0.42Xu$
- For prestressing tendons and in IS: 456-2000 for reinforcement. For design purposes, the partial safety factor γ_m equal to 1.15 shall be applied.

3.1.2 Limit state of collapse (Compression):

Prestressed Concrete compression members in framed structures, where the mean stress in the concrete section imposed by tendons is less than $2.5 N / mm^2$, may be analysed as reinforced concrete compression members in accordance with IS:456-2000 in other cases specialist literature may be referred to.

3.1.3 Limit state of Collapse (Tension):

Tensile strength of the tension members shall be based on the design strength (0.87 times characteristic strength of prestressing tendons) and the strength developed by any additional reinforcement may usually be assumed to be acting at its design stress (0.87 times characteristic strength of reinforcement); in special cases it may be necessary to check the stress in the reinforcement using strain compatibility.

3.1.4 Limit state of Collapse (Shear):

The ultimate shear resistance of the concrete alone, V_c , should be considered at both sections uncracked and cracked in flexure, the lesser value taken and, if necessary, shear reinforcement provided.

3.1.5 Sections uncracked in Flexure:

The ultimate shear resistance of a section uncracked in flexure,

$$V_c = V_{co}$$

$$V_{co} = 0.67bD\sqrt{ft + 0.8 f_{cp} * ft}$$

3.1.6 Sections cracked in Flexure:

The ultimate shear resistance of a section cracked in flexure,

$$V_c = V_{cr}$$

$$V_{cr} = (1 - 0.55 f_{pc} / f_p) \tau_c * bd + M_o * V / M$$

3.1.7 Sections cracked in Flexure:

When V, the Shear force due to the ultimate loads, is less than V_c , the Shear force which can be carried by the concrete, minimum shear reinforcement should be provided in the form of stirrups such that shear reinforcement should be provided in the

$$A_{sv}/b_{sv} = 0.4/0.87f_y$$

3.1.8 Maximum Shear forces:

In no circumstances should the Shear force V, due to ultimate loads exceeds the appropriate values given in table below multiplied by bd .

Table	Maximum Shear Stress					
Concrete grade	M30	M35	M40	M45	M50	M55 and over
Maximum shear stress N/mm ²	3.5	3.7	4.0	4.3	4.6	4.8

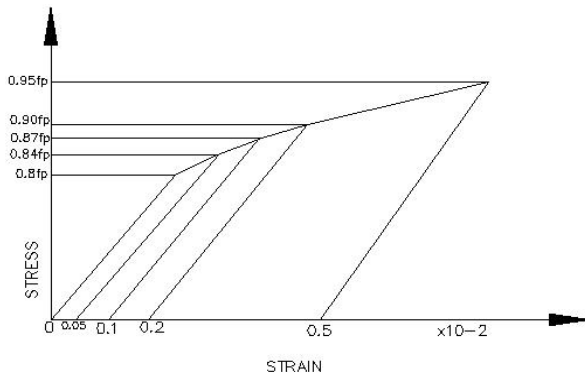


FIG.C. WIRES (STRESS RELIEVED) STRANDS AND BARS

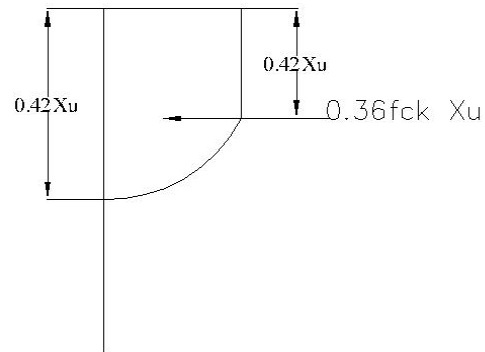


FIG.B. STRESS BLOCK PARAMETERS

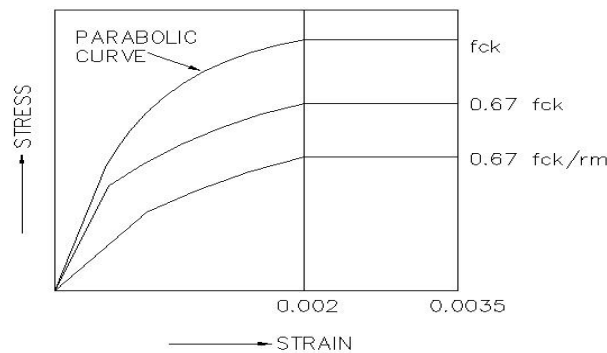


FIG.A. STRESS STRAIN CURVE FOR CONCRETE

3.2 Design of Purlin

Data for purlin design:

Weight of sandwich panel = 17.4 kg/m²

Roof slope = 19.55°

Live load = 75 - (2 x 9.55)
= 55.9 kg/m²

Wind pressure = 100 kg/m²

Spacing of purlins = 1.4m

Weight of sheeting = 17.4 x 1.4
= 24.36 kg/m

Live load = 73.75 m

Self weight = [(0.05 x 0.195) + (0.05 x 0.425)] x 2500
= 77.5 kg/m

Total = 175.61 kg/m

Wind load = 70 x 1.4 = 98 kg/m

Net uplift = 98 - 77.5 - 24.36

= -3.86 kg/m.

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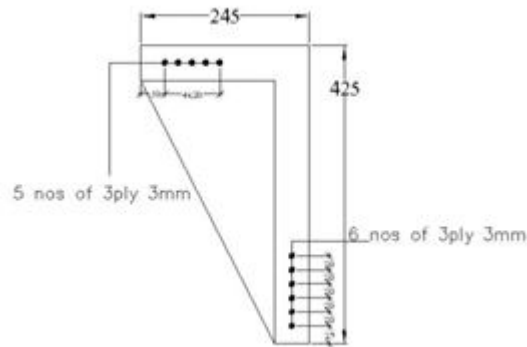
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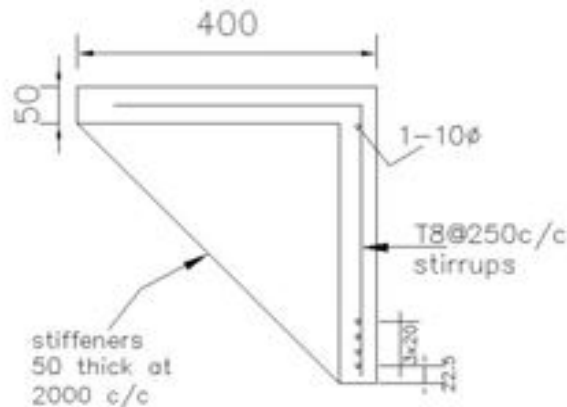
The cross-sectional details of purlin are as shown below: (fig: 12)



3.3 Design of Cladding Runner

Positioning:

- Spacing of runners = 1.7 m
- Dead load on vertical plate = $100 + (17.4 * 1.7) = 130$ kg/m.
- Load on horizontal plate (due to wind) = $1.7 * 70 = 119$ kg/m.
- c/c length of AB = 37.5 cm.
- c/c length of BC = 37.5 cm.

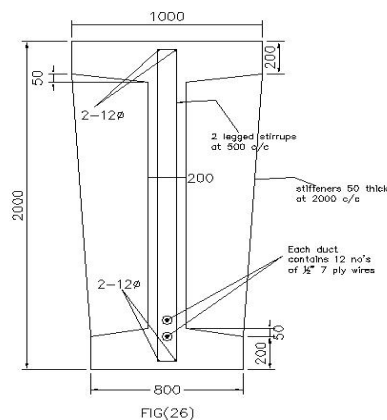
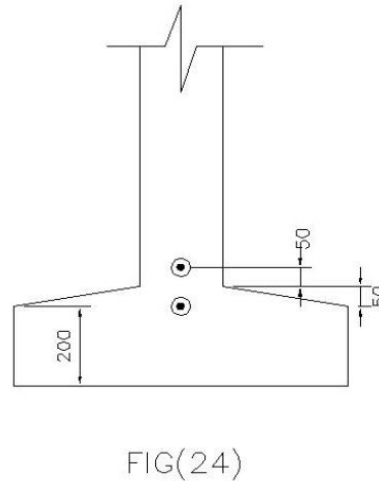
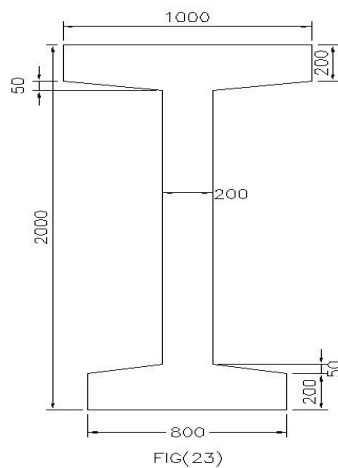


3.4 Gantry Girder:

Design data for E.O.T. cranes:

Capacity (tonnes)	Bay width nominal, (mm)	Static wheel load (Tonnes)	Weight crab (Tonnes)	Overall width of crane	Wheel spacing (mm)	
					1300	+2900 +1300
75	30000	31.0	25.0	7100	1300	+2900 +1300
40	30000	38.5	18.0	7000	-	5600
30	24000	28.5	12.0	6600	-	5000
20	24000	21.0	9.0	6250	-	5000
10	24000	12.7	5.0	5400	-	4200
5	24000	8.7	3.0	5400	-	4200

(All girders have a span of 12.0 metres)



Mid-section of gantry girder
(prestressing cable has parabolic profile)

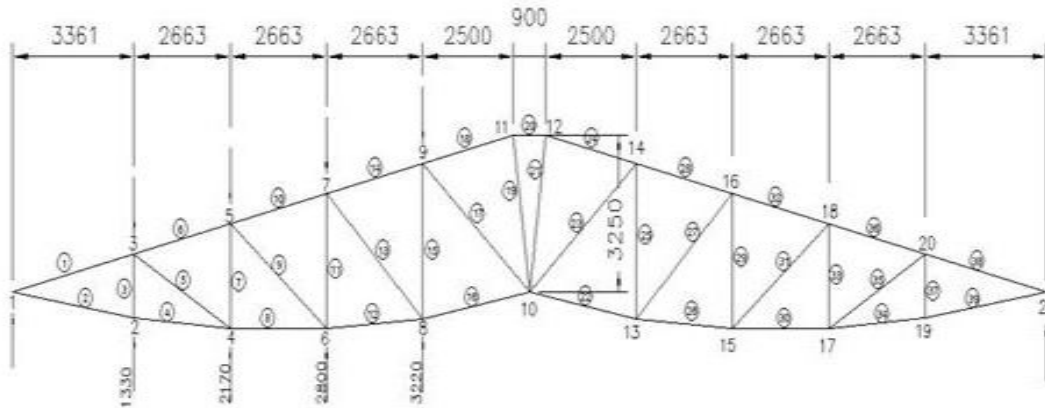
3.5 Design of Roof Trusses:

3.5.1 For Bay BC Spanning 30 Meters:

Member	Area of Steel	
5 and 35	0.7 % = 560 mm ²	6 No.s of 12 Ø
9 and 31	0.7 % = 560 mm ²	6 No.s of 12 Ø
13 and 27	0.7 % = 560 mm ²	6 No.s of 12 Ø
17 and 23	0.7 % = 560 mm ²	6 No.s of 12 Ø
19 and 21	2.8 % = 2240 mm ²	12 No.s of 12 Ø

Design of struts:

Each of the struts has sufficient concrete to resist the compressive forces. Hence nominal reinforcement of 0.8% (i.e. 6 No.s of 12 Ø) are to be provided. Typical sections of all members are shown in the main drawing.

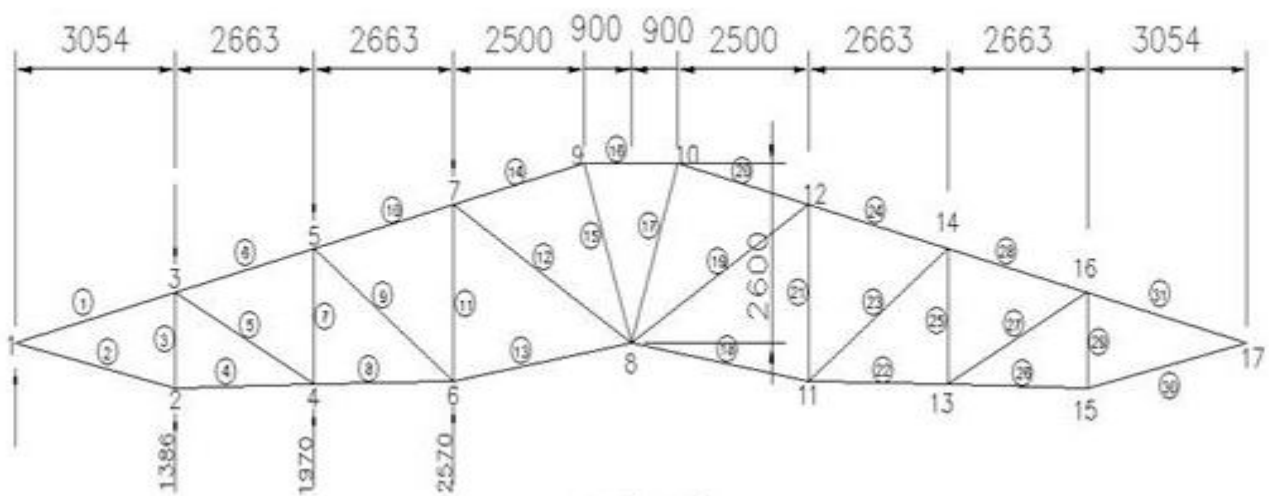


3.5.2 For Bay BC Spanning 24 Meters:

Member	Area of Steel	
5 and 27	0.7 % = 315 mm ²	4 No.s of 12 Ø
9 and 23	0.7 % = 315 mm ²	4 No.s of 12 Ø
13 and 19	0.7 % = 315 mm ²	4 No.s of 12 Ø
15 and 17	2.8 % = 1260 mm ²	12 No.s of 12 Ø

Design of struts:

Only nominal reinforcement of 0.8% (i.e. 4 No.s of 12 Ø) is sufficient for the sections. Typical sections of all members are shown in the main drawing.



IV. CONCLUSION

Precast concrete is coming of age in India. In the past decade a number of factories manufacturing precast elements have sprung up in various parts of our country, though this process has been used extensively in Europe a few decades back. The reasons for turning to precast technology are principally the following:

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- Doubling of labour cost in the last couple of years.
- Non availability of skilled labour.
- Lack of space on site for various construction activities.
- Pressure from the client to expedite the construction process once the designs are frozen.
- Improved technologies to joining of various elements and making them watertight.

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