Design and Analysis of Industrial Shed Using the Pre-Stressed Concrete

Y. Venkata Sai[1], A. Prithvi[2], Produtur Bhanodaya[3]

[1] Assistant Professor, Department of Civil Engineering, Sree Rama Engineering College, Tirupati, Andhra Pradesh, India
[2]Assistant Professor, Department of Civil Engineering, Sree Rama Engineering College, Tirupati, Andhra Pradesh, India
[3]PG Scholar, Department of Civil Engineering, Sree Rama Engineering College, Tirupati, Andhra Pradesh, India

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 prestressingdd 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, structural steel etc.,

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. 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. 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. 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. Concrete in which there have been introduced internal stress of such magnitude and distributions that stresses resulting from given external loading are counteracted to a desires degree in reinforced cement concrete members are called Prestressed Concrete. 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. If the high tensile steel simply buried in the concrete as in ordinary reinforced concrete, the surrounding concrete will have to crack very seriously before the full strength of the steel is developed. Hence it is necessary to prestrech the steel with respect to concrete. By pre-streching and anchoring the steel against the concrete, desirable stresses and strains are produced in both materials The configuration of the truss is such that the diagonal members have zero force in them. This is advantageous since the diagonal members in a truss of normal configuration will be in tension and these warrants prestressing which in turn will result in increased costs. On re-analyzing a truss of above mentioned configuration as a rigid frame, it is seen that tension is induced in the diagonal members along with a moment. But this is minimal and can always be taken care of by reinforcing steel in the member

The organizational framework of this study divides the research work in the different sections. The Literature review is presented in section 2. Further, in section 3 shown Design and Analysis of Shed and Conclusion are presented by last sections 4.

LITERATURE REVIEW

``AIJAZ AHMAD ZENDE, PROF. A. V. KULKARNI, ASLAM HUTAGI As it is seen in the present work, the weight of steel can be reduced to 27% for the hostel building ,providing lesser dead load which in turn offers higher resistance to seismic forces. Comparison in the second example showed that even though PEB structures provides clear span, it weighs 10% lesser than that of Conventional Buildings. For longer span structures, Conventional buildings are not suitable with clear spans. Pre-engineered building are the best solution for longer span structures without any interior column in between as seen in this present work, an industrial structure has been designed for 88m. With the advent of computerization, the design possibilities be came almost limitless. Saving of material on low stress area of the primary framing members makes Pre-engineered buildings more economical than Conventional steel buildings especially for low rise buildings spanning up to 90.0 meters with eave heights up to 30.0 meters. PEB structures are found to be costly as compared to Conventional structures in case of smaller pan structures.

D.RAKESH, V.SANJAY GOKUL, G.AMAR - In this study comparison of displacement and steel quantity is done in conventional type of truss and pre engineered structure. In this study pre engineered structure shows less displacements in columns and less consumption of steel. Pre-engineered steel structures building offers low cost, strength, durability, design flexibility. Based on the analytical and design results thereon of conventional and pre-engineered steel buildings. Comparison in the second example showed that even though PEB structures provides clear span, it weighs 10% lesser than that of Conventional Buildings. For longer span structures, Conventional buildings are not suitable with clear spans. Pre-engineered building are the best solution for longer span structures without any interior column in between as seen in this present work, an industrial structure has been designed for 88m. With the advent of computerization, the design possibilities became almost limitless .Saving of material on low stress area of the primary framing members makes Pre-engineered buildings more economical than Conventional steel buildings especially for low rise buildings spanning upto 90.0 meters with eave heights up to 30.0 meters. PEB structures are found to be costly as compared to Conventional structures in case of smallers pan structures.

D.RAKESH, V.SANJAY GOKUL, G.AMAR - In this study comparison of displacementand steel quantity is done in conventional type of truss and pre engineered structure. In thisstudy pre engineered structure shows less displacements in columns and less consumptionof steel. Pre-engineered steel structures building offers low cost, strength, durability, design flexibility. Based on the analytical and design results thereon of conventional and pre-engineered steel buildings.

.JAYAVELMURUGAN, J.R.THIRUMAL, PADMANABHAN HARIDAS - Steel is such a versatile material that every object we see in our daily life has used steel directly or indirectly. There is no viable substitute to steel in construction activities. Steel remains and will continue to remain logical and wide choice for construction purpose, environmentallyalso,asmuchofthesteelusedisrecycled. Steelbuilding offers more design and architectural flexibility for unique or conventional styling .Its strength and large clear spans mean the design is not constrained by the need for intermediate support walls. As your requirements changes over the years, you can reuse, relocate, & modify the structure.

ADITYA DUBEY - It is seen that weight of pre-engineered building depends on bays pacing, with increasing bay spacing up to certain spacing, the weight reduces and further increase makes the weight heavier. Comparison shows that even though PEB structure provides clear span, it weighs 10% lesser than conventional steel buildings. It can be seen that PEB's reduce the steel used by 36% than that required for the CSB. Reduction in the steel quantity definitely reducing the dead load. It is seen that due to reduction in dead load in PEB, size of foundation also reduces. And this is the main factor for the cost reduction

DESIGN AND ANALYSIS OF SHED

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.

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 γm =1.5 shall be applied in addition to this.
- Area of stress block = 0.36 fck. 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 γm equal to 1.15 shall be applied.

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 / mm2 , may be analysed as reinforced concrete compression members in accordance with IS:456-2000 in other cases specialist literature may be referred to.

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.

Limit state of Collapse (Shear):
The ultimate shear resistance of the concrete alone, Vc , should be considered at both sections un cracked and cracked in flexure, the lesser value taken and, if necessary, shear reinforcement provided.

Sections un cracked in Flexure:
The ultimate shear resistance of a section un cracked in flexure, Vc= Vco

Sections cracked in Flexure:
The ultimate shear resistance of a section cracked in flexure, Vc= Vcr

Sections cracked in Flexure:
When V, the Shear force due to the ultimate loads, is less than Vc , 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 Asv/bsv = 0.4/0.87f

Maximum Shear forces:
In no circumstances should the Shear force V, due to ultimate leads 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

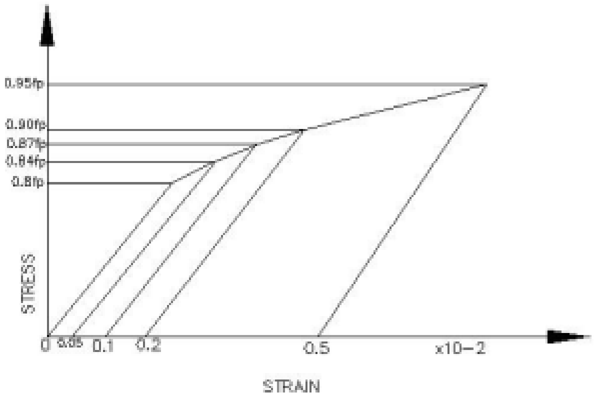


Fig :Wires

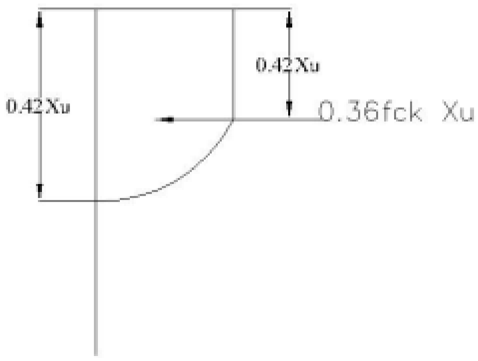


fig: Stress Block Parameters

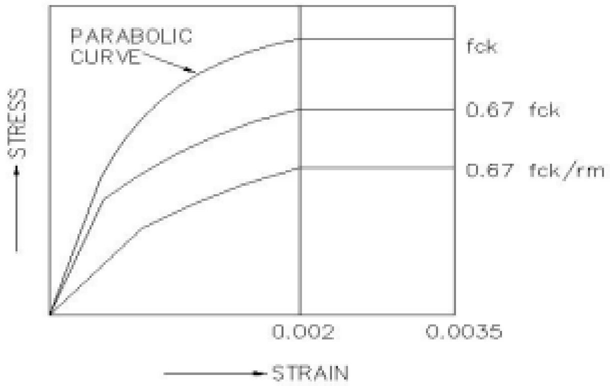
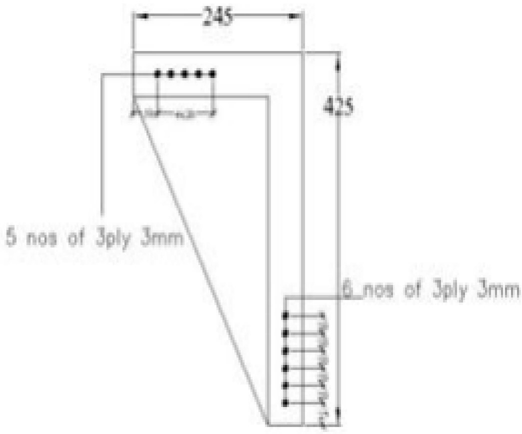


Fig: stress strain curve for concrete

Design of Purlin Data for purlin design:

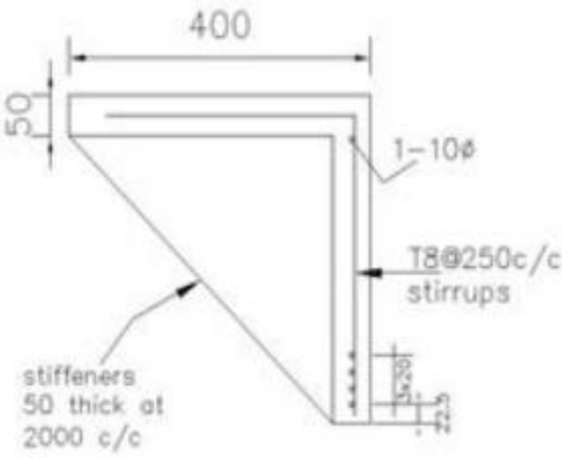
Weight of sandwich panel	= 17.4 kg/m2
Roof slope	= 19.550
Live load	= 75-(2 x 9.55) = 55.9 kg/m2
Wind pressure	= 100 kg/m2
Spacing of purlins	= 1.4m
Weight of sheeting	= 17.4 x 1.4 = 24.36 kg/m
Live load	= 73.75 m
Self weight	= [(0.05 x 0.195)+(0.05 x 0.425)] x 2500 = 77.5 kg/m
Total	= 175.61 kg/m
Wind load	= 70 x 1.4 = 98 kg/m
Net uplift	= 98-77.5-24.36 = -3.86 kg/m

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



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.

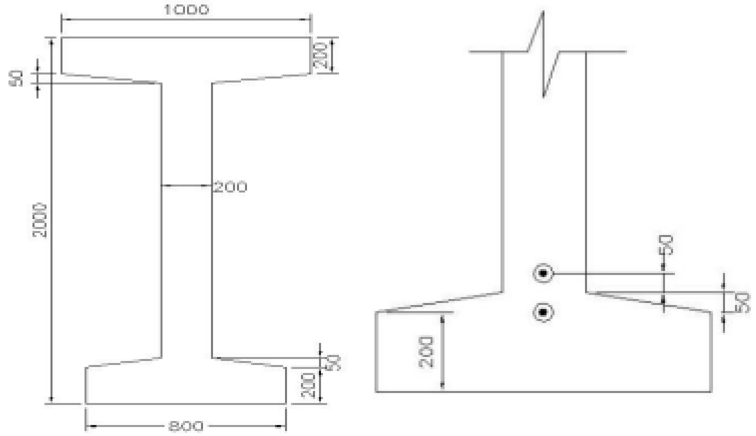


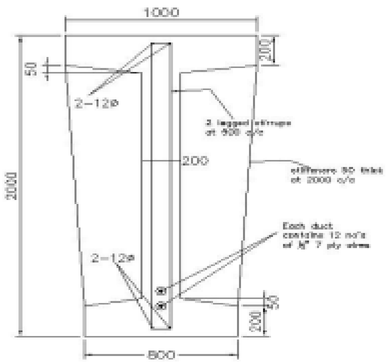
Gantry Girder:

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)	
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)



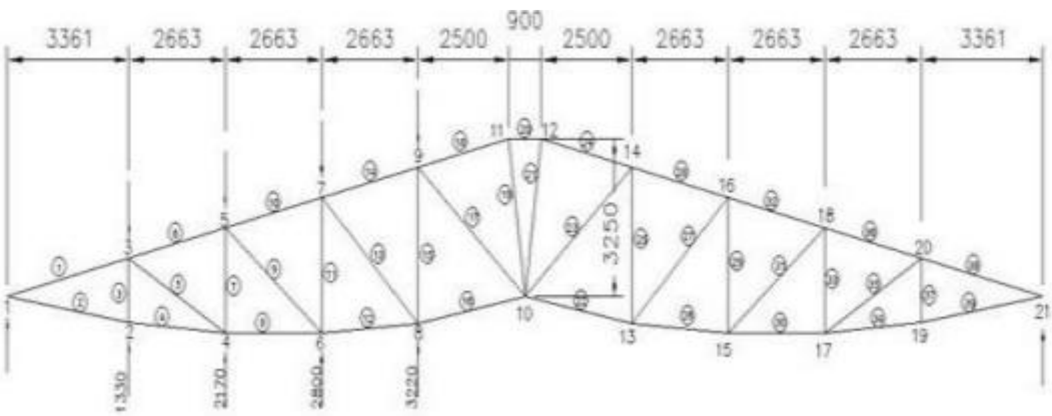


Design of Roof Trusses:

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 % = 2240mm^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.

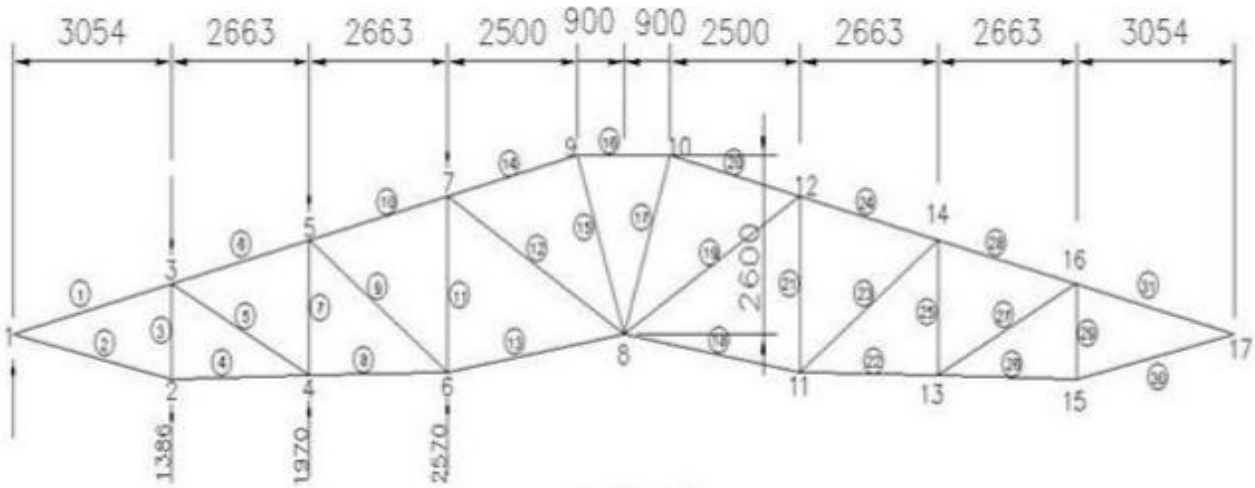


For Bay BC Spanning 24 Meters:

International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 12 Issue 2, February-2023, Impact Factor: 7.957

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.



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 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 water tight.
- Availability of vendors to provide pre stressing solutions.
- Availability of mechanized equipment to lift heavy elements and put the min place.
- Availability of form finishes in concrete is convincing architects also to consider pre cast pre stress solution.

Keeping in view the above it would be prudent to going for precast prestressed concrete to replace conventional cast-in-situ/ structural steel. As the project submission shows it is technically possible to replace all elements with precast pre stressed concrete. Cost wise this may be initially on the higher side but we are sure with time the cost will eventually have to come down. Further there will be substantial reductions in the annual maintenance of a structure where structural steel is replaced with prestressed concrete. This aspect will also have to be considered while making a choice of construction material.

ACKNOWLEDGMENT

The satisfaction that accompanies with the successful completion of the model would be put incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crown all the efforts with success.

REFERENCES

[1]. Lin,t.y., design of prestressed concrete structure.
[2]. Murashev, v.l., sigalov, E.y. and baikov, v.n., design of reinforced concrete structure.
[3]. Sioalov, E.y and Stroongin, s. reinforced concrete.
[4]. code of practice for prestressed concrete (first revision of is:1343)
[5]. IS: 456 Indian standards for plain and reinforced concrete.
[6]. Dale C. Perry, Herbert S. Saffir, James R. McDonald, “Performance of Metal Buildings in High Winds”, Journal of Wind Engineering and Industrial Aerodynamics, 36 (1990) 985-999 985, Elsevier Science Publishers.
[7]. Syed Firoz, Sarath Chandra Kumar B, S. Kanakambara Rao,” Design Concept of Pre Engineered Building”, IJERA Vol. 2, Issue 2,Mar- Apr 2012, pp.267-272.
[8]. IS875- Part II (1987), Indian Standard Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures.
[9]. IS1893- Part I (2002) Indian Standard Criteria for Earthquake Resistant of Design of Structure