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Comparative Study of Design Wind Pressures for Steel Industrial Shed According toIS875: 1987 (Part 3), IS875:2015 (Part 3) and MBMA Code

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Abstract

The paper is related to calculation of wind load on structural members of steel industrial shed structures. Analysis of truss is done for different factors of terrain categories, class of structure, topography, height & structure size, and calculated wind loads as per provisions of Indian Standard Code. The paper presents comparative results of study to urge optimum design of steel industrial shed structure. This study gives a thought to hold out the planning of an industrial warehouse. Design of structural members with maximum efficiency & minimum cost is always a challenge to the Architects & Engineers. The most important & frequently encountered combination of construction materials is that of steel & concrete with application in multistory building. This provides better & more realistic assessment of cost involved for having any structure. As a result, there has been an increasing global awareness about the durability aspect of building. The study is achieved by deigning a typical frame of a proposed Industrial Warehouse building using both the concepts and analyzing the designed frames using the structural analysis and design software Staad.Pro.

Keywords: Terrain Category, Topography, Load Combination ,Dead Load, Live Load, Wind Load, AutoCad

1. Introduction

Steel is a material which has high strength per unit mass. Hence it is used in construction of structures with large column-free space. An industrial shed is basically a framed structure formed by connecting various members at their ends to form a system of triangles, arranged in pre-decided pattern depending upon the span, type of loading and functional utilities of client.. In industrial buildings, steel trusses are commonly used. A pitched roof is a roof made up of two angled pieces which meet in the middle, with gables at either end. A pitched roof is a roof with a sloping surface or surfaces. Its angle is usually more than 20 degrees. Some definitions of pitched roof are more specific - requiring a pitch of more than 10 degrees, or a roof with two slopes that meet at a central ridge. Pre-engineered building: Pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated. The basis of the PEB concept lies in providing the section at a location only according to the requirement at that spot.

Any building used by the industry to accommodate the production activity, stock raw materials, stock finished product before supply is known as an industrial building. Roof truss and the portal frame are used to cover and shelter the area of an industrial building. As per the requirement of an industrial building, the suitable kind of roof truss and the portal frame is utilized. A roof truss is designed for dead load, live load, wind load and their combinations as per Indian Standards. An economy of an industrial building depends on the configuration of the structure, type of roof truss and portal frame utilized, forces acting on building and selection of steel sections needed as per force employed.

2. Objective

The main objective of this paper is an attempt is made to optimize the quantity of steel consumption in PEB structures.

1. To determine the wind coefficients which result in the minimum quantity of steel are noted.
2. To differentiate the provisions for wind load given by IS875:1987 (PART3), IS875:2015(PART 3) MBMA 1996AISC
3. To study the researches being carried out with wind loading on industrial sheds.
4. To give the optimum and economical requirement of steel for the economic construction.

3. Warehouse Particulars

Type of building: Partially open

Type of structure: Industrial Structure

Location: Nagpur, Mumbai, Guntur

Basic wind speed: 44m/s

Type of building: Industrial Warehouse

Height: 6.00 m

Number of spans: 1 Nos

Single span width: 16.00 m

Total span width: 90.00 m

Number of bays: 13 Nos

Single bay length: 7.5.00 m

Support condition: Pinned

Coefficient of internal friction: (+/- 0.5)

PEB roof slope: 10 degree

Design considerations as per IS 875:1987 and IS 875 :2015 PART I, II, III have been employed in calculating loads. A-type geometry is explored in the work.

4. Loads

The loads acting on the structure includes dead load, live load, snow load, wind load, earthquake load, crane load, erection load, accidental load, etc.The load calculation for the structure can be carried out in accordance with IS : 875 – 1987 and IS : 1893 - 2000. For this structure wind load is critical than earthquake load, Hence, load combinations of dead load, live load, crane load and wind load are incorporated for design.

4.1 Dead Load

Dead load comprises of self-weight of the structure, weights of roofing, G.I. sheets, gantry girder, crane girder, purlins, sag rods, bracings and other accessories. The dead load distributed over the roof is found to be 0.438 kN/m excluding the self weight. This load is applied as uniformly distributed load over the rafter while designing the structure by PEB concept. For CSB concept the load is applied as equivalent point load of 0.657 kN at intermediate panel points and half the value at end panel points over the roof truss. shows the procedure for dead load calculation.

4.2 Live Load

According to IS : 875 (Part 2) – 1987, for roof with no access provided, the live load can be taken as 0.75 kN/m2 with a reduction of 0.02 kN/m2 for every one degree above 10 degrees of roof slope, explicitly as in [6]. Total uniformly live load acting on the rafter of the PEB structure is found to be 4.5 kN/m. Similar to dead load, live load is also applied as point loads at panel points for CSB structure and is found to be 6.75 kN at intermediate panel points and half this value at end points. Reference [6] shows the procedure for live load calculation.

4.3 Wind Load

Wind load is calculated as per IS : 875 (Part 3) – 1987. The basic wind speed for the location of the building is found to be 39 m/s from the code, The wind load over the roof can be provided as uniformly distributed load acting outward over the PEB rafter, and as point loads acting outward over the CSB panel points. For side walls, the wind load is applied as uniformly distributed loads acting inward or outward to the walls according to the wind case.

In this paper we calculated wind load calculations for 3 different cities as Nagpur, Mumbai and Guntur having same basic wind speed with reference to IS 875 (PART 3):1987 and IS 875 (PART3):2015.

4.4 Load Combinations

Load combinations can be adopted according to IS : 800 – 2007. Sixteen different load combinations adopted for the analysis of the frame in both the concepts, and are listed as follows:

1) 1.5DL+1.5LL+1.5CL1

2) 1.5DL+1.5LL+1.5CL2

3) 1.5DL+1.5LL+1.5CL3

4) 1.5DL+1.5LL+1.5CL4

5) 1.5DL+1.5WL(θ=0+)

6) 1.5DL+1.5WL(θ=90+)

7) 1.5DL+1.5WL(θ=0-)

8) 1.5DL+1.5WL(θ=90-)

9) DL+LL+CL1

10) DL+LL+CL2

11) DL+LL+CL3

12) DL+LL+CL4

13) DL+WL(θ=0+)

14) DL+WL(θ=90+)

15) DL+WL(θ=0-)

16) DL+WL(θ=90-)

Note: DL – Dead Load

LL – Live load

CL – Crane Load

WL – Wind load

5. Staad. Pro Procedure

The Staad. Pro software package is a structural analysis and design software which helps in modeling, analyzing and designing the structure. The software supports standards of several countries, including Indian standard. The procedure includes modeling the structure, applying properties, specifications, loads and load combinations, analyzing and designing the structure. This software is an effective and user-friendly tool for three dimensional model generation, analysis and multi-material designs.

Figure 1. 2D Model of structure on Staad Pro & 2D frame showing Dead Load

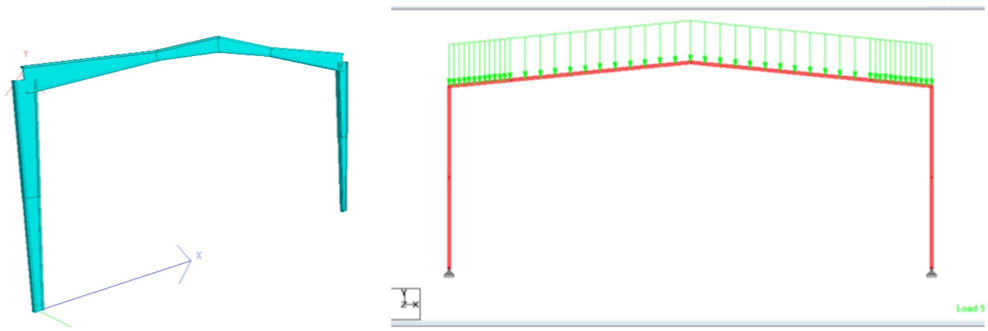


Figure 2. 3D frame showing Dead Load & 2D frame showing Live Load

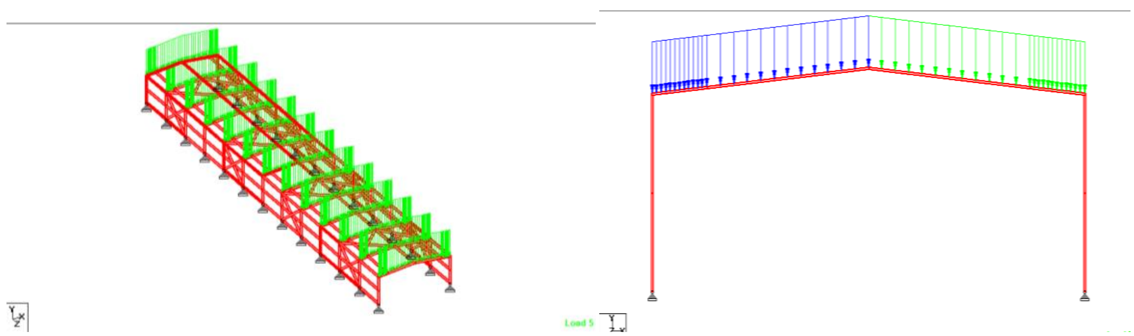


Figure 3. Wind load acting on Wall A Wind load acting on Wall B

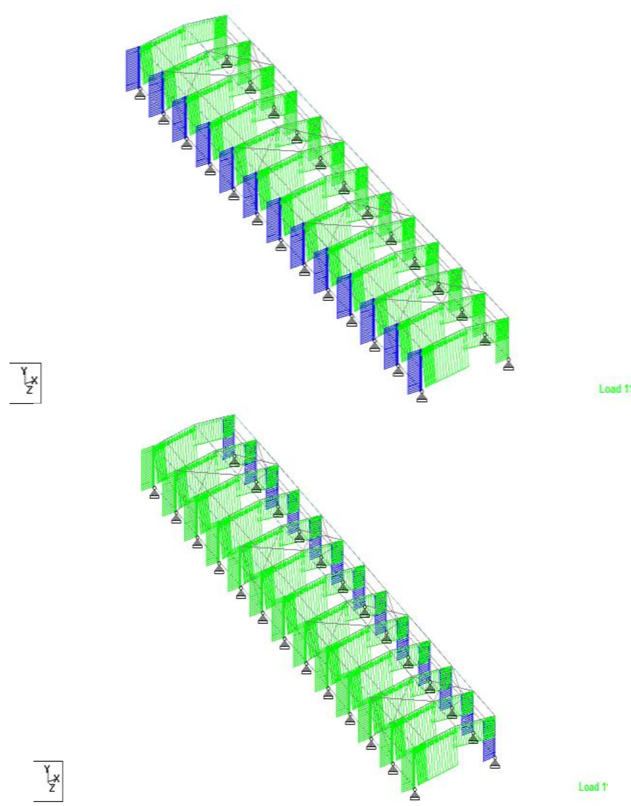
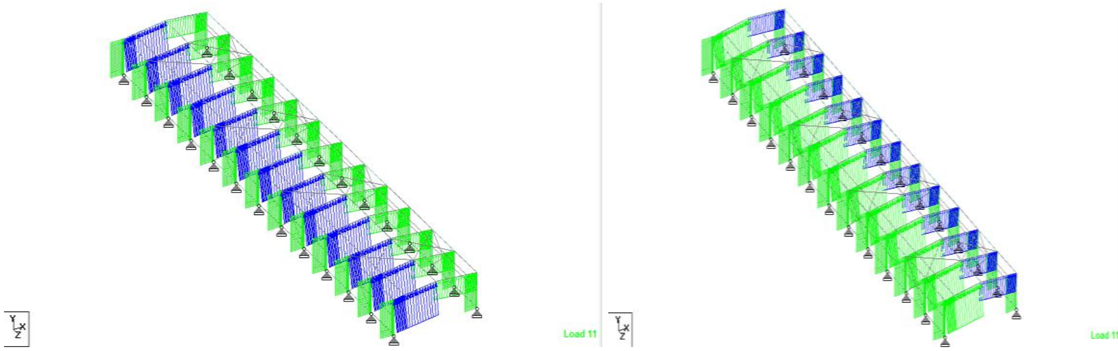


Figure 4. Wind load acting on Roof C & Wind load acting on Roof D



6. Results

Comparison of Wind Forces from Different Codes

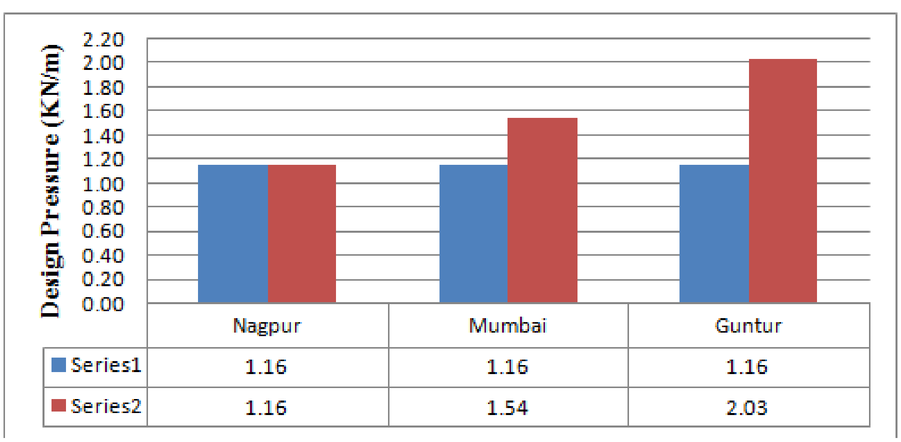
Wind loads are calculated by taking single terrain category of sub-urban type terrain and basic wind speed of 44m/s. Comparison of equations of all the codes to calculate forces are given.

1. Design Pressure v/s cities: It is observed that there is increase in Design wind presuure by 24% and 43% by IS 875:1987PART 3and IS875:2015PART 3 respectively.

Table 1

Code	**IS 875 (PART3)**		
	1987	2015	2015
City	Nagpur	Mumbai	Guntur
Vb(m/s)	44	44	44
Vz(m/s)	44	50.6	58.19
Pz(KN/m2)	1.16	1.54	2.03
%Increase	-	24%	43%

Figure 1. Design Pressures v/s Cities (Vb=44m/s)



2. Wind Pressure coefficients by IS code and MBMA

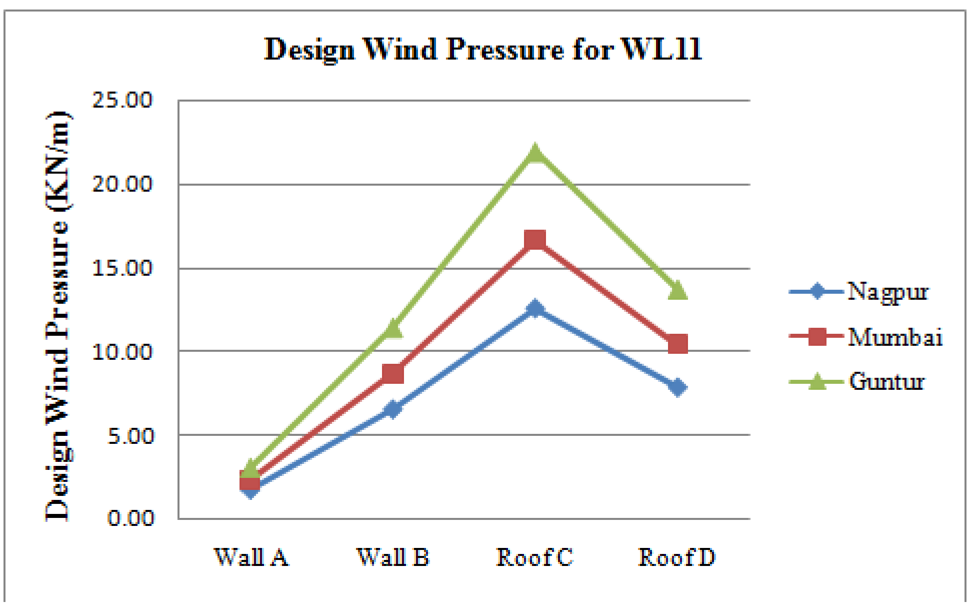
Pressure coefficients by IS Code for Partially opened building

IS CODE	AA	CC	DD	BB
11	0.5	1.14	0.9	0.75
12	-0.75	0.9	1.14	-0.2
13	1.2	0.44	-0.1	0.25
14	-0.25	-0.1	0.44	1.2
15	-1.0	1.3	1.3	1.0
16	1.0	1.3	1.3	-1.0

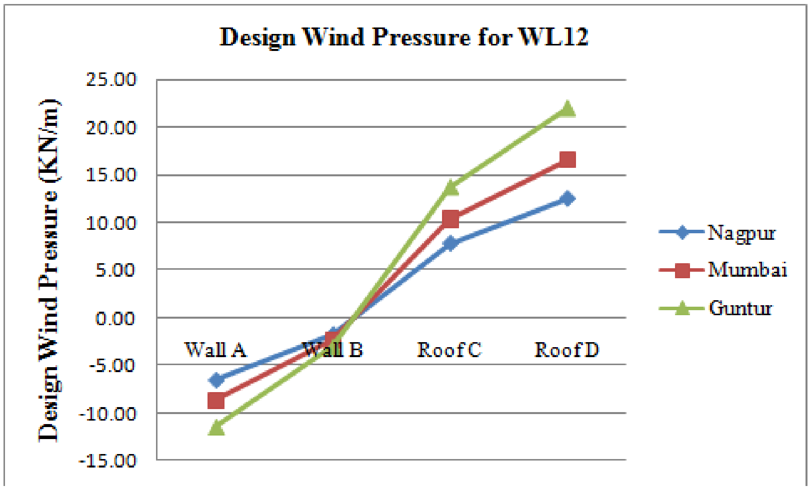
3. Pressure coefficients by MBMA Code

MBMACODE	AA	CC	DD	BB
11	0.25	1.00	0.65	0.55
12	-0.55	0.65	1.00	-0.25
13	0.65	0.6	0.25	0.15
14	-0.15	0.25	0.6	0.65
15	-0.70	1.00	0.65	0.70
16	0.70	0.65	1.00	-0.70

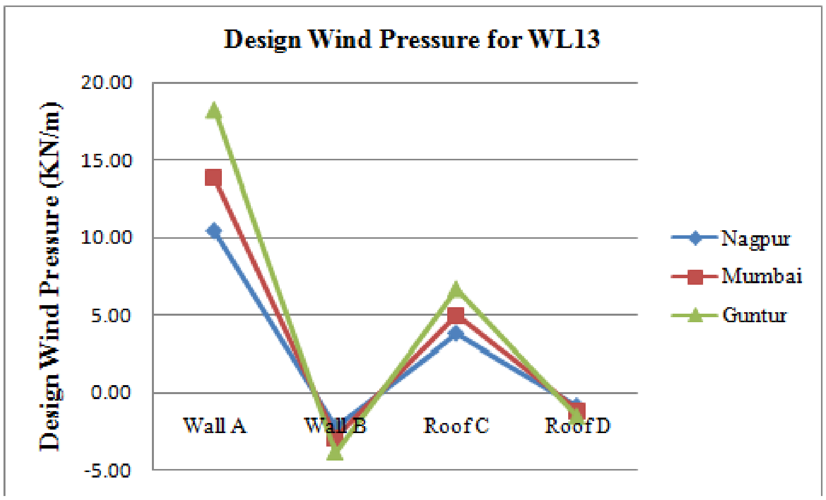
4. Wind Loads for Case WL11



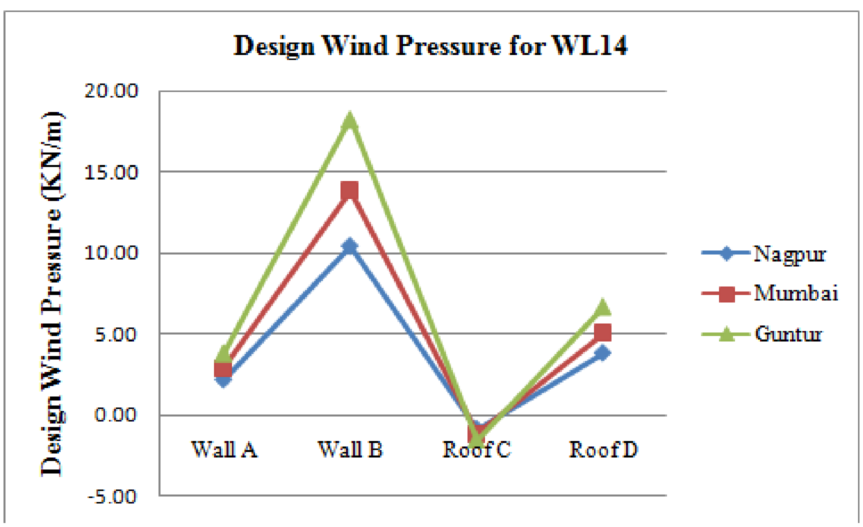
5. Wind Loads for Case WL12



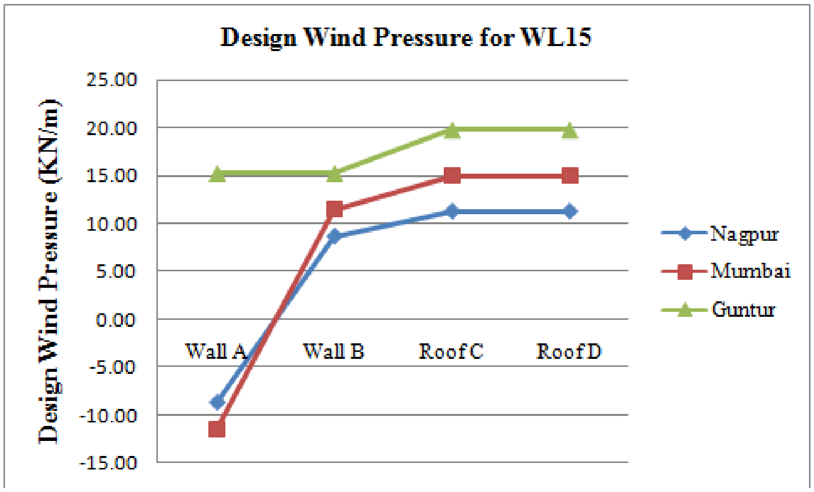
6. Wind Loads for Case WL13



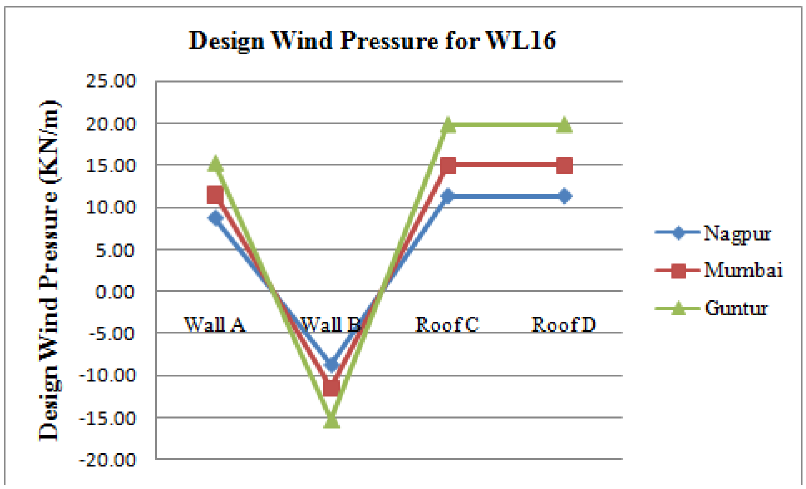
7. Wind Loads for Case WL14



8. Wind Loads for Case WL15



9. Wind Loads for Case WL16



10. Minimum Section Sizes Designed For Nagpur City

Member NO	**section**	**depth of web (dw)mm)m m**	**web thick (tw) mmw) mm**	**flange width (fw)mmmm**	**flange thick(tf) mm**	**Actual ratio**
101,201	Taperd	300-450	5	150	5	0.97
102,202	Taperd	450-600	5	150	5	0.93
301		600-300	5	150	5	0.90
302		300-300	5	150	5	0.97
401	Taperd	300-300	5	150	5	0.97
402		300-600	5	150	5	0.90

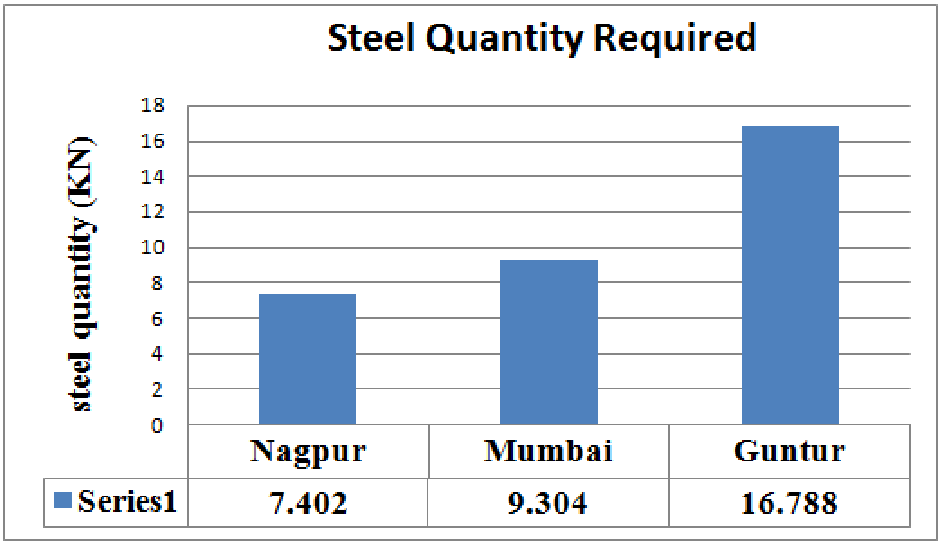
11. Minimum Section Sizes Designed For Mumbai City

Member No	section	depth of web (dw)mm)m m	web thick (tw) mmw) mm	flange width (fw)mmmm	flange thick(tf) mm	Actual ratio
101,201	Taperd	300-600	6	150	6	0.93
102,202	Taperd	600-700	6	150	6	0.93
301		750-400	5	150	5	0.97
302		400-400	5	150	5	0.94
401	Taperd	400-400	5	150	5	0.94
402		400-750	5	150	5	0.97

12. Minimum Section Sizes Designed For Guntur City

Member No	section	depth of web (dw)mm)m m	web thick (tw) mmw) mm	flange width (fw)mmmm	flange thick(tf) mm	Actual ratio
101,201	Taperd	300-500	12	180	12	0.95
102,202	Taperd	500-750	12	180	12	0.91
301		900-600	10	180	10	0.92
302		600-600	8	180	8	0.9
401	Taperd	600-600	8	180	8	0.9
402		600-900	10	180	10	0.92

Graph Showing Quantity of Steel Required for Each City



7. Conclusion

Based on the analysis results obtained the following conclusions are made:-

1. “Serviceability Criteria”: Deflection limits by IS code are higher than deflection limits by MBMA.
2. There is considerable change in the increase in quantity of steel only in coastal zone. It is better and efficient if wedesign according to old version.
3. The main difference between the Indian Code (IS800-2007) to the other equivalent American Codes are in the classification of the cross-section of the steel member.
4. Limiting Ratios of section are higher weight in IS800:2007 than MBMA
5. Section with very thin webs are are used in order toreduce the weight of section.
6. Live load is 0.75 KN/m2 in IS code & whereas it is 0.57KN/m2 in MBMA. Thus, concluded that loading as per Indian codes is greater than MBMA code.
7. It was observed in industries most of the projects done with AISC/MBMA. Reasons to preferring AISC/MBMA Code are IS 800:2007 has not considered slender sections which are often encountered in cold formed thin sections because there is another code IS 801 for this. May be that is the reason people are using AISC code & the main reason to use the AISC code for PEB structures is due the fact that it leads to an economical structural solution as compared to the Indian Code.

6. Future Scope

Purchase of raw material is an integral part of any business. These raw materials need to be kept in a safe place, hence in order to overcome this need warehouse are constructed. In future due to rapid growth in industrialization there will occur a great need to construct economically efficient warehouses. The design will serve the purpose of storage of goods.

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