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COMPARITIVE STUDY OF ANALYSIS & DESIGN FOR INDUSTRIAL SHED BY WSM AND LSM

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Abstract - *For a design engineer the integrity, safety and economic feasibility of the structure are of utmost importance. In the earlier general code of constructions in steel (i.e., IS 800: 1984), the design philosophy used was the Working Stress Method which ensures that the working stress in the member is computed under the action of the working loads, and is less than the permissible stress. Since this method was focusing only on the serviceability at working loads, the Limit State Method of design was introduced in the latest revision of code (i.e., IS 800:2007). This approach for design is based on attainment of the relevant limit state. Since in India it was introduced recently, it is an important task to study these two design philosophies so as to find most appropriate and economical design philosophy as per the requirement of the design engineer. As a result, we looked at a variety of literature evaluations on this topic, which is significant in the industry. We completed our analysis on such a structure because there were no articles especially on long span large height industrial sheds. This paper presents, the comparative study of the Working Stress Method (WSM) and Limit State Method (LSM) through analysis and design of a large span and a large height industrial shed equipped with gantry girder and the results are concluded in the form of tables and graphs.*

Key Words: **Industrial Shed, LSM, WSM, Large Span Large Height, Weight Optimization, Economy**

1. INTRODUCTION

We are living in an age that is dominated by the wonders of technology. Globalization has influenced architecture and evolved from short stone and wood structures to steel structures. Today, many buildings and infrastructure are built with structural steel which has made it the world's most dependable building material. The current growth in industrialization is greatly influenced by the development of structural steel as a building material mainly since they are sturdy, long-lasting, and easy to construct. Steel structures are utilised for a range of structures in modern construction, including massive industrial buildings. An Industrial shed is generally a steel structure that can be used for various purposes.IS 800:2007 was introduced as limit state method of design for steel structures superseding IS 800:1984 which was based of Working Stress Method.

1.1 Aim & Objective

The aim of this paper is to compare a Large Span and Large Height Industrial Shed by Limit State method and Working Stress method of design.

Thus, the objective is to Analyze and Design an Industrial Shed using Limit State Method and Working Stress Method and to compare both the methods in order to present a more cost-efficient structure.

2. LITERATURE REVIEW

Various research papers have been presented by the researchers till date. Some important papers are discussed below:

Prof. Ravindra Bhimrao Kulkarni and Rohan Shrikant Jirga published a paper on the design of tension members using the limit state approach and the working stress approach. For both equal and unequal angles, comparisons were made using design samples, charts, and graphs. They came to the conclusion that designing tension members using angle sections by the limit state approach is more cost effective than using the working stress approach, which saves between 12 to 54 % of economy [1].

M. Krishnamoorthy and D. Tensing conducted research on compression member design using IS 800: 2007 and IS 800: 1984, comparing the design of columns with both ends fixed based on strength to weight ratio and load carrying capacity against different sections for column lengths of 2m, 3m, and 4m. In this study, they manually designed column members using FOS, load combinations using respective design methodologies and showed comparable results using graphs for different concepts. As a result, it was determined that WSM has a marginally larger percentage of load-carrying capacity than LSM, and the strength-to-weight ratio is governed by weight per unit length [2].

In a work presented by Trilok Gupta and Ravi K. Sharma, comparative study and analysis of trusses made of three

types of sections (pipe, tube, and angle) was done for Limit State Method and Working State Method using STAAD Pro software. They found that Limit State Method (LSM) of design consumes less steel and provides consistent safety and serviceability. And also observed that Tube Section is the most economical section when designed by LSM being the lightest among the three sections and aesthetical appearance is good [3].

Prof. S.S. Patil and L.A. Pasnur used the Limit State Method and the Working Stress Method to perform a detailed comparison analysis on structural components such as tension and compression elements. For the design of angle sections, the respective design philosophies were applied, and after receiving the findings, a full comparison was made and illustrated using graphs of load carrying capacity vs thickness, as well as varied lengths for both methodologies. They concluded that for tension members, utilizing the angles sections designed by Limit State design philosophy is less expensive than using the Working Stress design philosophy, with savings ranging from 12 to 54 percent, and for compression members, IS 800-1984 gives somewhat larger load carrying capacity than IS 800-2007, with a gain of about 15%. As a result, to attain economy the working stress method is preferrable over limit state method [4].

Dinesh Kumar Gupta and Mirza Aamir Baig aimed to compare analysis of the Limit State Method and Working Stress Method for an industrial steel storage shed. The analysis was carried out in STAAD Pro software. They observed that the area of the section when designed using LSM was approximately 12% less as compared to the WSM. Thus, they concluded that for structural design, the limit state technique is more dependable and cost-effective than the working stress method [5].

Chetan Jaiprakash Chitte, a researcher, used IS 800:2007 and IS 800:1984 to analyze and design Pratt Truss. STAAD.Pro was used to do the analysis, while the design was done manually. He observed that the limit state method saves 23 % in steel weight when compared to the working stress method, and thus concluded that the limit state method is more dependable and cost-effective for designing roof trusses [6].

3. METHODOLOGY

Analysis & Design of an industrial shed of length 60m consisting of a portal frame with bay spacing of 6m, having 24m span and 24m height up to eaves level equipped with a gantry girder at 18m for boiler house of sugar factory using Working Stress Method of design and Limit State Method of design is compared.

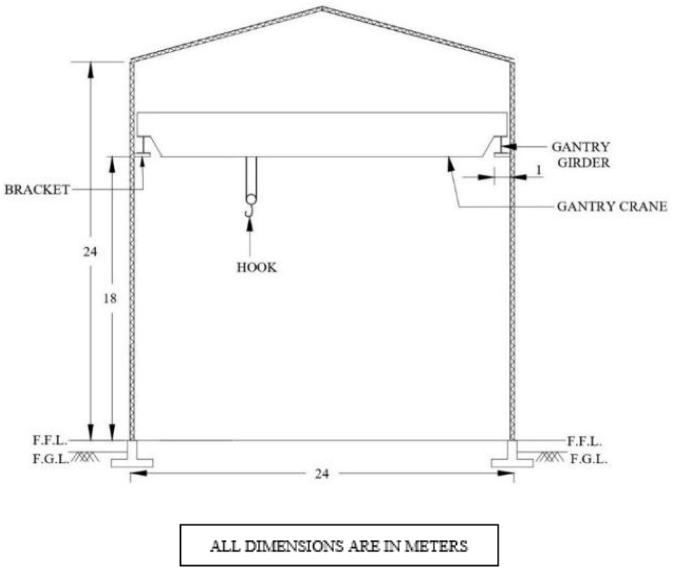

Fig -1: Typical Industrial Shed with Gantry Girder

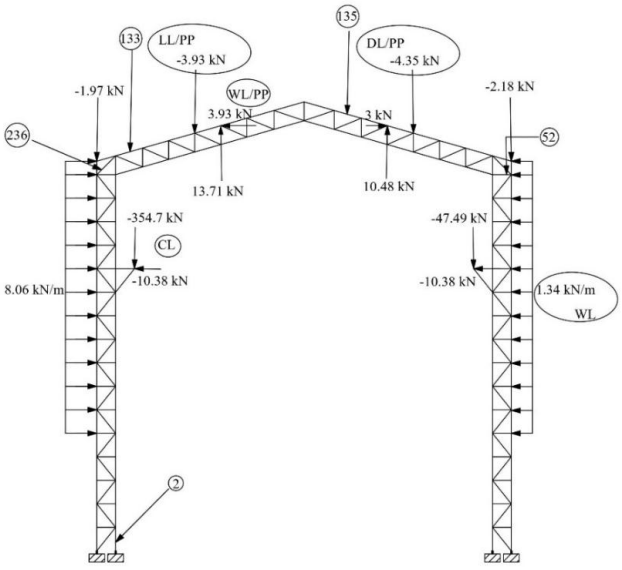

Fig -2: Load Cases

3.1 Modelling

Spacing between the column and rafter sections (Front to front) is taken as 1200mm.

Following sections are used for our structure:

Table -1: Section Properties

MEMBER	WSM	LSM
Columns	UC 203x203x46.1 (Above Gantry) UC 254x254x73.1 (Below Gantry)	UC 203x203x46.1 (Above Gantry) UC 254x254x73.1 (Below Gantry)
Rafter	ISMC 250	ISMC 200
Bracings	ISMC 100 & ISMC 125	ISA 80x80x6 & ISA 100x100x8
Purlins	ISMC 300	ISMC 300

3.2 Analysis and Design

After modelling of structure and successful application of loads on it, analysis of the structure was performed in STAAD Pro software. After analysis following values for axial forces were obtained from which the maximum force values are considered for design of respective members. Manual design calculations were done for these respective members.

Table -2 STAAD.Pro Results of Members having highest Axial forces for LSM

Member Type	Member No.	Combination	Design Force (kN)
Column	2	1.5 x (DL + WL)	1313.43 (C)
Rafter	133	1.5 x (DL +WL)	298.046 (C)
Lacing	236	1.5 x (DL + WL)	345.33 (C)
Tie	52	1.2 x (DL + LL +WL)	34.216 (C)

Table -3 STAAD.Pro Results of Members having highest Axial forces for WSM

Member Type	Member No.	Combination	Design Force (kN)
Column	2	0.75 x (DL + WL)	637.785 (C)
Rafter	135	0.75 x (DL +WL)	145.634 (T)
Lacing	236	0.75 x (DL + WL)	163.695 (C)
Tie	52	0.75 x (DL + LL +WL)	24.352 (C)

4. RESULT

After analysis and design of the intermediate frame the weight obtained for LSM and WSM is 113.977. kN and 122.688 kN respectively.

Table -4 Weight analysis of Members for LSM

STEEL TAKE-OFF		
Section	**Length (m)**	**Weight (kN)**
UC 254X254X73.1	72	51.493
ISMC 200	52.43	11.479
UC203X203X46.1	28.11	12.683
ISMC 100	9.6	1.799
ISA 100X100X8	93.66	22.161
ISA 80X80X8	41.57	7.792
ISMC 150	12.29	4.022
ISMC 350	2	1.672
ISMC 200	2	0.876
		Total Weight = 113.977

Table -5 Weight analysis of Member for WSM

STEEL TAKE-OFF		
Section	**Length (m)**	**Weight (kN)**
UC 254X254X73.1	72	51.493
ISMC 250	52.43	15.708
UC203X203X46.1	28.11	12.683
ISMC 100	51.17	9.591
ISMC 125	93.66	23.888
ISMC 250	12.29	7.364
ISMC 400	2	1.96
	Total Weight =	**122.688 kN**

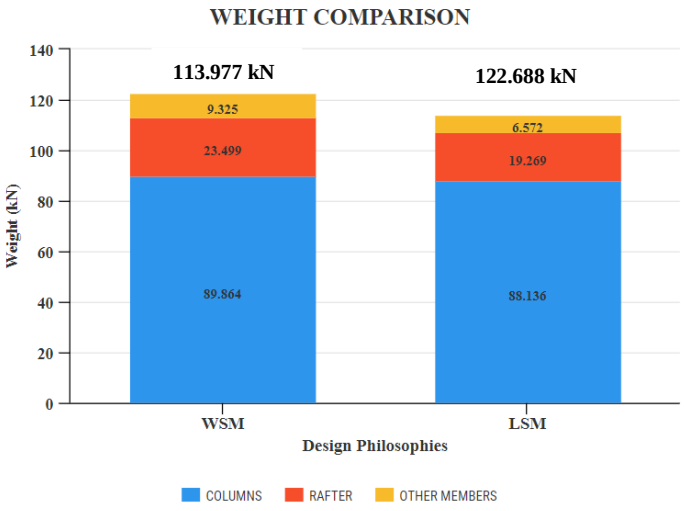

Fig-3 Weight Comparison of Individual Members

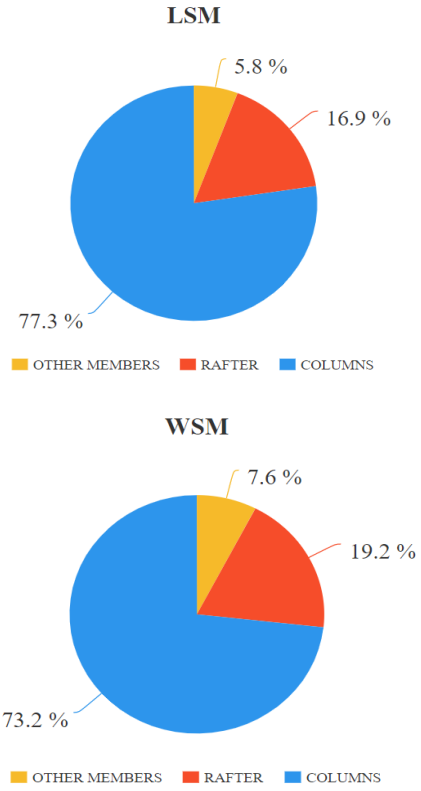

Fig -4 Percent Weight distribution of Individual Members

The sections are utilised to the fullest and the values for the members are shown below:

Table -6 Utilization Ratios of members from STAAD.Pro

Components	WSM	LSM
Columns	0.822	0.743
Rafter	0.69	0.671
Lacings	0.645	0.632

5. CONCLUSIONS

The analysis and design of an industrial shed having 24m span and 24m height was carried out and a detailed comparison between Limit State Method and Working Stress Method was done. Following are the key points of the comparison:

- The value of total weight of the column when designed by Limit State Method is 88.136 kN and when designed by Working Stress Method is 89.864 kN.
- For rafters, weight obtained by Limit State Method is 19.269 kN whereas weight obtained by Working Stress method is 23,499 kN.
- The total weight of the structure including bracings as well as gantry brackets is 113.977 kN when designed by Limit state Method and 122.688 kN when designed by Working stress method.
- As per the above values it was found that the total weight of the structure when designed by Limit State Method is 7.64 % less as compared to the total weight of the structure when designed by Working Stress Method.

From the above points it can be concluded that for a Large Span Large Height Industrial Shed Limit State Method of Design can be adopted for better weight optimization and economy of the structure.

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