International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 06, June-2019

Comparative Analysis of Industrial Structure in Pre-Engineered Building with Conventional Steel Building

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Abstract— In present years, the concept of Pre-Engineered Building in creation format of structures has helped into optimizing a design. Steel industry sector is developing more hastily in almost throughout elements of the world. In a hazard of global warming the usage of steel structures is not only efficient but also sustainable at the time. In Pre-Engineered Buildings (PEB) steel structures (Pre-fabricated) time is being the maximum significant aspect is built in very short duration period. In any type of Industrial structures and Pre-Engineered Buildings (PEB) Maximum Span, Column free suitable structures are the most vital in fulfils this requirement at the aspect of decreased time and price in comparison to conventional structures. Here this is study is achieved by planning 3D frame of an Industrial Warehouse constructing the use of the thoughts and studying the frames using appropriate assessment and design software after due validation. In this research, an industrial structure warehouse is analyzed and designed according to the Indian standards (IS 800-2007) and additionally through referring American Standard (AISC LRFD). The various loads like dead, live, wind, seismic and snow loads according as per IS codes are considered for the present work for relative study of Pre-Engineered Buildings (PEB) and Conventional Steel Building (CSB). To compare the consequences of the numerous parametric study to perform the variations in terms of shear force, support reaction, weight correlation and cost evaluation.

Keywords— Pre-Engineered Building, Conventional Steel Building, Ware House, Tapered Section, STAAD Pro V8i

I. INTRODUCTION

Buildings & companies are one of the primeval creation activities of people. The present modern concept of house buildings the technology of creation has progressive since the established order from simple construction. India has emerged as one of the key worldwide markets for pre-engineered buildings steel structures. A plenty of growth has been given to do with the way how recognition towards steel buildings had been changing to developed a country. Today's the scene is such that PEB's are expected to about 25% to 30% of marketplace share within the creation industry sector. The most recent improving technology was continuously increasing the maximum clear-span competencies of steel structures. In India the industry has fast development of steel building makes for exciting analyzing and it can have commenced all with the on location fabrication model. With the opening up of the economy during the 1990s but, such things started to change. In the might of the PEB enterprise this became the cause for predominantly "manufacturing plant constructed" structures and to achieve economy growth. In PEB technology steel is one of the world's most reused material and toward the finish of any steel product's life, practically 100% of it tends to be reused without losing its engineering properties, preferred and ecological construction methods. The tropical nation like in India to give great protection impact and would be highly suitable for a PEB structures. PEBs is an ideal construction sector for in remote & hilly areas. A recently survey through the Metal Building Associations (MBMA) shows that nearby 50% to 60% of the non-residential near to the ground rises constructing in USA are pre-engineered buildings. This flexibility would seem to with ease provide itself to optimization of member cross-section shapes. In Industrial building systems, the partitions can be formed of steel columns with cladding which may be of profiled or plain sheets, Galvanised Iron sheets, roofing, precast concrete, or masonry work. The wall must be effectively in strong to resist the lateral pressure because of wind or seismic activity resistance. As the PEBs offers fastest technique to construct the warehouses structures as compared to conventional methods and its demand for a broad range activities of construction will growth over the afterward four years. A growing range of distinguished International contractors and designers, who formerly certain conventional steel structural buildings entirely, have recently converted to the PEB approach.

II. FRAMING SYSYTEM

A. Concept of Conventional Steel Building

Conventional steel buildings (CSB) are small rise steel buildings with a roofing structures of truss with roof coverings. The criterion selection process of roof truss also includes the gradient of the roof, pitch of the roof, fabrication and transport techniques, aesthetics, climatic conditions, etc. In a Conventional steel building design uses selected hot rolled "T" type steel sections that are regular in period but need to be reduce, punched, and bolted on site. The necessity of materials is delivered or produced in the plant and are placed to the site. The need for further economy of creation region and the design of the conventional industrial buildings is governed through beneficial necessities. The Structural members are very hot rolled and are utilized in conventional buildings. Steel roof trusses are normally used for industrial buildings, work shop buildings, packaging areas, warehouses and even for residential buildings, faculty buildings, places of work whereas the construction work is to be completed in a short length of time. In high winds the structural performance of these buildings is well agreed and for the maximum part, suitable code provisions are presently in area to that that make certain excellent behavior. In a roof truss the entire section of every member is subjected to uniform stress and consequently the strength of every member is wholly utilized. A roof truss is essentially frame structure formed through connecting various members at their ends to form a system of triangle, organized in pre-determined pattern depending upon the distance, type of loading and functional requirements.

B. Concept of Pre-Engineered Building

Pre-Engineered steel structures are fabricated or created necessity in the plant itself. The production of structural members is done on customer requirements. The buildings were pre-engineered due to the fact they actually depend on general engineering designs for the limited amount of configurations. A pre-engineered building (PEB) is designed by the producer to be fabricated using a pre-determined inventory of raw materials and production techniques that may be efficiently satisfy a wide variety of a structural and aesthetic view of design requirements within a few geographic manufacturing sectors these buildings are also called as Pre-Engineered Steel Buildings. Generally, a PEB is an inflexible jointed plane frame from hot-rolled or cold-rolled sections, helping the roofing and side cladding through hot-rolled or cold-formed sections purlins and sheeting rails. Z and C-shaped cold formed steel members may be used as secondary structural elements to fasten and support to the outside cladding. Steel building system usually a variety of wall materials, the unique creations and still the maximum popular being steel siding, supported by means of`sidewall or end wall girts. In order to perfectly layout a pre-engineered building, engineers consider the clear span among the bearing factors, bay spacing, roof slope, dead loads, superimposed loads, collateral loads, wind uplift, deflection criteria, internal crane system and maximum realistic size and weight of the fabricated members. The use of an optimum least section leads to the equipped savings in steel and price reduction.

Fig. 1: Pre-Engineered Warehouse Structure

III. METHODOLOGY

In the research work, by using STAAD Pro V8i structural software three dissimilar types of 3D steel buildings are designed for static and vibrant forces. In this work, an industrial warehouse structure of length 60m with bay spacing at 6m along the length, 24m width and 8.402m eave height in which 2.1 m from ground level is used for brick work and remaining 6.3 m is used for cladding. The slope of roof is taken as 9.91° for both Pre-Engineered Steel Building and Conventional steel buildings and roofs are protected with GI sheet. The spacing of the purlins is maintained as 1.5m and girts is maintained as 2.1m. Pinned type of support condition can be used. The building layout plan of the proposed industrial warehouse structure considered for the study is as shown below in figure:

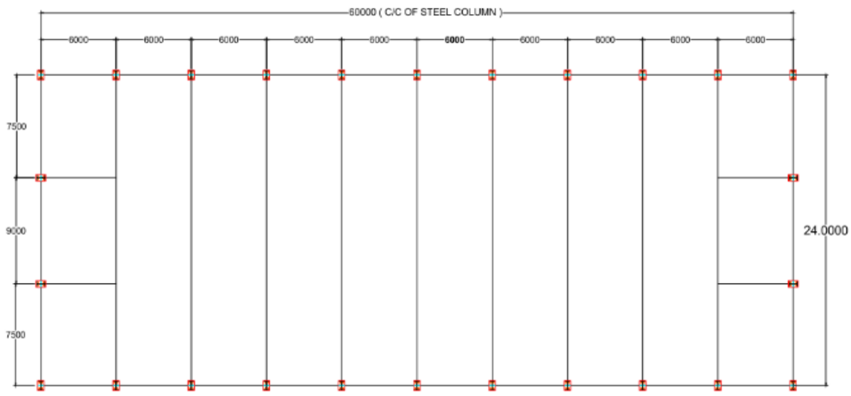

Fig 2. Plan Layout of Warehouse Structure

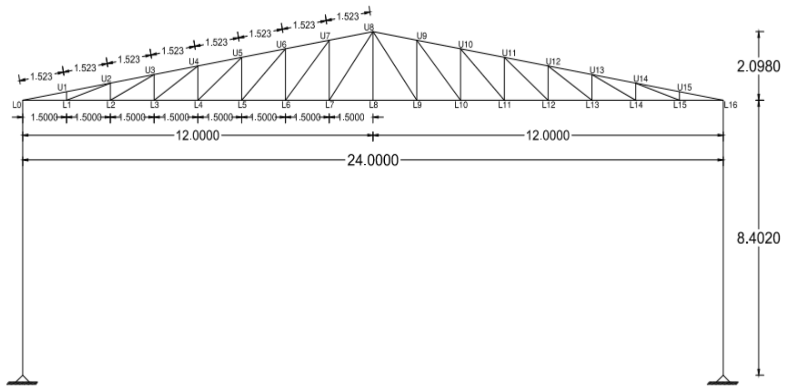

Fig. 3: Elevation of Warehouse Structure

IV. LOADING CALCULATIONS

A. *Dead Load*

Dead load calculation (IS 875-1987 Part-I):

Total load on purlin:

Weight of sheet = 0.058 kN/m^2
Weight of fixing = 0.025 kN/m^2
Weight of services = 0.1 kN/m^2
Spacing of Purlin = 1.523 m
Total weight on Purlin = 0.183 kN/m^2
Total weight on Purlin = weight (kN/m^2) × spacing of Purlin
= 0.183 × 1.523
= 0.278 kN/m
Assume weight of purlin= 0.10 kN/m
Weight of truss = (Span/3+5) × 10
= (24/3+5) × 10
= 0.130 kN/m^2
= 0.103 × plan length
= 0.103 × 1.5
= 0.154 kN/m
Total dead load = 0.532 kN/m

B. *Live Load*

Live load calculation (IS 875-1987 Part-II):

Live load on purlin = 750 – 20 (θ – 10) ……. (Slope less 10˚)
Live load = 750 – 20 (θ – 10)
= 750 – 20(9.91 – 10)
= 0.751 kN/m^2
Live load on purlin = 0.539 × spacing of purlin
= 0.751 × 1.523
= 1.143 kN/m
Live load on truss = 2/3 × load on purlin
= 2/3 × 1.143
= 0.762 kN/m

C. *Wind Load*

Wind load calculation (IS 875-1987 Part-III):

Basic wind speed = Vb = 39 m/s
Design wind speed = $V_z = K_1\ K_2\ K_3\ V_b$
Design wind pressure = $P_z = 0.6\ V_z^2$
Wind pressure on roof = $(C_{pe} - C_{pi})$
Where,
C_{pe} = Coefficient of external wind pressure
C_{pi} = Coefficient of internal wind pressure
K_1 = Risk coefficient
K_2 = Terrain height and structure size factor
K_3 = Topography factor
For all general building and structure,
Mean probable design life = 50 years
Risk coefficient K_1 = 1.0
Terrain category = 3 ……..… (As height of building 10 m)

Class B ……..…… (As horizontal or vertical dimension in between 20 to 50 m)
$K_2 = 0.99$
K_3 = topography factor
$K_3 = 1$
Design wind speed = $V_z = K_1 \times K_2 \times K_3 \times V_b$
$= 1.0 \times 0.99 \times 1.0 \times 39$
$= 38.61$ m/s
Design wind pressure = $P_z = 0.6 \times V_z^2$
$= 0.6 \times 38.61^2$
$= 894$ N/m^2
Wind Load F = (Cpe – Cpi) x A x P in kN
Where, Cpe – External Coefficient
Cpi – Internal Coefficient
A– Surface Area in m2
P – Design Wind Pressure in kN/m^2

D. ***Load Combinations***

Table 1. Load Combinations as per Design Codes

AISC-89/MBMA-86	IS 800-2007
Limit state of serviceability	Limit state of serviceability
(DL+LL)	(DL+LL)
(DL+WL/EL)	(DL+WL/EL)
(DL+CL)	(DL+LL+CL)
(DL+.05WL/EL+CL)	(DL+0.8LL+0.8WL/EL+0.8CL)
Limit state of strength	Limit state of strength
(DL+LL)	1.5(DL+LL)
(DL+CL)	1.5(DL+WL/EL)
0.75(DL+WL/EL)	(0.9DL+1.5WL/EL)
0.75(DL+WLRL-P)	(1.5DL+1.5LL+1.05CL)
0.75(DL+0.58WL/EL+CL)	(1.5DL+1.05LL+1.5CL)
	(1.2DL+1.2LL+0.6WL/EL+1.05CL)
	(1.2DL+1.2LL+0.6WL/EL+1.2CL)
	(1.2DL+1.2LL+1.2WL/EL+0.53CL)
	(1.2DL+1.2LL+1.2WL/EL+0.53CL)

V. STAAD PRO PROCESS

In the modern study, STAAD Pro V8i programming has been utilized in order to analyses and design PEB and CSB. The industrial warehouse structures we are designing is of Pre-Engineered structure. The sizable majority of the channel sections and angle sections are available in the steel tables of STAAD Pro V8i are the C or else I sections. In any case, for the design of PEB, there is likewise one command known as tapered sections. Optimum Tapered sections are one in which we can assemble the web, flange, their thicknesses, and so on. STAAD Pro is the structural engineering professional's decision for steel, concrete, timber, aluminum, and cold-formed steel design of practically any structure including of culverts, petrochemical plants, tunnels, bridges, piles, and substantially more through its adaptable demonstrating condition, propelled highlights. For making plans or breaking down any shape on STAAD Pro V8i, we first of all need to create a model of it. For demonstrating in STAAD Pro V8i various types of section properties, members, steel tables, materials are presented. Not just this, there are the plan codes of different countries feed. In the beams and columns act as line component and slabs, walls and shear walls, and so forth go about as plate component.

Optimum Tapered sections are for the most part accommodated for rafters & columns. The modelling of warehouse structure using software and how the tapered sections are collected and placed as below:

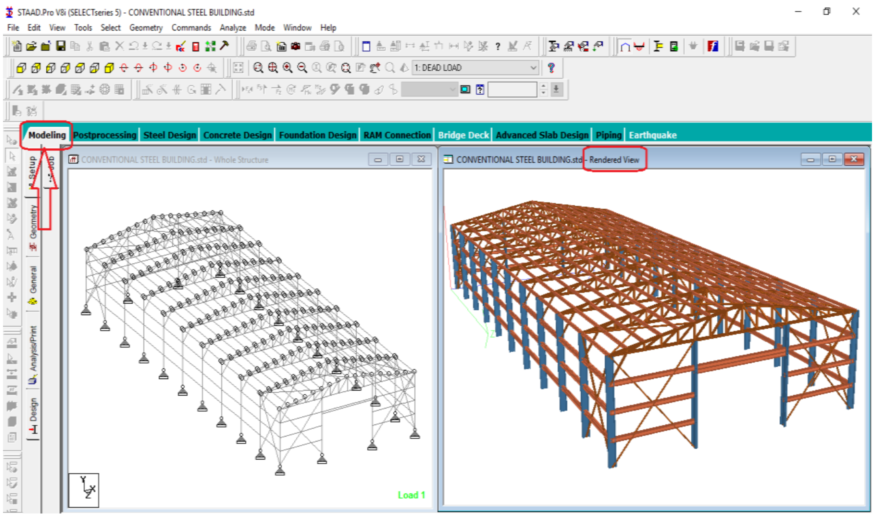

Fig. 4: Modelling and Rendered View of CSB Structure

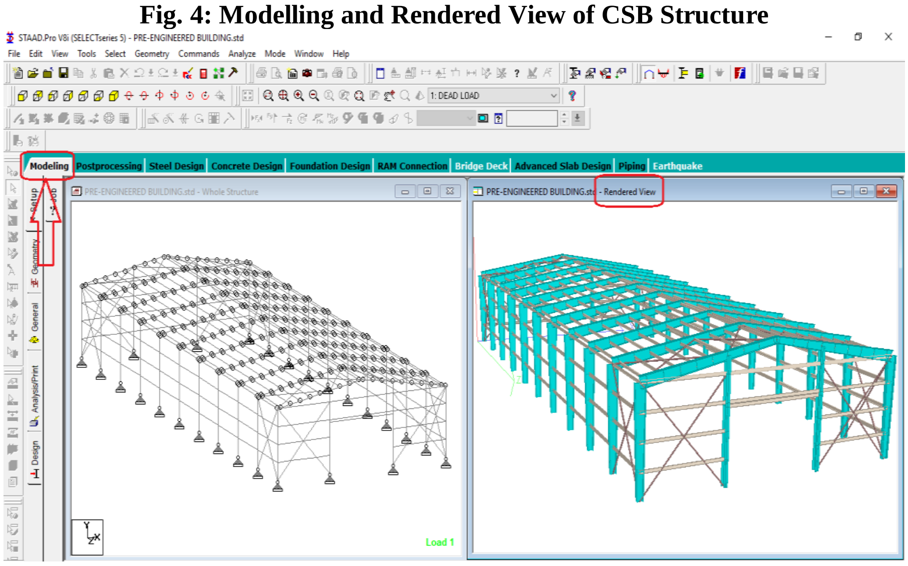

Fig. 5: Modelling and 3D View of PEB Structure

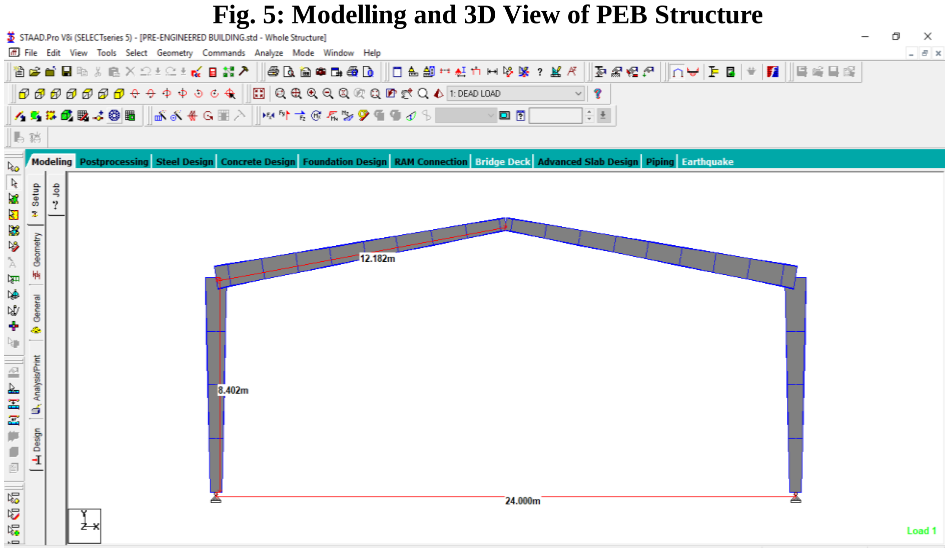

Fig. 6: Assembled Tapered Section

VI. RESULTS AND PERFORMED ANALYSIS

The structural analysis and design of the structural constructing taken into consideration changed into executed using the Staad Pro software database which may be very user pleasant and powerful. Graphical representation shows results obtained from software as below:

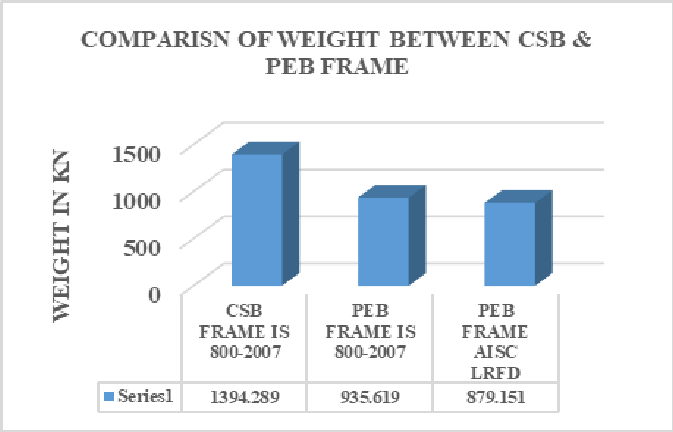

Fig. 7: Weight Correlation

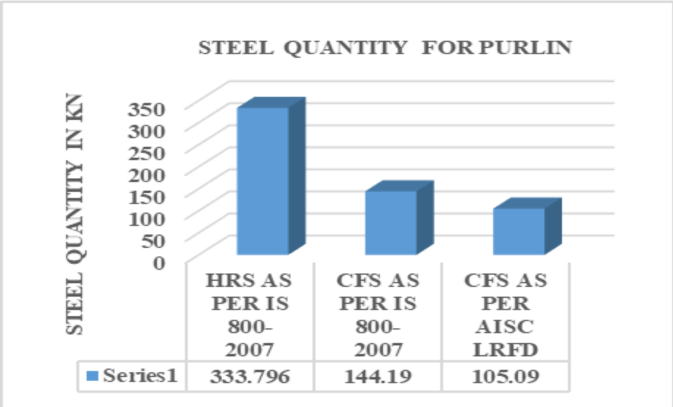

Fig. 8: Steel Quantity required for HRS section and CFS section used for Purlin members

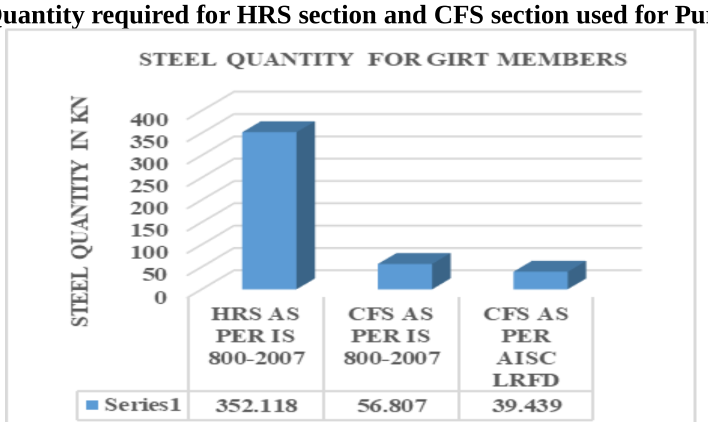

Fig. 9: Quantity of steel required for HRS section and CFS section used for Girt members

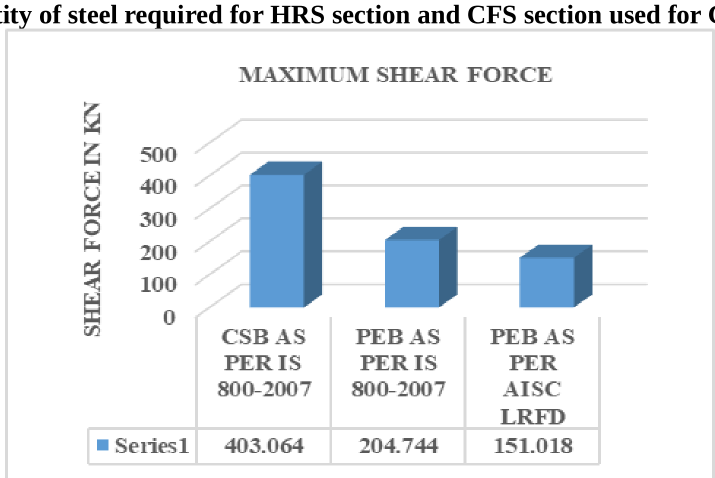

Fig. 10: Maximum Shear Force

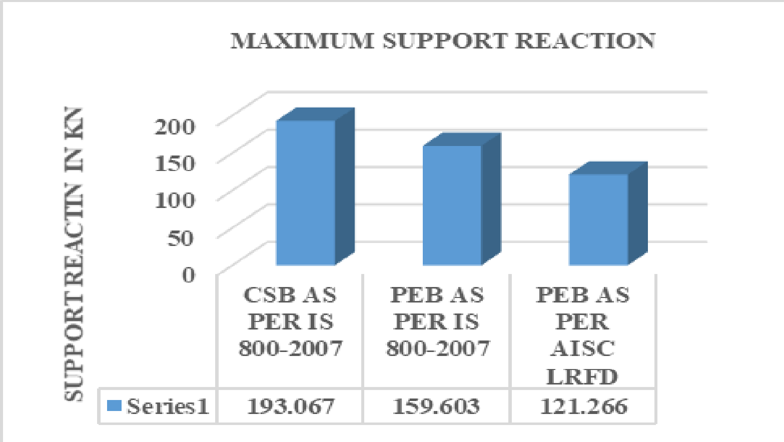

Fig. 11: Maximum Support Reaction

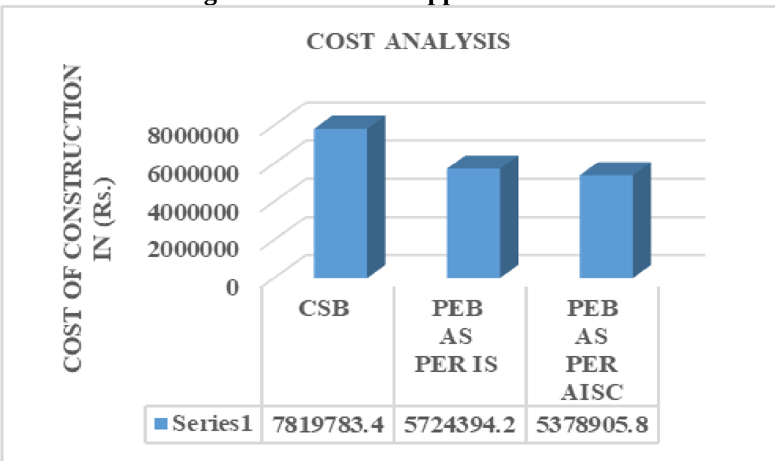

Fig. 12: Cost Analysis

VII. CONCLUSIONS

In our everyday existence steel is versatile material that each object we see used in steel immediately or circuitously. In the observe of self-weight of the models indicated that the self-weight for PEB is much less than that of CSB in the equivalent geometry. As consistent with the design outcomes acquired for the duration of this dissertation work it is noted that the weight of PEB as consistent with Indian code structure by 34% and weight of PEB as consistent with American code structure with the aid of 38% as compared to lesser than the weight of CSB structure. Cold formed steel section over hot rolled section as purlin section members is essentially lighter than 57 % and also girt section members for cold formed steel over hot rolled section is reduced than 85%. The shear force of PEB are lesser than the CSB which in turn decreases the material required for the structure. Support reaction for PEB is slighter compared to CSB. It is visible that there is around 28% saving cost in as consistent with PEB Indian code and also 32% saving cost in PEB American code constructing related to CSB building.

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