Preliminary Estimation of Structural Steel for Industrial Steel Structures

A RESEARCH REPORT

Submitted by

BALPREET SINGH

11609149

RC1611-A25

In partial fulfillment for the award of the degree of

MASTERS OF TECHNOLOGY

IN

STRUCTURE ENGINEERING

Under the guidance of

Mr. Manoharan Rajalingam

Head of Department (H.O.D.)

Department of Structural Engineering

School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY
Phagwara–144411, Punjab (India)

DECLARATION

I hereby declare that the dissertation Literature review titled "**Preliminary Estimation of structural steel for industrial steel structures**" is an authentic record of my own research work carried out as a requirement for the preparation of M-Tech dissertation for the award of Masters of Technology Degree in Structure Engineering from Lovely Professional University, Phagwara, Punjab, under the guidance of Mr. Manoharan Rajalingam, during the period between January 2017 and March 2017. All the information furnished in this review is based upon my intensive work and is completely genuine to the best of my knowledge.

Date:

Balpreet Singh

11609149
RC1611A25

CERTIFICATE

Certified that this project report entitled "**Preliminary Estimation of structural steel for industrial steel structure"** submitted independent by student of School of Civil Engineering, Lovely Professional University, Phagwara are carrying out the work under the direction of me for the Award of Degree. The report has not been submitted to a university or institution for the award of any degree.

Signature of Supervisor

Mr.ManoharanRajalingam

Professor (Head Of Department)

ACKNOWLEDGEMENT

Any accomplishment requires the efforts of people and, this is not different. So it has bees also complete with cooperation of many persons. I am thankful to guide **“Mr. Manoharan Rajalingam”** gave me the golden opportunity to do this wonderful research on the topic **“Preliminary Estimation of structural steel for industrial steel structures”**, which also helped us in doing a lot of Research and I came to know about so many new things.

Secondly I would also like to thank my parents and friends who helped me a lot in finishing this project within the limited time.

TABLE OF CONTENTS

S No. Content Page No

_Declaration
Acknowledgement
Abstract
List of Tables
List of Figures

1. Chapter1:INTRODUCTION…………………….……………..................1
   1.1 General
   1.2 Objective of the study

2. Chapter 2: LITERATURE REVIEWS………………………………………3
   2.1 General
   2.2 Summary of reviews
   2.3 Scope of the study

3. EXPERIMENTAL PROGRAMME

4. CONCLUSION

5. REFERENCES………………………………

ABSTRACT

This study covers the various methods for estimating the preliminary quantities of steel structures by using various methods that are commonly adapted in Industrial practices. Some existing real time samples were considered for this study and the results would be compared by calculating the steel quantity by the automated method based on stability design of steel structures as described in AISC specification 360 - 2010. The research work primarily focuses on the design optimization and construction of pre engineered buildings due to the salient characteristics of light weight, faster erection and enduring strength. The results arrived from different methods and that of the stability analysis of steel structures are tabulated and compared with final quantities which are available from database and the applicability of more suitable method for the preliminary steel estimation would be recommended. In this juncture, the literature review and manual calculation of some of the stability methods are presented in this report.

CHAPTER 1
INTRODUCTION

1.1 General

The project is based on the preliminary estimation of industrial steel structure by the help of various methods which are used in checking the stability and weight of the structure. The preliminary estimation of steel quantities and stability analysis is done by the manual calculation according to the stability design of steel structures AISC specifications 360 -2010. The comparison between different methods of stability analysis is done for making the structure more stable.

OBJECTIVE OF STUDY

The aim of the study is to do preliminary estimation of industrial steel structure by the help of various stability analysis methods that are used for checking the stability of steel structure. The study is carried to reduce the overall cost of the structures by the use of different methods which are used for the calculation study. Keeping in view that cost reduction could not effect the overall tensile strength of structure. The steel structure are light weight as compared to concrete structures, so the use of steel structure should be done more . The results arrived from different methods and that of the stability analysis of steel structures are tabulated and compared with final quantities.

CHAPTER 2

LITERATURE REVIEW

2.1 General

B.K RAGHU PRASAD(2014) has presented the concept of Pre-engineered building . These building material construction is fast and light weight . The Pre-engineering structure are more advantages than conventional steel building in terms of cost, quality control speed in construction and erection. India is a developing country country in terms of construction, economy, so construction of pre engineering building are increasing day by day. PEB has high strength and ductility has compared to other concrete buildings.

Balwant (2013) presents optimizations bill of quantities for construction of pre-engineered buildings. Structural steel building members are to fixed properly for better safety of structure during erection. Pre-engineered construction consist of steel frames ,columns of steel and other rolled sections of steel .sections are available for covering the roofs . Transportation shops is constructed for transportation purpose after complete finishing of the trains. Transporting engines will come here and it will carry out the all new train from the rail coach factories

CARTER (2008) has presented the concept A Comparisons Frame Stability Method in ANSI/AISC three six zero-zero five. In this paper three different methods are being used for finding the design and stability of steel columns of frame. AISC manual is used for getting the certain values used for checking the stability of steel columns. Two simple un braced frames are used .LRFD (Loadand resistance factor design) and ASD load combinations are applied in the paper.

EXPERIMENTAL PROGRAMME

General

In this project the preliminary estimation of steel for industrial steel structures is done by using different estimation methods and for stability checking direct stability analysis method is used .In this study we are comparing the results of different methods for knowing best by which effect of stability can be reduced in the steel structures.

There are four methods for estimation of structural steel:

1. GIFA
2. GEFA
3. Volume based method
4. Member based method

GIFA(Gross internal floor area):-

GIFA value is used for obtaining the value of internal floor area excluding the external floor area.

For eg. The school contains three floor each with internal floor area 1.5m^2 and according to the definition the gross internal area amounts to be 4.500m$^{2.}$

Assume the range of the structure=200kn/m^2

Than the weight of structure wiil be = range×area

=200kn/m^2×4.500m^2

=900kn

The value for GEFA will be also related to GIFA

Volume based method :-

Consider a cylindrical column of size =3.8m×0.250m×0.300m

=l×b×h

=0.285m^3

Assume range of structure =200kn/m^2

Than the weight of structure will be = 200kn/m^2×0.285m^3

=57kn/m

Member based method :-

Strucrural steel is normally priced by weight. For example the standard method for specifying the dimensions of an wide flange beam W6×23, in which 6inch i.e (0.15 m) deep with weight of 23lb/ft i.e (75.44m)

Computing the structural steel weight:

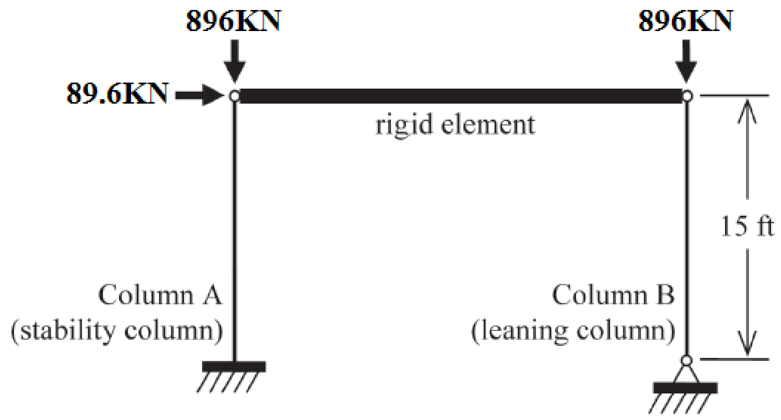
Section	Number	Length(m)	Total length	Weight/m	Total weight
W14×132	1	6.09	6.09	40.24	245kn
W14×120	1	9.14	9.14	36.58	334kn
W16×40	5	6.09	30.45	12.19	371kn
W27×94	1	9.14	9.14	28.65	261kn
W18×50	2	9.14	18.28	15.24	278kn
W14×43	1	6.09	6.09	13.1	80kn
W18×84	3	4.57	13.71	25.6	350kn
W14×109	8	4.57	36.56	33.23	1215kn
W24×68	1	10.36	10.36	20.73	214kn
W16×20	1	7.62	7.62	7.92	60.3kn

A Comparison of Frame Stability Analysis Methods:-

There are three methods which are used for finding the comparison of frame stability. These four methods helps the readers in understanding the differences between them

1. The 2nd-Order Analysis Method
2. The 1st-Order Analysis Method
3. Direct Analysis

Two simple un-braced frame as shown:



The Second-Order Analysis Method

The design parameters are

Pu = 200 kips =896kn
K_X = 2.0
K_Y = 1.0
$x = y$ = 4.57m

Mux = (89.6kn) (4.57m)
= 409.47knm
Cb = 1.67
Lb = 4.57m

K=3EI/L3
=3(2e8)(4.15e-4)(4.57*475.2)^3
=2.64kn/mm

1st order drift of the frame is
Δ1st = (89.6)/(2.64kn/mm)
=34.036mm
Y_i = 896kn+896kn
= 1792kn
Nodal load = Ni
Ni=0.002Yi
=0.002(1792)
=3.58kn

P_{nt} = 896kn P_{lt} = 0kn
M_{nt} =0 M_{lt}=409km-m

Therefore:-
$\Delta 1st / L$ =(34.036)/(4572mm)
=0.0075

R_m=0.856

For moment frame, Rm=1-o.15(Pmf/Pstory)

= 1-0.15(896/896)

= o.85

Rm= value of resistance

With $\Delta H = \Delta 1st$ and ΣH = 89.6kn

$\Sigma P_{e2} = r_m/(\Delta 1st\ /L)$

= 0.856 (89.6kn)/(0.0075)

= 10236.55kn

Thus, gravitational load:

$\alpha\Sigma P_{nt}\ /\Sigma P_{e2}$

= 1.0 (896kn +896kn)/10236.55kn

= 0.1762

From Eq. C the Amplifications are:

$$B2_{=} \quad \frac{1}{1-\frac{\propto\sum Pnt}{\sum Pn2}}$$

$$=\frac{1}{1-0.175}\geq 1$$

$$= 1.21\geq 1.0$$

Amplified axial force:

$\Sigma Pleaning\ /\Sigma Pstability$ = (896kn)/(896kn)

=1

$K_{x*} = K_x(1 + \Sigma P\text{-}leaning\ /\ \Sigma P\text{-}stability)^{0.5}$

= 2.842

$Pr = Pnt + B_2\ Plt$

= 896kn + 1.21(0 kn)

$=896kn$

$K_{x*} = 2.842, K_y = 1.05$

$L_x = L_y = 4.57m$

Amplification moments value:

$Mrx = B1Mnt + B2Mlt$

$= (0\ knm) + 1.21\ (4408.32knm)$

$= 5334.06knm$

$Cb = 1.67$ (when one moment end is equal to zero)

$Lb = 4.57m$

Base on the design parameter :

$P_c = \varphi_c\ P_n$

$= 3230.08kn$

$M_{cx} = \varphi_b\ M_{nx}$

$=8419.89knm$

$P_r/P_c= \frac{896kn}{3230.08kn}$

$=0.278$

Than the value becomes

$$\frac{Pr}{Pc}+\frac{8}{9}\left(\frac{Mrs}{Mcx}\right)=0.277+\frac{8}{9}\left(\frac{533.06knm}{8419.89knm}\right)$$

$= 0.856$

The W14×90 is adequates becoz $0.856 \leq 1.0$.

First-Order Analysis

Design of first order analysis:

The first-order analysis method is:

$\alpha = 1.0$
$K = 1.0$

The given frame the additional lateralload is based on the fi rst-order drift ratio, Δ/l *and* ,gravitational load Yi.

$$\Delta = \Delta 1st,$$

$$\Delta 1st /l = (34.036)/(4572mm)$$

$$= 0.00744$$

$$Yi \quad = 896kn+896kn$$

$$= 1792kn$$

$$Ni \quad = 2\,(\Delta 1st /L)Yi \geq 0.0042Yi$$

$$= 2\,(0.0075)*(1792kn) \geq 0.0044*(1792kn)$$

$$= 27.99kn \geq 7.52kn$$

$$= 27.99kn$$

The 2nd order drift is less than 1.5 time the fi rst-order Additional

$$\alpha p_r \quad = 1(896kn)$$

$$= 896kn$$

And for steel frame

$$0.5Py = 0.5Fy\ Ag$$

$$= 0.5(50\ ksi)(26.5\ in.2)$$

$$= 2970.24kn$$

Because $\Delta 2nd < 1.5\Delta 1st$ and $\alpha Pr < 0.5Py$, the use of this method is permitted.

The loading for this method is the same as that shown in Figure 1, except for the addition of a notional load of 28kn coincident with the lateral load of 89.6kn shown, resulting in a column moment, *Mu*, of 5789knm

$K1 = 1.0.$

$P_{e1} = \pi 2EI/(K_1L)*2$

$= 39558.4kn$

The column moment at 1 axis is zero , so moment gradient :

$Cm = 0.6 – 0.4(m_1/m_2)$

$=0.6$

From Equation C2-2,

$\alpha Pr /Pe_1 = 1(896kn)/(39558.4kn)$

$= 0.0236$

$$B_1=\frac{Cm}{1-\frac{\propto Pr}{\propto Pe1}}\geq 1$$

$=0.623 \geq 1$

Axial loads and design perimeters are :

$Mrx = B_1 Mu$

$= 1.0\ (5789\text{knm})$

$= 5789\text{knm}$

$c_b = 1.68$

$L_b = 4.57\text{m}$

Base on the design perimeters, the axial loads :

$p_c = \varphi c p_n = 4480\text{kn}$

$M_{cx} = \varphi b^* M_{nx} = 8419.89\text{knm}$

The ratio of axial load:

$P_r/P_c = \frac{896kn}{4480kn} = 0.200$

becoz $P_r / P_c \geq 0.2$ and eqn is fine

$P_r/P_c \quad \frac{8}{9}\left(\frac{Mrs}{Mcx}\right) = 0.277 + \frac{8}{9}\left(\frac{5789.59knm}{8419.89knm}\right)$

$= 0.823$

since $0.823 \leq 1$

Design of direct analysis

The direct analysis method is ratio of second order drift$\Delta 2nd$, to first-order drift, $\Delta 1st$, and required when this ratio exceeds 1.5:

Nodal load = $0.002Y$

EA^* and EI^* are reduced stiffness.

Thus the notional load can be applied as min. lateral load: Yi = 896kn + 896kn = 1792kn Ni = 0.002Yi = 0.002(1792kn) = 3.58kn For Col. A,1st-order : P_{nt} = 896kn, Plt = 0 kn Mnt = o knm, M_{lt} = 4408.3knm To determine the second-order amplifi cation, the reduced stiffness, EI^*, must be calculated. αPr = 1.0(896kn) = 896kn and $0.5Py = 0.5Fy\ Ag$ =2970.24kn Thus, because $\alpha Pr < 0.5Py$, $\tau b = 1.0$ and $EI^* = 0.8\tau bEI$ = 0.8EI

For P-δ amplification there are no moments and no need to calculate B_1.
For P-Δ amplification. $EI^* = 0.8EI$,

$$\Delta 1st = 1.25(34.036)$$

$$= 42.545$$

The fi rst-order drift ratio is determined from the amplified drift of 42.545

$$\Delta 1st / L = (42.545)/(2160.57\text{mm})$$

$$= 0.00933$$

, $R_m = 0.856$

$\Delta H = \Delta 1st$ and $\Sigma h = 89.6$kn

$$\Sigma P_{e2} = R_m \frac{\Sigma H}{(\Delta 1st/L)}$$

$$= 0.856 \frac{896kn}{0.00933}$$

$$= 81629\text{kn}$$

thus,

$$\alpha \Sigma P_{nt} / \Sigma P_{e2} = 1(896\text{kn}+896\text{kn})/81629\text{kn}$$

$$= 0.220$$

The amplification is :

$$B_2 = \frac{1}{1 - \frac{\alpha \Sigma Pnt}{\Sigma Pe2}} \geq 1$$

$$= \frac{1}{(1-0.220)} \geq 1.0$$

$$= 1.28 \geq 1.0$$

$$= 1.28$$

The amplified axial load and parameters :

$P_r = P_{nt} + B_2P_{lt}$

$=896kn + 1.28(0 \text{ kips})$

$= 896kn$

$K_x = K_y = 1.0$

$L_x = L_y = 4.57m$

Moment and design perimeter are :

$M_{rx} = B_1M_{nt} + B_2M_{lt}$

$= 0 + 1.28(4408.32knm)$

$=5642.64knm$

$C_b = 1.67$

$L_b = 4.57m$

Flexural strength:

$P_c = \varphi cP_n = 4480kn$

$M_{cx} = \varphi b*M_{nx} = 8419.89knm$

Compressive load :

$P_r/P_c=\frac{896kn}{4480kn}$

$= .200$

$P_r /P_c \geq 0.2$

$P_r/P_c +\frac{8}{9}\left(\frac{Mrs}{Mcx}\right)=0.200+\frac{8}{9}\left(\frac{5642.64knm}{8419.89knm}\right)$

$= 0.796$

The W14×90 is adequate since 0.796≤1.0.

CONCLUSION

The stability analysis for a steel frame was done using the following three methods:

1. The 2nd-Order Analysis Method
2. The 1st-Order Analysis Method
3. The Direct Analysis

The results for stability of the frame was calculated manually using all the above three methods. Direct analysis method showed better results for stability than other two methods.

REFRENCES

`

1. 1.B.K RAGHU PRASAD (2014).Optimization of Pr Engineered Buildings. *et al. Int. Journal of Engineering Research and Applications*
2. .BALWANT(2013). Optimization of bill of quantities for construction of pre-engineered buildings. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958
3. CHARTER(2008) A Comparison of Frame StabilityAnalysis Methods in ANSI/AISC 360-05