International Journal For Technological Research In Engineering
Volume 7, Issue 12, August-2020 *ISSN (Online): 2347 - 4718*

DESIGN AND ESTIMATION OF METAL STAIRCASE BY USING STAAD.Pro

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Abstract: Designing of stairways is a ubiquitous part of architectural design. The principal objective of this paper is to present the results of design and estimation of a metal stair case for a multistory building by using STAAD.Pro. The design involves load calculations manually and analyzing the whole structure by STAAD.Pro. The design method followed is Limit state design conforming to Indian standards code of practice. STAAD.Pro features a state of the art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation analysis and design to visualization and results verification, STAAD. Pro is professional choice. We analyzed and designed a metal stair case [3-D frame] for all possible load combinations (dead live &wind loads). STAAD.Pro has a very interactive user interface which allows the users to draw the model and input the load values and dimensions. We have analyzed and designed the stair case and columns in STAAD foundation. we have designed the shallow foundation for the column. The estimation of design effort and cost plays vital role in authorizing funds and controlling budget during the project development process. The results were presented.

Key Words: metal staircase, analysis, design, STAAD.Pro, cost estimation

I. INTRODUCTION

Stairways are an essential part of multi-story buildings and industrial structures that provide vertical access for occupants. This vertical access can be used to move from one level to another and provides a means of egress in an emergency. Stairways provide a safe and efficient option for travelling within a building. The design and layout of stairways is dependent on the intended use, occupant load and serviceability requirements. This design will focus on steel framed stairway design and associated steel components in an effort to highlight code requirements, stair design methodology, and delegated design considerations.

A staircase has two main elements. First, the substructure (foundation) transfers the loaded weight of the staircase to the ground; it consists of components such as columns and footings. Second, the superstructure of the staircase is the horizontal platform that spans the space between columns. Different types of stair cases were in use.

STRAIGHT STAIRCASE:

Straight stairs are stairs without any changes in direction. They are certainly one of the most common types of stairs found in both residential and commercial properties. Below are examples of straight floating stairs made with a variety of stringer styles, railing types, and wood species.

U-SHAPED STAIRCASE:

U-shaped stairs are essentially two parallel flights of straight stairs joined by a landing that creates a 180-degree turn in the walk line.

BIFURCATED STAIRCASE:

This type of stair is commonly used in public buildings at their entrance hall. The stair has a wider flight at the bottom, which bifurcates into two narrower flights, one turning to the left and the other to the right, at the landing.

L-SHAPEDSTAIR CASE:

The L shaped stair is a variation of the straight stair with a bend in some portion of the stair. This bend is usually achieved by adding a landing at the transition point.

LADDER STAIRCASE:

These types of stairs are very useful for tight space areas with a spot on both sides. Ladder design is not used as a main stair because they are usually helpful in connecting the floor area to the roof area. These staircases are available in a variety of design in the market.

FLOATING TYPE STAIR CASE :

A floating staircase is an architectural masterpiece for small, dual floor office and duplex's. Floating staircase is the one which are in floating position which often don't require the support from all sides. It is fixed in top, bottom and centre. Such staircase can be made with the help of wooden, glass or stone steps. They usually appear like they are floating in space. The floating treads are attached on one side, either to wall or a stringer.

SPIRAL STAIRCASE:

Spiral stairs follow a helical arc. They usually have a very compact design and the treads radiate around a central pole. These staircases are mostly found in modern houses, restaurants, pubs, beach house etc. and are in the innovation style.

In the present work we have proposed a steel staircase for R-block in URCET (Usha Rama College of Engineering &Technology) for the purpose of an emergency exit in the case of a fire/other accident. It is proposed to an existing building. That's why a metal staircase is used as an emergency exit without disturbing the main structure. STAAD.Pro stands for Structural Analysis and Designing Program. This Software is most used Software for Civil Engineering designing. Mainly the Software reduces your manual calculation and time and provides great accuracy.

U-shaped stairs are essentially two parallel flights of straight stairs joined by a landing that creates a 180-degree turn in the walk line. In this we are using u-shaped staircase for easy accessibility.

II. METHODOLOGY

The methodology adopted in this work is provided in the below flochart.

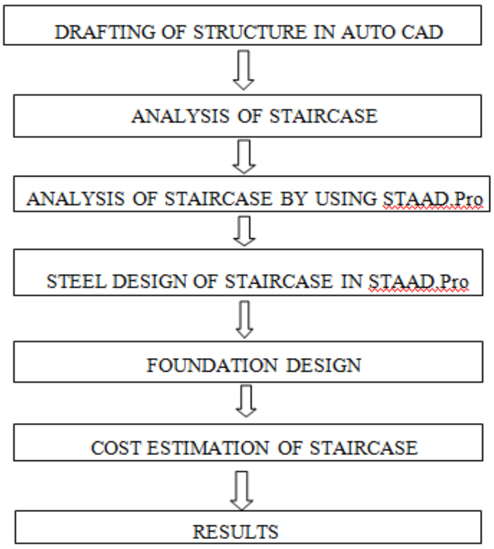

Fig.1 Methodology

DRAFTING OF STRUCTURE IN AUTO CAD:

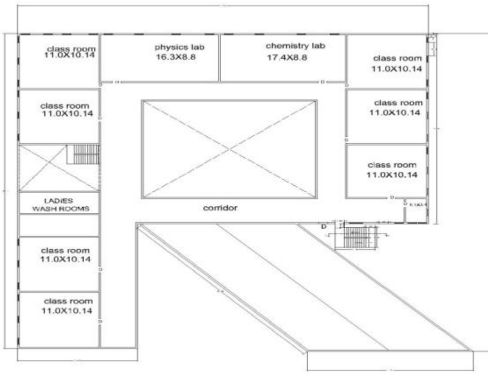

Fig.2 Drafting of Stair case location

The R- block of Usha Rama College of Engineering &Technology is considered as case study and a metal staircase is provided without disturbing the structure. The plan shows the detailed view of staircase and its position.

- Rise: 170 mm
- Thread: 300m m
- Length: 1.8 m
- Height of the floor: 3.4 m
- Length of landing: 3.8 m
- Length of step: 1.8 m
- Width of landing:1.25 m
- Stair hall dimension:5.2 x 3.4 m

LOAD CALCULATIONS FOR STAIRCASE

DEAD LOAD:

Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self-weight of structural members, permanent partition walls, fixed permanent equipment's and weight of different materials. It majorly consists of the weight of roofs, beams, walls and column etc. which are otherwise the permanent parts of the building.

Dead load=(10x2x60)x2+(4x60)

=2400+240

=2640 (fully occupied factor)

Loading area=1.25x (1.8+0.2+1.8)

=4.75m

=(2400x0.54)+240(4.75)

=1296+1140

=2436KN/ M^2

LIVE LOAD:

Live loads are either movable or moving loads without any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. Live load keeps on changing from time to time. These loads are to be suitably assumed by the designer. It is one of the major load in the design. The minimum values of live loads to be assumed a given in IS 875 (part 2)–1987. It depends upon the intended use of the building.

Live load=5KN/ M^2 (From code book IS 875 part 2, clause no 3.2.3)

ANALYSIS OF STAIRCASE IN STAAD.pro:

Appropriate model dimension (2D or 3D) recommended for the application of analysis procedures is also justified in detail. The load calculations includes considerations of dead load, live load, wind load .

The staircase Modelling, establishes a set of recommendations for the simplification of the geometry of the structure, definition of elements and materials, and the assignment of mass and boundary conditions, among others.

A thorough explanation is presented that addresses the minimum requirements in the modelling in column bents. The behaviour of staircase and foundations, the superstructure is discussed briefly.

Fig.3 STAAD Pro window

REATION OF MODEL:

By the help of node curser, given the node values in STAAD.Pro according to span, width & height of the staircase and join a Nodes using added beam curser. Finally stair case geometry is done.

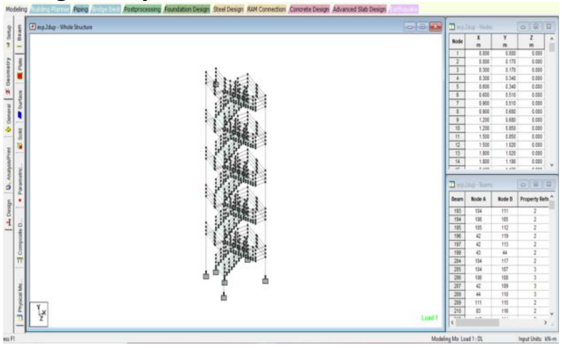

Fig.4 Creation of model in STAAD Pro

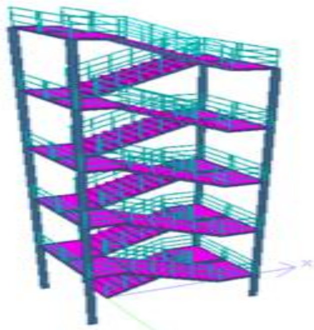

Fig.5 3-D Model

PROPERTY ASSIGN:

In this section, assign the property's to staircase. We choose ISMB 100 for the beams, ISMB 200 for the columns and with plate thickness is 10mm. A fixed support is the most rigid type of support or connection. It constrains the member in all translations and rotations

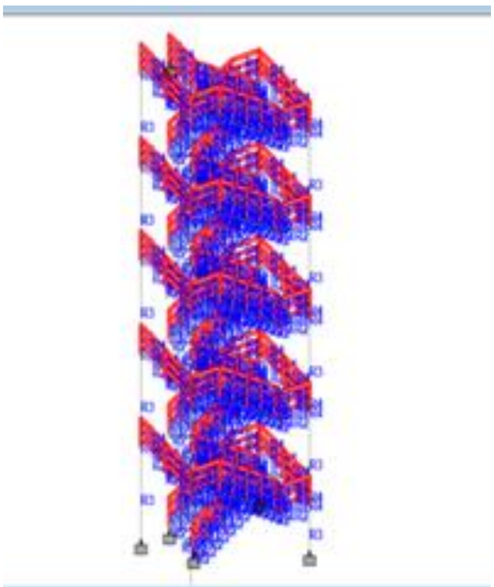

Fig.6 Assigning properties for model

DEAD LOAD ASSIGNING:

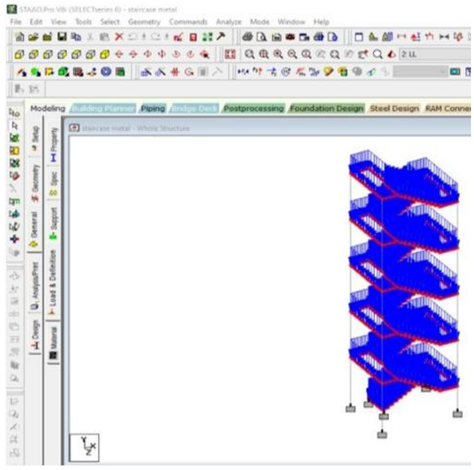

Fig.7 Assigning Dead loads to the model

LIVE LOAD ASSIGNING

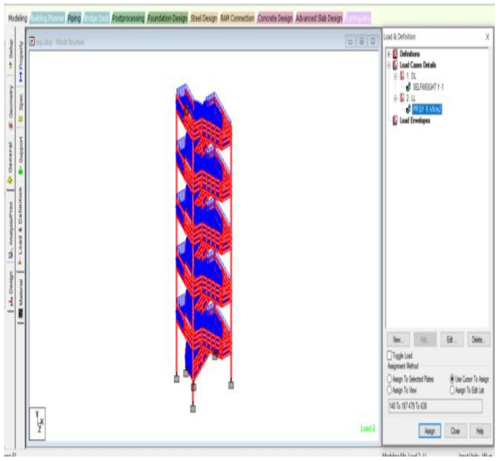

Fig.8 Assigning Live loads to the model

REACTIONS:

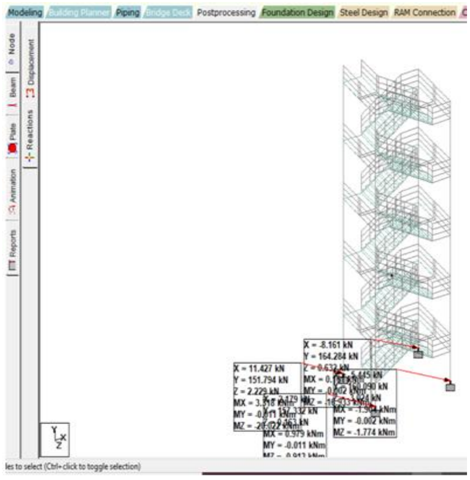

Fig.8 Reactions and moments

Table.1. Reactions and moments

s.no	Reactions along Y-direction	Moments along x-direction
A	157.332	0.979
B	160.09	-1.404
C	164.284	0.161
D	151.794	3.318

III. STEEL DESIGN

For design of steel using IS800:2007 we must give the basic parameters of material. They are yield strength of steel is 415N/mm2, allowable shear stress of steel is 50N/mm2 and allowable bearing stress is 100N/mm2.

STEPS FOR STEEL DESIGN:

After analysing the total structure
Go to design
↓
Select current code
↓
IS 800:2007
↓
Select parameters
↓
Like fx
Fy Ld
Kx
KY
↓
Go to define parameters
↓
FX=415000KN/M^2
↓
Add
FY=275000KN/M^2
Kx=1.0
KY=1.0
Kz=1.0
↓
Select the structure
↓
Assign to selected beams
↓
For each property
↓
Go to commands
↓
Check code
Add
Fixed group
↓
Add

Group
Add
Members take off
↓
Add
Select
↓
Add
Select optimization
↓
Add
Take off
↓
Add
Assign to selected beams
↓
Analysis/print
↓
Run analysis
Thus the steel design is completed

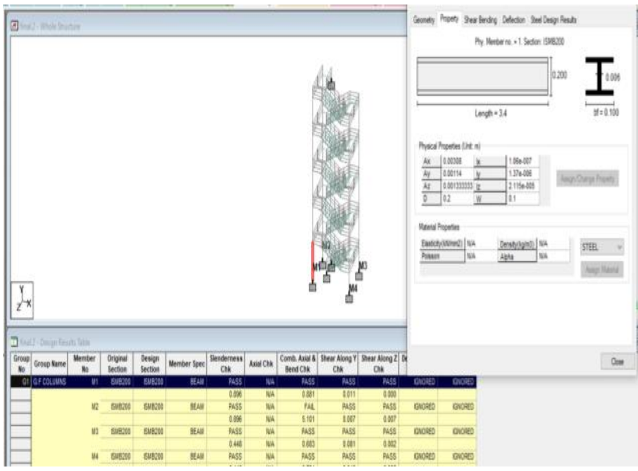

Fig.9 Steel Design

Table.2. Design Section Properties

Prop	Section	Area (cm^2)	Lyy (cm^4)	Lzz (cm^4)	J (cm^4)
2	ISMB 100	11.400	12.50	182.00	2.120
3	ISMB 200	30.800	137.00	2.11 E+3	10.600
4	RECT 0.2x0.02	4.000	1.333	1.333	2.250

FOUNDATION:

A shallow foundation is provided to transfer of load of super structure to the soil at the base of the substructure. If the bearing capacity of the soils is good and the soil is good and the structural load will not cause any settlement of underlying soil layer, then shallow foundation be selected .

Also shallow foundation is mostly used for residential building construction purposes.

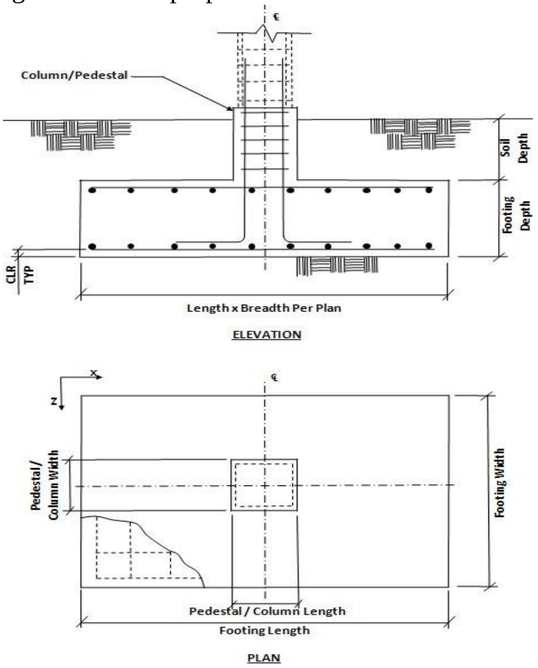

Fig.10 Foundation Design

Design Type: Calculate Dimension:
Footing Thickness (Ft): 305.000 mm
Footing Length - X (Fl): 1000.000 mm
Footing Width - Z (Fw): 1000.000 mm
Eccentricity along X (Oxd): 0.000 mm
Eccentricity along Z (Ozd) : 0.000 mm
Column dimensions
Column Shape: Rectangular Column
Length - X (Pl) : 0.200 m
Column Width - Z (Pw) : 0.100 m
Pedestal
Include Pedestal? No
Pedestal Shape: N/A Pedestal Height (Ph) : N/A
Pedestal Length - X (Pl) : N/A
Pedestal Width - Z (Pw) : N/A
Concrete and rebar properties
Unit Weight of Concrete: 25.000 KN/M^3
Strength of Concrete: 25.000 N/MM^2
Yield Strength of Steel: 415.000 N/MM^2
Minimum Bar Size: Ø6
Maximum Bar Size: Ø32
Minimum Bar Spacing: 50.000 mm
Maximum Bar Spacing: 500.000 mm
Pedestal Clear Cover (P, CL) : 50.000 mm
Footing Clear Cover (F, CL) : 50.000 mm
Soil properties
Soil Type: Drained
Unit Weight: 22.000 KN/M^3
Soil Bearing Capacity: 100.000 KN/M^2
Soil Surcharge: 0.000kN/m2
Depth of Soil above Footing: 0.000 mm
Cohesion: 0.000 KN/M^2 Min
Percentage of Slab: 0.000
Coefficient of Friction: 0.500
Factor of Safety Against Sliding: 1.500 Factor of Safety Against Overturning : 1.500
Design Calculations
Footing Size
Initial Length (Lo) = 1.000 m
Initial Width (Wo) = 1.000 m
Uplift force due to buoyancy = 0.000KN
Effect due to adhesion = 0.000KN
Area from initial length and width, Ao = Lo X Wo 1.000m2
Min. area required from bearing pressure, Amin = P / qmax = 1.991 m2
Top Reinforcement Design
Minimum Area of Steel (Astmin) = 549.000 mm2 Calculated Area of Steel (Ast) = 549.000 mm2
Provided Area of Steel (Ast, Provided) = 549.000 mm2
Astmin<= Ast, Provided
Steel area is accepted Governing Moment = 3.113 KNM
Selected bar Size (db) = Ø6
Minimum spacing allowed (Smin) = 50.000 mm
Selected spacing (S) = 73.368 mm
Smin <= S <= Smax and selected bar size < selected maximum bar size...
The reinforcement is accepted.

CONNECTIONS

The connections provided in steel structures can be classified as 1) riveted 2) bolted and 3) welded connections. Riveted connections were once very popular and are still used in some cases but will gradually be replaced by bolted connections. This is due to the low strength of rivets, higher installation costs and the inherent inefficiency of the connection. Welded connections have the advantage that no holes need to be drilled in the member and consequently have higher efficiencies. However, welding in the field may be difficult, costly, and time consuming. Welded connections are also susceptible to failure by cracking under repeated cyclic loads due to fatigue which may be due to working loads such as trains passing over a bridge (high-cycle fatigue) or earthquakes (low-cycle fatigue). A special type of bolted connection using High Strength Friction Grip (HSFG) bolts has been found to perform better under such conditions than the conventional black bolts used to resist predominantly static loading. Bolted connections are also easy to inspect and replace. The choice of using a particular type of connection is entirely that of the designer and he should take his decision based on a good understanding of the connection behaviour, economy and speed of construction. Ease of fabrication and erection should be considered in the design of connections. Attention should be paid to clearances necessary for field erection, tolerances, tightening of fasteners, welding procedures, subsequent inspection, surface treatment and maintenance. In our project bolted connections are consider by the reason of above benefits.

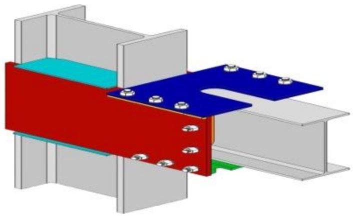

Fig.11 Bolted Connection

COST ESTIMATION

The estimation of design effort and cost plays a vital role in authorizing funds and controlling budget during the project development process. Typically, the design phase consists of various engineering activities that require substantial efforts in delivering final construction documents for bid preparation.

MATERIAL COST FOR STAIRCASE

ISMB 100=we need 30-ISMB sections of length (6units)
Total length= No of sections x length
=30x60
Total length=180 mts
Weight of section per meter=180x8.90
Total weight=1602 kg
Total price=Total weight x Rate of steel
Rate of steel=43/kg
=1602 x 43
Total price=68,886/-
Total weight of steel=1597 kg
Total price=Total weight x Rate of steel
=1597 x 43
Total price=68,671/-
Total cost for I-sections= 68886 + 68671
Total cost for I-sections=1, 37,557/-

RAILINGS:

As per market rate for 1 foot railing price =400/-
Total length of railing=Outer railing + Inner railing
Outer railing=88mts
Inner railing=33mts
Total length=88+33
Total length=121mts
Conversion:
1 meter=3.28foot
121 meters=121 x 3.28
=396.88
So price of railing
400Rs per 1 foot
So for 396.88 foot
Price = 396.88 x 400
=Rs.1, 58,752/-

Table-3 MATERIAL COST FOR STAIRCASE

S.no	Description of work	No's	Q (m^3)	Wt of steel (KG/M^3)	Cost (Rs)
1	Riser	20	5.4x10^6	145.6	19656
2	Thread	18	9.72x10^6	9.72	13122

Labour cost is estimated to be Rs. 1, 14,850Rs/-
Machinery cost is estimated to be Rs. 9600/-

TOTAL COST:

Table-4 Total cost

S.no	Item	Cost(Rs/-)
1	Steel materials for staircase	1,37,557
2	Railings	1,58,752
3	Steps	
	Risers	19,656
	Treads	13,122
4	Labour charges	1,14,850
5	Machinery charges	9,600
	TOTAL	4,53,537

Total cost=Rs.**4, 53,537**
Take 2% of miscellaneous cost= 4,53,537 x (2/100) =9071
Cost of project= 4,53,537 + 9071
=Rs.4, 62,608

IV. CONCLUSIONS

For emergency exit a metal stair case is proposed for the multistory building. There is also a condition that, the stair case should be provided at the outer side of the structure without disturbing the main structure for the purpose of easy removal and also used for shifting into another place.
The stair case has been designed in STAAD Pro.
Steel Structure and foundation for the structure has been designed.
ISMB 100, ISMB 200, Rectangular sections of 0.2X0.02 have been used in the design.
We consider the total load carrying of staircase with the factor of safety 1.5.
Cost estimation for the structural steel, railings, labour and machinery costs were done.
The cost of the project is 4, 62,608/- with a project duration nearly one and half month.

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