Wind Analysis of a Industrial Steel Structure with Varying Connections in the Member

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***Abstract*— In this report, type of structure and most feasible type of connection, different types of connections, compare the node displacements and to suggest a suitable type of connection are studied. Analysis is carried out by using STAAD Pro. to see the range of parameters such as node displacement, beam relative displacement, beam end forces, weight and beam forces such as maximum axial forces, bending moments and shear forces of the structure.**

Keywords—Bolted; welded; shear and moment connections; wind load; maximum node displacement; bending moment; shear force; weight and axial force.

I. INTRODUCTION

Connections are the glue that holds a steel structure together. Connections facilitate flow of moments and different types of forces in members and also allow transfer of forces up to foundation level. The ultimate moto or goals of connection design is to have a economical, safe and not so complex design, so that without any difficulty it can be produced and assembled at site. Connection depends on type of loading, strength, stiffness, economy and difficulty or ease of erection. Connecting materials such as angles, plates etc. are fixed to one member at workshop and other member in the field.

A. Objectives

- To study the range of moments and general connection details.
- To study the type of structure and most feasible type of connection.
- To study different types of connections.
- To compare the node displacements and to suggest a suitable type of connection.

II. CONNECTIONS

A. Bolted connections

- Nuts

  Types of nuts

  a. Standard : height is approx. 0.8 d
  b. High : height is 1.2 to 2 d
  c. Low : height is 0.4 d
  Where, d = diameter of bolt

- Washers

  Types of washers
  a. Standard washers
  b. Standard but hardened for slip-resistant connections
  c. Wedge washers for connection to flange of I-sections.

- Bolts

  Type of bolts
  a. Black bolts
  b. Turned bolts
  c. Ribbed bolts
  d. High-Strength bolts

B. Welded Connections

Types of welds
- Fillet weld
- Groove weld
- Slot and plug weld

C. Shear connections

A connection is required to transfer a force only and there may not be any moment acting on the group of connectors, even though the connection may be capable of transmitting some amount of moment. Such a connection is referred as a shear, simple, pinned, force connection.

Types of simple connections
- Lap and butt joints
- Truss joint connections
- Connections at beam column junctions
  a. Web angle connection
  b. Seat angle connection
  c. Stiffened seat angle connection
  d. Header plate connections
- Tension and flange splices

D. Moment Resistant Connections

A connection which is capable of transferring moment, axial force and shear from one member to another is referred as moment resistant connection.

Types of Moment Resistant connections

- Eccentrically loaded connections
- T-stub connections
- Flange angle connections

III. Methodology

I. *General*

The present work is carried to study the difference between structural connections and behavior of structure with different types of structural connections. The software used for the analysis is STAAD Pro V8i. A plan of three storey steel structure building is considered as a model, analysis is done using STAAD Pro V8i. and the design of structural joints is carried manually using excel sheets.

Following studies are carried:

- Difference between bolted and welded connections
- Behavior of structure with different structural connections at different location of structure.
- Different types of structural connections will be checked for wind speed
- The range of moments and general connection details are studied.
- The most feasible type of connection for the type of structure is studied

II. *STAAD Pro V8i*

STAAD Pro V8i is a full featured program that can be used for the simplest programs or the most complex projects. This software gives better result of steel structures.

III. *Modeling And Analysis*

- Procedure followed to generate the models

  Fifteen different types of framed steel structure of three story industrial building are modeled. Following parameters are considered

Table 1: Physical Properties

Sl.no	Material	Steel	Concrete
1	Yield strength	250 N/mm^2.	-
2	Modulus of elasticity	2x10^5 N/mm^2	25x10^3 N/mm^2
3	Density	7850 kg/m^3	25 kN/m^2
4	Grade	250 N/mm^2	M25
5	Poisson's ratio	0.3	0.2

Table 2: Description of the types of models

Sl. no	Numbers of models	Model 1	Model 2	Model 3	Model 4	Model 5
1	Plan size	12m x 12m	12m x 12m	40m x 40m	40m x 40m	40m x 40m
2	Bay size	6m	6m	20m	20m	20m
3	Height	3.2m	3.2m	3.2m	3.5m	3.7m
4	Column size	ISWB 600	ISWB 600	ISWB 600	ISWB 600	ISWB 600
5	Beam size	ISHB 450	ISHB 450	ISHB 450	ISHB 450	ISHB 450
6	Central beam size	-	UB610 x229x1 39.9	UB610 x 229x13 9.9	UB610 x229 x139.9	UB610 x 229x13 9.9
7	Rectangular concrete plinth beam size	250m mx 600m m	250mm x 600mm	250mm x 600mm	250mm x600m m	250m x600m m

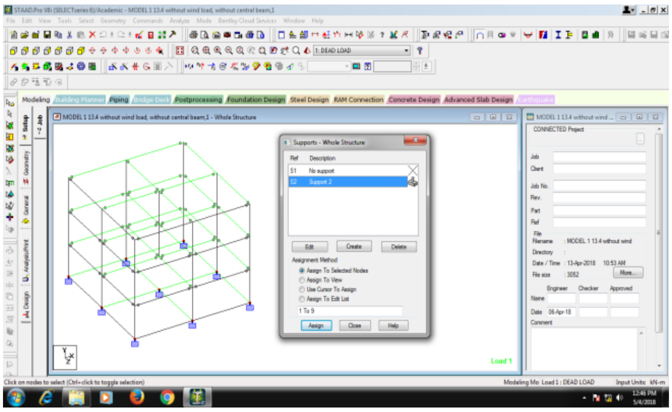

Figure 1: Modeling in Staad ProV8i

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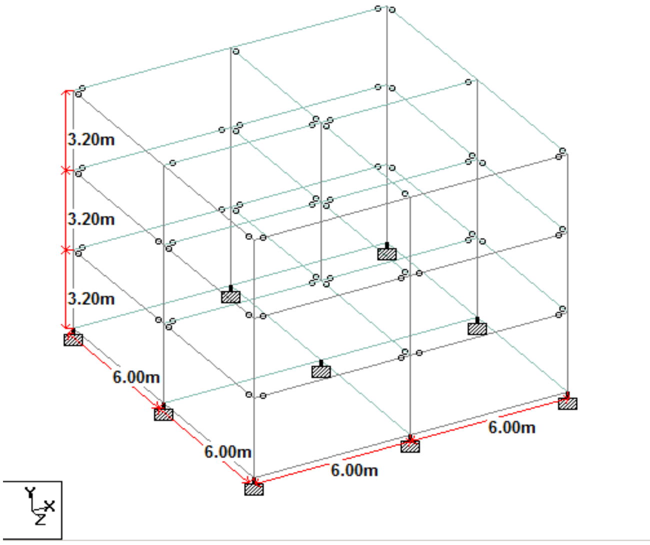

Figure 2: Model 1 with bay size 12 m X12 m

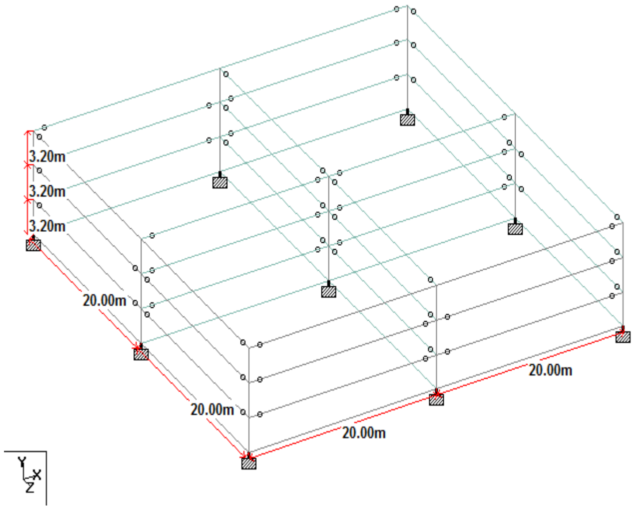

Figure 4: Model 3 with bay size 40 m X40 m

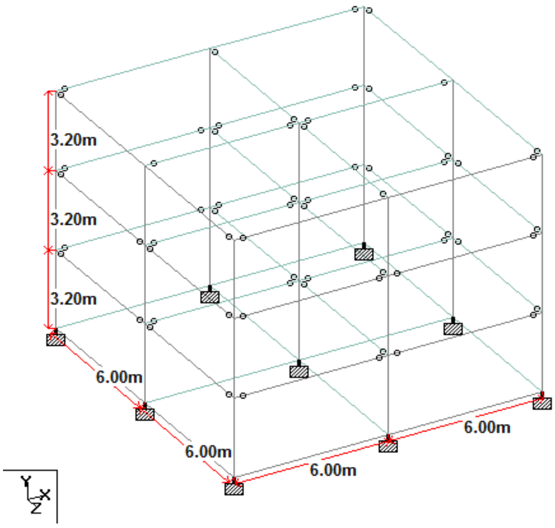

Figure 3: Model 2 with bay size 12 m X12 m

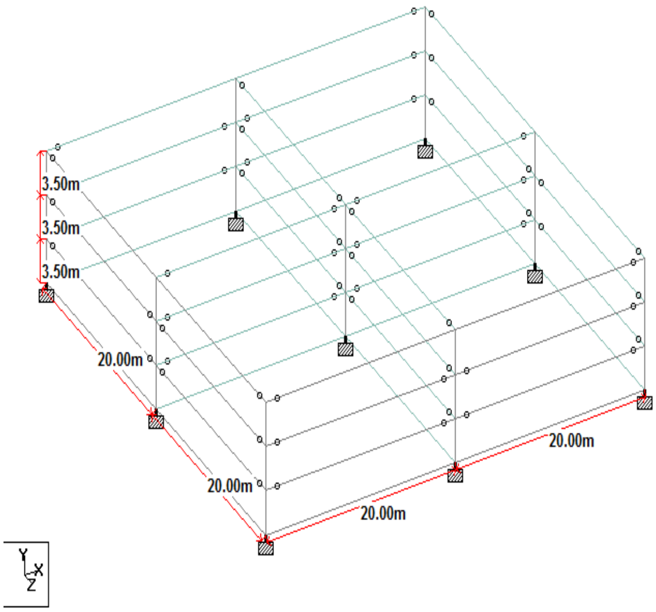

Figure 5: Model 4 with bay size 40 m X40 m

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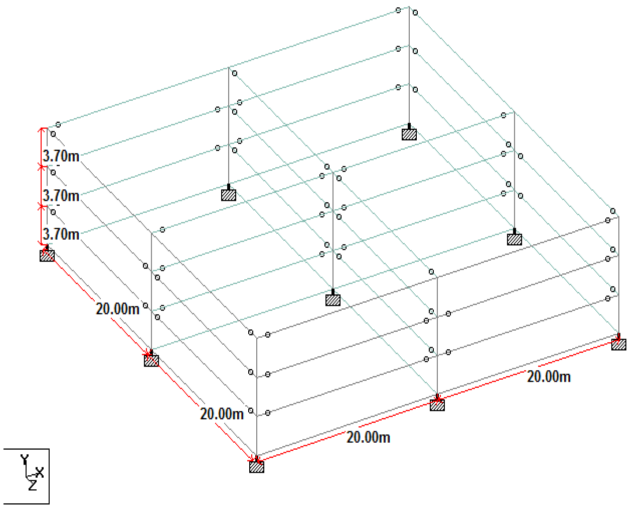

Figure 6: Model 5 with bay size 40 m X40 m

Table 3: Calculated Wind Forces

Sl. No	Story no.	Height in m	F kN/m^2	Amount of wind force acting per meter on member in kN/m
1	1st and 2nd floor	3.7	1.5	5.55
2	3rd floor	1.85	1.5	2.775
3	1st and 2nd Floor	3.5	1.5	5.25
4	3rd floor	1.75	1.5	2.625

IV. CALCULATION OF FORCES

A. *Calculation of wind load*

According to IS 875 (Part III) 1987.

- Design wind speed, $V_z = V_b \times k_1 \times k_2 \times k_3$

  $V_b = 33$ m/s
  $k_1 = 1.0$
  $k_2 = 1.10$
  $k_3 = 1.0$
  $V_z = 33 \times 1.0 \times 1.10 \times 1.0$
  $V_z = 36.3$ m/s

- Wind pressure, $p_z = 0.6 \times V_z^2$

  $p_z = 0..6 \times 36.3^2$
  $p_z = 790.614$ N/m^2

- Design wind pressure, $p_d = k_d \times k_a \times k_c \times p_z$

  $p_d = 0.9 \times 0.9 \times 1 \times 790.614$
  $p_d = 640.397$ N

- Wind load on individual members,

  $F = (C_{pe} - C_{pi})\ A \times p_d$
  $F = (0.7 - (-0.2))\ A \times 640.397$
  $F = 576.35$ A N
  $F = 0.576$ kN/m^2

As calculated wind loads are nominal a minimum wind load of 1.5 kN/m^2 is considered for analysis.

Table 4: Results for Displacements ant relative Displacement

Plan size in m	Height in m	Self-weight in kN	Displacement in mm	Relative Displacement in mm
12 x 12	3.2	4146.83	3.368	1.025
12 x 12	3.2	4082.39	40.76	1.84
40 x 40	3.2	41521.33	37.884	126.567
40 x 40	3.5	41531.93	41.426	551.469
40 x 40	3.7	41538.99	43.786	551.469
12 x 12	3.2	4142.45	63.128	4.275
12 x 12	3.2	4146.83	3.423	1.025
40 x 40	3.2	41521.33	37.945	126.567
40 x 40	3.5	41531.93	41.499	551.47
40 x 40	3.7	41538.99	43.868	551.47
12 x 12	3.2	4142.45	26.842	3.711
12 x 12	3.2	4146.83	3.328	1.025
40 x 40	3.2	41521.33	37.917	126.567
40 x 40	3.5	41531.93	41.462	551.14
40 x 40	3.7	41538.99	43.824	551.14

Table 5: Results for Bending Moment and Shear Forces

Plan size in m	Height in m	Beam Force in kN	Bending moment in kNm	Shear force in kN
12 x 12	3.2	1888.31	16.54	15.90
12 x 12	3.2	1492.79	387.91	198.68
40 x 40	3.2	21126.15	176.71	53.01
40 x 40	3.5	21122.07	176.71	53.01
40 x 40	3.7	21119.4	176.71	53.01
12 x 12	3.2	1540.83	221.90	69.34
12 x 12	3.2	1914.55	15.90	15.90
40 x 40	3.2	21155.24	176.71	53.01
40 x 40	3.5	21153.42	176.71	53.01
40 x 40	3.7	21152.23	176.71	53.01
12 x 12	3.2	1587.43	455.02	284.04
12 x 12	3.2	1868.04	30.65	17.88
40 x 40	3.2	21142.17	176.71	`68.92
40 x 40	3.5	21137.71	176.71	66.43
40 x 40	3.7	21134.79	176.71	64.92

V. RESULT AND DISCUSSIONS

After the analysis significant change in parameters such as node displacement, beam relative displacement, beam end forces, weight and beam forces such as maximum axial forces, bending moments and shear forces of the structure are noticed.

VI. DISCUSSION AND CONCLUSION.

A. In the first model the connections are fixed. Hence the node displacements observed in this model are minimum.
B. In the sixth model, the joints are hinged (releases are provided). Here maximum displacements are observed.
C. In the eleventh model, only the joints where the columns overlap or have a joint are hinged. It is observed that the values of node displacement range between the first and sixth model. All the three models have the same geometry and member sizes.
D. These trials were taken for different models, different member sizes, different length and span sizes. However the results are similar to first trial.

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E. From the above results, we can conclude that the fixed connections are best suited as the node displacements are minimum and are less than H/250 mm. which is the minimum requirement for a structure to be safe under displacements.

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