Civil and Environmental Research www.iiste.org
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) DOI: 10.7176/CER
Vol.11, No.2, 2019

Behavior of Multi-Story Building With and Without Shear Wall Under the Effect Wind Loads

Mustafa Wassef Abdulmajeed
Assistant Teacher. Building and Construction Engineering Department, Al-ISRAA University, Baghdad, Iraq

Abstract
Shear walls are specially designed structural walls that are incorporated in buildings to resist lateral forces that are created in the plane of wall due to wind, earthquake and flexural members. This paper presents the study and comparison of the distinction between the wind behaviors of buildings with and while not shear wall victimization Staad professional.
Keywords, Shear wall, STAAD PRO , Wind behavior
DOI: 10.7176/CER/11-2-05
Publication date:March 31st 2019

1. Introduction
The high rise building represent the optimum like areas particularly in dense and expensive areas, together with excellence in execution and esthetically conjointly different considerations that everyone over the globe. Some high-rise buildings regarding the globe see
Figure (1.1)

Figure 1.1: some high-rise buildings about the world

1.2 Structural Systems for Tall Buildings
The following classification is planned for the structural systems of tall buildings for all the categories specifically, steel buildings, ferroconcrete buildings, and composite buildings.[5]:
1. Rigid frame systems
2. Braced frame and shear-walled frame systems
3. Stabilizer systems
4. Framed-tube systems
5. Braced-tube systems
6. Bundled-tube systems

1.2.1 Rigid Frame Systems
Rigid frame systems are utilized in both steel and reinforced concrete construction. Rigid frame systems for resisting lateral and vertical loads have long been accepted for the design of the buildings. Rigid framing, namely moment framing, is based on the fact that beam-to-column connections have enough rigidity to hold the nearly unchanged original angles between intersecting components. Owing to the natural monolithically behavior, hence the inherent stiffness of the joist, rigid framing is ideally suitable for reinforced concrete buildings [5].

For a rigid frame the strength and stiffness are proportional to the dimension of the beam and the column dimension, and inversely proportional to the column spacing. , Especially for the buildings constructed in seismic zones, a special attention should be given to the design and detailing of joints, since rigid frames are more ductile and less vulnerable to severe earthquakes when compared to steel braced or shear- walled structures. (Fig.1.2)

Figure. 1.2: Rigid Frame Systems

1.2.2 Braced Frame and Shear-Walled Frame Systems

Rigid frame systems are not efficient for buildings taller than 30 stories, because lateral deflection due to the bending of columns causes the drift to be too large. On the other hand, steel bracing or shear walls with or without rigid frame (brace systems and shear wall systems), increases the total rigidity of the building and the resulting system is named as braced frame or shear-walled frame system. Namely, systems composed of steel bracing or shear walls alone, or interacting with the rigid frames can be accepted as an improvement of the rigid frame system. These systems are stiffer when compared to the rigid frame system, and can be used for buildings over 30 stories, but mostly applicable for buildings about 50 stories in height. .[5]

1.2.2.1 Braced Frame Systems

Braced frame systems are utilized in steel construction. This system is a highly efficient and economical system for resisting horizontal loading, and attempts to improve the effectiveness of a rigid frame by almost eliminating the bending of columns and girders, by the help of additional bracing. It behaves structurally like a vertical gravity loads, and diagonal bracing components so that the total set of members forms a vertical cantilever truss to resist the horizontal loading.

1.2.2.2 Shear-Walled Frame Systems

Resist lateral wind and seismic loads acting on a building and transmitted to them by the floor diaphragms. Shear walls are generally parts of the elevator and service corps, and frames to create a stiffer and stronger structure. These elements can have various shapes such as, circular, curvilinear, oval, box-like, triangular, or rectilinear. This system structurally behaves like a concrete building with shear walls resisting all the lateral loads. (Fig.1.3)

Figure. 1.3 Buildings with Shear Wall

1.3. Tall building codes
- ASCE/SEI 7-10
- (2006 – 2009) IBC
- ACI 318 – 05 /08

المسودة الاولية لمدونة الزلزال العراقية (م.ب.ع) .

1.4 Difference between Law Rise Buildings and Tall Buildings
A tall- building is defined as a building 35 meters or greater in height, which is divided at regular intervals into occupiable levels. To be considered a high-rise building, an edifice must be based on solid ground and fabricated along its full height.[3]The cut-off between tall and low buildings is 35 meters. A low-rise building is defined as any occupy able building which is divided at regular intervals into occupiable levels and which is lower than a high-rise, i.e., lower than 35 meters. To be considered a low-rise building, an edifice must be based on solid ground and fabricated along its full height and have at least one floor above the ground [3].see (fig1.4) for law rise and tall building difference.

Figure 1.4: Tall and law buildings

2. Loads on High Rise Buildings
2.1 Loads
Structural members must be designed to support specific loads. Loads are those forces for which a given structure should be proportioned. In general, loads may be classified as dead or live.
2.1.1dead Load
Dead loads consist of the weight of all materials of construction incorporated into the building including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items, and fixed service equipment including the weight of ranes.[1]
2.1.2 Live Load
Live loads are those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load. Live loads on a roof are those produced:
(1) During maintenance by workers, equipment, and materials
(2) During the life of the structure by movable objects such as planters and by people.
- The ACI Code does not specify loads on structures; however, IBC-2012 and the American National Standards Institute (ANSI) [5] prescribe occupancy loads on different types of buildings. Some typical values are shown in Table 2.1. Table 2.2 shows the density of various materials.
- The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall in no case be less than the minimum uniformly distributed unit loads required by Table (2-1).

ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) DOI: 10.7176/CER
Vol.11, No.2, 2019

Table 2. 1 Typical Uniformly Distributed Design live Loads

Occupancy or Use	Uniform psf (kN/m²)
Apartments (see residential)	
Access floor systems	
Office use	50 (2.4)
Computer use	100 (4.79)
Armories and drill rooms	150 (7.18)
Assembly areas and theaters	
Fixed seats (fastened to floor)	60 (2.87)
Lobbies	100 (4.79)
Movable seats	100 (4.79)
Platforms (assembly)	100 (4.79)
Stage floors	150 (7.18)
Balconies (exterior)	100 (4.79)
On one- and two-family residences only, and not exceeding 100 ft.² (9.3 m²)	60 (2.87)
Bowling alleys, poolrooms, and similar recreational areas	75 (3.59)
Catwalks for maintenance access	40 (1.92)
Corridors	
First floor	100 (4.79)
Other floors, same as occupancy served except as indicated	
Dance halls and ballrooms	100 (4.79)
Decks (patio and roof)	
Same as area served, or for the type of occupancy accommodated	
Dining rooms and restaurants	100 (4.79)
Dwellings (see residential)	
Elevator machine room grating (on area of 4 in.² (2580 mm²))	
Finish light floor plate construction (on area of 1 in.² (645 mm²))	
Fire escapes	100 (4.79)
On single-family dwellings only	40 (1.92)
Fixed ladders	
Garages (passenger vehicles only)	40 (1.92)
Trucks and buses	N

ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) DOI: 10.7176/CER
Vol.11, No.2, 2019

Table 2 .1 Typical Uniformly Distributed Design live Loads

Occupancy or Use	Uniform psf (kN/m^2)
Grandstands (see stadium and arena bleachers)	
Gymnasiums, main floors, and balconies	100 (4.79) Note (4)
Handrails, guardrails, and grab bars	See Sectio
Hospitals	
Operating rooms, laboratories	60 (2.87)
Private rooms	40 (1.92)
Wards	40 (1.92)
Corridors above first floor	80 (3.83)
Hotels (see residential)	
Libraries	
Reading rooms	60 (2.87)
Stack rooms	150 (7.18) Note (3)
Corridors above first floor	80 (3.83)
Manufacturing	
Light	125 (6.00)
Heavy	250 (11.97)
Marquees and canopies	75 (3.59)
Office buildings	
File and computer rooms shall be designed for heavier loads based on anticipated occupancy	
Lobbies and first floor corridors	100 (4.79)
Offices	50 (2.40)
Corridors above first floor	80 (3.83)
Penal institutions	
Cell blocks	40 (1.92)
Corridors	100 (4.79)
Residential	
Dwellings (one- and two-family)	
Uninhabitable attics without storage	10 (0.48)
Uninhabitable attics with storage	20 (0.96)
Habitable attics and sleeping areas	30 (1.44)
All other areas except stairs and balconies	40 (1.92)
Hotels and multifamily houses	
Private rooms and corridors serving them	40 (1.92)
Public rooms and corridors serving them	100 (4.79)
Reviewing stands, grandstands, and bleachers	100 (4.79) Note (4)

Table 2. 2 Density of Various Materials

Material	Density	
	lb/ft^3	kg/m^3
Building materials		
Bricks	120	1,924
Cement, portland, loose	90	1,443
Cement, portland, set	183	2,933
Earth, dry, packed	95	1,523
Sand or gravel, dry, packed	100–120	1,600–1,924
Sand or gravel, wet	118–120	1,892–1,924
Liquids		
Oils	58	930
Water (at 4°C)	62.4	1,000
Ice	56	898
Metals and minerals		
Aluminum	165	2,645
Copper	556	8,913
Iron	450	7,214
Lead	710	11,380
Steel, rolled	490	7,855
Limestone or marble	165	2,645
Sandstone	147	2,356
Shale or slate	175	2,805
Normal-weight concrete		
Plain	145	2,324
Reinforced or prestressed	150	2,405

2.2 Wind Load

Buildings and their components are to be designed to withstand the code- Specified wind loads. Calculating wind loads is important in design of the Wind force-resisting system, including structural members, components and cladding, against shear, sliding, overturning and uplift actions. See fig 2.1

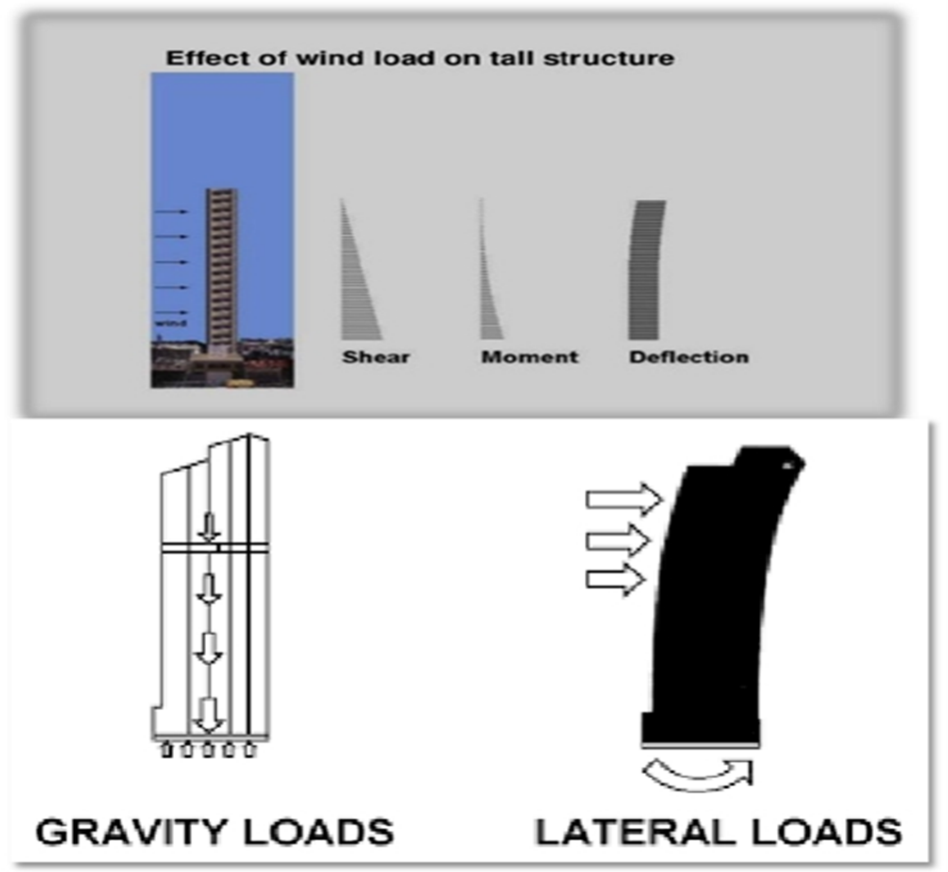

Figure 2.1 effect of wind load on building

2.2.1 Methods of Determination Wind Load

The design wind loads for buildings and other structures shall be Determined according to one of the following procedures [ASCE7-10]:

(1) Method – Simplified procedure for low-rise simple diaphragm buildings.

(2) Method – Analytical procedure for regular shaped building and structures.

2.2.1.1 Method – Simplified Procedure

The simplified procedure is used for determining and applying wind pressures in the design of simple diaphragm buildings with flat, gabled, and hipped roofs and having a mean roof height not exceeding the least horizontal dimension or 60 feet (18.3 m), whichever is less, and subject to additional limitations.

2.2.1.2 Method – Analytical Procedur

Wind loads for buildings and structures that do not satisfy the conditions for using the simplified procedure can be calculated using the analytical procedure provided that it is a regular shaped building or structure, and it does not have response characteristics making it subject to a cross-wind loading, vortex shedding, instability due to galloping or flutter, or does not have a site location that require special consideration. [ASCE7-10]

Method 1 can't use for determination of wind load due to building height (64m) and it use for building with law rise (< 18.3 m) so we will be use method 2 for determine wind load.

2.3 Procedure for Determined Wind Load

2.3.1. Determine Velocity Pressure

Velocity pressure, qz, evaluated at height z shall be calculated by the following equation [ASCE7-10]:-

Where:-

qz = velocity pressure
Kd = wind directionality factor
Kz = velocity pressure exposure coefficient
Kzt = topographic factor defined
V= basic wind speed

2.3.1.1. Determine Kd

Kd find from Table (2-3).

Table (2-3)

Structure Type	Directionality Factor K_d*
Buildings Main Wind Force Resisting System Components and Cladding	 0.85 0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures Square Hexagonal Round	 0.90 0.95 0.95
Solid Freestanding Walls and Solid Freestanding and Attached Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers Triangular, square, rectangular All other cross sections	 0.85 0.95

2.3.1.2 Find Kzt

Kzt find from

Kzt = (1 + K1K2K3)2

Where:-

K1, K2, and K3 are given in Table (2-4) shown below. If site conditions and Locations of structures do not meet all the conditions specified in Table (2-4). then Kzt = 1.0.

Table (2-4)

Parameters for Speed-Up Over Hills and Escarpments						
Hill Shape	$K_1/(H/L_h)$			γ	μ	
	Exposure				Upwind of Crest	Downwind of Crest
	B	C	D			
2-dimensional ridges (or valleys with negative H in $K_1/(H/L_h)$)	1.30	1.45	1.55	3	1.5	1.5
2-dimensional escarpments	0.75	0.85	0.95	2.5	1.5	4
3-dimensional axisym. hill	0.95	1.05	1.15	4	1.5	1.5

Notes:

1. For values of H/L_h, x/L_h and z/L_h other than those shown, linear interpolation is permitted.
2. For $H/L_h > 0.5$, assume $H/L_h = 0.5$ for evaluating K_1 and substitute 2H for L_h for evaluating K_2 and K_3.
3. Multipliers are based on the assumption that wind approaches the hill or escarpment along the direction of maximum slope.
4. Notation:
   - H: Height of hill or escarpment relative to the upwind terrain, in feet (meters).
   - L_h: Distance upwind of crest to where the difference in ground elevation is half the height of hill or escarpment, in feet (meters).
   - K_1: Factor to account for shape of topographic feature and maximum speed-up effect.
   - K_2: Factor to account for reduction in speed-up with distance upwind or downwind of crest.
   - K_3: Factor to account for reduction in speed-up with height above local terrain.
   - x: Distance (upwind or downwind) from the crest to the building site, in feet (meters).
   - z: Height above ground surface at building site, in feet (meters).
   - μ: Horizontal attenuation factor.
   - γ: Height attenuation factor.

Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) DOI: 10.7176/CER
Vol.11, No.2, 2019

2.3.1.3 Find Kz

Kz find from equation below :-

1- The velocity pressure exposure coefficient Kz may be determine from
the following formula or from the Table (2-5):-

For 15 ft. ≤ z ≤ zg

Kz = 2.01(z/zg)2/α

For z < 15 ft.

kz = 2.01(15/zg)2/α

2- α and zg in Table (2-6)

3- Linear interpolation for intermediate values of height z is acceptable

K_1 determined from table below

$$K_2 = (1 - \frac{|x|}{\mu L_h})$$

$$K_3 = e^{-\gamma z/L_h}$$

Table 2.5 velocity pressure exposure coefficients , Kz and Kh

Height above ground level, z		Exposure		
ft	(m)	B	C	D
0–15	(0–4.6)	0.57	0.85	1.03
20	(6.1)	0.62	0.90	1.08
25	(7.6)	0.66	0.94	1.12
30	(9.1)	0.70	0.98	1.16
40	(12.2)	0.76	1.04	1.22
50	(15.2)	0.81	1.09	1.27
60	(18)	0.85	1.13	1.31
70	(21.3)	0.89	1.17	1.34
80	(24.4)	0.93	1.21	1.38
90	(27.4)	0.96	1.24	1.40
100	(30.5)	0.99	1.26	1.43
120	(36.6)	1.04	1.31	1.48
140	(42.7)	1.09	1.36	1.52
160	(48.8)	1.13	1.39	1.55
180	(54.9)	1.17	1.43	1.58
200	(61.0)	1.20	1.46	1.61
250	(76.2)	1.28	1.53	1.68
300	(91.4)	1.35	1.59	1.73
350	(106.7)	1.41	1.64	1.78
400	(121.9)	1.47	1.69	1.82
450	(137.2)	1.52	1.73	1.86
500	(152.4)	1.56	1.77	1.89

Table 2.6

In metric

Exposure	α	z_g (m)	$\hat{a}$	$\hat{b}$	$\bar{\alpha}$	$\bar{b}$	c	ℓ (m)	$\bar{\epsilon}$	z_{min} (m)*
B	7.0	365.76	1/7	0.84	1/4.0	0.45	0.30	97.54	1/3.0	9.14
C	9.5	274.32	1/9.5	1.00	1/6.5	0.65	0.20	152.4	1/5.0	4.57
D	11.5	213.36	1/11.5	1.07	1/9.0	0.80	0.15	198.12	1/8.0	2.13

2.3.1.4 Find V

Basic wind speed From Iraqi code by using wind map in (figure 2.2)
below (م.ب.ع) المسودة الاولية لمدونة الزلزال العراقية

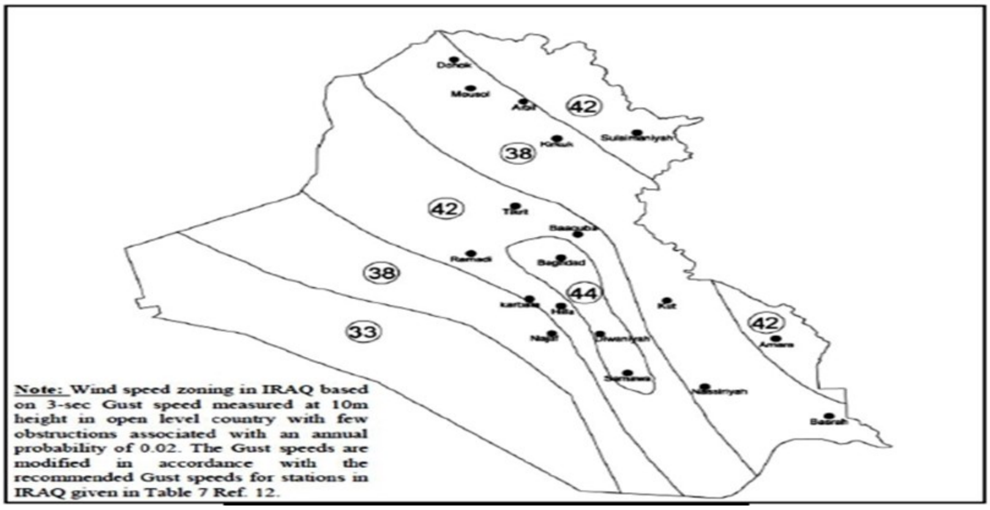

Figure 2.2 wind speed zoning in Iraq

2.3.2 Determine the Design Wind Pressure (P) or Design Wind Load (F)
The design wind load pressure is given by following equation:-
P = qz G Cp - qi (GCpi) (N/m2)
Where:-
q = qz for windward walls evaluated at height z above the ground z.
q = qh for leeward walls, sidewalls, and roofs, evaluated at height h.
qi = qh for windward walls, side walls, leeward walls, and roofs of enclosed buildings and for negative internal pressure evaluation in partially enclosed
G = gust-effect factor.
Cp = external pressure coefficient from.
(GCpi) = internal pressure coefficient from.
2.3.2.1 Find G
The gust-effect factor for a rigid building or other structure is permitted to be taken as 0.85.
2.3.2.2 Find Cp
Cp find from Table 2.7

Table 2.7

Wall Pressure Coefficients, C_p			
Surface	L/B	C_p	Use With
Windward Wall	All values	0.8	q_z
Leeward Wall	0-1	-0.5	q_h
	2	-0.3	
	≥4	-0.2	
Side Wall	All values	-0.7	q_h

3. Case Studies
3.1 Introduction
Building engineered with structural walls are usually stiffer than framed structures reducing the possibility of excessive deformations and hence damage. The necessary strength to avoid structural damage under wind load can be achieved by providing a properly detailed longitudinal and transverse reinforcement. by adopting special detailing measures, depending ductile response can be achieved under major earthquakes.

Lateral forces, that is, the forces applied horizontally to a structural derived from winds or earthquakes cause shear and overturning moments in walls. the shear forces tend to tear the wall just as if you had a piece of paper attached to a frame and changed the frames shape from a rectangular to parallelogram. this changing of shape is generally referred as racking. at the ends of shear walls, there is a tendency for the wall to be lifted up at the end where the lateral force is applied.

3.2 Description of the Structure
The structures, used for the analyses, are assumed to be serving as school buildings. The detailed descriptions of the building is the follows:

Building has a regular plan (40m x 25m) as shown in Figure 3.1.each building contains 12 floors and the height of the building (42) meters The structural system is select as concrete frames with identical columns of 50/50 centimeters in size, and beams of dimension 50/30 centimeters. Each floor slab has 16 centimeters thickness and the story height is 3.5 meters.

Hight of each storey	**3.5 m**
Number of storey	**Twelve (G+11)**
Shear wall thickness	**250 mm**
Grade of concrete and steel	**M20 and Fe 415**
Size of beam	**500 x300 mm²**
Size of column	**500 x 500 mm²**
location	**Baghdad**

ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) DOI: 10.7176/CER
Vol.11, No.2, 2019

3.3 – Deflection Diagram

Table 3 – 1

Building with shear wall		
Storey Numbers	Bending moment	Shear force
Storey12	14.274	23.483
Storey11	19.303	25.717
Storey10	18.873	25.541
Storey9	19.049	25.627
Storey8	19.152	25.697
Storey7	19.285	25.792
Storey6	19.449	25.911
Storey5	19.646	26.054
Storey4	19.876	26.219
Storey3	20.104	26.400
Storey2	20.393	26.582
Storey1	19.524	26.586

Table 3 – 2

Building without shear wall		
Storey Numbers	Shear force	Bending moment
Storey12	29.824	26.478
Storey11	32.221	33.985
Storey10	32.076	33.380
Storey9	31.845	32.835
Storey8	31.573	32.147
Storey7	31.239	31.312
Storey6	30.836	30.302
Storey5	30.360	29.112
Storey4	29.811	27.737
Storey3	29.181	26.157
Storey2	28.456	24.372
Storey1	27.549	21.913

Table 3.3

Storey Numbers	Displacement of 12 storey building without shear wall (mm)	Storey Numbers	Displacement of 12 storey building with shear wall (mm)
Storey12	6.428	Storey12	2.183
Storey11	6.359	Storey11	2.185
Storey10	6.204	Storey10	2.143
Storey9	5.966	Storey9	2.084
Storey8	5.647	Storey8	2.002
Storey7	5.248	Storey7	1.899
Storey6	4.768	Storey6	1.776
Storey5	4.206	Storey5	1.634
Storey4	3.571	Storey4	1.471
Storey3	2.857	Storey3	1.290
Storey2	2.074	Storey2	1.078
Storey1	1.225	Storey1	0.839

ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) DOI: 10.7176/CER
Vol.11, No.2, 2019

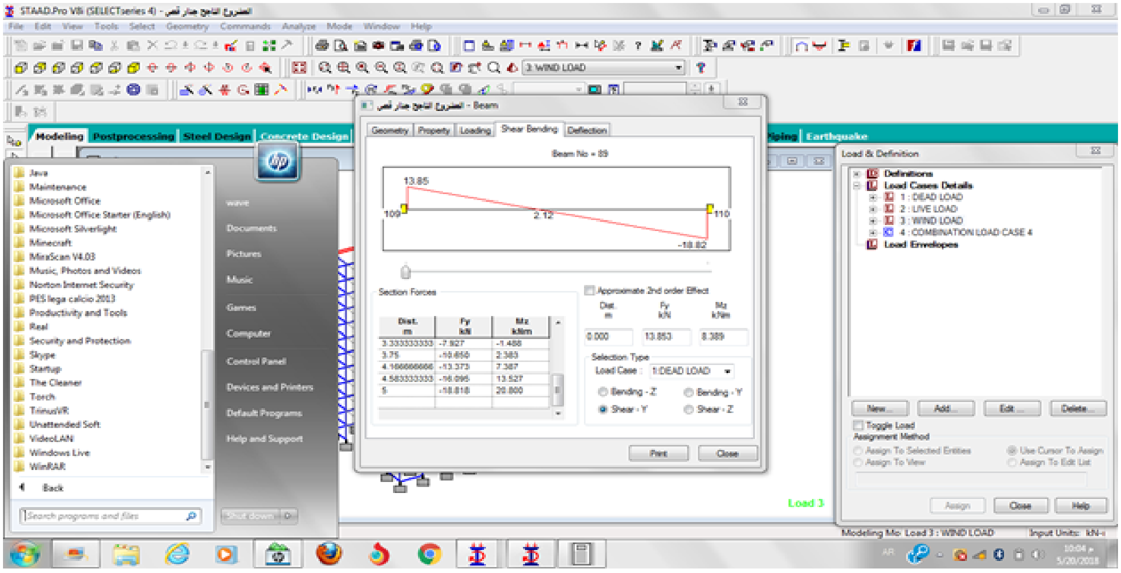

Figure. 3.1 Buildings with Shear Wall (shear bending)

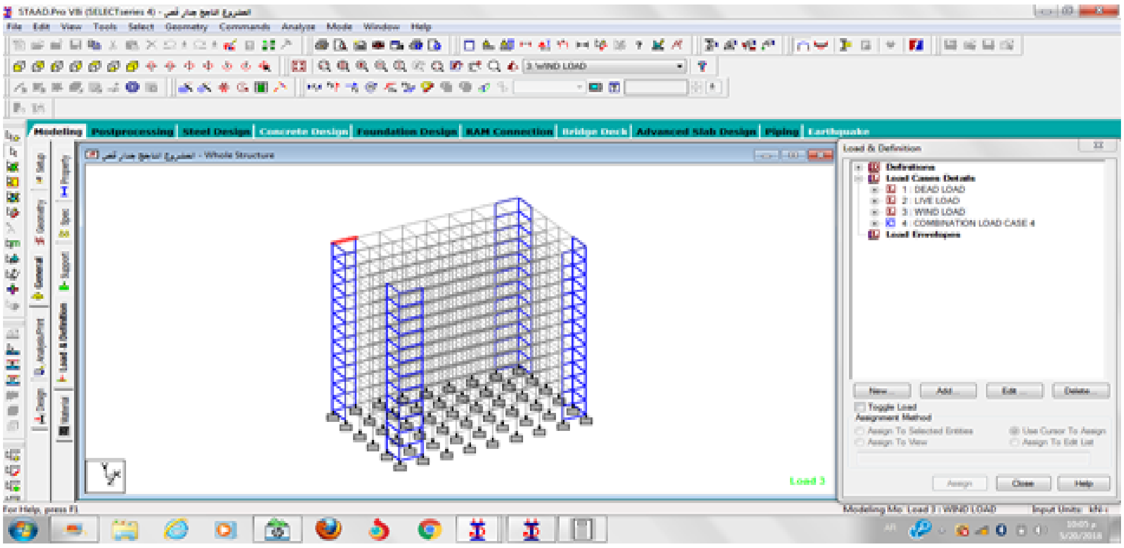

Figure. 3.2 Buildings with Shear Wall

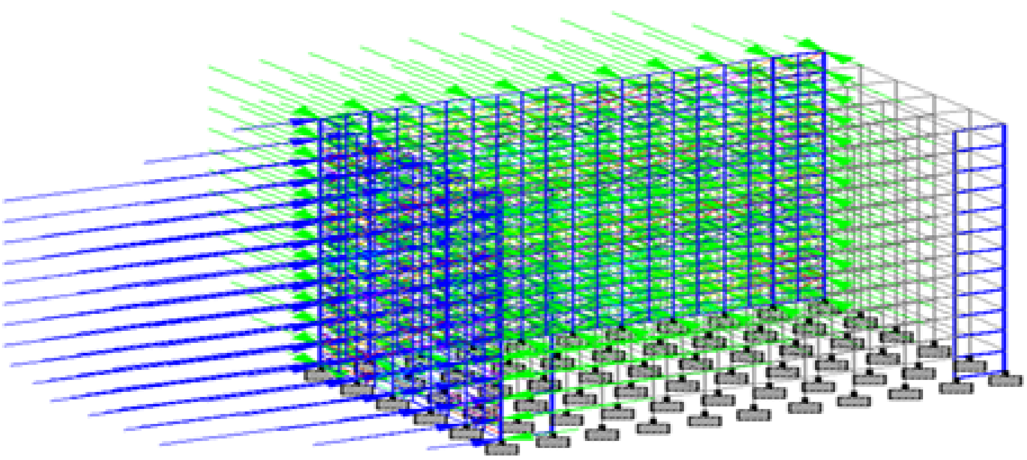

Figure .3.3 wind load applied to the shear wall building

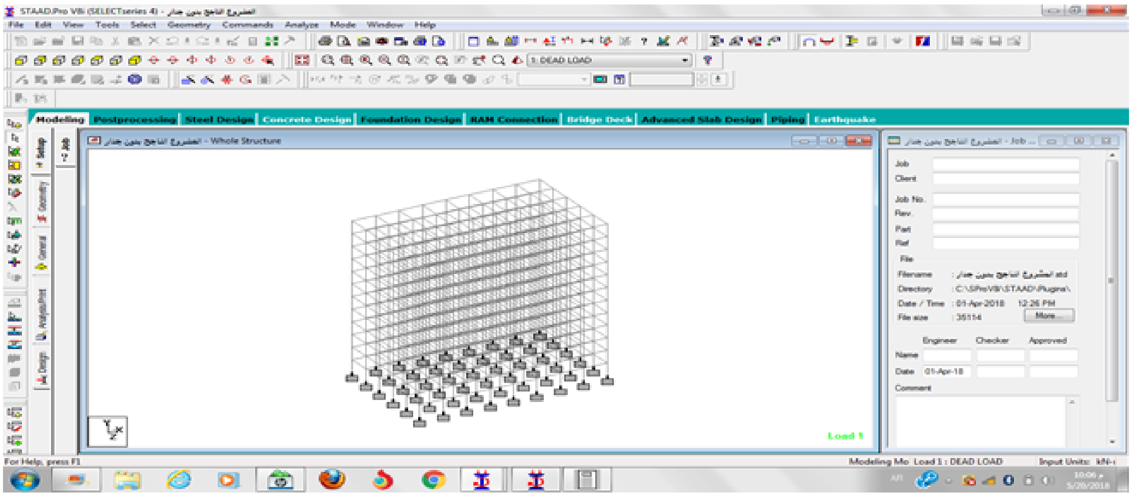

Figure 3.4 Building without shear wall

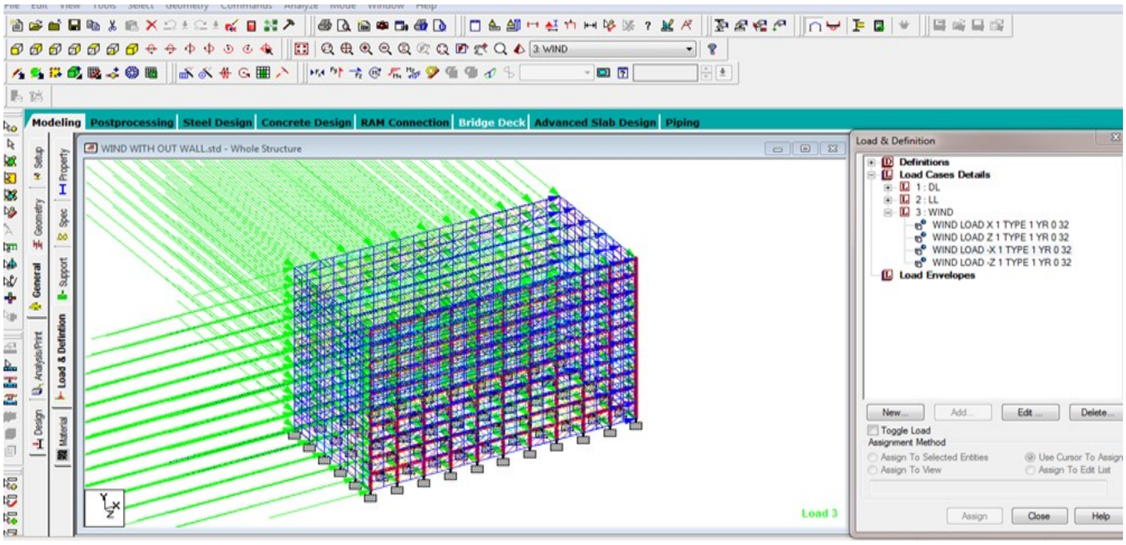

Figure 3.5 wind load applied without shear wall building

3.4 – Result and Discussion

- Comparison between displacement of 12storey building without shear wall and with shear wall at each floor level are shown in table 3.3
- Comparison between Shear force of 12storey building without shear wall and with shear wall at each floor level are shown in table 3.1 and table 3.2
- Comparison between Bending moment displacement of 12storey building without shear wall and with shear wall at each floor level are shown in table 3.1 and table 3.2

4. Conclusion

After the results showed us, grasp the extent of the impact of the shear wall on the building, and facilitate them to resist the momentum and shear forces that come back from the impact of wind on the building. We found it important and really important to use the shear in close high buildings, particularly in areas with high winds and hurricanes, as a result of this prevents the incidence of fabric and human losses within the buildings.

References

1. Structural Concrete theory And Design Fifth Edition M.Nadim Hassoun South Dakota State University Akthem Al-Manaseer.
2. Design Of Concrete Structures Fourteenth Edition Nilson .
3. Reinforced Concrete Design Of tall Buildings Bungales.
4. Foundation Analysis And Design Fifth Edition Joseph E.Bowles , Re., S.E.
5. Building And Environment M. Halis Gunel, H. Emre Ilgin.
6. Website.