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Abstract: Analysis and design of buildings for static forces is a routine affair these days because of availability of affordable computers and specialized programs which can be used for the analysis. On the other hand, dynamic analysis is a time consuming process and requires additional input related to mass of the structure, and an understanding of structural dynamics for interpretation of analytical results. Reinforced concrete (RC) frame buildings are most common type of constructions in urban, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to the wind and earthquake. Here the present works (problem taken) are on a 35th storied regular building. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 132 m. This paper describes seismic analysis of high-rise building using program in STAADPro. with various conditions of lateral stiffness system. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the for the zones and the post processing result obtained has summarized.

Keywords: High-rise building, RCC Building, Equivalent Static Analysis, Foundation, Displacement

1. Introduction

Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc. In essence all these loads are dynamic including the self weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis.

The criteria of level adopted by codes for fixing the level of design seismic loading are generally as follows:-

(a) Structures should be able to resist minor earthquakes (< DBE), without damage.

(b) Structures should be able to resist moderate earthquakes (DBE) without significant Structural damage but with some non- structural damage.

(c) Structures should be able to resist major earthquakes (MCE) without collapse.

"Design Basis Earthquake (DBE) is defined as the maximum earthquakes that reasonably can be expected to experience at the site once during lifetime of the structure. The earthquake corresponding to the ultimate safety requirements is often called as Maximum Considered Earthquakes (MCE). Generally, the DBE is half of MCE" . During an earth quake, ground motion occur in a random fashion both horizontally and vertically, in all directions radiating from the epicenter .The ground accelerations cause structures to vibrate and induce inertial forces on them. Hence structures in such locations need to be suitably designed and detailed to ensure stability, strength and serviceability with acceptable levels of safety under seismic effects[24].

The magnitude of the forces induced in a structure due to given ground acceleration or given intensity of earth quake will depend amongst other things on the mass of the structure, the material, and type of construction, the damping, ductility، and energy dissipation capacity of the structure. By enhancing ductility, and energy dissipation capacity in the structure, the induced seismic forces can be reduced and a more economical structure obtained or alternatively, the probability of collapse reduced.

Dynamic analysis methods: - It is performed to obtain the design seismic force and its distribution to different level along the height of the building and to the various lateral load resisting elements for the regular buildings and irregular buildings also as defined in IS-1893-Part-1-2000 in clause 7.8.1[14, 15].

(I) Regular building-

(a) Those > than 40 meter height. in zone IV th and V th.

(b) Those > 90 meter height in zone II nd and III rd

(II) Irregular building-

(a) all framed building higher than 12 meter in zone IV th and V th.

(b) Those greater than 40 meter in zone II nd and III rd.

The last two decades have seen a remarkable increase in the rate of construction of tall buildings in excess of 150m in height. Figure 1 shows the number of such tall buildings constructed per decade (CTBUH, 2008)[6, 8, 9] and reveals an almost exponential rate of growth. A significant number of these buildings have been constructed in the Middle East, and many more are either planned or already under construction. Dubai has now the tallest building in the world, the Burj Dubai, which is estimated to exceed 800m in height when completed, but another taller tower, the Nakheel Tall Tower, is currently under construction and will eventually exceed 1000m in height. "Super-tall" buildings in excess of 300m in height are presenting new challenges to engineers, particularly in relation to structural and geotechnical design. Many of the traditional design methods cannot be applied with any confidence since they require extrapolation well beyond the realms of prior experience, and accordingly, structural and geotechnical designers are being forced to utilize more sophisticated methods of analysis and design. In particular, geotechnical engineers involved in the design of foundations for super-tall buildings are leaving behind empirical methods and are employing state-of-the art methods increasingly. This paper will review some of the challenges that face designers of very tall buildings in the Middle East, primarily from a geotechnical viewpoint. Some characteristic features of such buildings will be reviewed and then geological, geotechnical and seismic characteristics of the Middle East will be taken [3, 16, 17].

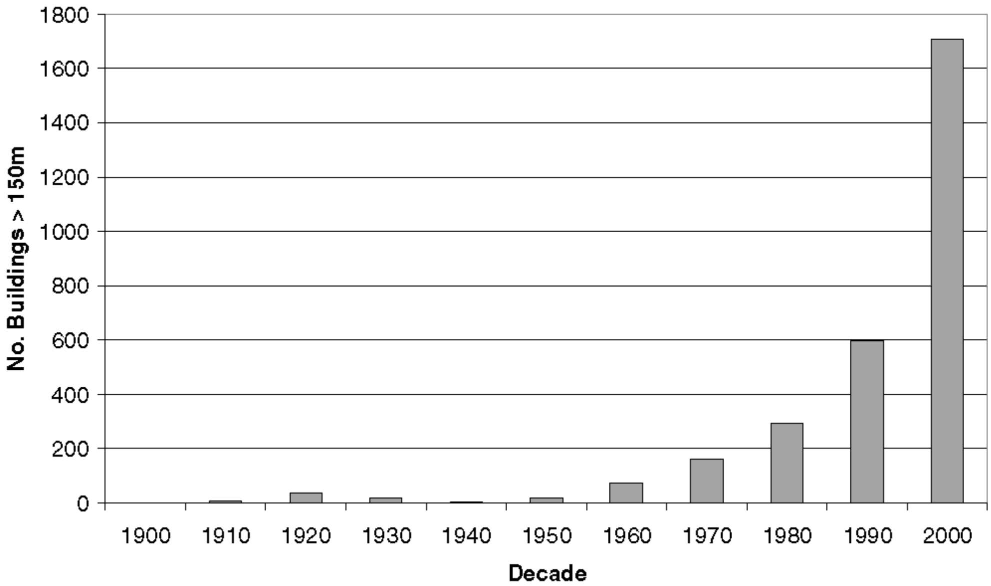

Figure 1 Number of tall building projects built per decade

2. Some pertinent characteristics of tall buildings

2.1 General Characteristics

There are a number of characteristics of tall buildings that can have a significant influence on foundation design, including the following:

1. The building weight, and thus the vertical load to be supported by the foundation, can be substantial. Moreover, the building weight increases non-linearly with height, as illustrated in Figure 2 (Moon, 2008)[19]. Thus, both ultimate bearing capacity and settlement need to be considered carefully.
2. High-rise buildings are often surrounded by low-rise podium structures which are subjected to much smaller loadings. Thus, differential settlements between the high- and low-rise portions need to be controlled.
3. The lateral forces imposed by wind loading, and the consequent moments on the foundation system, can be very high. These moments can impose increased vertical loads on the foundation, especially on the outer piles within the foundation system. The structural design of the piles needs to take account of these increased loads that act in conjunction with the lateral forces and moments.
4. The wind-induced lateral loads and moments are cyclic in nature. Thus, consideration needs to be given to the influence of cyclic vertical and lateral loading on the foundation system, as cyclic loading has the potential to degrade foundation capacity and cause increased settlements.
5. Seismic action will induce additional lateral forces in the structure and also induce lateral motions in the ground supporting the structure. Thus, additional lateral forces and moments can be induced in the foundation system via two mechanisms:

a. Inertial forces and moments developed by the lateral excitation of the structure;
b. Kinematic forces and moments induced in the foundation piles by the action of ground movements acting against the piles.

6. The wind-induced and seismically-induced loads are dynamic in nature, and as such, their potential to give rise to resonance within the structure needs to be assessed. The risk of dynamic resonance depends on a number of factors, including the predominant period of the dynamic loading, the natural period of the structure, and the stiffness and damping of the foundation system.

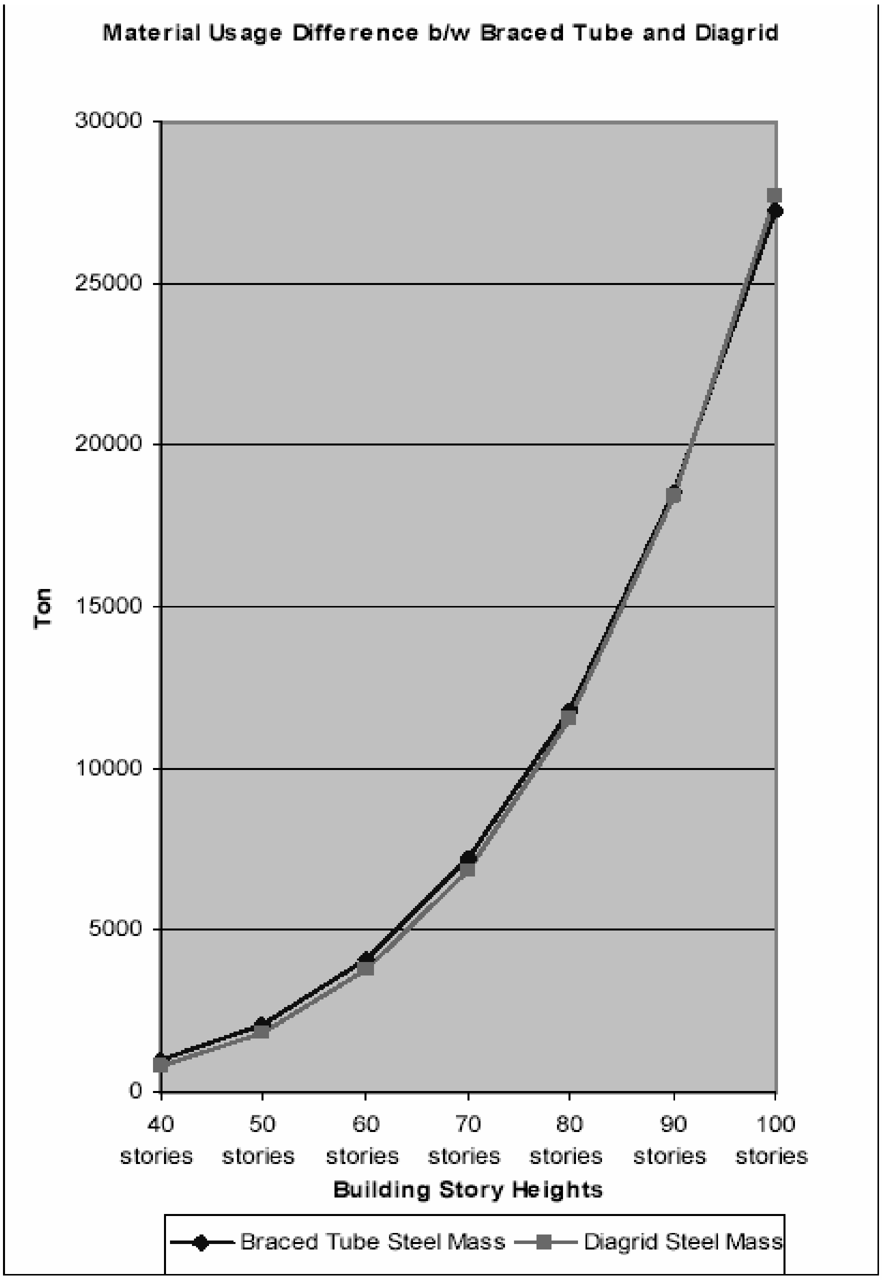

Figure 2 Example of Non-Linear Increase in Building Weight with Increasing Height (Moon, 2008)

2.2 Dynamic Characteristics

The dynamic response of tall buildings poses some interesting structural and foundation design challenges. In particular, the fundamental period of vibration of a very tall structure can be very high, and conventional dynamic loading sources such as wind and earthquakes have a much lower predominant period and will generally not excite the structure via the fundamental mode of vibration. However, some of the higher modes of vibration will have significantly lower natural periods and may well be excited by wind or seismic action. These higher periods will depend primarily on the structural characteristics but may also be influenced by the foundation response characteristics. As an example, the case of a 1600m tall concrete tower will be considered. The tower is assumed to have a mass of 1.5 million tonnes, a base diameter of 120m and a top diameter of 30m.

3. Foundation of tall building

Foundation design has traditionally focused on loads applied by the structure, but as pointed out by Poulos (2007)[20, 21, 22], significant loads can also be applied to the foundation system because of ground movements[25]. There are many sources of such movements, and the following are some sources that may be relevant to tall buildings:

1. Settlement of the ground due to site filling or dewatering. Such effects can persist for many years and may arise from activities that occurred decades ago and perhaps on sites adjacent to the present site of interest. Such vertical ground movements give rise to negative skin friction on the piles within the settling layers.
2. Heave of the ground due to excavation of the site for basement construction. Ground heave can induce tensile forces in piles located within the heaving ground. Excavation can also give rise to lateral ground movements, which can induce additional bending moments and shears in existing piles.
3. Lateral and vertical movements arising from the installation of piles near already-installed piles. These movements may induce additional axial and lateral forces and bending moment in the existing piles.
4. Dynamic ground motions arising from seismic activity. Such kinematic motions can induce additional moments and shears in the piles, in addition

to the inertial forces applied by the structure to the foundation system.

4. Geotechnical of Middle East

This section will present some of the available information on geological and geotechnical characteristics of the Arabian Peninsula (Figure 3), with particular emphasis on the Emirate of Dubai. Evans (1978)[11] has provided a summary of the geology and the soil conditions for a number of countries in the Middle East, and some of the information below is taken from this source, although more recent published information is now available on some areas, particularly Kuwait and Saudi Arabia. The major elements of the structural geology of the Arabian Peninsula are the Arabian Shield, and the Arabian Shelf, and these, together with the interior platform and the basins, are summarized by Kent (1978)[11].

The geology of the Arabian Gulf area has been substantially influenced by the deposition of marine sediments resulting from a number of changes in sea level during relatively recent geological time. The area is generally relatively low-lying (with the exception of the mountainous regions in the north-east), with near-surface geology dominated by deposits of Quaternary to late Pleistocene age, including mobile Aeolian dune sands, evaporite deposits and marine sands. The geology of the United Arab Emirates (UAE)[22, 23], and the Arabian Gulf Area, has been substantially influenced by the deposition of marine sediments associated with numerous sea level changes during relatively recent geological time. With the exception of mountainous regions shared with Oman in the north-east, the country is relatively low-lying, with near-surface geology dominated by deposits of Quaternary to late Pleistocene age, including mobile aeolian dune sands, sabkha/ evaporite deposits and marine sands. Alrifai (2007) [2] presents some data on unconfined compressive strength (UCS) for relatively shallow strata, and has found that the UCS values are low, generally between 1 and 3 MPa, with a considerable scatter in the data. There is relatively little published information on foundation design parameters for buildings in Dubai. Poulos and Davids (2005) [23] have presented some information on pile design parameters.

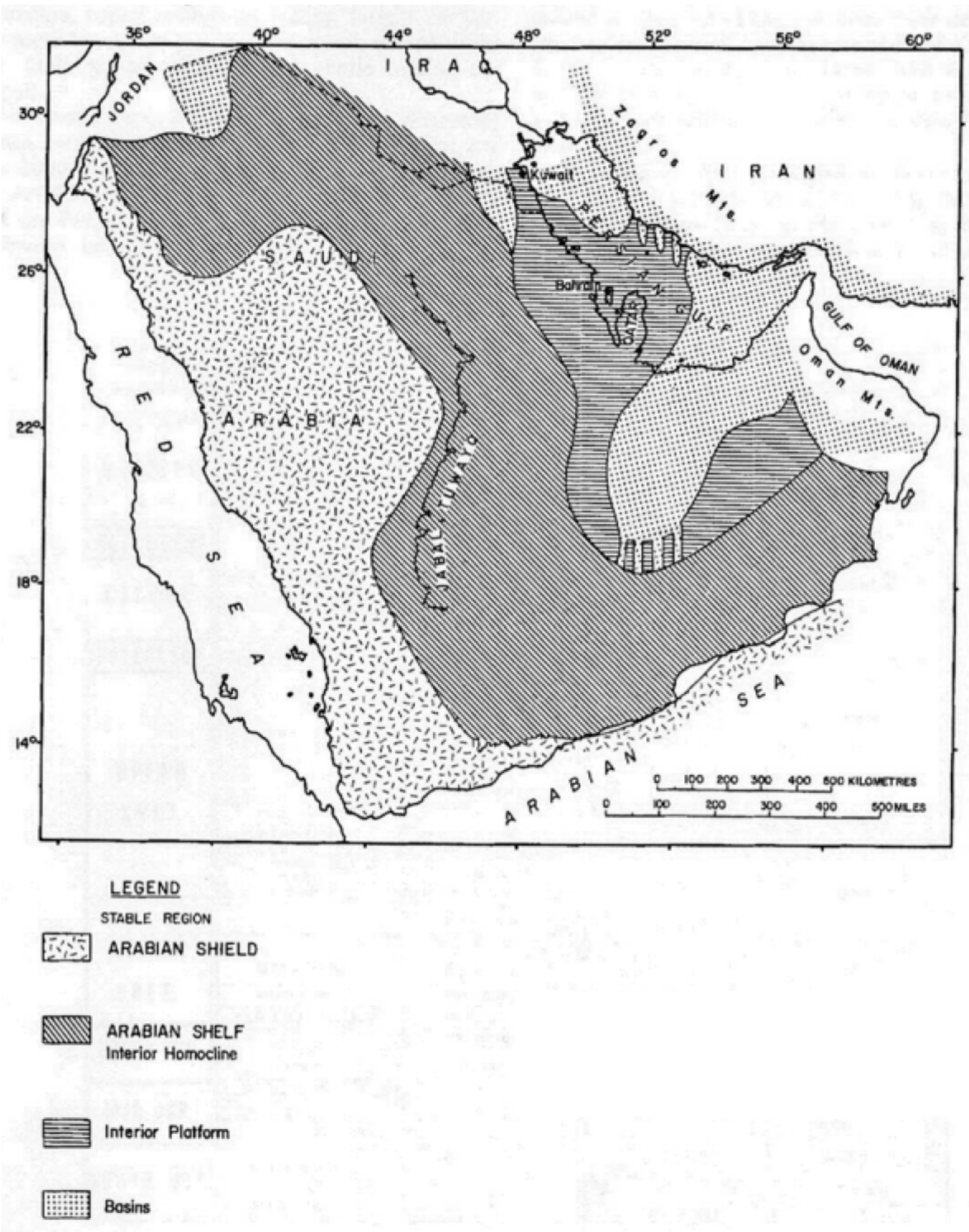

Figure 3 Summary of Structural Geology of the Arabian Peninsula
(Evans, 1978)[11]

5. Dynamic Loading

Issues related to dynamic wind loading are generally dealt with by the structural engineer, with geotechnical input being limited to an assessment of the stiffness and damping characteristics of the foundation system[12, 13]. However, the following general principles of design can be applied to dynamic loadings:

- The natural frequency of the foundation system should be greater than that of the structure it supports, to avoid resonance phenomena. The natural frequency depends primarily on the stiffness of the foundation system and its mass, although damping characteristics may also have some influence.
- The amplitude of dynamic motions of the structure foundation system should be within tolerable limits. The amplitude will depend on the stiffness and damping characteristics of both the foundation and the structure Table 1.

Quantity	Value	Comments
Limiting Tolerable Settlement mm	106	Based on 52 cases of deep foundations. Std. Deviation = 55mm. Factor of safety of 1.5 recommended on this value
Observed Intolerable Settlement mm	349	Based on 52 cases of deep foundations. Std. Deviation = 218mm
Limiting Tolerable Angular Distortion rad	1/500 1/250 (H<24m) 1/330 (24<H<60m) 1/500 (60<H<100m) 1/1000 (H>100m)	Based on 57 cases of deep foundations. Std. Deviation = 1/500 rad From Chinese Code (MOC, 2002) H = building height
Observed Intolerable Angular Distortion rad	1/125	Based on 57 cases of deep foundations. Std. Deviation = 1/90 rad

Table 1 Suggested Serviceability Criteria for Structures (Zhang and Ng, 2006)[26]

It is of interest to have some idea of the acceptable levels of dynamic motion, which can be expressed in terms of dynamic amplitude of motion, or velocity or acceleration (e.g. Boggs, 1997)[7]. Table 2 reproduces guidelines for human perception levels of dynamic motion, expressed in terms of acceleration (Mendis et al, 2007)[18]. These are for vibration in the low frequency range of 0-1 Hz encountered in tall buildings, and incorporate such factors as the occupant's expectancy and experience, their activity, body posture and orientation, visual and acoustic cues. They apply to both the translational and rotational motions to which the occupant is subjected. The acceleration levels are a function of the frequency of vibration, and decrease as the frequency increases. For example, allowable vibration levels at a frequency of 1 Hz are typically only 40-50% of those acceptable at a frequency of 0.1 Hz. It is understood that, for a 10 year return period event, with a duration of 10 minutes, American practice typically allows accelerations of between 0.22 and 0.25m/s2 for office buildings, reducing to 0.10 to 0.15 m/s2 for residential buildings.

Level of	Acceleration m/s2	Effect
1	<0.05	Humans cannot perceive motion
2	0.05 - 0.1	Sensitive people can perceive motion. Objects may move slightly
3	0.1 - 0.25	Most people perceive motion. Level of motion may affect desk work. Long exposure may produce motion sickness.
4	0.25 - 0.4	Desk work difficult or impossible. Ambulation still possible.
5	0.4 - 0.5	People strongly perceive motion, and have difficulty in walking. Standing people may lose balance.
6	0.5 - 0.6	Most people cannot tolerate motion and are unable to walk naturally.
7	0.6 - 0.7	People cannot walk or tolerate motion.
8	> 0.85	Objects begin to fall and people may be injured.

Table 2 Human Perception Levels of Dynamic Motion (Mendis et al, 2007) [18]

6. SEISMICITY

Some earlier information on the seismicity of the Eastern Mediterranean and the Middle East has been summarized by Ambraseys (1978) [3]. On the basis of somewhat limited information, the following relationships were suggested for the maximum acceleration (amax) and velocity (vmax), in terms of the earthquake magnitude M and the focal distance from the source to the site, R:

$$\log(a_{max}) = 0.46 + 0.63M - 1.10\log(R) \qquad (1)$$

$$\log(v_{max}) = -1.36 + 0.76M - 1.22\log(R) \qquad (2)$$

The above relationships were considered to be applicable for an earthquake magnitude M no greater than 6. Site-specific assessments made for the Emirates towers in Dubai, carried out in 1996, indicated that the peak ground acceleration (PGA) for the horizontal component of motion was 0.072 for a 475 year return period and 0.12 g for a 2000 year return period. The corresponding PGA values for vertical components were suggested to be 0.043 and 0.073 g. More recently, the United States Geological Survey (USGS) has published a seismic risk map. This map indicates that most of the Arabian Peninsula is relatively benign from a seismic viewpoint, but in the vicinity of Dubai, a peak bedrock acceleration of the order of 0.2g may occur with a 10% probability in 50 years, i.e. with a return period of 475 years. Abdalla and Al-Homoud (2004)[1] have presented the results of a seismic hazard assessment of the United Arab Emirates (UAE) based on a probabilistic approach. They have concluded that the most seismically active region in the UAE is the northern section, which includes Dubai. For this area, the PGA on bedrock was found to range between about 0.22g for a return period of 475 years to 0.38g for a return period of 1900 years. The former value is consistent with that for the area around Dubai from the USGS map in Figure 8, but they are significantly larger than the values assessed for the Emirates Towers. It would therefore appear desirable for careful site specific studies to be made for future developments in the UAE, rather than adopting a more "broad-brush" approach for the region. It is relevant to note that there was a significant "shake" in Dubai in September 2008 that caused the evacuation of a number of high-rise buildings. The epicentre of the earthquake was in southern Iran, about 400km from Dubai, and measured 6.2 on the Richter scale.

7. Calculus Model and Methods Of Analysis

All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low-to medium-rise buildings. It begins with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code. Equivalent static analysis can therefore work well for low to medium-rise buildings without significant coupled lateral-torsional modes, in which only the first mode in each direction is considered. Tall buildings (over, say, 75 m), where second and higher modes can be important, or buildings with torsional effects, are much less suitable for the method, and require more complex methods to be used in these circumstances.

For the analysis of multi storied building following dimensions are considered which are elaborated below. In the current study main goal is to compare the Dynamic Analysis for different zones (Table 4) of symmetrical (Rectangular) building [5](Table 3).

Static and Dynamic Parameters:-

Design Parameters- Here the Analysis is being done for 35 stories (rigid joint regular frame) building by computer software using STAAD-Pro.

	Particulars	Dimension/Size/Value
.1	Model	Stories 35
.2	Seismic Zones	IInd، IIIrd
.3	Floor height	3.6m
.4	Depth of foundation	2.4m
.5	Building height	132m
.6	Plan size	25mx45m
.7	Total area	1125Sq.m
.8	Size of columns	0.9mx0.9m
.9	Size of beams	0.3mx0.50m

10	Walls	a)External-0.20m) b)Internal-0.10m)
.11	Thickness of slab	150mm
.12	Earthquake load	UBC
.13	Type of soil	Type -II, Medium soil
14	Ec	fck N/ mm2(Ec is short term√5000 (static modulus of elasticity in N/ mm2
.15	Fck	fc k N/ mm2(Fck is characteristic√0.7 cube strength of concrete in N/ mm2
.16	Live load	3.50kN/ m2
.17	Floor finish	1.00kN/ m2
.18	Water proofing	2.500kN/ m2
19	Specific wt. of RCC	kN/ m2 25.00
.20	Specific wt of infill	kN/ m2 20.00
.21	Static analysis	.Equivalent static lateral force method
22	Software used	STAAD-Pro for both static and dynamic analysis
23	Specified characteristic	compressive strength of 150mm cube at 28 days for C-30 grade concrete - 30N/ mm2

Table 3 Dynamic Characteristic Parameters

Z	1	2A	2B	3	4
UBC	0.075	0.15	0.2	0.3	0.4

Table 4 Zones Coefficient

the interaction of a building, its foundation and the underlying soils may have important effects on the behavior of each of these components as well as on the overall system behavior

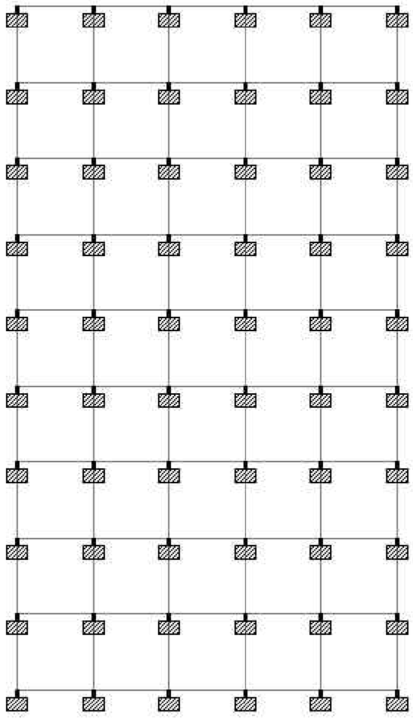

Figure 4 Plan of regular building

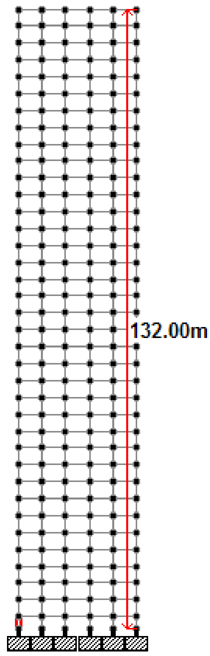

Figure 5 Elevation View of regular building

Figure 6. 3D model

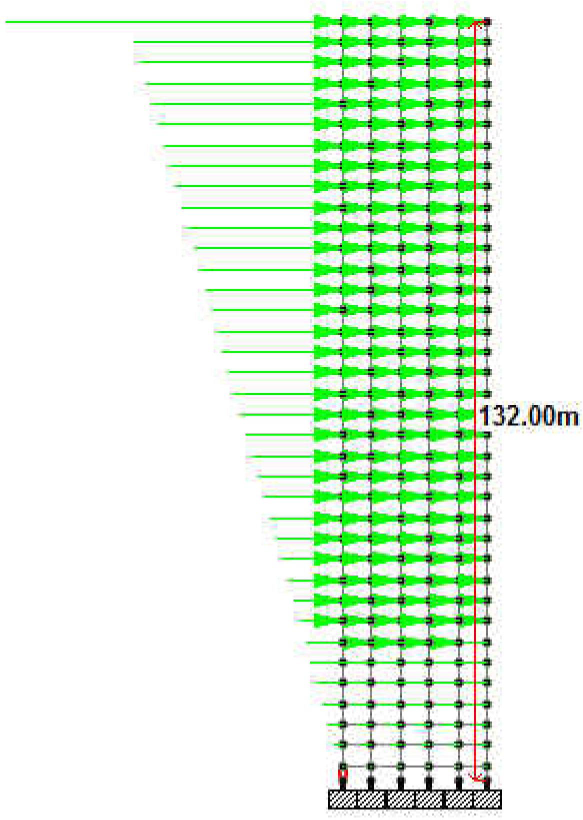

Figure 7 Earthquake Loading (Dynamic Loading)

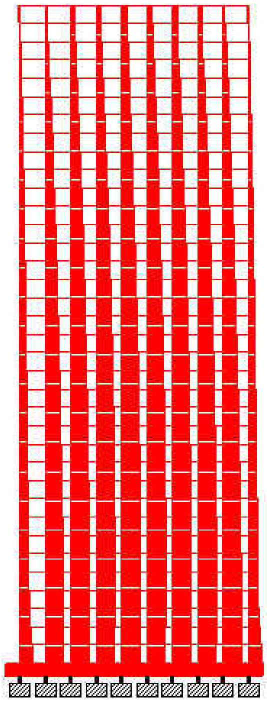

Figure 8 Shear Force Diagram

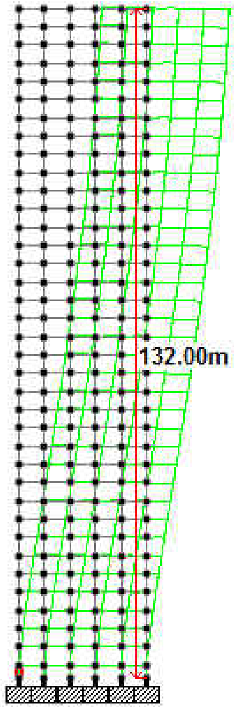

Figure 9 Deflection diagram (Dynamic Loading)

		Zone			
		I	2A	2B	III
Node	L/C	Axial Force kN	Axial Force kN	Axial Force kN	Axial Force kN
83	EQX	1547.07	2975.14	3808.18	5355.25

Table 5 Comparison of Axial Forces for Vertical Members

		Zone			
		I	2A	2B	III
Node	L/C	Shear Force kN	Shear Force kN	Shear Force kN	Shear Force kN
447	EQX	100.7	193.6	176	348.6

Table 6 Comparison of Shear for Vertical Members

		Zone			
		I	2A	2B	III
Node	L/C	Torsion kN.m	Torsion kN.m	Torsion kN.m	Torsion kN.m
2149	EQX	0.795	1.529	1.957	2.572

Table 7 Comparison of Torsion for Vertical Members

		Zone			
		I	2A	2B	III
Node	L/C	Bending kN.m	Bending kN.m	Bending kN.m	Bending kN.m
78	EQX	492.97	948	1213.5	1706.4

Table 8 Comparison of Bending for Vertical Members

8. conclusions

The results as obtained zone I, 2A, 2B and zone III using STAAD PRO 2006 Dynamic Analysis are compared for different categories under different nodes and beams.

As per the results in Table 6 and 7, we can see that there is not much difference in the values of Shear Forces and torsion moment as obtained by Dynamic Analysis of the RCC Structure.

As per the results in Table 5 and 8, we can see that the values for Axial Force and Bending Moments there is much difference.

This paper takes mainly the character of the geological nature of the Arab region. The research was mainly subjected to discussing seismic loads. By reviewing the seismic impact, it is evident the importance of taking into account the foundation soil.

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