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Structural Dynamic Analysis Of High-Rise Buildings

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Abstract

Accommodation Is Becoming A Challenge To Urban Dwellers Because Of Large Migration Of People From Rural To Urban Areas. To Solve This Problem, Developers Have Adopted Planning, Designing And Construction Of Tall Buildings In Small Parcels Of Land. Tall Buildings Cannot Be Erected Without Proper Analysis And Design Of Respective Elements That Make Up A Building Including The Soil Which The Building Will Rest On. The Objective Of This Report Is To Analyze The Dynamics Of A Twenty-Storey Tall Building Subjected To Live Load, Its Own Self Weight, Lateral Loads And Seismic Loads. The Building Is Meant For Commercial Office Purpose. The Method Used For Analysis Is The Shear Wall System Of Analysis Of Tall Buildings Using The Etabs Modelling Software. The Analysis Was Done To Asce And Aci318-14 Codes. The Results Of The Analysis Done With The Software Showed That The Maximum Displacement Of The Building When Subjected To All Loading Combinations Is 213.33mm In Storey 20 Occurring In The X-Direction. Also, Maximum Drift Is 0.006384mm Occurring In Storey 7. This Maximum Displacement And Drift Are Within The Accepted Limits Of The Codes For Tall Buildings. Hence, Satisfying The Purpose Of The Analysis And Making It Satisfactory For The Building To Be Erected.

1.1 Introduction

Over The Years, The Need For The Dynamic Analysis Of Tall Buildings Cannot Be Overemphasize When It Comes To Urban Dwelling Where Accommodation Is A Challenge To Urban Dwellers Due To The High Influx Of People To The City. The Design Of Tall Buildings Essentially Involves A Conceptual Design, Approximate Analysis, Preliminary Design And Optimization, To Safely Carry Gravity And Lateral Loads. The Design Criteria Are, Strength, Serviceability, Stability And Human Comfort. Manual Calculations For Nodal Analysis, Displacements, Moments, Lateral Force, Acceleration And Resonance Are Usually Energy Taking And Time Consuming. Hence, The Need To Use A Finite Element Modelling Softwares To Analyze These Criteria Becomes A Huge Advantage To The Design Engineer.

1.2 Objective And Aims Of The Study

The Objective Of This Study Is To Examine The Structural Dynamic Analysis Of A 20-Storey Tall Building Using A Finite Element Modelling Software (Etabs). The Aim Of The Study Will Be To Arrive At Suitable Structural Analysis To Satisfy Strength, Serviceability, Stability And Human Comfort And Assess Their Structural Weights In Weight/Unit Area In Square Feet Or Square Meters. This Will Initiate Structural Drawings And Specifications To Enable Construction Engineers To Proceed With Fabrication And Erection Operations.

1.3 Limitation Of The Study

Structural Dynamic Analysis Of Tall Buildings Consists Of Many Stages And Factors And All Cannot Be Evaluated In This Assignment. Hence, It Will Be Limited To The Use Of Etabs Software For The Modelling And Analysis.

Material Used Will Be Concrete And Rebars. Concrete Is Assumed To Be Uncracked. No Effects From Creep, Shrinkage Or Temperature Effects Have Been Analyzed For Concrete.

2.0 Structural Dynamics

Structural Dynamics Is A Type Of Structural Analysis Which Covers The Behavior Of A Structure Subjected To Dynamic (Actions Having High Acceleration) Loading. Any Structure Can Be Subjected To Dynamic Loading. Dynamic Analysis Can Be Used To Find Dynamic Displacements, Time History, And Modal Analysis.

Structural Analysis Is Mainly Concerned With Finding Out The Behavior Of A Physical Structure When Subjected To Force. 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 First Law Of Motion) Can Be Ignored And The Analysis Can Be Simplified As Static Analysis.

Dynamic Analysis For Simple Structures Can Be Carried Out Manually, But For Complex Structures Finite Element Analysis Can Be Used To Calculate The Mode Shapes And Frequencies.

A Dynamic Load Can Have A Significantly Larger Effect Than A Static Load Of The Same Magnitude Due To The Structure's Inability To Respond Quickly To The Loading (By Deflecting). The Increase In The Effect Of A Dynamic Load Is Given By The Dynamic Amplification Factor (Daf) Or Dynamic Load Factor (Dlf):

Daf=Dlf=Umax/Ustatic

Where U Is The Deflection Of The Structure Due To The Applied Load.

2.2 Tall Buildings

A Building Is Defined As High-Rise When It Is Considerably Higher Than The Surrounding Buildings Or Its Proportion Is Slender Enough To Give The Appearance Of A Tall Building (Otis, 2006). The Construction Of High-Rise Buildings Started At The End Of The 19th Century In Chicago (Hallebrand And Jakobsson,2016). This Was Made Possible Because Of New Inventions Such As The Safe Elevator In 1853 And The Telephone In 1876, That Enabled Transport Of Building Materials And The Ability To Communicate To Higher Levels. In Addition, The Building Materials Changed As They Went From Wood And Masonry To Using Steel Frames With Lighter Masonry Walls. Earlier Buildings That Were Built With Heavy Masonry Walls Was Limited To Certain Heights By Its Own Self-Weight. With Steel Frames The Masonry Could Be Thinner And Act Only As Facade For Weather Protection And Taller Buildings Could Be Constructed.

The Introduction Of New Materials Permitted The Development Of Light Weight Skeletal Structures Which When Coupled With Improved Design Methods And Construction Technologies Empowered Continuous Growth In The Height Of Tall Buildings. Starting From The 11- Storey Metal Framed Home Insurance Building In Chicago In 1883, And Then Followed The 9-Storey First All-Steel Framed Rand-Mcnally Building In1889, The 20-Storey Vertical Trussed Masonic Temple In 1891, The 60-Storey Woolworth Building In New York In 1913. The American Tall Building Development Got To Its Crowning Point In 1931 With The 102-Storey Braced Steel Frame Of Empire State Building That Attained The Height Of 381m. After A Period Of About 40 Years In 1973, This Great Edifice Was Superseded By The 442m Tall, 110-Storey Framed-Tube World Trade Centre Twin Towers In New York And Quickly Followed In 1974 By The 442m Tall Bundled-Tube Sears Tower In Chicago.

During The Industrial Revolution In Europe The Need For Warehouses, Factories And Multi-Storey Buildings Were Huge. Europe Also Played A Major Role In Developing New Materials Such As Glass, Reinforced Concrete And Steel. Before 1945 The High-Rise Buildings In Europe Were Few And Below The 100meter Limit And It Was Not Until After The

Second World War The Construction Of High-Rise Buildings Excelled. This Had To Do With The Reconstruction Of All Destroyed Cities And The Expanded Demand For Offices And Residential.

Traditionally, The Principle Drive To Construct Tall Buildings Has Always Been The Desire To Cope With Pressing Demand Of Housing Units And The Need To Expand National Economies. Hong Kong, For Example Is Known To Be One Of The Most Significant Financial Capitals In Asia, And As A Result Has A Long History In The Use Of High-Rises For Offices And Residential Purposes. According To Chung (2003), The Embargo Placed On Trading With China By The United Nations Paved Way For The Emergence Of The Economic Growth Of Hong Kong. Attractive Tax Policy Spurred The Influx Of Foreign Investors Thereby Turning Hong Kong To An Economic Hub. From Kunze (2005), Britain And Europe Witnessed An Intense Housing Deficiency As A Result Of Bomb Damage From The World War Ii. Thus, Large-Scale Housing Projects Mostly Made Of Tall Buildings Were Considered To Be A Modern And Effective Way Of Meeting The Demand. The Middle East Region Has Witnessed Rapid Development In Terms Of Economic And Infrastructural Development In Recent Years. As A Result, Many High-Rises Have Been Built. Based On Arabat(2005), The Principal Reason For The Huge Development Of The Region Was The Recognition Of The Need To Expand Their Economy So As To Make It Less Reliant On Oil Revenue. Therefore, Tourism, Enhanced By The Presence Of World-Class High-Rises Has Been Used As An Alternate Source Of Revenue. Some Of The Most Remarkable Structures Include: The Burj Dubai, Burj Al Arab (Built On A Man-Made Island In 1999), Burj Khalifa (The Tallest Building In The World) Among Others.

2.3 Tall Building Development In Africa

In 2009, The Un Population Fund Opined That The Population Of Africa Had Reached 1,022,234,000, Thus Making Africa The Second Most Populous Continent On Earth Just Behind Asia. At This Rate, The Continent's Population Is Expected To Reach 1.9 Billion By The Year 2050 And This Will Definitely Spur Developmental Challenges Especially In The Urban Cities. At The Onset, Very Few African Cities Characterized By The Presence Of Major Financial And Commercial Activities Possessed Large Skylines. Some Of These Cities Are Cape Town (South Africa), Lagos (Nigeria), Abidjan (Cote D'ivoire), Harare (Zimbabwe), Nairobi (Kenya), And Johannesburg (South Africa).

S/N	Building's Name	Height	Floors	Country	Year
1	Carlton Centre	223m	50	South Africa	1973
2	Ponte City Apartments	173m	54	South Africa	1975
3	Bahia Centre	161m	31	Algeria	2008
4	Nitel Building	160m	32	Nigeria	1979
5	Marble Towers	152m	32	South Africa	1973
6	Pearl Dawn	152m	31	South Africa	2010
7	Sa Reserve Bank Building	150m	38	South Africa	1988
8	Villagio Vista	150m	35	Ghana	2011
9	Metlife Centre	150m	28	South Africa	1993
10	88 On Field	147m	26	South Africa	1985

Table 1: List Of High-Rise Buildings In Africa. Source: [Wikipedia]

Starting From The Mid-2000s, More Tall Buildings Have Been Built In Some Other Cities In Africa. They Are: Kampala (Uganda), Port Louis (Mauritius), Addis Ababa (Ethiopia), Maputo (Mozambique), Dar Es Salaam (Tanzania) And Abuja (Nigeria). Table 1 Presents The African Top High-Rise Buildings. Shifting Attention From Africa To Nigeria, It Is Important To Know That The Population Of Africa's Most Populous Nation Was Estimated To Be About 200 Million In 2020 And Is Also The Seventh Most Populous Country In The World And Is Blessed To Be One Of The Most Economically Developed Nations On The African Continent, Occupying A Land Area Estimated At About 923,768 Sq. Km. However, Despite Its Size, Advanced Development Is Significantly Localized Around Two Cities: Lagos And Abuja. Beyond These Two Mega Centres, Development Is Marginal. Their Dominance Can Largely Be Attributed To The Fact That Most Of The Major Financial And Governmental Activities Are Conducted In These Two Cities. This Poor Developmental Plan Has Put So Much Pressure On The Provision Of Buildings, Infrastructure And Urbanization Of These

Two Cosmopolitans. Coping With The Massive Influx Of Citizens From The Rural Areas In Search Of Greener Pasture Has Been An Austere Task. Table 2 Shows The Top 10 Tall Buildings In Nigeria.

S/N	Building's Name	Location	Height	Floors	Year
1	Nitel/Necom House	Lagos	160m	32	1979
2	Union Bank Headquarters	Lagos	124m	28	N/A
3	Cocoa House	Ibadan	105m	26	1965
4	Independence House	Lagos	103m	23	1960
5	Cbn Building	Lagos	100m	19	U/C
6	Great Nigeria House	Lagos	95m	22	N/A
7	National Oil Headquarters	Lagos	83m	23	1984
8	Stock Exchange House	Lagos	83m	22	N/A
9	Uba House	Lagos	80m	20	N/A
10	Eagle House	Lagos	78m	20	1985

Table 2: List Of Tall Buildings In Nigeria

Note: N/A Means Not Available; U/C Means Under Construction

Presently, The Development Of High-Rises In Nigeria Has Been Influenced By Urban Needs, Constraints, And A Host Of Other Commercial Reasons That Task The Engineer's Ingenuity (Ejim,2003). Lagos, The Former Capital Of Nigeria And The Major Economic Hob In The West African Sub-Region Has The Highest Number Of Tall Buildings In Nigeria. The Transference Of The Nation's Capital To Abuja In The Late 1980's Has Led To The Degrade State Of Major Tall Buildings In Lagos. The Abuja Skyline Is Made Up Of Mostly Mid-Range Buildings, With Just Few Tall Buildings. Only Recently Have Tall Buildings Begun To Appear. Most Of The Buildings Are Modern, Thereby Reflecting That It Is A New City. The Millennium Tower, The Nigerian Cultural Centre, And The Municipal Building (All Part Of The Proposed Nigerian National Complex) Are Part Of The Many Projects In The Central District Of Nigeria's Capital City Of Abuja. At 170 Meters, The Millennium Tower Would Be The Tallest Building In Nigeria, Going Beyond The 160m High Nitel Building.

2.4 Structural Design Aspect Of Tall Buildings

The Design Of Any Building Is Anchored To The Three Fundamental Aspects Of Safety, Economy And Aesthetics. The Economics Of Constructing Tall Buildings Is Greatly Affected By Wind As Their Height Increases. To Counteract Wind Loads And Keep Building Motions Within Comfortable Limits Robust Structural Systems That Drive Up Costs Must Be Adopted. According To Ede (2014), The Design Process Of High-Rise Building Generally Follows A Well-Defined Iterative Procedure. Preliminary Calculations For Member Sizes Are Usually Based On Gravity Loading Augmented By An Arbitrary Increment To Account For Wind Forces. A Check Is Then Made On The Maximum Horizontal Deflection, And The Forces In The Major Structural Members, Using Some Rapid Approximate Analysis Technique. The Procedure Of Preliminary Analysis, Checking, And Adjustment Is Repeated Until A Satisfactory Solution Is Obtained. Then, A Rigorous Final Analysis, Using A More Refined Analytical Model Will Then Be Made To Provide A Final Check On Deflections And Member Strengths. This Will Usually Include The Second-Order Effects Of Gravity Loads On The Lateral Deflections And Member Forces (P-Delta Effects). The Provision Of Adequate Stiffness, Particularly Lateral Stiffness, Is A Major Consideration In The Design Of A Tall Building For Several Important Reasons. For The Ultimate Limit State, The Lateral Deflection Must Be Limited To Prevent Second-Order P-Delta Effects Due To Gravity Loading Being Of Such Magnitude As To Precipitate Collapse. In Fact, It Is In The Particular Need Of Concern For The Provision Of Lateral Stiffness That The Design Of High-Rise Building Largely Departs From That Of A Low-Rise Building. One Simple Parameter That Affords An Estimate Of The Lateral Stiffness Of A Tall Building Is The Drift Index, Defined As The Ratio Of The Maximum Deflection At The Top Of The Building To The Total Height. Sound Engineering Judgment Is Required When Deciding On The Drift Index Limit To Be Imposed. Also, All Codes Require Tall Buildings To Provide Alternative Means Of Exit From Each Floor In Case Of Emergency. All These Safety Measures And Many Other Not Listed Here Contribute To The Safety Of The Occupants Of High-Rise Buildings.

There Are Various Ways Of Dynamic Analysis Of A Structure. They Include:

1)The Linear Time History Analysis Method: In This Method, It Is Assumed That The Entire Response History And The Material Properties Of The Structure Can Be Modelled Or Resolved In A Linear Elastic Domain. It Is Assumed That No Part Of The Structure Will Yield.
2) The Response Spectra Analysis Method: In This Method, It Is Assumed The Structure Is In Elastic Domain But The Time Variable Is Eliminated From The Solution. It Is A Popular Method Because It Provides A Relative Accurate Method Of Analysis. It Focuses On Estimating The Maximum Structural Response And Determining The Acceleration. The Elimination Of Time Variable Greatly Reduces The Quantity Of Data That Must Be Processed Or Stored In The Computer. The Response Spectra Value Only Looks At One Value Which Is The Maximum Value.

3) The Non-Linear Or Inelastic Time History Analysis Method: It Is Assumed That The Response Of The Structure Induces Some Strain In The Material Beyond The Yield Strain. This Method Directly Incorporates Into The Solution The Magnitude And Time History Of Past Yield Behaviour.

2.5 P-Delta Effects

P-Delta Is A Geometric Non-Linear Effect That Occurs In Structures That Are Subjected To Compressive Loads And Lateral Displacement. Under The Action Of Compressive Loads And Lateral Displacement, Tall Slender Structured Will Experience Additional Stresses And Deformations Due To The Change Of Position Of The Structure. First-Order Structural Analysis Will Normally Consider Small Displacements And Will Compute Equilibrium Of The Structure And Internal Stresses Based On The Undeformed Geometry. However, Second Order Analysis Considers The Deformed Geometry Of The Structure And May Require An Iterative Approach For The Computation Of Equilibrium. During The Simultaneous Action Of Vertical And Horizontal Loads, The Structure Deflects Due To The Action Of The Horizontal Load. As The Structure Deflects, The Position Of The Vertical Load P Shifts By A Distance Such That The Vertical Load Shifts By A Distance Such That The Vertical Load Instead Of Acting Axially Along The Column Now Induces A Moment Reaction At The Base. The Interaction Of The Compressive Force And Lateral Displacement To Produce Additional Secondary Effects In A Structure Is Handled Under P-Delta Analysis.

2.6 Subsystems And Components Of Tall Buildings

The Subsystems Or Components Of The Tall Building Structural Systems Are Essentially The Following;
1)Floor Systems
2)Vertical Load Resisting Systems
3)Lateral Load Resisting Systems
4)Connections
5)Energy Dissipation Systems And Damping

2.7 Loads

Loads That Has To Be Taken Into Consideration When Designing A Building Are Vertical Loads From Self-Weight, Imposed Loads, Snow Loads And Horizontal Loads From Both Wind And Unintended Inclinations. For Tall Buildings, The Horizontal Loading From Wind Is Usually The Design Load. The Vertical Loads Are The Self-Weights, Finishing Loads And Live Loads And They Are Transferred To The Foundation Through Columns, Load-Bearing Walls Or Towers. The Live Load Depends On The Type Of Usage In The Building And On The Standard Used For Designing. In Eurocode, The Live Load Varies From 0.5–5.0 Kn/M2 . The Higher Value Is Often Used For Offices To Take The Variable Partitioning And The Greater Live Load In Corridor Areas Into Account. Some Reduction Of The Live Load Can Be Made Depending On The Number Of Stories, But May Never Exceed 40% For Any Construction Element. The Horizontal Load From Wind Working As A Distributed Load On The Facade, Which Transfers The Load To The Slabs. The Slabs Are Working As Diaphragms And Provides The Lateral Transfer Of The Shear Load To The Vertical Elements And Also As A Stability Unit For The Compression Flange Of The Steel Beam Beneath. The Shear Forces In The Diaphragms Occur Mainly In The Concrete Because Of Its In-Plane Stiffness. The Horizontal Loads Are Transferred From The Slabs To The Beams Through Welded Studs. Depending On How The Slabs Are Connected To The Facade, The Stress Distributions In The Slabs Will Vary. For Example, The Slabs Can Be Connected Directly To The Facade, Which Gives A Distributed Load. The Facade Can Also Be Connected To Columns Which Will Provide Point Loads Instead. The Load Distribution

Depends On The Stiffness Of The Elements As Stiffer Units Attract More Load Than Weaker. When Designing Vertical Walls In A Building Both Shear And Bending Deformation May Occur. For Low Robust Walls The Bending Is Negligible And For Tall Slender Structures Shear Is Negligible. Considering The Entire Building The Shear Wall Becomes Tall And Slender, However, The Walls In Each Plane Are Low And Robust Making It Susceptible To Both Shear And Bending. For A Tall Building The Deformation Shapes From Bending And Shear Can Be Seen In Fig 1.

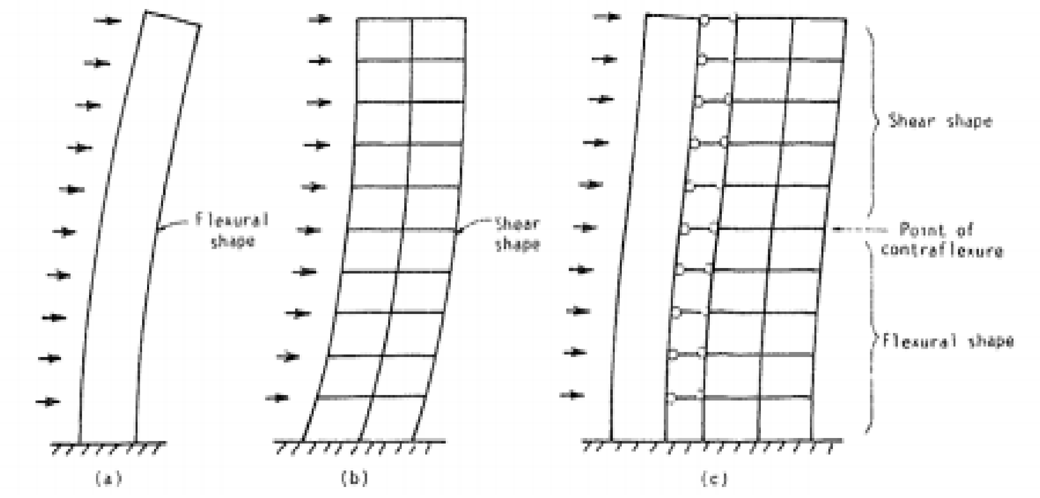


Fig. 1: Deformation Shapes Of A Tall Building. A) Bending Deflection, B) Shear Deflection And C) Total Deflection (Smith And Coull, 1991)

2.8 Seismic Design Categories

The National Earthquake Hazards Reduction Program(Nehrp) Recommended Seismic Provisions Recognizes That, Independent Of The Quality Of Their Design And Construction, Not All Buildings Pose The Same Seismic Risk. Factors That Affect A Structure’s Seismic Risk Include:

- The Intensity Of Ground Shaking And Other Earthquake Effects The Structure Is Likely To Experience And

- The Structure’s Use Including Consideration Of The Number Of People Who Would Be Affected By The Structure’s Failure And The Need To Use The Structure For Its Intended Purpose After An Earthquake.

The Provisions Uses The Seismic Design Category (Sdc) Concept To Categorize Structures According To The Seismic Risk They Could Pose. There Are Six Sdcs Ranging From A To F With Structures Posing Minimal Seismic Risk Assigned To Sdc A And Structures Posing The Highest Seismic Risk Assigned To Sdc F. As A Structure’s Potential Seismic Risk As Represented By The Seismic Design Category Increases, The Provisions Requires Progressively More Rigorous Seismic Design And Construction As A Means Of Attempting To Ensure That All Buildings Provide An Acceptable Risk To The Public. Thus, As The Sdc For A Structure Increases, So Do The Strength And Detailing Requirements And The Cost Of Providing Seismic Resistance.

2.9 Natural Frequency

Frequency Is Measured In Hertz And Is A Measurement For Cycles Per Second, Which In This Case Mean How Many Times The Building Sways From Side To Side In 1 Second. The Natural Frequency Of A Building Is The Frequency That The Building Sways In When It Is Returning To Its Original Position After It Has Been Excited. The Intensity Of The Exciting Force Will Affect The Acceleration And Speed Of The Building’s Movements, But The Frequency Will Be Same Regardless To The Force. What Determines A Buildings Natural Frequency Is Roughly Its Self-Weight, Stiffness And

Height. A Heavy And Stiff Structure Will Not Sway As Much As A Light And Slender Structure Will. While Limit Values For Vertical Vibrations In Floorings Are Regulated In Eurocode, Horizontal Movements Are Not. There Are Guidelines And Recommendations But No Clear Regulations. There Are Numbers Of Studies Made On This Field And They Mainly Concern Buildings With A Natural Frequency Of 0 - 1.0 Hz. The Studies Are Made In That Range Because Low Frequencies Become The Biggest Problems In Terms Of Motion Sickness With The Building's Inhabitants. Skyscrapers Are Tall And Slender And Tend Therefore To Have Low Natural Frequencies And Big Deflections. This Means Long Distances For The Building To Sway And If The Acceleration Of The Movement Is High, People Inside Can Feel Nauseous. Dampers Can Be Used To Reduce The Swaying And Help The Building Back To Its Position Quicker, But That Will Not Be Investigated Any Further In This Report. It Is Complicated To Calculate A Buildings' Natural Frequency, Even With The Support Of Fem (Finite Element Method), And It Is Therefore Necessary To Use An Approximation Method To Estimate The Frequency In An Early State Of The Design Process. Later, When More Parameters Are Known, It Could Be Very Helpful To Create A Fem-Model Of The Structure To Verify The Frequency. Finite Element Software Can Calculate Multi Degree Of Freedom Systems And Simulate The Motion Induced By External Forces Such As Wind.

3.0 Methodology

3.1 Description Of The Tall Building Model

The Model Is A 20-Storey Tall Building For Commercial Purpose With An Elevator Shaft. The Shaft Will Be Analyzed To Help With The Stability Of The Structure. Each Floor Of The Building Is 3.2m High Making The Overall Height Of The Building To Be 64m. It Is Assumed That The Structure Will Be Constructed In Geographical Area With Average Wind Velocity Is 50m/S And Seismic Activities. The Building Will Be Analyzed To Withstand Lateral Loads And Seismic Activities.

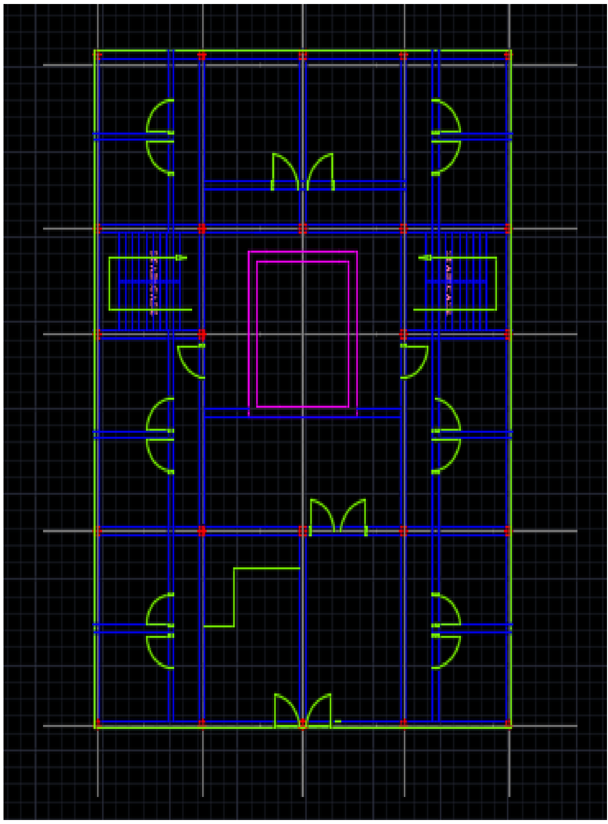


Fig. 2 Floor Plan

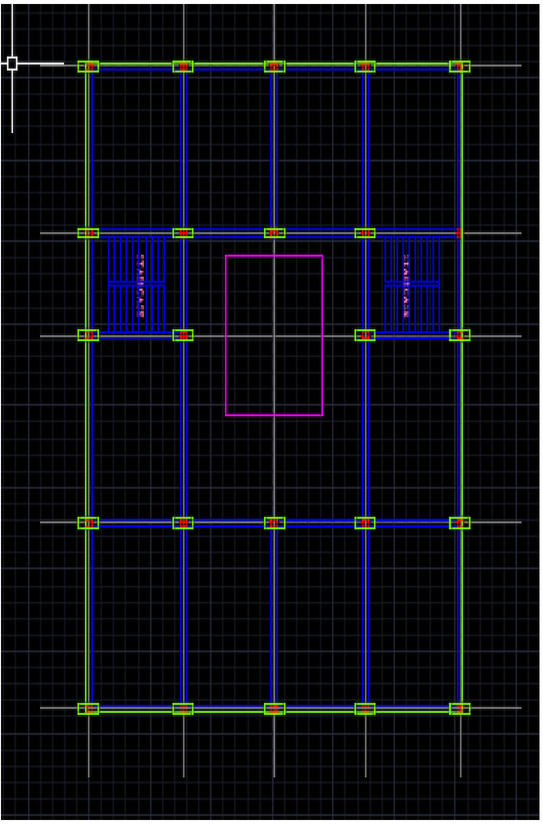


Fig. 3 Location Of Columns And Beams

3.2 Dynamic Analysis Parameters

A Twenty-Story Building Is Assigned To Seismic Design Category (Sdc) D. For Shear Wall System, Three Design Parameters Are Specified;
1)Response Modification Coefficient R=4.5
2)System Over Strength Factor=3
3)Deflection Amplication Factor Cd=3
Ss = 0.75g
S1=0.22g
Tl=6.0s
Importance Factor 1e=1.0

Beam Sizes Include
300mm X 500mm

Column Size
300mm X 800mm
300mm X 450mm

Slab Thickness
Slab =150mm

Average Beam Length And Column Spacing =4m
Typical Storey Height = 3.2m
Bottom Storey Height = 4.0m

Load Data
Dead Load = 4.2kn/M
Live Load = 2.2kn/M

Roof Load Data
Dead Load = 0.25kn/M
Live Load = 0.75kn/M

3.3 Procedure For Dynamic Analysis In Etabs

These Involves:

1) Obtaining The Architectural And Structural Design Of The Building;
2) Geological Information Of The Area;
3) Inputting Material And Section Properties;
4) Defining Material Property;
5) Member Section Definitions;
6) Creating The Model Of The Structure;
7) Loading Arrangement;
8) Assigning Loadings;
9) Load Case For Dynamic Analysis;
10) Perform Dynamic Linear Analysis; And Checking The Results. (These Are Represented In Figures 4 To 5)

3.4 Loadings

The Load Combination Used In The Analysis Includes Live Load, Dead Load, Super Dead Load, Seismic Load And Wind Load. These Load Combinations Are Simulated In The Etabs Software. The Loadings Are Analyzed To Asce And Aci 318-14 Codes.

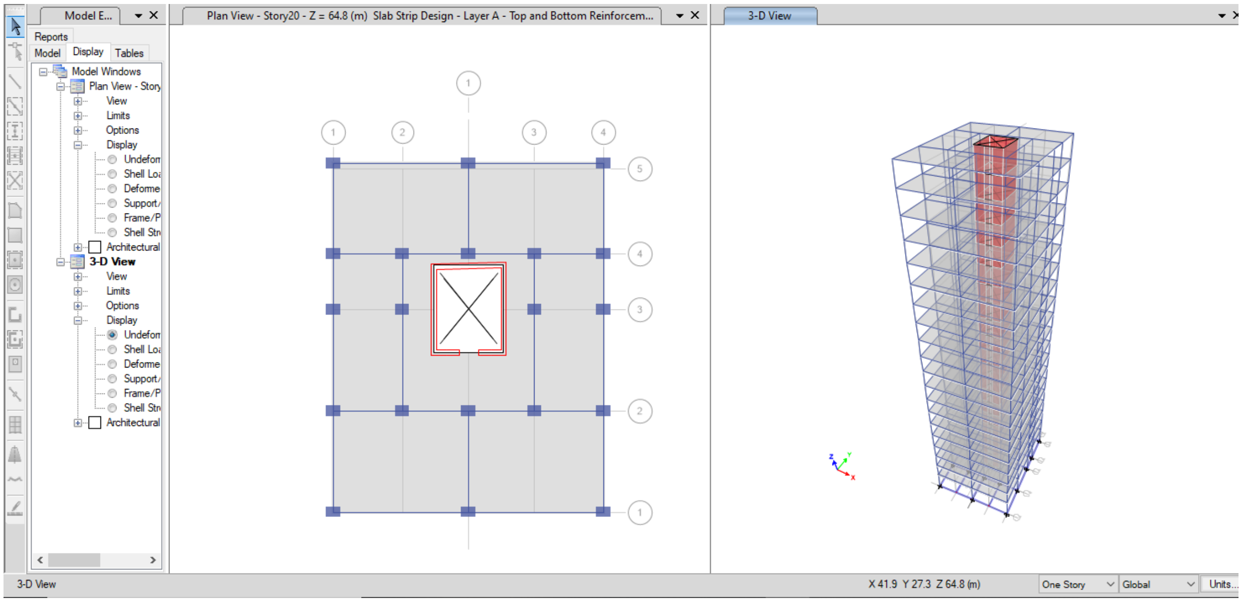
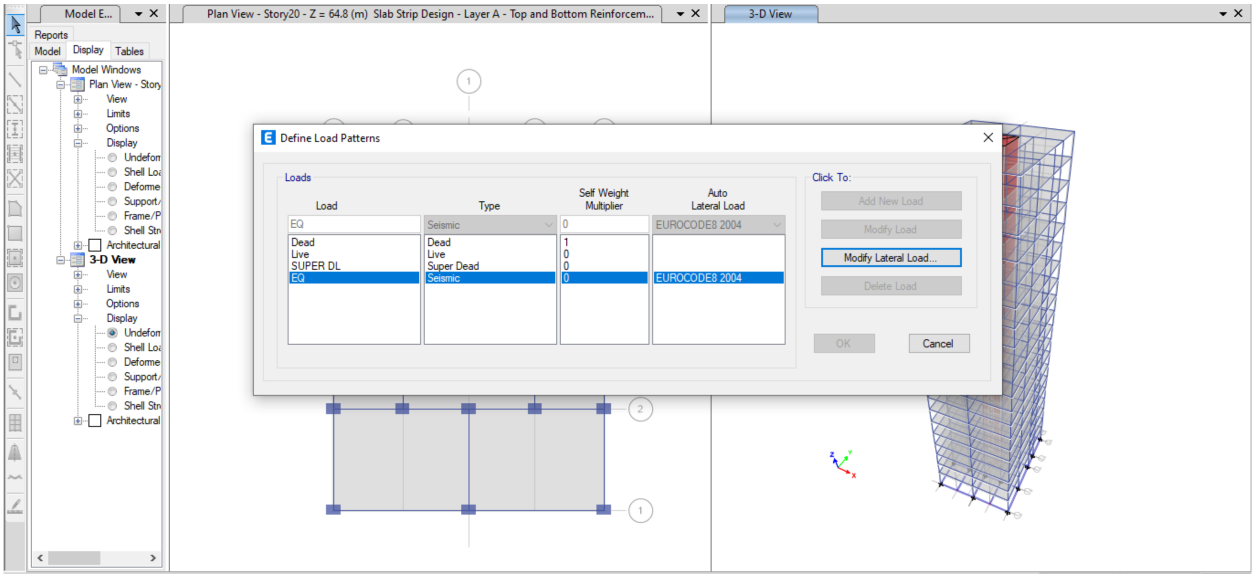


Fig. 4 Modeling



Load	Type	Self Weight Multiplier	Auto Lateral Load
EQ	Seismic	0	EUROCODE8 2004
Dead	Dead	1	
Live	Live	0	
SUPER DL	Super Dead	0	
EQ	Seismic	0	EUROCODE8 2004

Fig 5 Load Patterns Definition

4.1 Results And Discussion

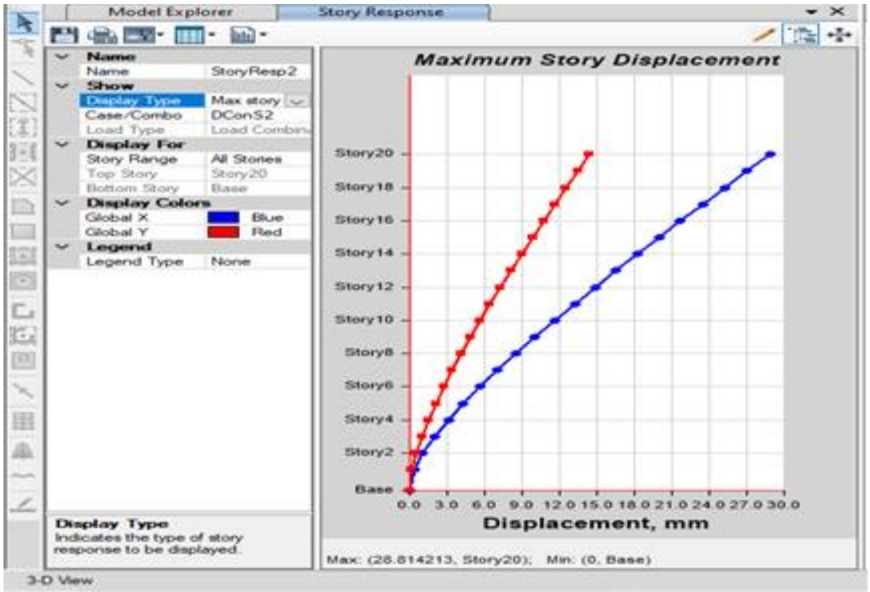
Maximum Displacement

Table 3 Shows The Maximum Displacement Of The Structure Under The Action Of Response Spectrum Analysis In Both X And Y Direction. From The Table The Maximum Storey Displacement Of The Building Is 213.33mm And It Occurs In X-Direction At Storey 20 Of The Building.

Table 3: Storey Response (Displacement)

		Displacement (Mm)	
Story	Elevation(M)	X-Direction	Y-Direction
Story20	64.8	213.333	203.799
Story19	61.6	204.768	195.624
Story18	58.4	196.816	187.735
Story17	55.2	188.245	179.283
Story16	52	178.987	170.205
Story15	48.8	169.024	160.489
Story14	45.6	158.376	150.152
Story13	42.4	147.089	139.238
Story12	39.2	135.226	127.809
Story11	36	122.866	115.94
Story10	32.8	110.104	103.723
Story9	29.6	97.048	91.262
Story8	26.4	83.821	78.676
Story7	23.2	70.569	66.105
Story6	20	57.462	53.713
Story5	16.8	44.713	41.702
Story4	13.6	32.589	30.323
Story3	10.4	21.448	19.909
Story2	7.2	11.79	10.922
Story1	4	4.309	3.992

Fig 6 Shows The Graph Of Maximum Displacement Which Was Obtained In X- Direction Of The Building In Each Storey.



Name
Name: StoryResp2
Show
Display Type: Max story
Case/Combo: DConS2
Load Type: Load Combin
Display For
Story Range: All Stories
Top Story: Story20
Bottom Story: Base
Display Colors
Global X: Blue
Global Y: Red
Legend
Legend Type: None

Display Type
Indicates the type of story response to be displayed.

Max: (28.814213, Story20); Min: (0, Base)

Fig. 6 Response Displacement

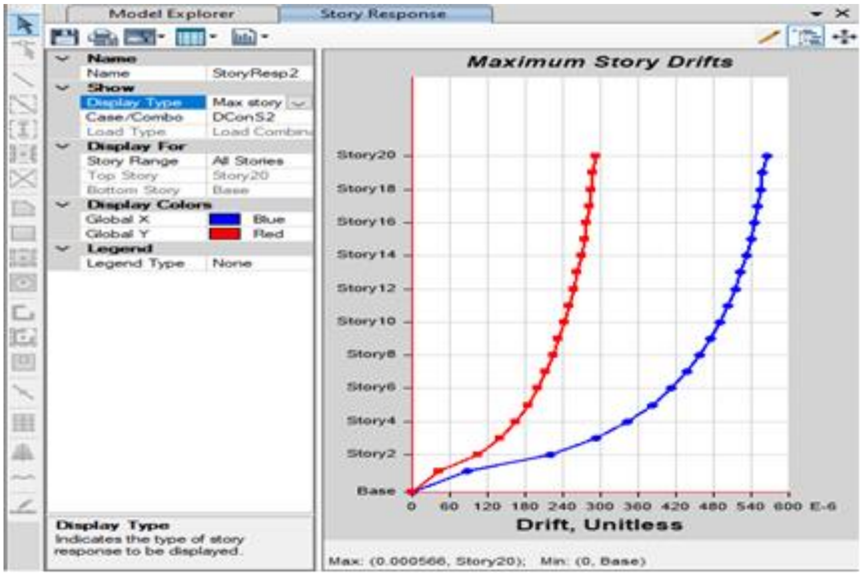
Maximum Drift

Table 4 Shows The Maximum Drift Of Each Floor Of The Building. The Maximum Drift Is At The Storey 7 And Has A Value Of 0.006384. Fig 7 Shows The Graph Of Storey Drift Of Each Storey Obtained From Dynamic Analysis.

Table 4: Storey Response (Drift)

	Drift		
Story	Elevation(M)	X-Direction	Y-Direction
Story20	64.8	0.002392	0.00245
Story19	61.6	0.002684	0.002509
Story18	58.4	0.003061	0.002738
Story17	55.2	0.003478	0.003091
Story16	52	0.003906	0.003454
Story15	48.8	0.004327	0.003811
Story14	45.6	0.004728	0.004149
Story13	42.4	0.0051	0.004463
Story12	39.2	0.005437	0.004747
Story11	36	0.005735	0.004996
Story10	32.8	0.005987	0.005205
Story9	29.6	0.006186	0.005368
Story8	26.4	0.006323	0.005477
Story7	23.2	0.006384	0.00552
Story6	20	0.006345	0.005476
Story5	16.8	0.006172	0.005315
Story4	13.6	0.005808	0.004988
Story3	10.4	0.005161	0.004413
Story2	7.2	0.004085	0.003465

Story1	4	0.001894	0.001577



Name
Name StoryResp2
Show
Display Type Max story
Case/Combo DConS2
Load Type Load Combina
Display For
Story Range All Stories
Top Story Story20
Bottom Story Base
Display Colors
Global X 🟦 Blue
Global Y 🟥 Red
Legend
Legend Type None

Display Type
Indicates the type of story response to be displayed.

Max: (0.000566, Story20); Min: (0, Base)

Fig. 7 Storey Response Plot (Drift)

Modes And Natural Frequency

As Seen In Table 6.1 Of The Appendix, The Natural Frequency Of The Building Is 0.36hz In Mode 1 And 6.702hz In Mode 12. The Period Where This Frequency Occurs Is 2.778secs And 0.149secs Respectively. Usually, Concerns For Tall Buildings Is Usually For Frequencies Between 0-1hz. Hence, The Building Will Require Dampers During Construction Due To The Low Frequencies That Originates When The Building Is Excited. Appendix B Shows The Different Mode Shapes Of The Building Up To Mode 12.

5.1 Conclusion/Recommendation

Planning And Analysis Of A Multi-Storey Residential Building Was Done To Standard Specification With Etabs. The Maximum Displacement And Storey Drift Were Obtained At Storey Twenty And Seven Respectively Of The Building In X-Direction. Static And Dynamic Analysis And Design Were Simulated For Each Member But The Scope Covers Results For Dynamic Analysis Which Was Performed To Aci318-14 And Asce Codes. The Results Concludes That The Fictional 20 Storey Tall Building Is Stable Enough To Withstand Wind Loads And Seismic Activities.

I Recommended That All Loadings Combinations, Design Parameters Should Be Properly Checked Before Running The Analysis On Etabs.

This Work Will Also Be Useful For Further Studies On Structural Dynamic Analysis Of Tall Buildings.

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