Structural Design Practices in the Philippines

Looking Back and Looking Beyond.

Engr. Jose A. Sy
Sysquared & Associates, Inc.
President/Ceo

AGENDA

01. Marcos Regime

02. August 21, 1983 : Ninoy Aquino’s Assassination

03. EDSA People Power Revolution

04. 1987 : Key Projects

05. 1990 – 1997 : Construction on the Rise

06. 1997 : Asian Financial Crisis

07. 2000 Onwards : Moving Forward

08. Look Ahead

Marcos Regime

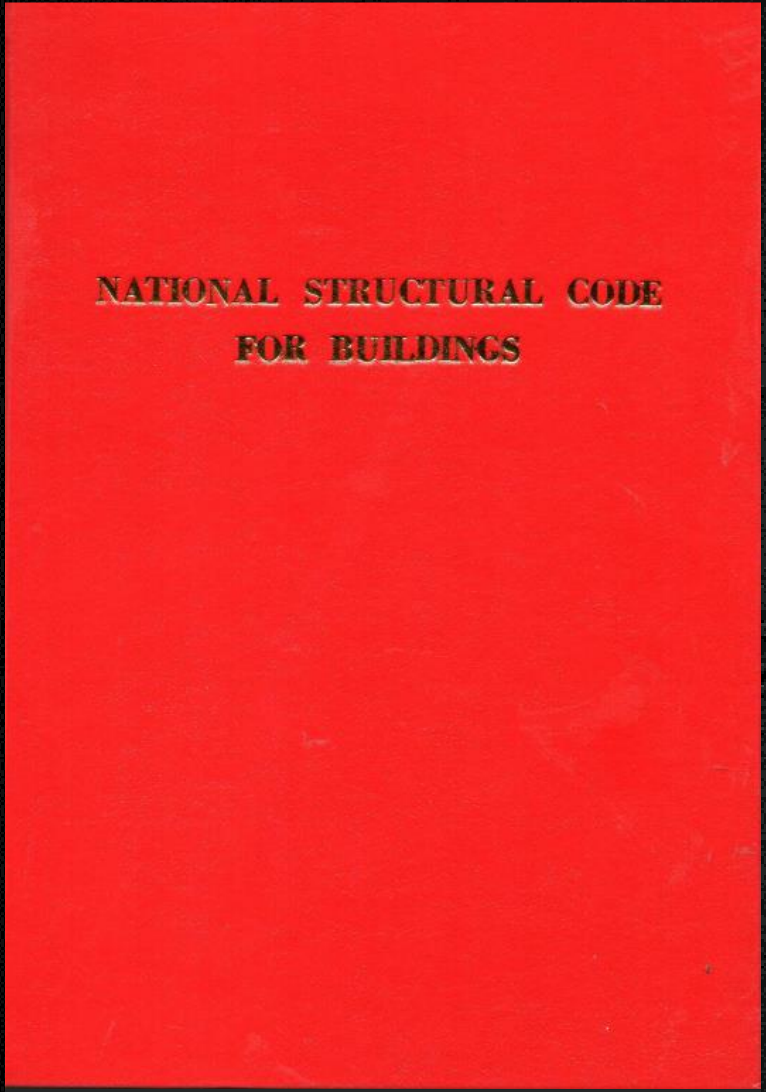
The collapse of Ruby Tower, a six-story condominium building, in the magnitude 7.3 1968 earthquake started the call for better design and construction practice in the Philippines

That time, no structural design code is available in the Philippines.

Seismic lateral design force is proportional to the building weight.

$$V = 0.10\ W$$

Marcos Regime



NSCB 1972

National Structural Code for Buildings, 1st Edition

- Based on the Uniform Building Code (UBC 1970)
- Divided the Philippines into 3 zones with corresponding seismic zone factors

$$V = ZKCW$$

- Ductility requirements are still not included from 1971 San Fernando Earthquake

Marcos Regime

Cultural Center of the Philippines (CCP)

Folk Arts Theatre

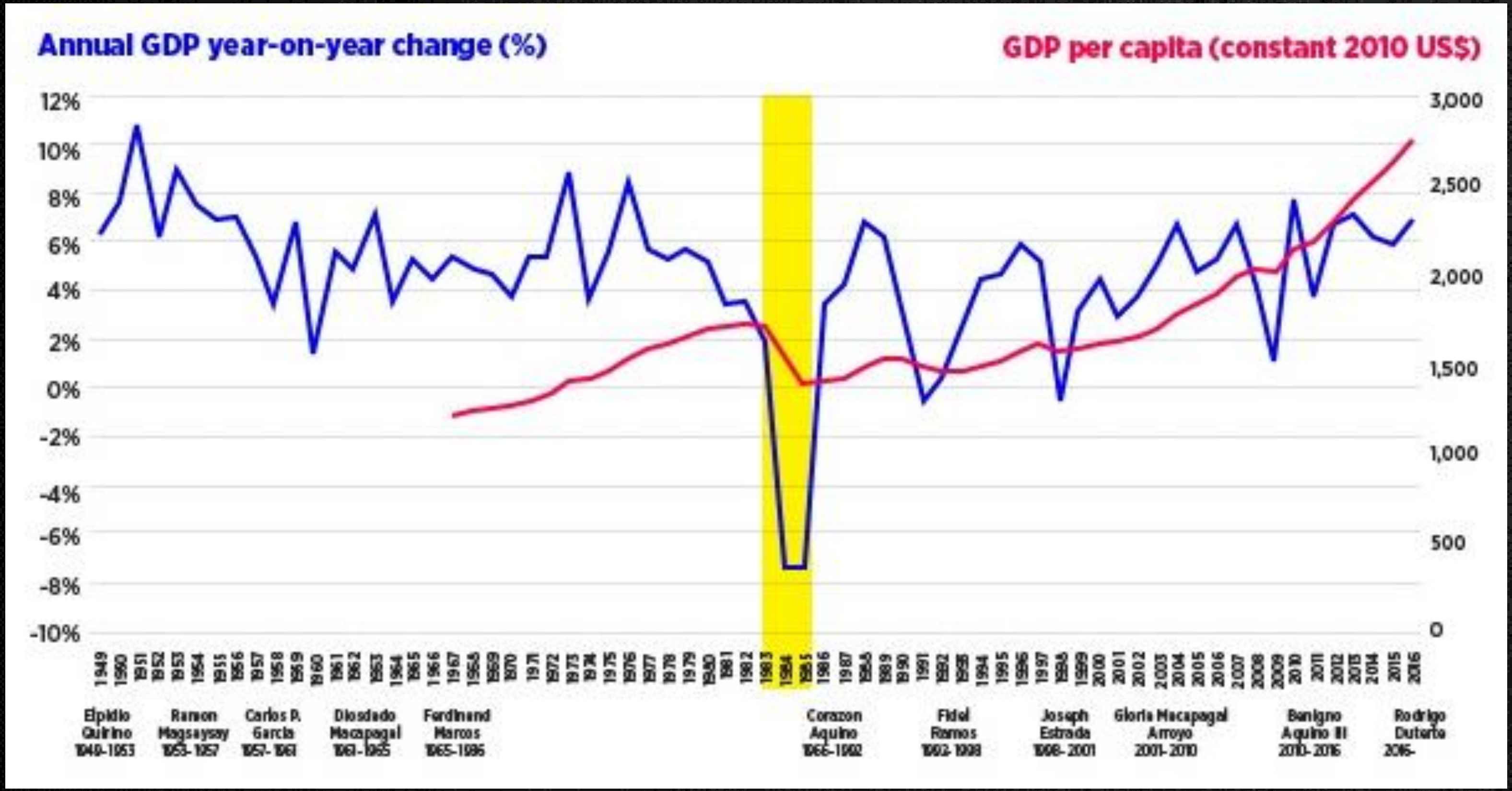
Philippine International Convention Center (PICC)

Philippine Heart Center

AUGUST 21, 1983

Ninoy Aquino Assassination

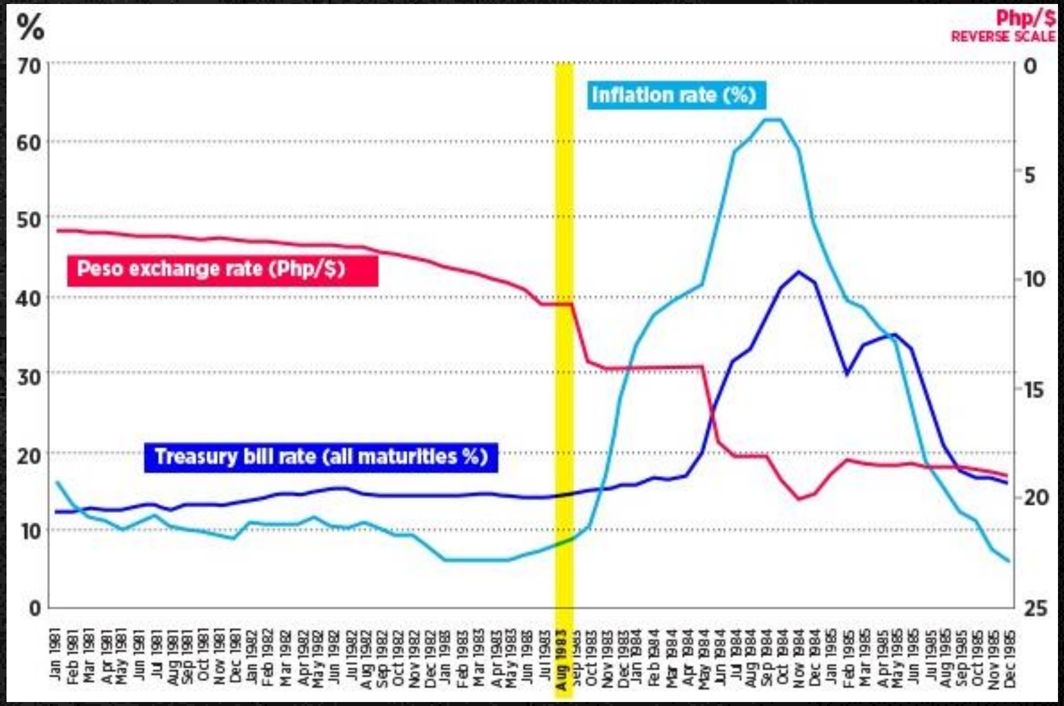
- Economic Status



"The period shortly after the Aquino Assassination in August 1983 and the Debt Moratorium in October 1983 saw the severest economic contractions in the Philippines since after World War II."

AUGUST 21, 1983
Ninoy Aquino Assassination

- Dollar Exchange Rate
  - The Philippines Peso to US Dollar Exchange rate was already suffering due to increasing debt, but it truly took a downfall almost immediately after the assassination.
  - The peso plunged 30% in 1983, and a further 50% in 1984, **1USD = 27 PHP**

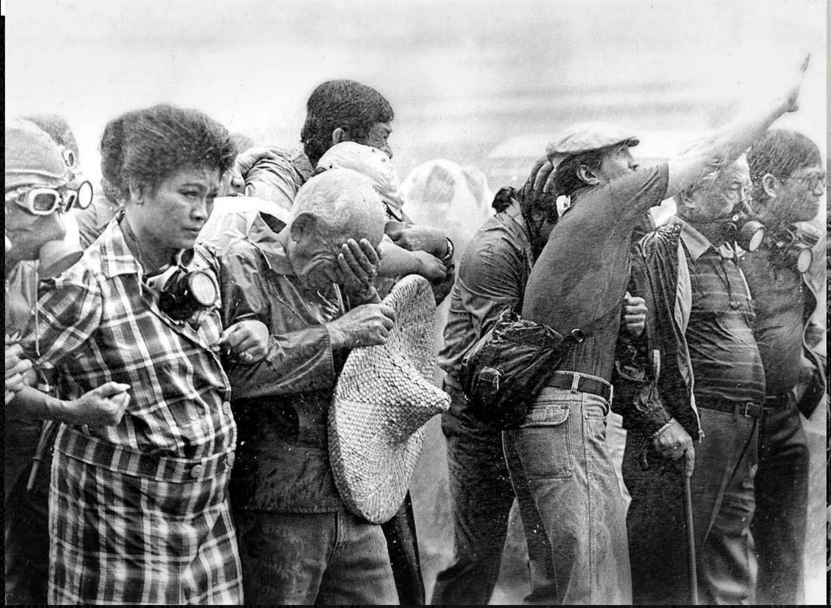


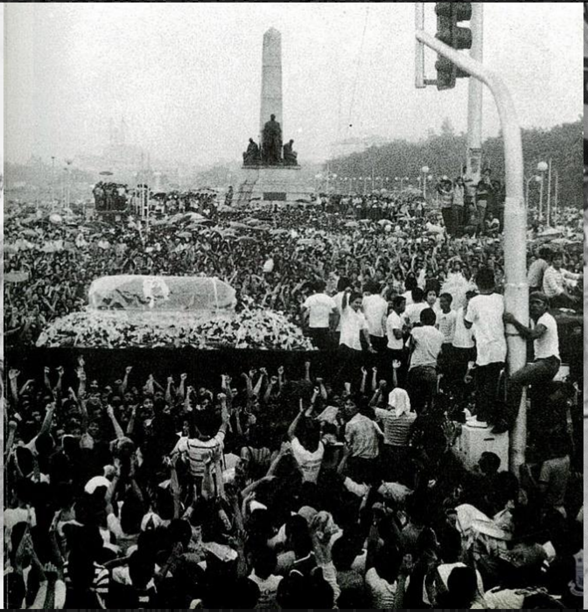
AUGUST 21, 1983

Ninoy Aquino Assassination

- Rampant Protests and Rallies

165 rallies, marches, and other demonstrations took place between August 21 and September 30, 1983. Protest demonstrations continued into the following year, with more than 100 held between October 1983 and February 1984.





AUGUST 21, 1983

Ninoy Aquino Assassination

- As a result, no construction activities were carried out
  - Decrease in overall government spending
  - Restrictive monetary policies became detrimental, especially in the industrial sector
  - Majority of government led programs gave focus to the agricultural sectors only, failing to address the needs of other industries
  - In effect, construction activities were at a standstill

AUGUST 21, 1983

Ninoy Aquino Assassination

Pacific Star (Nauru Building)

- Tallest building in the Philippines during the revolution
- 112.5 meters
- 29 stories with 4 basement levels

EDSA People Power Revolution

EDSA People Power Revolution

The Manila Times

Rally to the Flag!

Fair today

MANILA, PHILIPPINES, TUESDAY, FEBRUARY 25, 1986

MARCOS' LAST STAND

People's army set for blitz

By SHEILA S. CORONEL

Cory gov't formed today

The Manila Times

Rally to the Flag!

Fair today

MARCOS FLEES

Family, Ver off with him

Revolt's last day: 15 dead

BULLETIN TODAY

THE NATION'S LEADING NEWSPAPER

5 die in clash at TV site in QC

F.M. LEAVES R.P.

To seek asylum in US

President Marcos left last night for Clark Air Base (CAB) where a United States Air Force plane took him and his family to seek asylum in the United States.

The President stepped down from Malacañang after a three-day siege mounted by reformist troopers

EDSA People Power Revolution

1M kept vigil at Camp Crame

by REY M. LAGONSIN

UNDAUNTED by the curfew imposed by Mr. Marcos Monday night, an estimated one million people kept their vigil at the barricaded area along E. delos Santos Avenue until this morning.

Groups from all over Metro Manila have each secured their "quarters" beside the street islands and pedestrian sidewalks along the stretch of EDSA from Ortigas Avenue to Santolan Road fronting Camp Crame and Aguinaldo.

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Balanced news, fearless views

PHILIPPINE DAILY INQUIRER

WEDNESDAY, February 26, 1986 ★ P2 Vol. One No. 80

Businessmen heed call of Cory

by EDGAR MALAY

FOREIGN and local businessmen will reopen their establishments today in answer to President Corazon C. Aquino's call for cooperation in rebuilding the country's tattered economy.

Local businessmen, particularly those who sat in the defunct Philippine Productivity Council (PPC), under former President Marcos, have declared that they will contribute to the efforts of the government — which is supported by the people.

Businessmen have remained closed since the

To page 2

It's all over; Marcos flees!

By LUIS D. BELTRAN
Editor-in-Chief

THE PEOPLE of the Philippines who brought Ferdinand E. Marcos to the pinnacle of power two decades ago with their votes yesterday brought him crashing out of power with their bodies.

First destroying the legitimacy of Marcos' regime by denying him a new mandate last Feb. 7, the Filipino people then frustrated his attempts to stay in power by blocking his tanks with their bodies.

After three days of alternately blustering between threatened attacks and ineffectual curfew impositions, deposed President Marcos last night ended 20 years of autocratic, constitutional and authoritarian rule by accepting exile to the United States.

His departure wrote finis to a tense drama that saw his vast army abandoning him in droves and joining the ordinary Filipino in opposing the most repressive regime in Philippine history.

Marcos apparently masked his departure and lulled hordes of angry Filipinos by an oath-ta-

Marcos took power in 1965, was re-elected in 1969 and perpetuated himself in power by declaring Martial Law in 1972 and holding successive mock referenda and elections to gain new "mandates" from the Filipino people.

In the elections held last February 7, the first free elections since Mar-

was preceded by nationwide fears that he would trigger a bloodbath by making a last-ditch stand and his departure has made official the success of a virtually bloodless revolution led by his former Defense Minister Juan Ponce-Enrile and his former Vice-Chief of Staff General Fidel Ramos.

Marcos has been

OATH: President Corazon Aquino takes her oath of office before SC Senior Justice Claudio Teehankee at Club Filipino. Witnessing among others (from left) are daughters Pinky, and Ballsy, [illegible] Dona Aurora Aquino and a host of Opposition leaders.

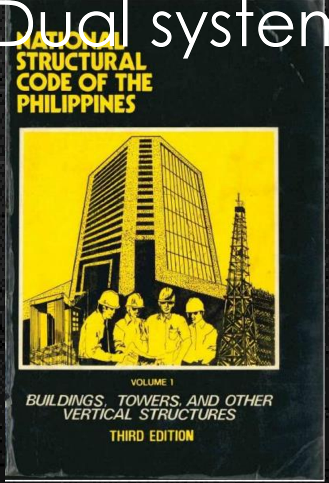
Cory Aquino forms new government

Pro-Cory MIA forces stopping

1987 : Key Projects

Pacific Plaza

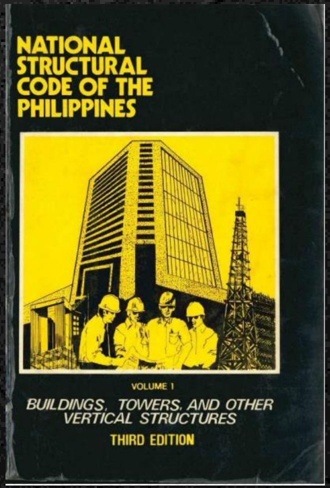
- Tallest building to be after the revolution
- 43 stories
- Designed using NSCP 1987 (based on UBC 1985)
  - Wind pressure, $P = C_e C_q q_s I$
  - Earthquake force, $V = ZIKCSW$
- First building in the Philippines to use 6000 psi concrete
- Dual system



1987 : Key Projects

SM Megamall

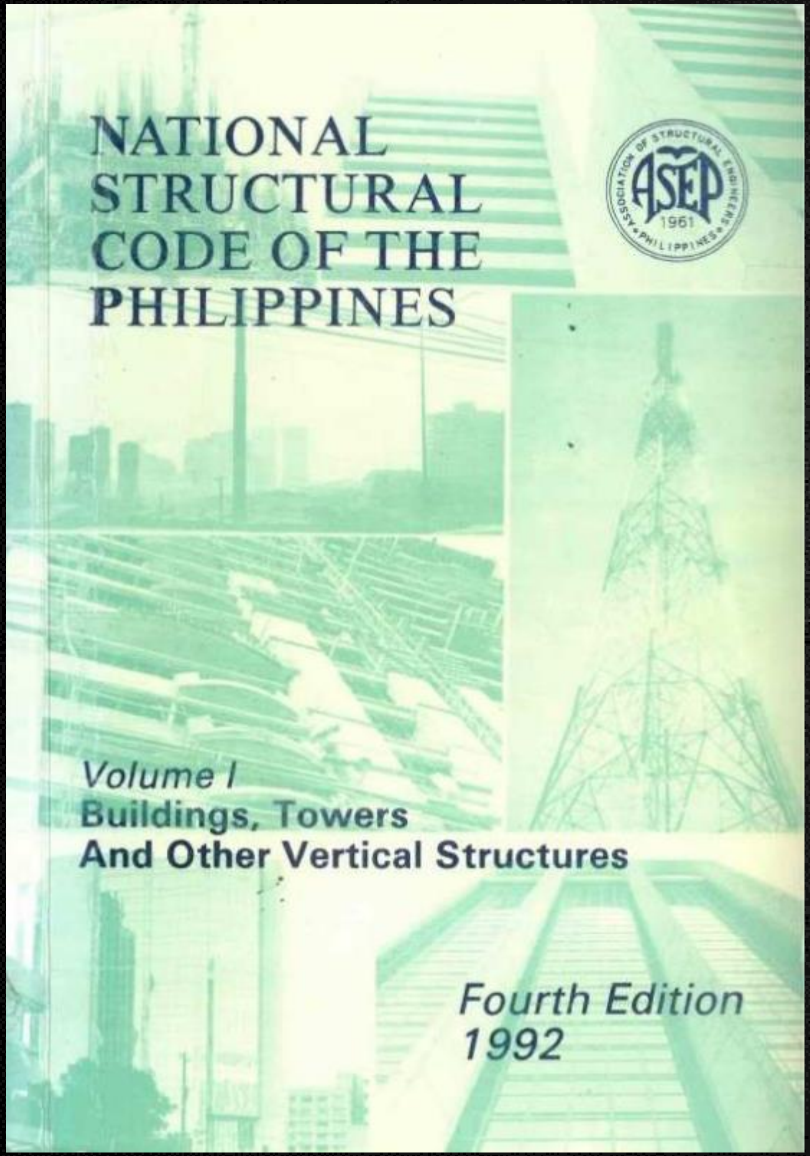
- Largest shopping mall in Asia in 1991
- 330,000 square meters total floor area
- Also designed using NSCP 1987
- Utilized post-tensioning for long span beams



1990 - 1997

The Magnitude 7.7 Luzon Earthquake in 1990 reminded us to further improve the structural design practice in the Philippines

1990 - 1997



National Structural Code for Buildings, 4th Edition

- Based on the Uniform Building Code (UBC 1988)
- Inclusion of Seismic Zone Maps (Zone 2 and 4)
- Introduction of response modification factors or "R-Factors"

$$V = (ZIC/R_w)W$$

1990 - 1997

Construction On the Rise

The country saw a boom in construction projects from the early to mid-90s

1990 - 1997

Construction On the Rise

PBCom Tower

-Tallest building in the Philippines

- 259 meters
- 52 storeys

GT International Tower

- 217 meters
- 47 storeys

Projects by the

1990 - 1997

Construction On the Rise

LKG Tower

- 180 meters
- 38 storeys

Ayala Tower One

- 160 meters
- 35 storeys

Projects by the

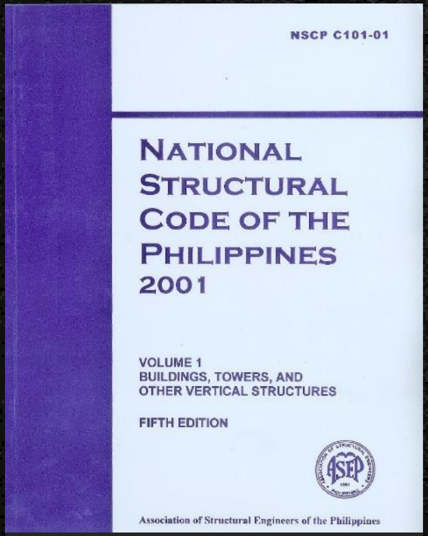
1997 : Asian Financial Crisis

- The Peso dropped from 26.2 Pesos per US Dollar at the start of the crisis to 43.173 Pesos. in 1998, it was down to 54 Pesos per US Dollar.
- Investment in the Philippines declined as a result of the limitations of investors to accessing capital.
- In June 1997, office vacancy rates for Makati were extremely low at 0.9%, but by September 1998, the Makati area then had a vacancy rate of 5.8%.

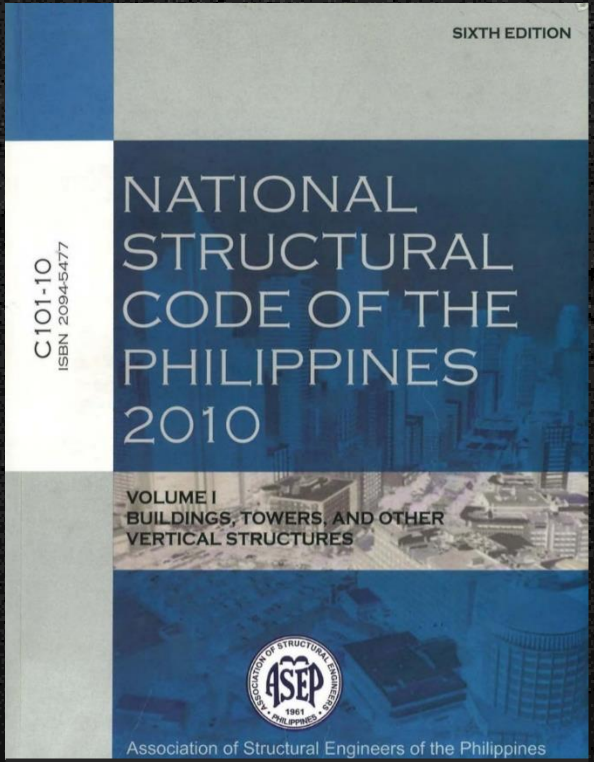
2000 Onwards

The National Structural Code of the Philippines continued to develop.

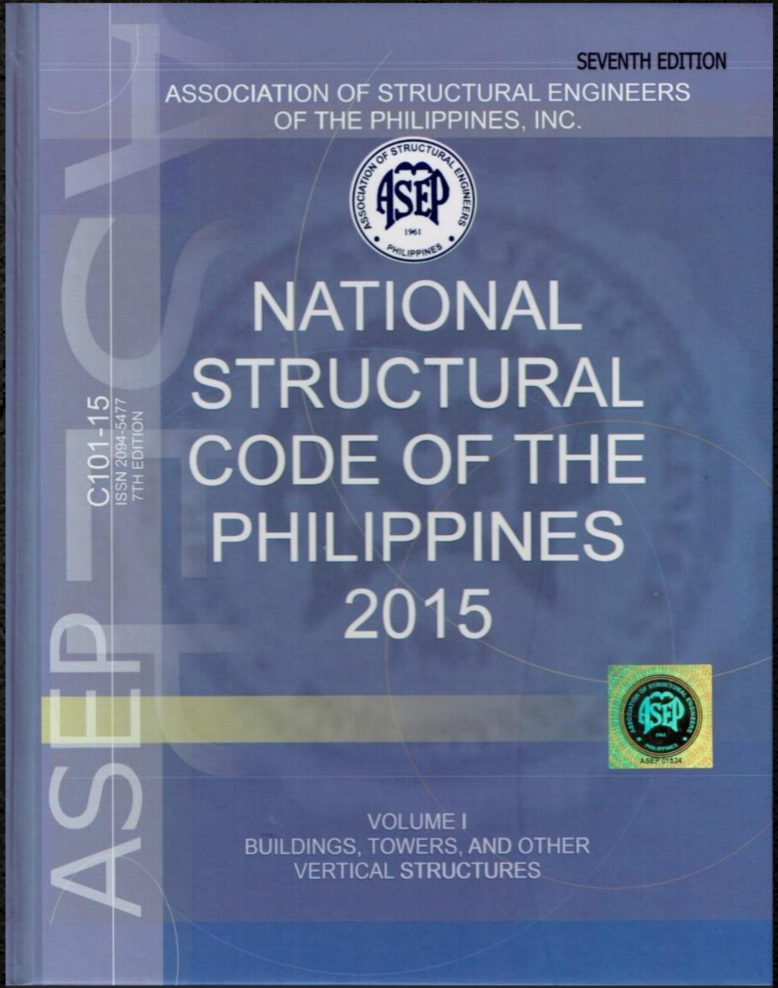
Provisions of UBC 1997 are still being adopted.



NSCP 2001



NSCP 2010

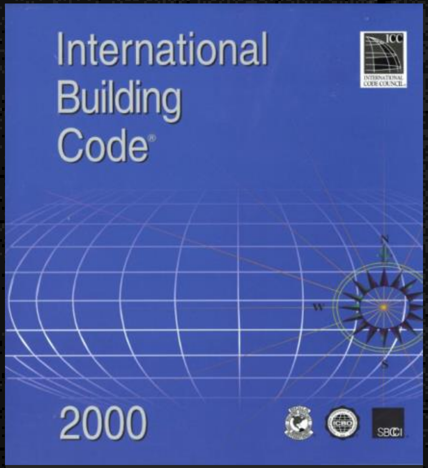


NSCP 2015

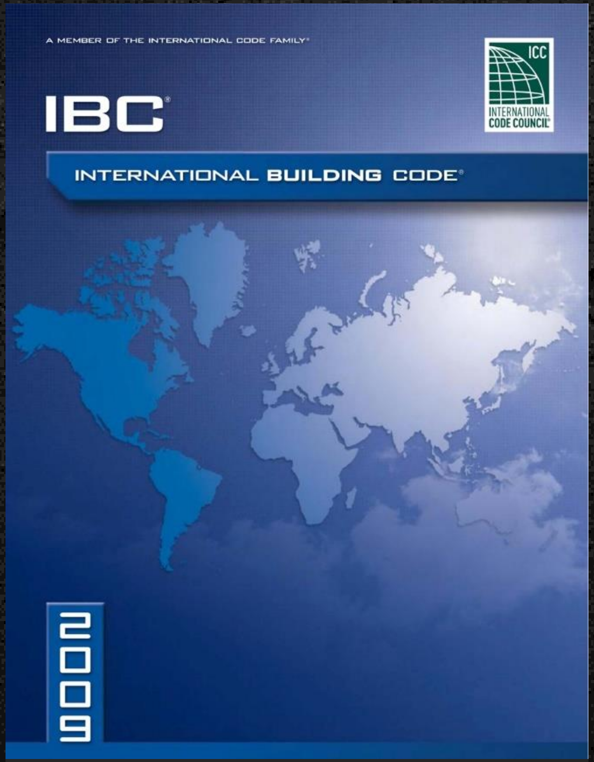
2000 Onwards

Meanwhile, international practice also advanced at a rapid pace.

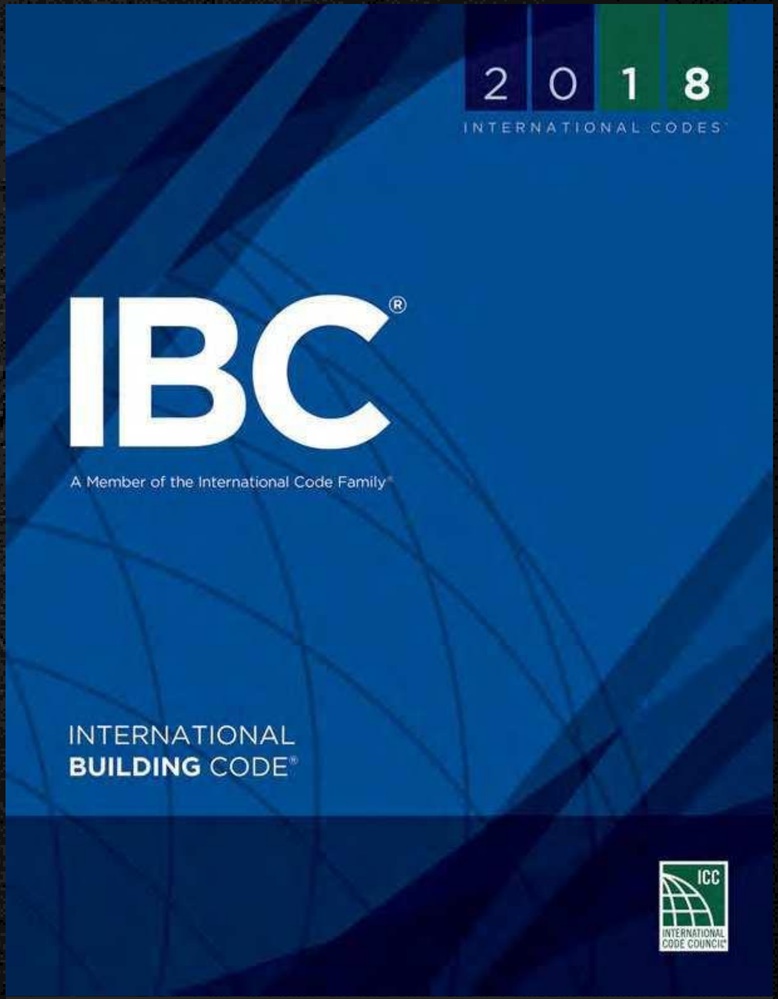
Seismic design is now based on mapped spectral accelerations.



IBC 2000



IBC 2009



IBC 2018

2000 Onwards

Building codes are intended to establish minimum requirements for providing safety to life and property from hazards.

- Specification of a *Prescriptive* Criteria
  - Acceptable materials for construction
  - Approved structural and nonstructural systems
  - Required minimum levels of strength and stiffness
  - Details of how a building is to be put together
- A certain level of performance is *implied* without assessing the actual performance capability of the building

Code Compliance or Achievement of Performance Objective?

Is code compliance enough?

2000 Onwards

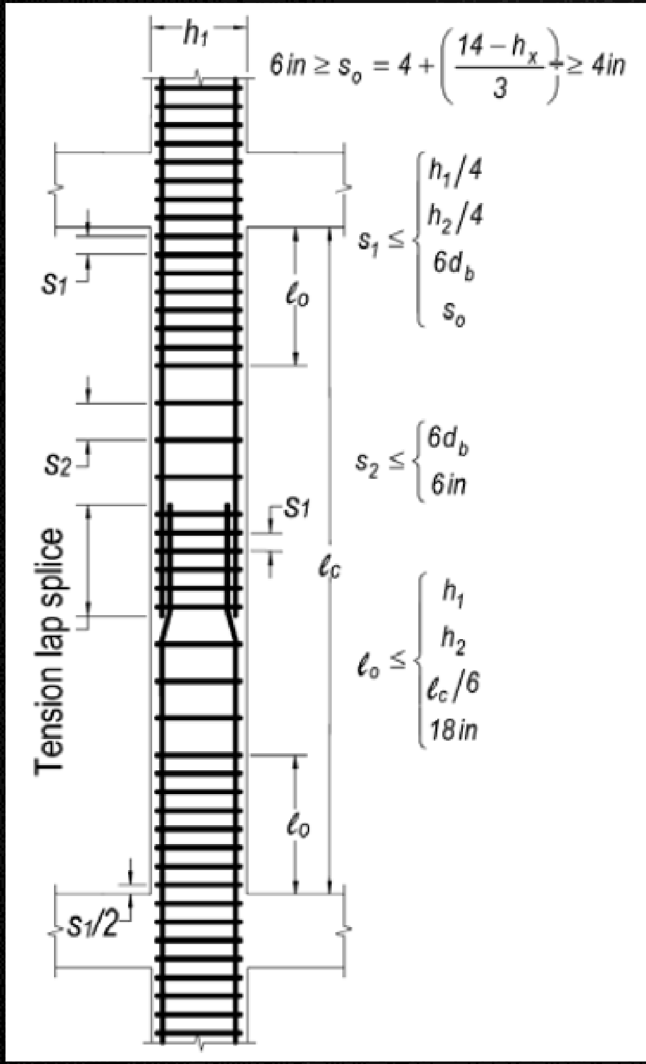
The development of seismic design criteria is a continuous process.

1933 Long Beach Earthquake — Minimum levels of lateral strength
1971 San Fernando Earthquake — Ability to deform without failure (Ductility)
1994 Northridge Earthquake — Damage can occur in code-compliant buildings

7.1M Mexico Earthquake

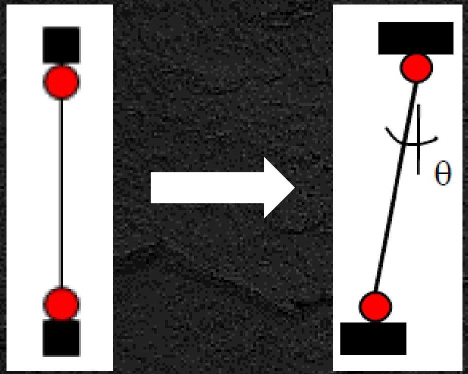
2000 Onwards

Confining Reinforcement of Columns



The Code Approach for Columns of Special Moment Frames

Specify ductility requirements at yield zones.



Specify maximum spacing of ties, say 100.

Intent is confinement for adequate ductility and hysteretic behaviour.

If we provide 125, our design is not code compliant.

Does this mean failure?

Will this specific column yield?

Do we need to provide the same ductility for all columns?

2000 Onwards

Performance is not guaranteed by code conformance.

Performance can be achieved without code conformance.

208.1.1 Purpose

The purpose of the succeeding earthquake provisions is primarily to design seismic-resistant structures to safeguard against major structural damage that may lead to loss of life and property. These provisions are not intended to assure zero-damage to structures nor maintain their functionality after a severe earthquake.

Explicit verification of performance is a must.

M9 Great Tohoku EQ

Changes in the state of knowledge and development of new analytical tools should translate to evolution in structural design practice.

2000 Onwards

Alternative Systems and Methods of Analysis

101.4 Alternative Systems

The provisions of this code are not intended to prevent the use of any material, alternate design or method of construction not specifically prescribed by this code, provided any alternate has been permitted and its use authorized by the Building Official (see Section 102).

Sponsors of any system of design or construction not within the scope of this code, the adequacy pf which had been shown by successful use and by analysis and test, shall have the right to present the data on which their design is based to the Building Official or to a board of examiners appointed by the Building Official or the project owner/developer. This board shall be composed of competent structural engineers and shall authority to investigate the data so submitted, to require tests if any, and to formulate rules governing design and construction of such systems to meet the intent of this code. These rules, when approved and promulgated by the Building Official, shall be of the same force and effect as the provisions of this code.

104.3 Analysis

Any system or method of construction to be used shall be based on a rational analysis in accordance with well-established principles of mechanics that take in to account equilibrium, general stability, geometric compatibility and both short-term and long-term material properties. Members that tend to accumulate residual deformations under repeated service loads shall have included in their analysis the added eccentricities expected to occur during their service life. Such analysis shall result in a system that provides a complete load path capable of transferring all loads and forces from their point of origin to the load-resisting elements. The analysis shall include, but not be limited to, the provisions of Sections 104.3.1 through 104.3.3.

2000 Onwards

Alternative Systems and Methods of Analysis

No provisions for other structural systems appropriate for tall buildings

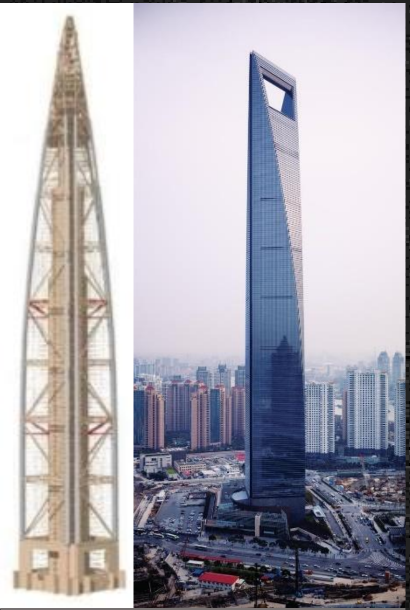
208.4.8.4 Alternative Procedures

208.4.8.4.1 General

Alternative lateral-force procedures using rational analyses based on well-established principles of mechanics may be used in lieu of those prescribed in these provisions.

208.4.8.4.2 Seismic Isolation

Seismic isolation, energy dissipation and damping systems may be used in the analysis and design of structures when approved by the building official and when special detailing is used to provide results equivalent to those obtained by the use of conventional structural systems.



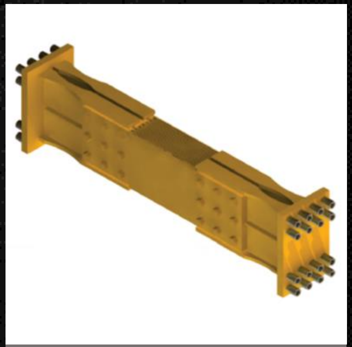
Outriggers

Diagrids

Base Isolators

Viscous Dampers

Tuned-mass Dampers



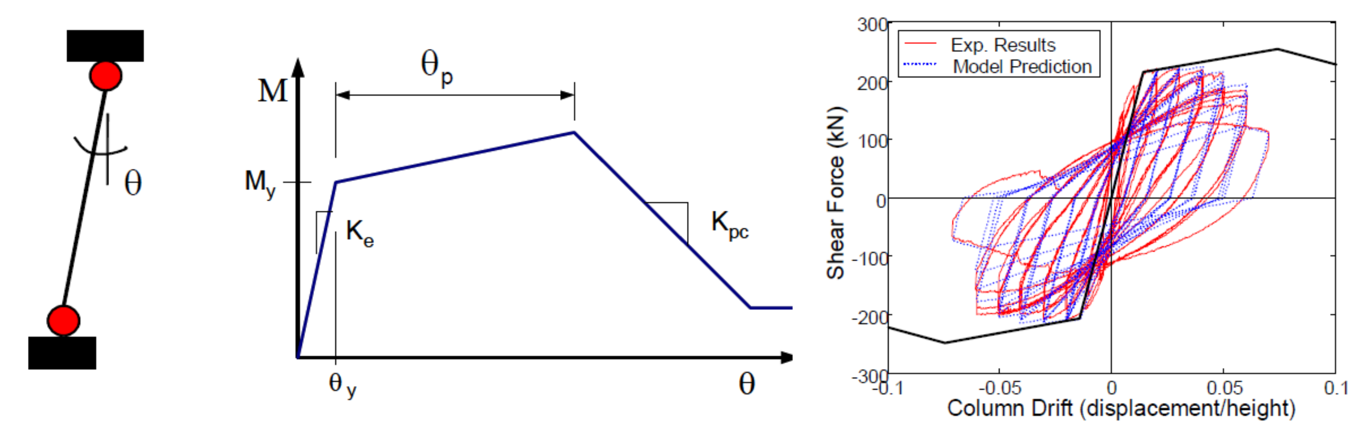
Viscoelastic Dampers

2000 Onwards

Alternative Systems and Methods of Analysis

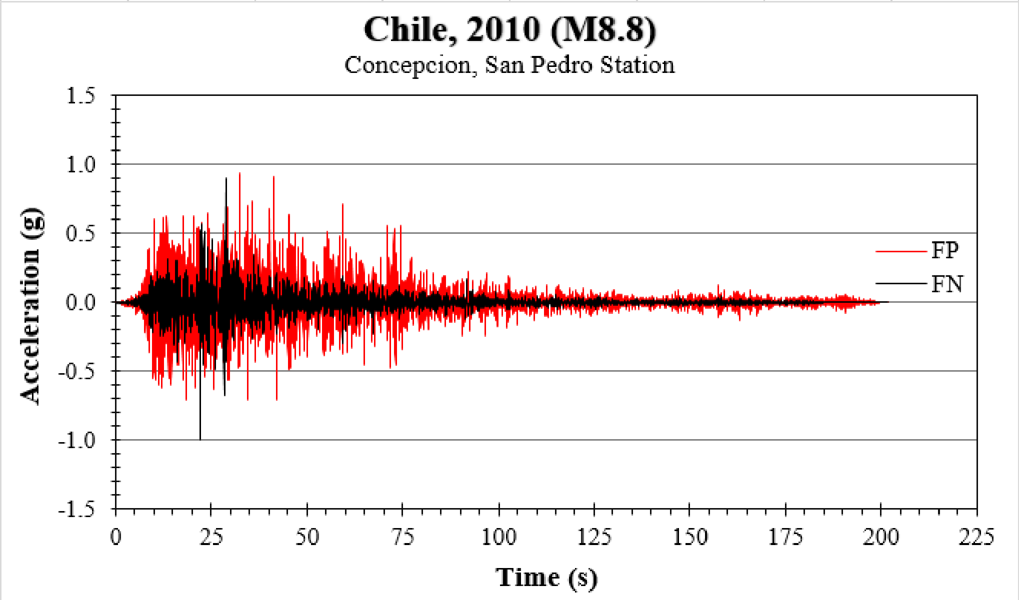
208.5.3.6.3.1 Nonlinear Time History Analysis

Nonlinear time history analysis shall meet the requirements of Section 208.4.4, and the time histories shall be developed and results determined in accordance with the requirements of Section 208.5.3.6.1. Capacities and characteristics of nonlinear elements shall be modeled consistent with test data or substantiated analysis, considering Importance Factor. The maximum inelastic response displacement shall not be reduced and shall comply with Section 208.6.5.



Time-history analysis provides an evaluation of dynamic structural response under loading which may vary according to the specified time function.

The nonlinearity comes from material and geometric nonlinearity, including P-delta and large-displacement effects.



2000 Onwards

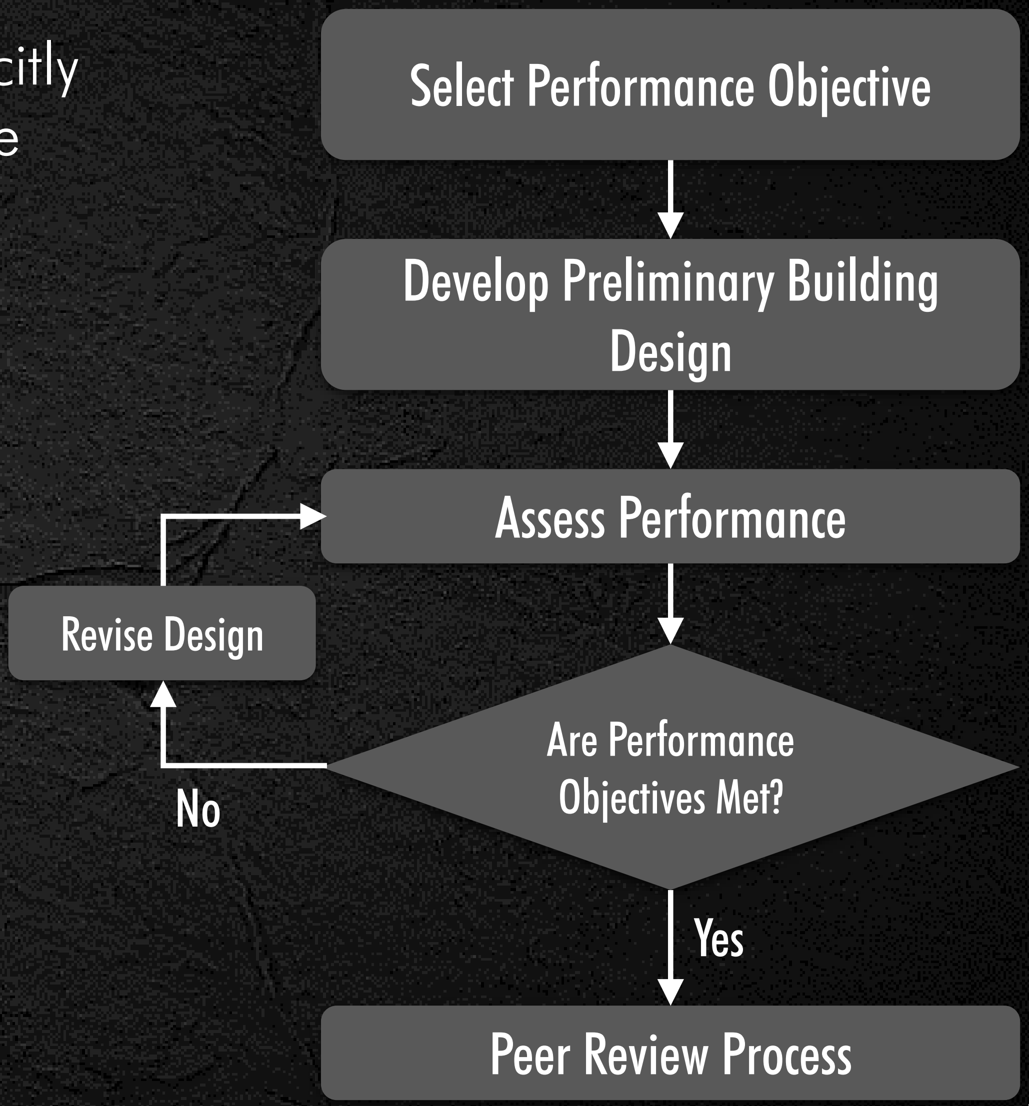
The performance-based seismic design process explicitly evaluates how a building is likely to perform given the potential hazard it is likely to experience.

Assess performance of buildings under multiple seismic events

Provide higher performance for critical structures than intended by the building code.

Deliver standard performance at a reduced cost

Can be applied to both <u>new</u> and <u>existing</u> buildings



2000 Onwards

For Risk Category II tall buildings, two performance objectives are investigated explicitly:

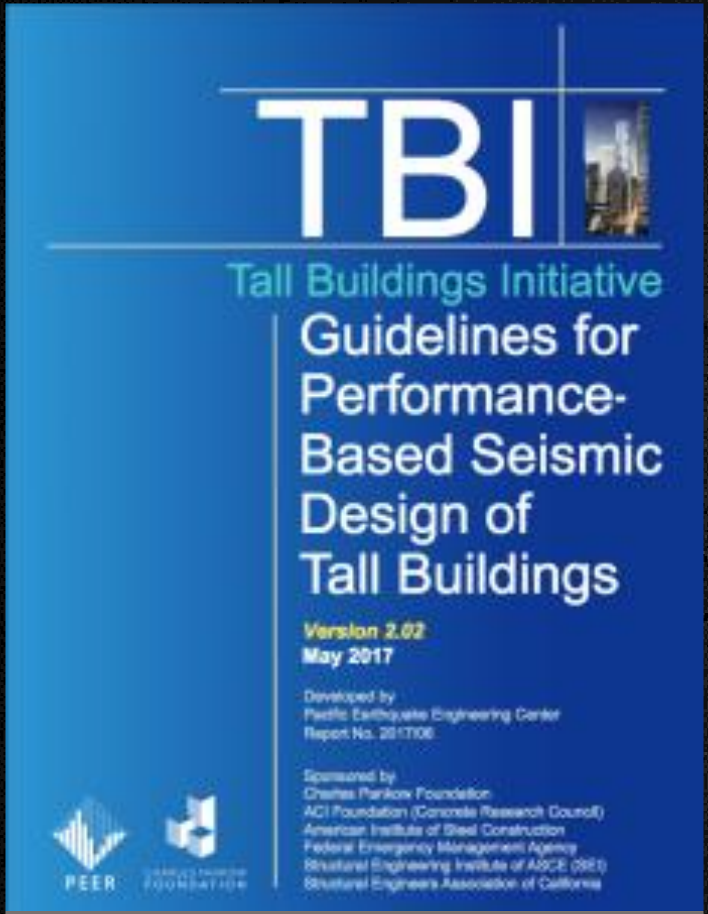
Level of Earthquake	Performance Objective
Service Level Earthquake (SLE): 50% probability of exceedance in 30 years (43-year return period)	Negligible damage in once-in-a-lifetime earthquake. Structure to remain essentially elastic with minor damage to structural and non-structural elements.
Maximum Considered Earthquake (MCE): 2% probability of exceedance in 50 years (2,475-year return period)	Response without loss gravity-load-carrying capacity; without inelastic straining of important lateral-force-resisting elements; and without experiencing excessive permanent lateral drift or development of global structural instability.

2000 Onwards

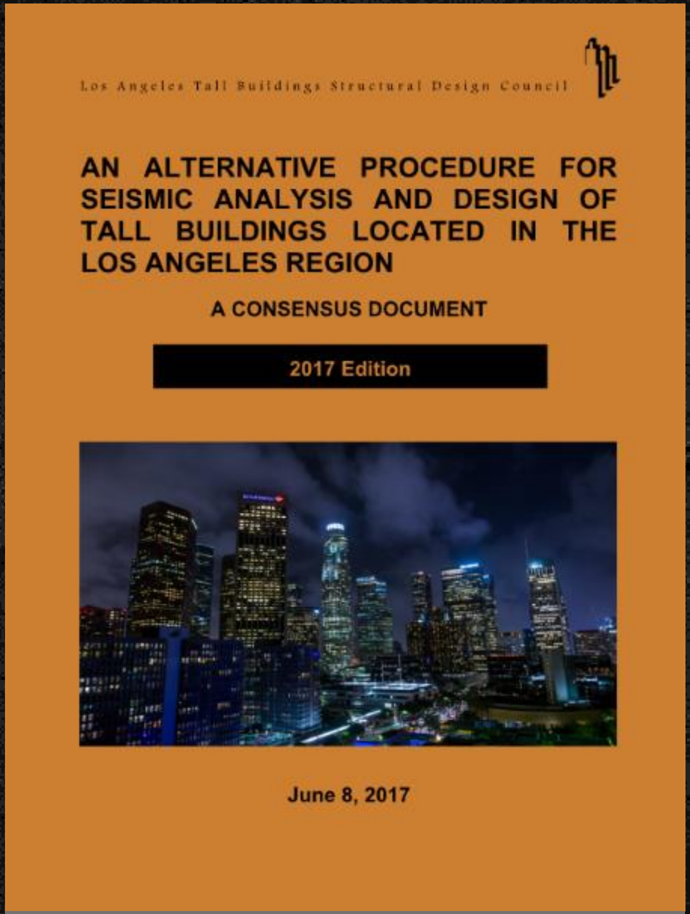
Standard Structural Performance Objectives

Earthquake Level	Performance Level			
	Operational	Immediate Occupancy	Life Safety	Collapse Prevention
Frequent (43 years)	Basic Objective	Unacceptable	Unacceptable	Unacceptable
Occasional (72 years)	Essential Objective	Basic Objective	Unacceptable	Unacceptable
Rare (475 years)	Safety-Critical Objective	Essential Objective	Basic Objective	Unacceptable
Very Rare (2475 years)	Not Feasible	Safety-Critical Objective	Essential Objective	Basic Objective

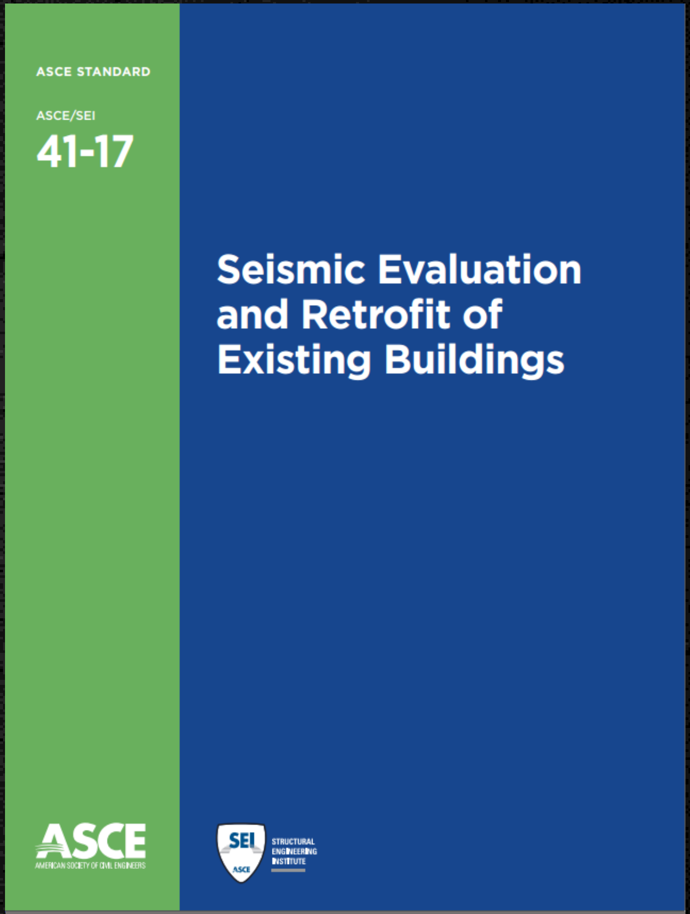
2000 Onwards



PEER TBI



LATBSDC



ASCE 41

2000 Onwards

Why PBD?

Integrating Aesthetics, Integrity, and Economy

Aesthetics

The art that exist within the built environment

Integrity

The backbone of structural engineering
Stability, Strength, and Stiffness

Economy

Enhancing the quality without sacrificing cost

2000 Onwards

Why PBD?

Buildings are getting taller.

Stratford Residences

Trump Tower

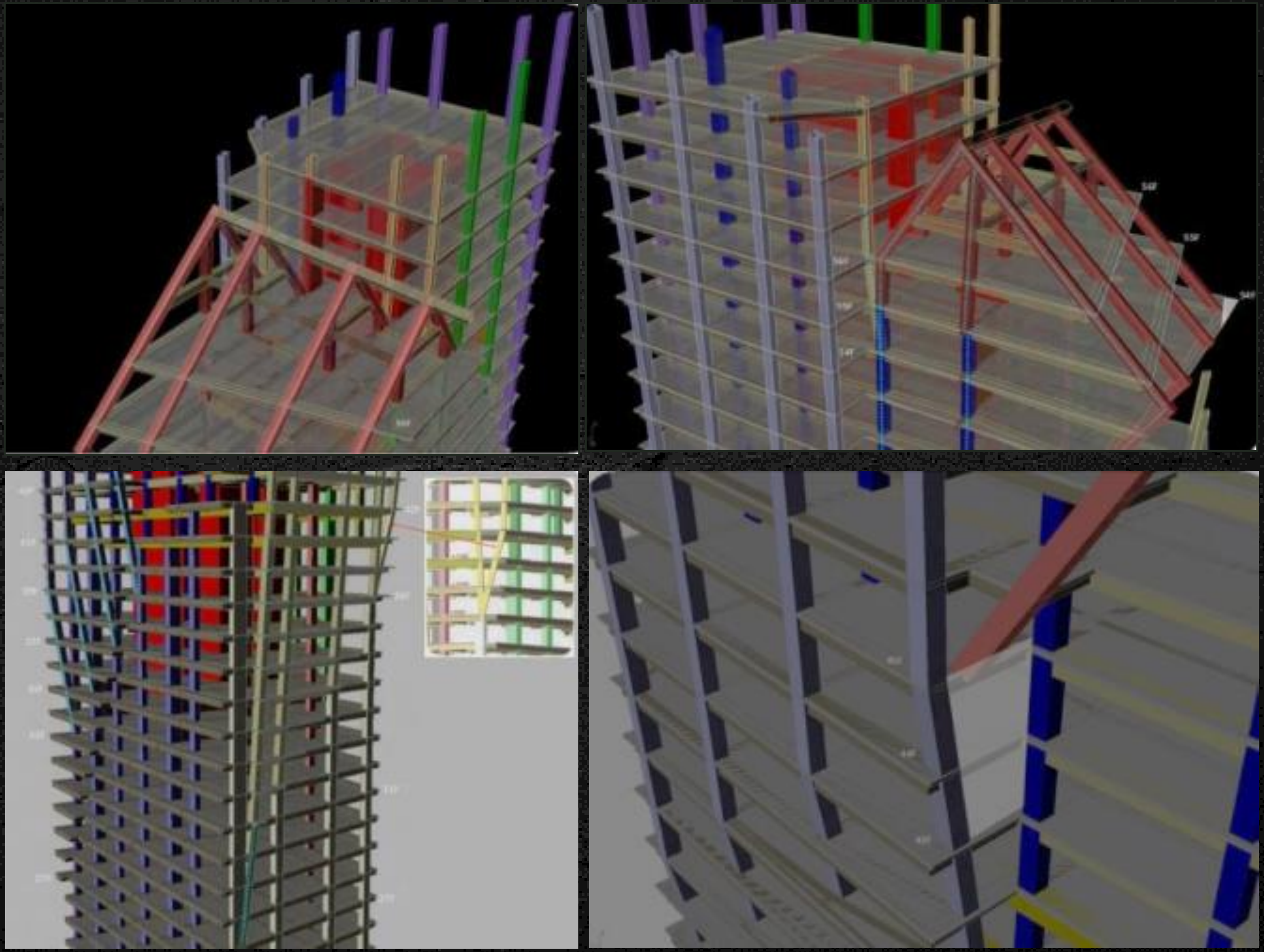
Gramercy Residences

2000 Onwards

Why PBD?

Buildings are getting more complicated.

The Spire



2000 Onwards

Why PBD?

Buildings are getting complex.

The Proscenium

Ayala Triangle Gardens

Park Central Towers

2000 Onwards

80 PBD Projects

Beacon Tower-2
Beacon Tower-3
Park Terraces Tower-1
Park Terraces Tower-2
Gramercy Residences
Milano Residences
Niagara Tower
Anchor Skysuites
One Shangri-la Place
Admiral Baysuites
Stratford Residences
Blue Residences
Ascott Residences
Discovery Primea
Edades Tower
One World Place Building
BDO Tower
M Place @ Ortigas
Shang Salcedo Place
Knightsbridge Residences

Green Residences
Sequoia at Two Serendra
The Suites
Kirov Tower
Sakura Tower
Lorraine Tower
Lincoln Tower
Proscenium Tower
Dettifoss Tower
Trump Tower
Sutherland Tower
Garden Tower-1
Garden Tower-2
Spire Tower
Shangri-la at the Fort
Livingstone Tower
Two Roxas Triangle
Iguazu Tower
The Rise
East Gallery Place

128 Nivel Hills Tower 1
128 Nivel Hills Tower 2
128 Nivel Hills Tower 3
Air Residences
Anchor Grandsuites
Sonata Premier Residential Tower
Sonata Premier Hotel Tower
Olive Residences
Ayala Triangle Garden Hotel
Ayala Triangle Garden Office
Fame Residences
Portico Tower 1
Menarco Tower
West Gallery Place
Nova Manila
Emerald North Tower
Emerald South Tower
Two Serendra Building
Azure North
Mandani Bay Ph. 1 Tower 1

Mandani Bay Ph. 1 Tower 2
STRC Apartment Ridge
The Connor
Glas Office Development
Mandani Bay Ph. 2 Tower 1
Mandani Bay Ph. 2 Tower 2
Mandani Bay Ph. 2 Tower 3
Mandani Bay Ph. 2 Tower 4
Sixth Tower at Proscenium
Proscenium Performance Hall
Shang Residences
Landmark BGC Office Tower
NAIA Terminal I
GSIS Building
Alphaland Makati Tower
Vertis North
Estancia
Frontera Verde
Benpres
Innoland Makati Tower

2000 Onwards

- 179 meters
- 53 storeys
- Designed using displacement-based design approach
- Utilized Tuned Liquid Column Sloshing Dampers to resist wind

Pacific Plaza Twin Towers

2000 Onwards

Designed more 250m using the Performance-Based Design approach

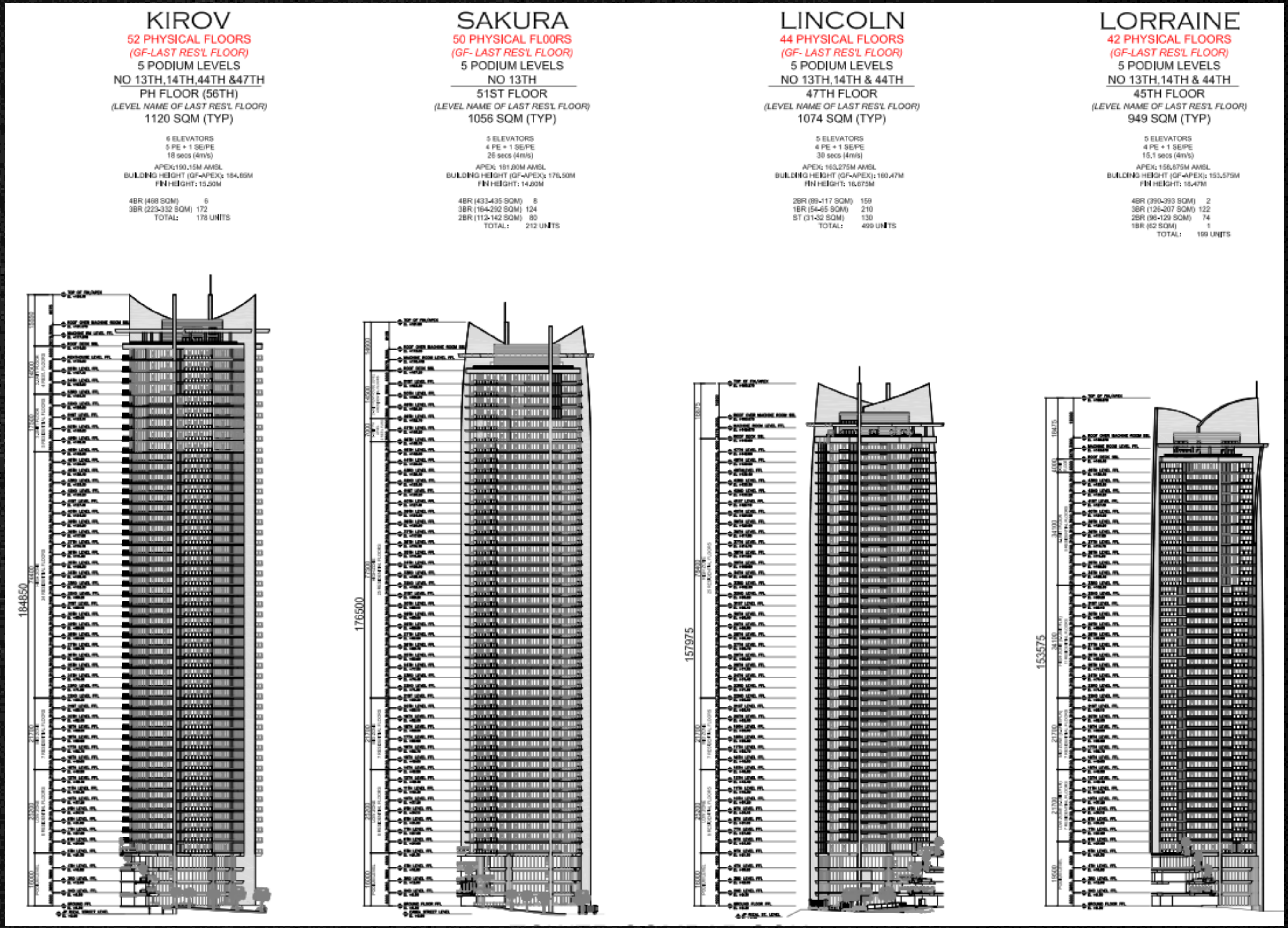
Shangri-La at the Fort

Trump Tower

Gramercy Residences

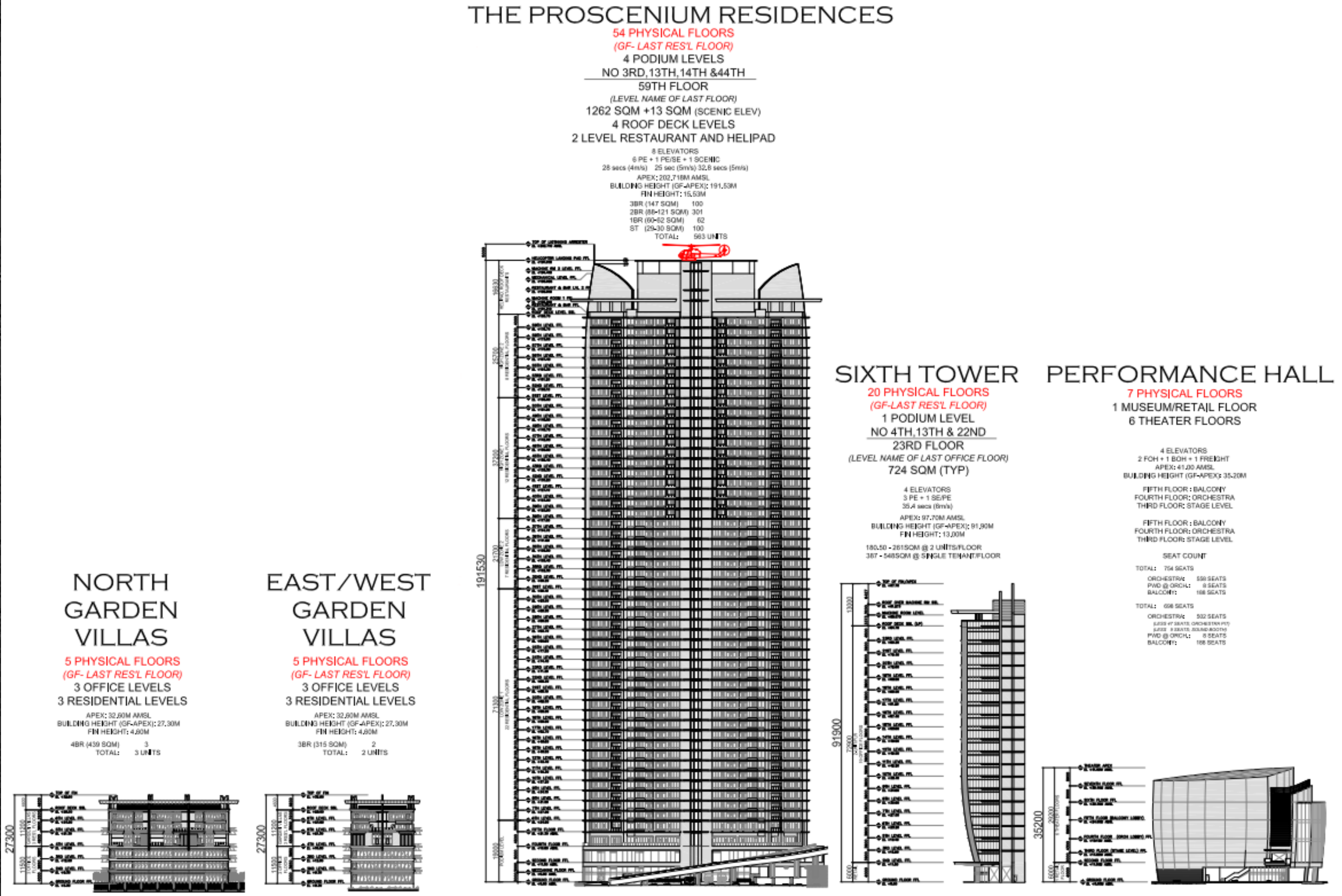
2000 Onwards

The Proscenium



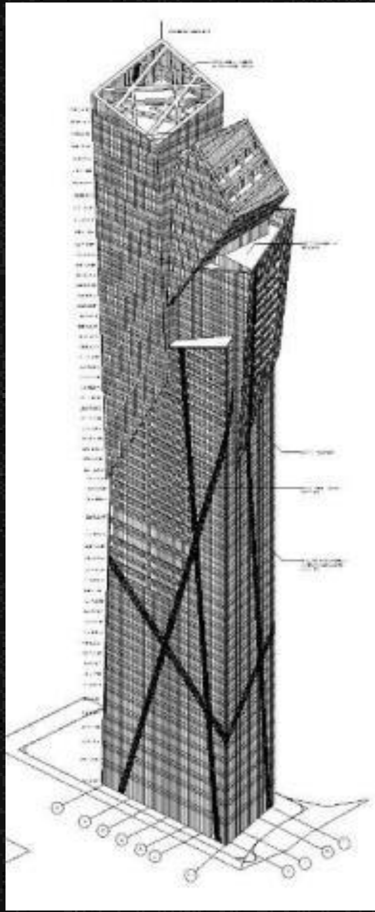
2000 Onwards

The Proscenium

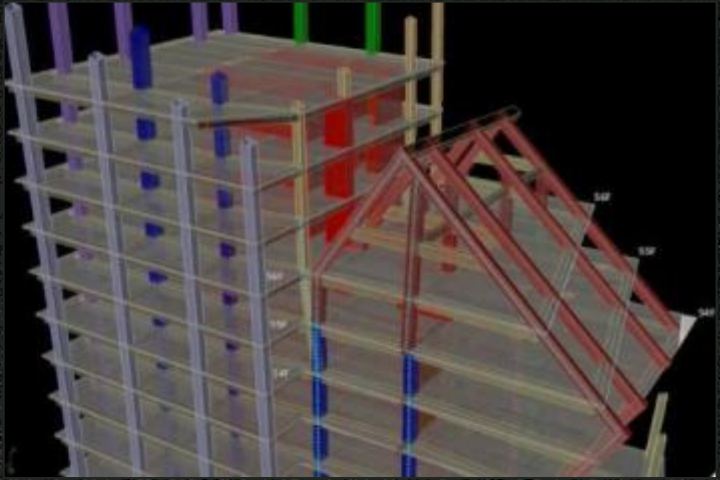


2000 Onwards

The Spire



Cladding Axometric

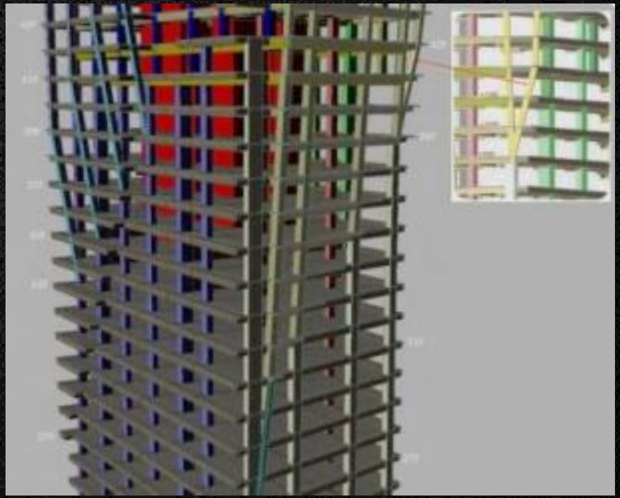


Vertical Irregularities

Asymmetrical Framing System of the Crown

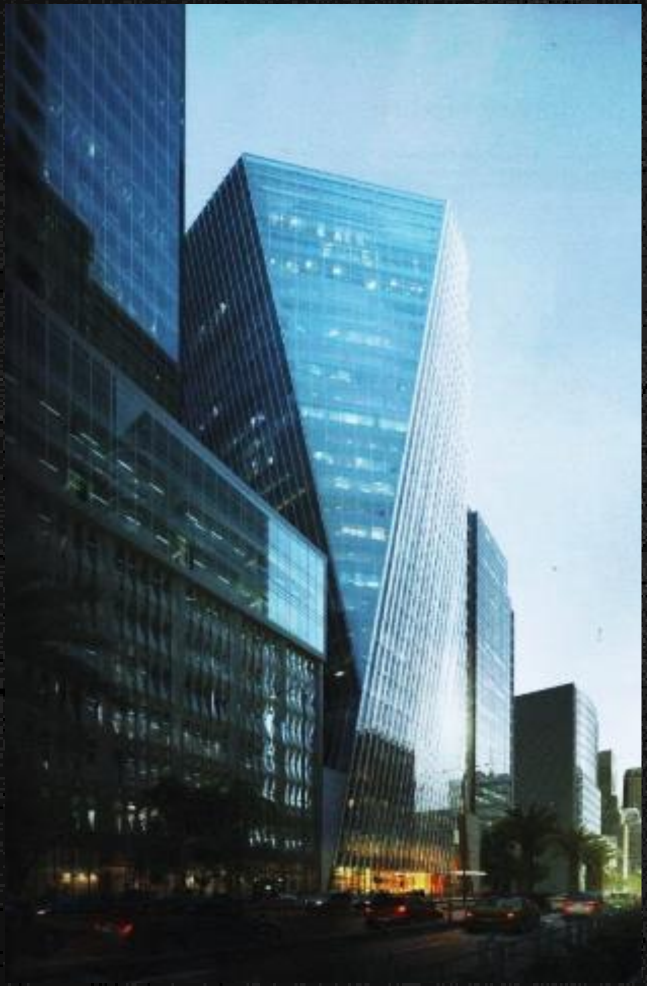
Vertical Irregularities

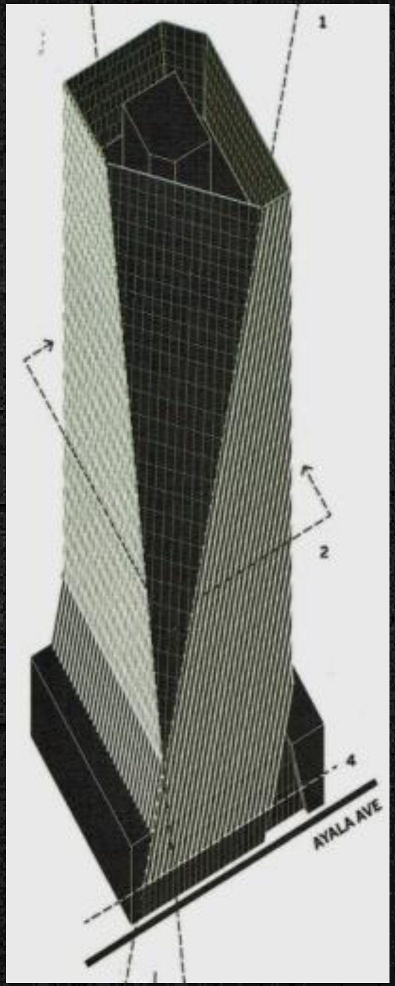
Mushrooming Column Diagonally Outward at Different Levels

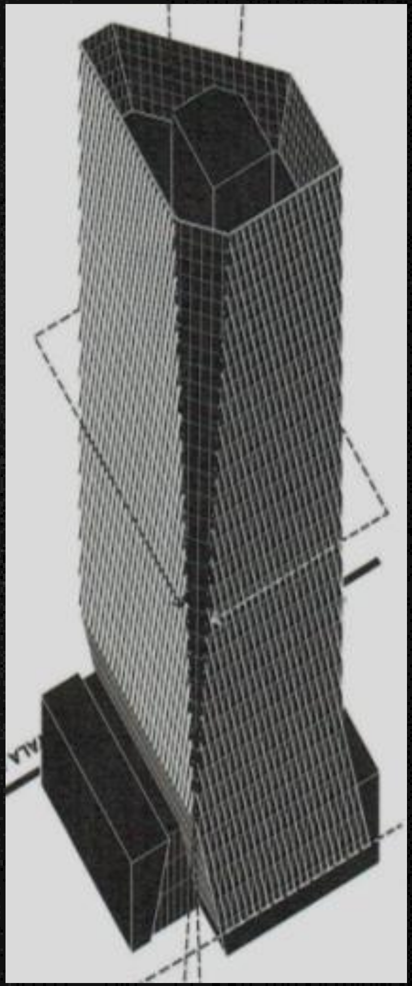


2000 Onwards

Nova Manila

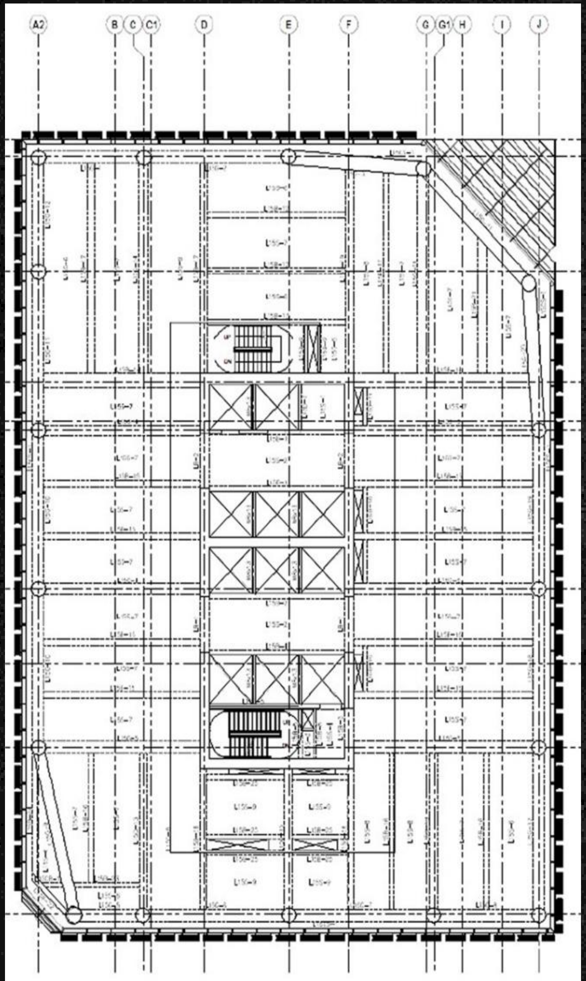


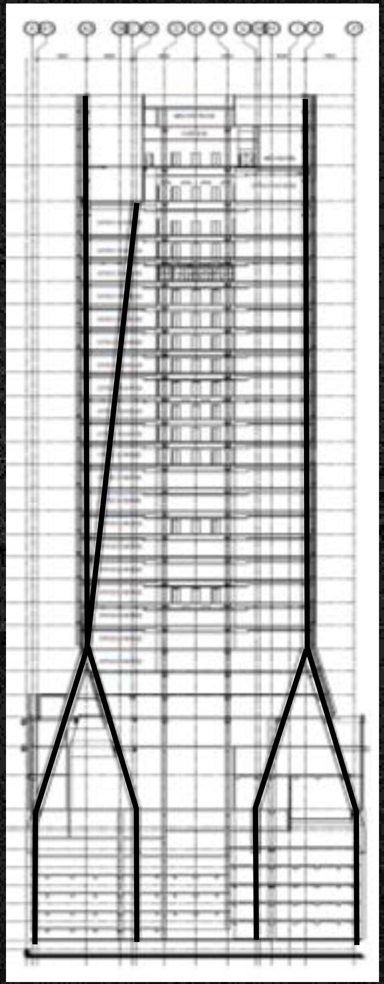




2000 Onwards

Nova Manila





2000 Onwards

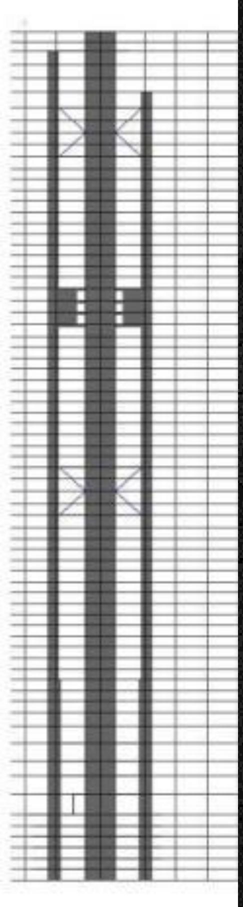
Started the application of energy-dissipating devices such as BRBs

Park Terraces

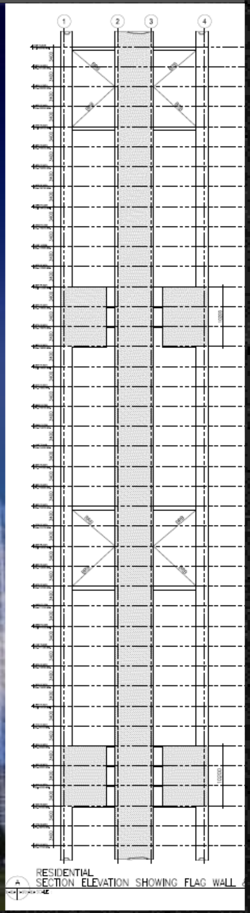
First Application of Buckling-Restrained Brace (BRB) in the

2000 Onwards

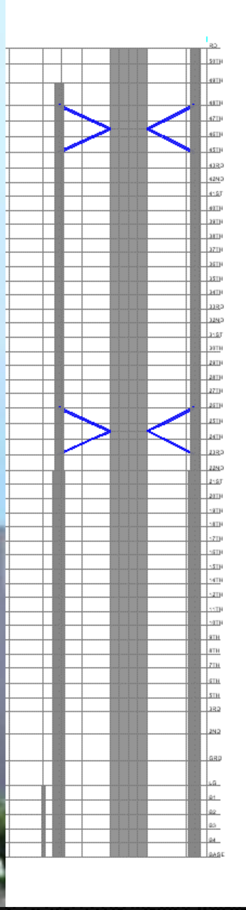
The Suites



Sonata Premier



East Gallery Place

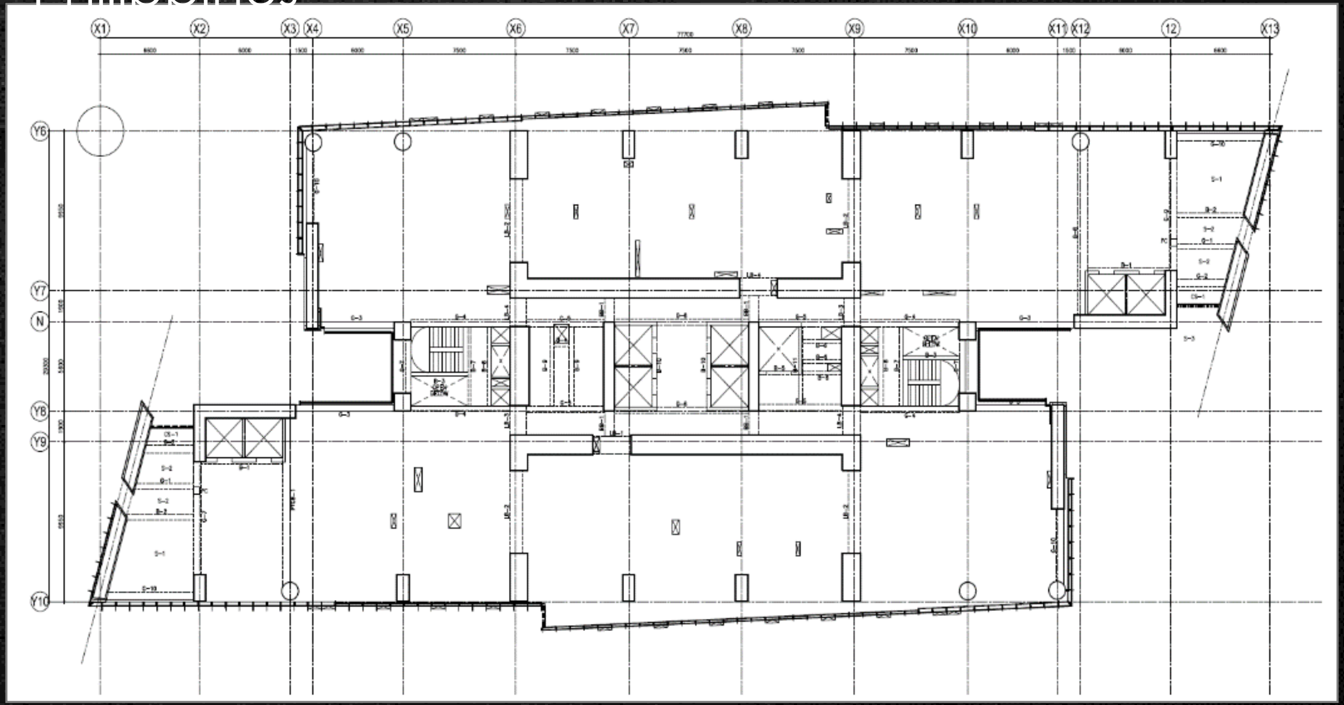


2000 Onwards

... until Viscoelastic Coupling Damper (VCD) was introduced in 2016.

Park Central Towers (Emerald)

- Consists of Two High-Rise Residential Towers
- South Tower (70-story, 235m) & North Tower (58-story, 197m)
- First application of Viscoelastic (VE) dampers in the Philippines

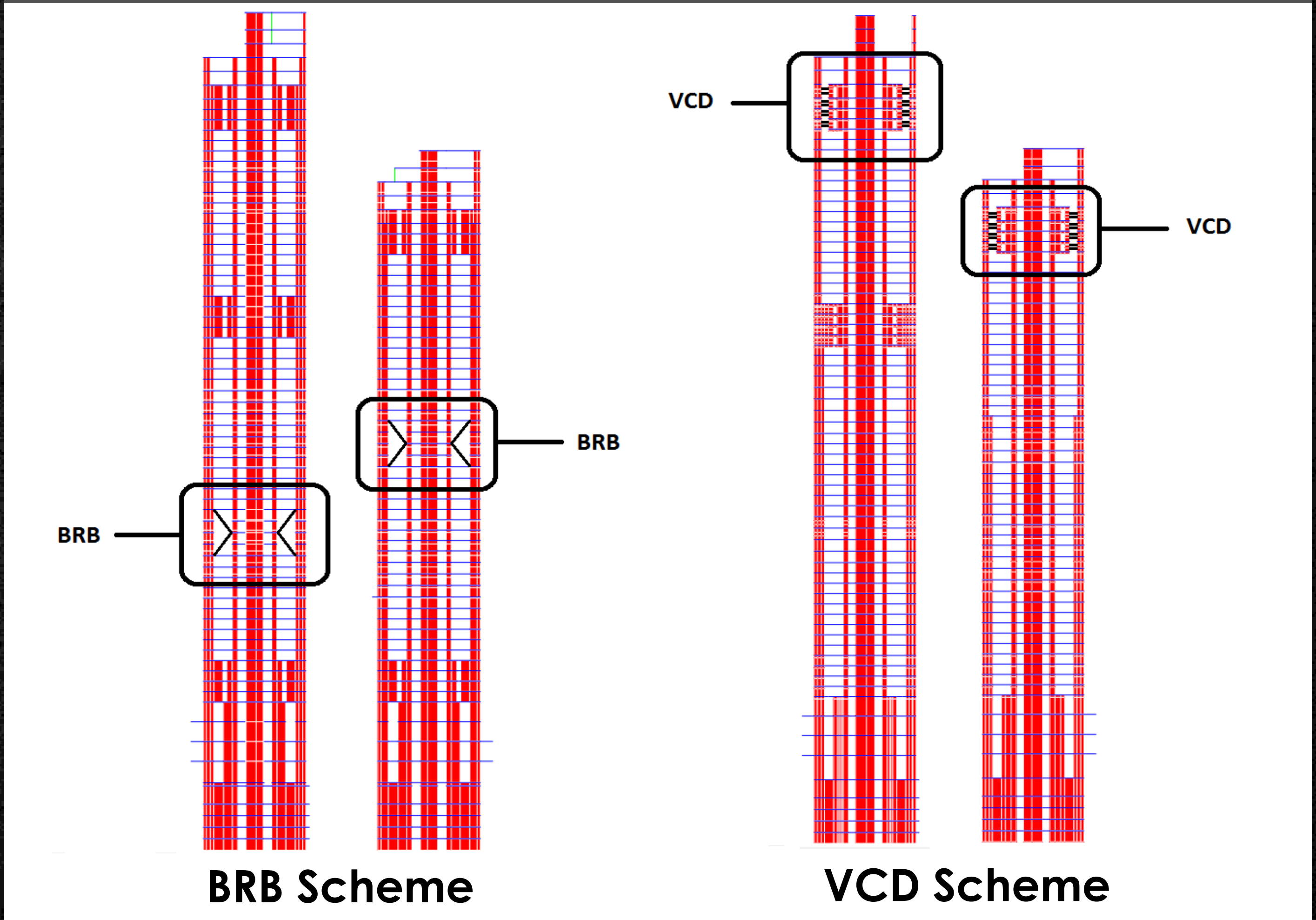


2000 Onwards

... until Viscoelastic Coupling Damper (VCD) was introduced in 2016.

Park Central Towers (Emerald)

First application of viscoelastic (VE) damper in the



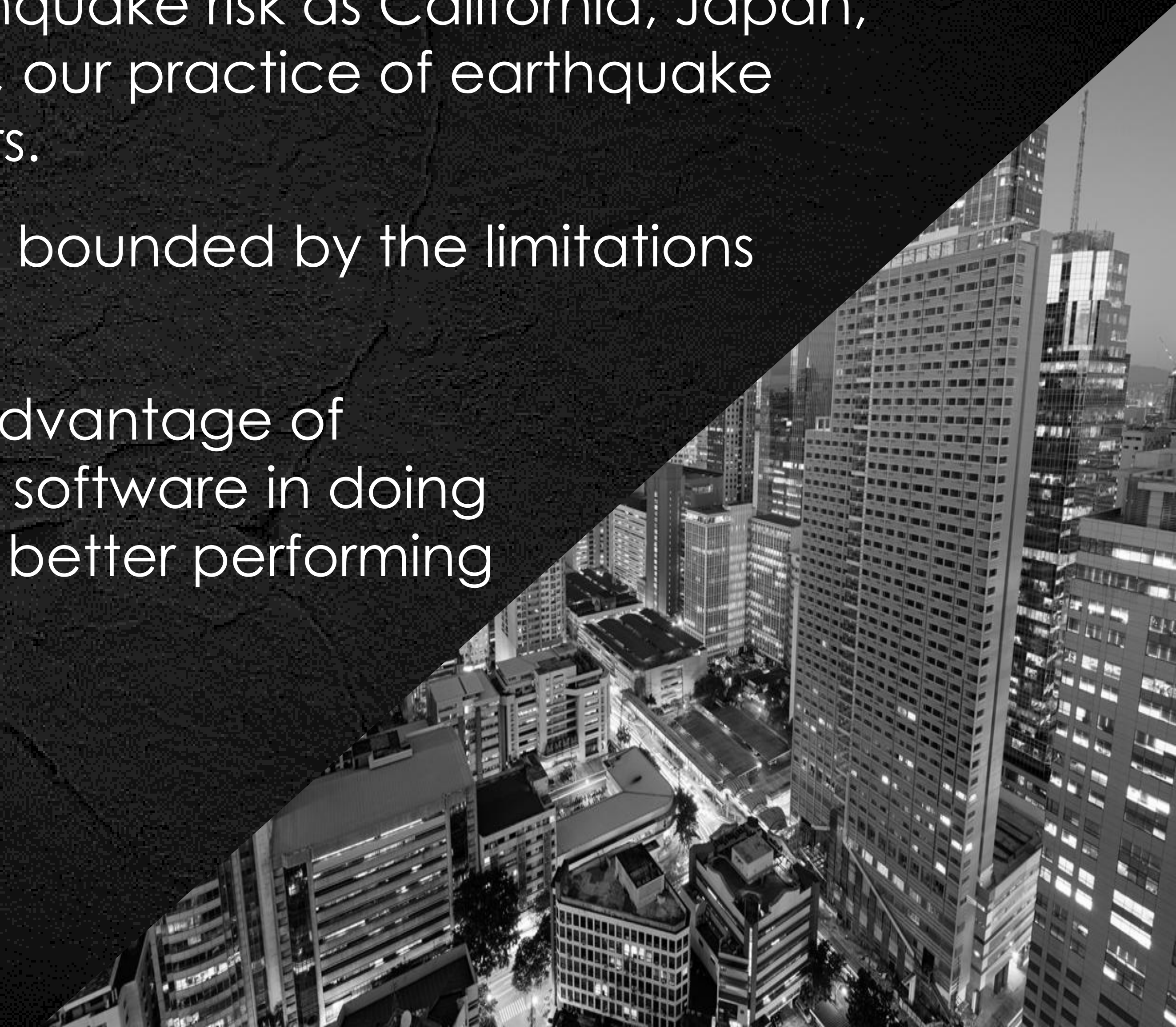
2000 Onwards

... until Viscoelastic Coupling Damper (VCD) was introduced in 2016.

Park Central Towers (Emerald)

Look Ahead

- The Philippines has the same earthquake risk as California, Japan, New Zealand, Haiti, etc. However, our practice of earthquake engineering is not at par with theirs.
- We believe that we should not be bounded by the limitations of the codes.
- We believe that we should take advantage of available powerful hardware and software in doing alternative approaches to ensure better performing buildings against earthquakes.
- Code compliance is not enough.
- Innovative approach is a must.



Challenges Inspire Innovations.

THANK **YOU**

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