CONCRETE ASIA 2017

Development of New Building Systems in Concrete

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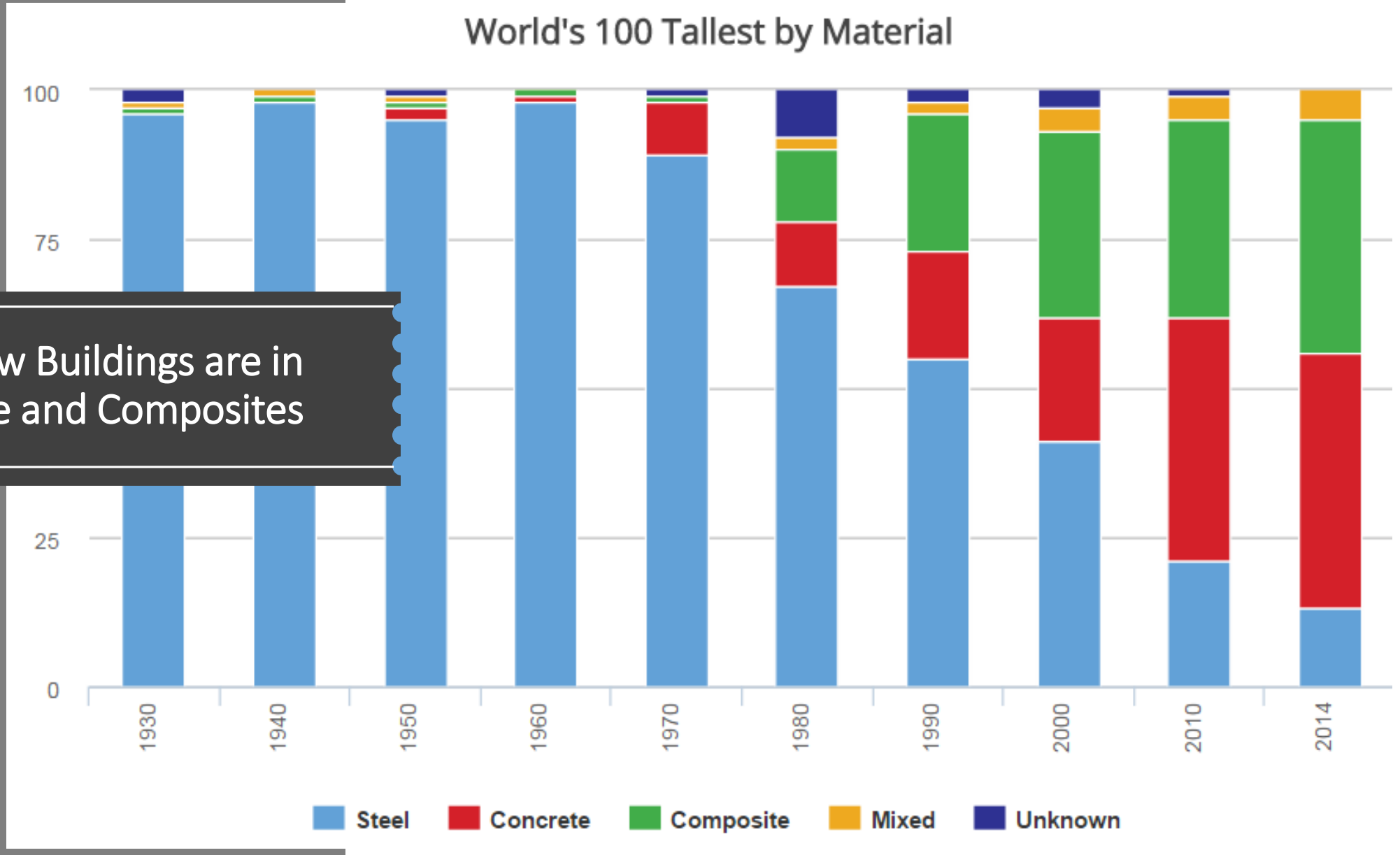
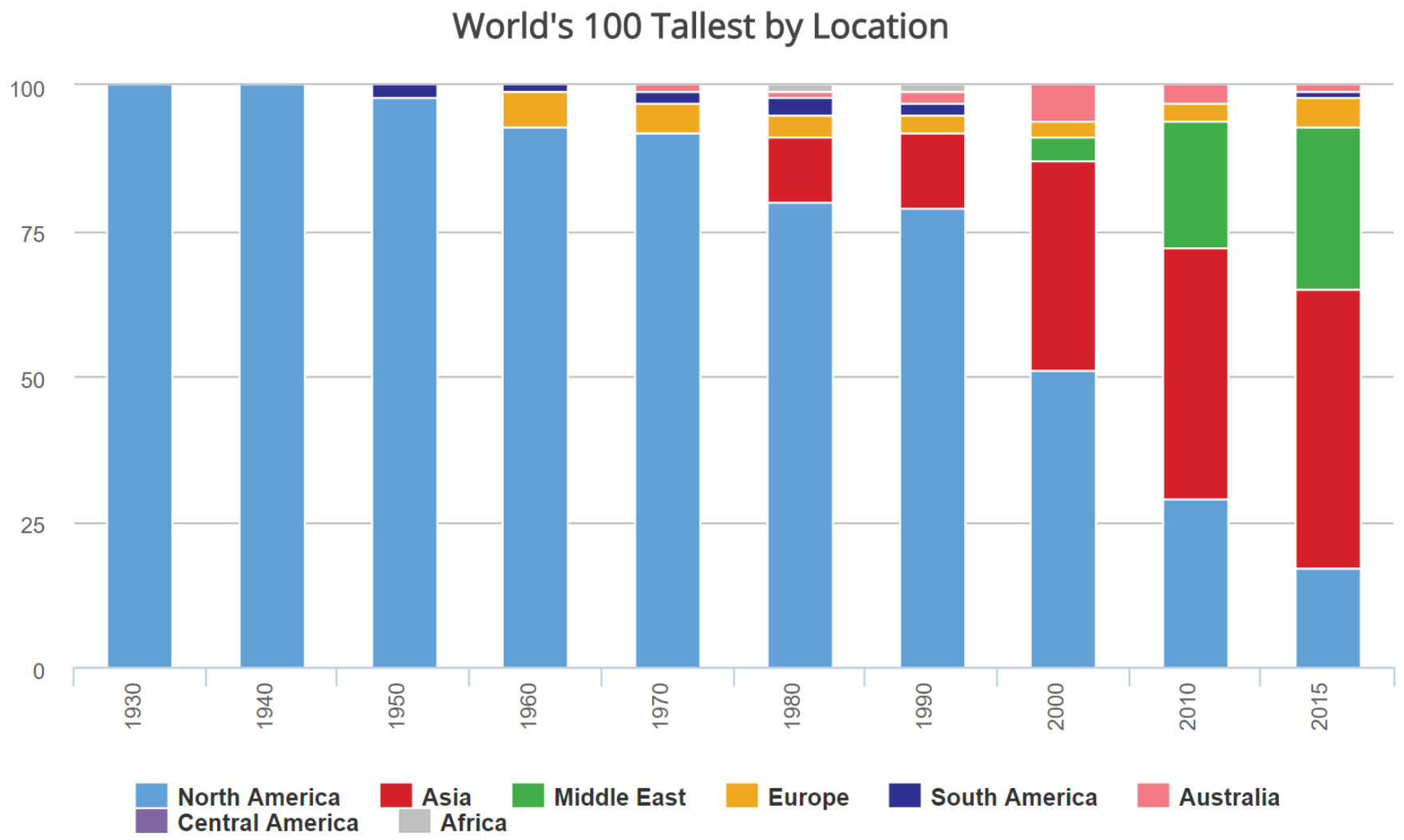
AIT Solutions
Technology • Engineering • Environment • Development • Management

Needs and Opportunities for New Building Systems

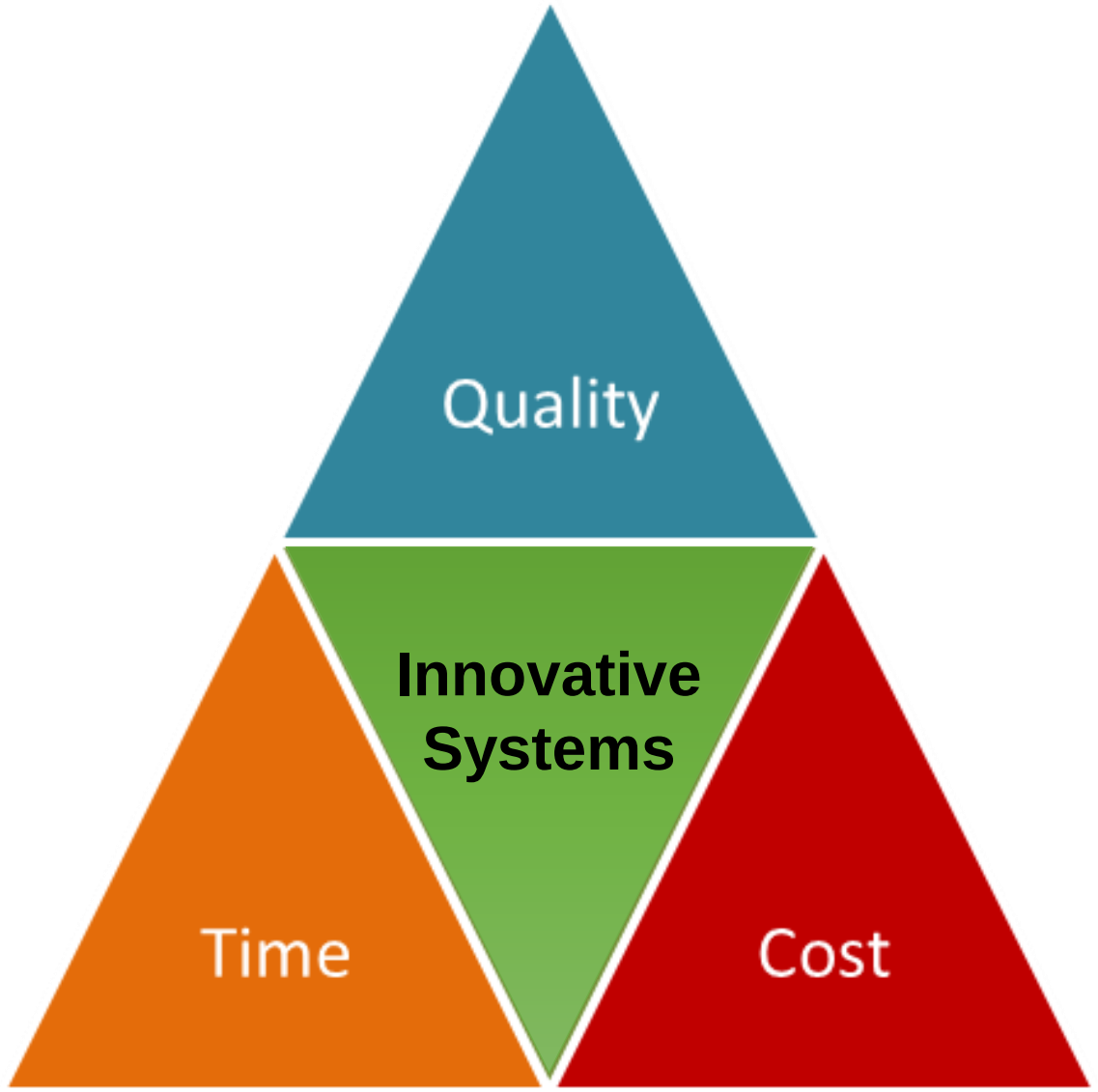
Most new Buildings are in Concrete and Composites



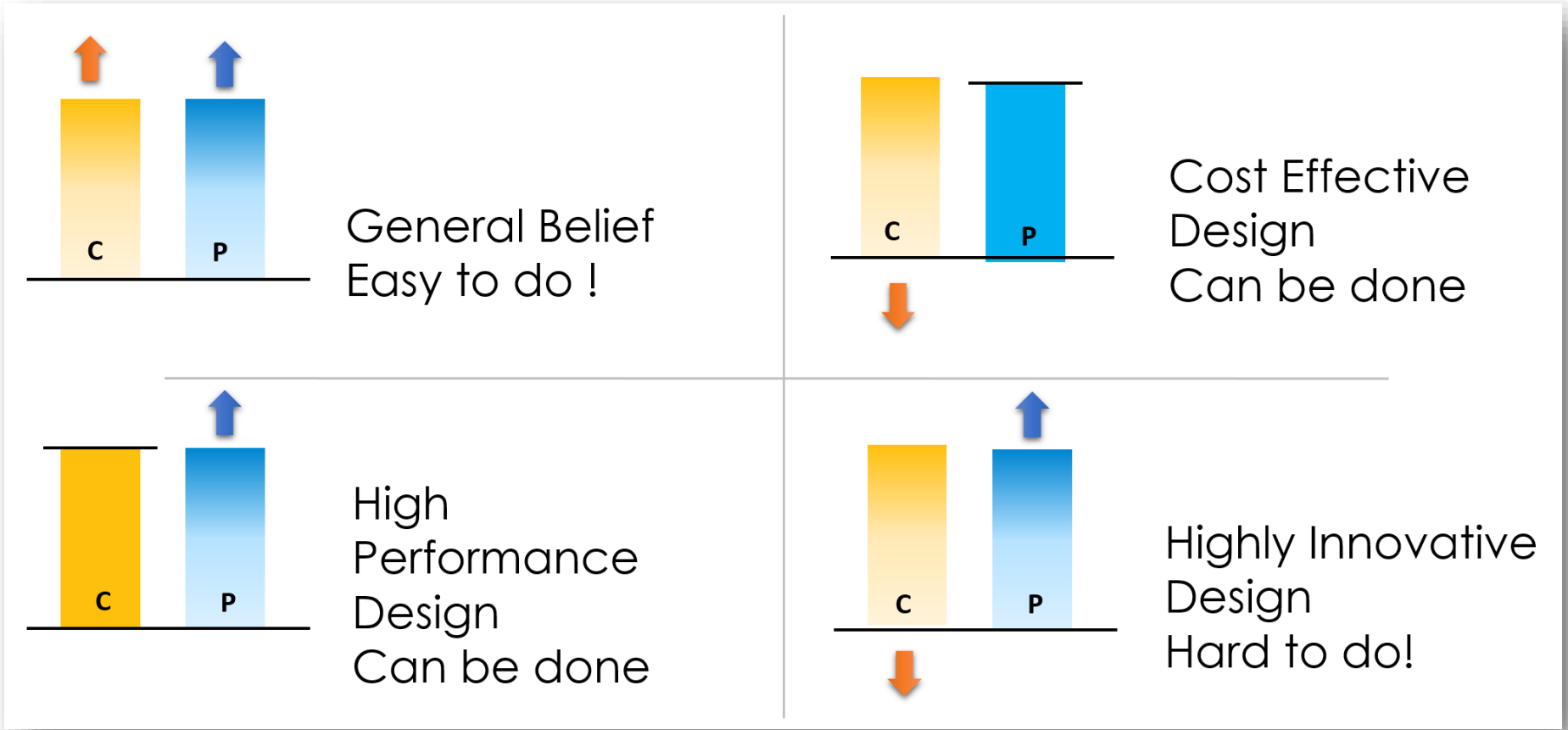
Most Tall Buildings in Asian Region



Innovative systems needed to balance the Triangle



Complexity is Increasing – Needing Innovations



- Bigger, taller, complex forms, **but** Lighter, smaller, thinner structural elements
- High performance, **but** Lower cost

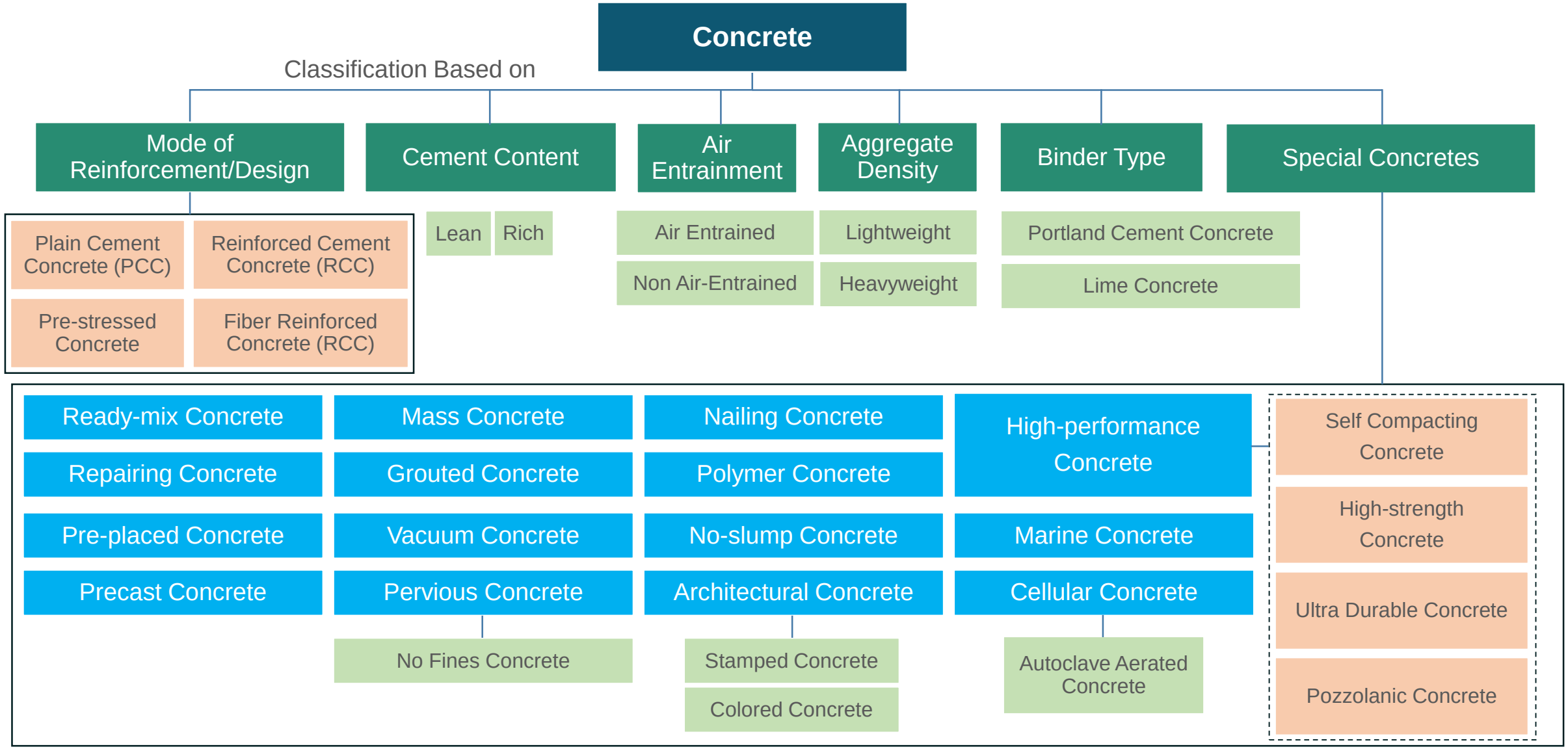
Higher Expectations from Public

- Smart Phone
- Smart Car
- Smart TV
- Smart Devices

Why not?

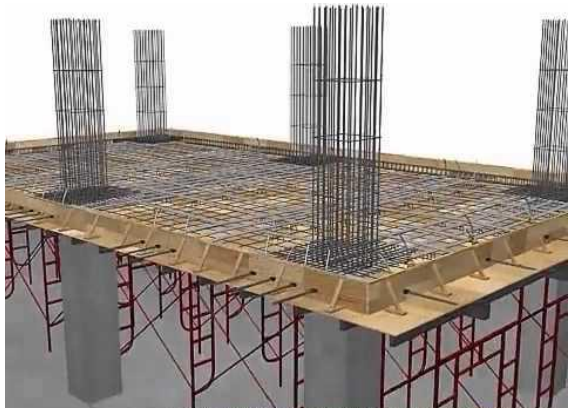
- Smart Homes
- Smart/ Resilient Buildings
- Smart/Resilient Infrastructure
- Smart/Resilient Cities

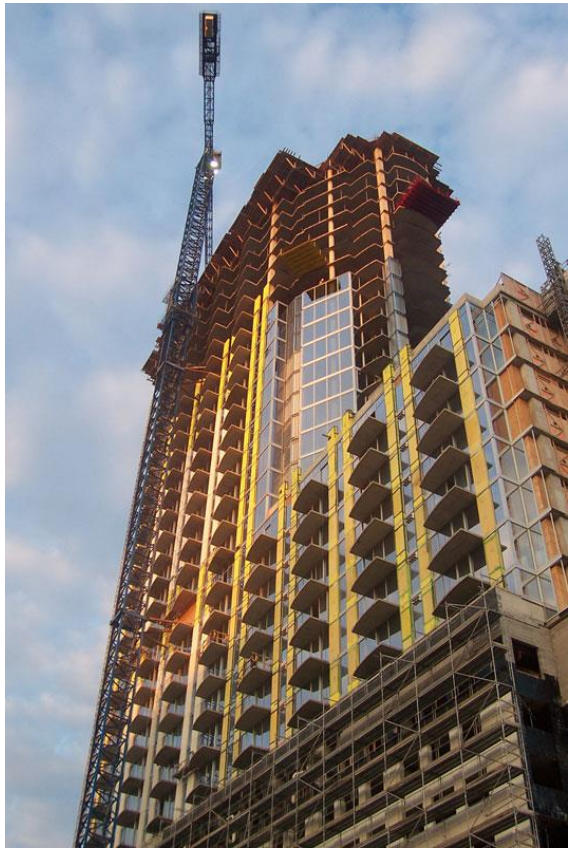
Concrete offers many areas for innovation



Post tensioning in Buildings has great potential

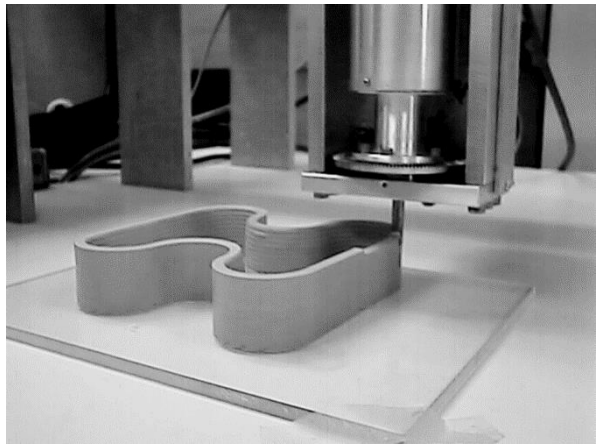
- Less weight
- Less steel
- Lower building height or higher building volume
- Lower construction cost
- Lower carbon footprint
- Lower embodied energy, waste and pollution
- Can be used in a variety of applications





A 173 m high PT building in Texas
- 44 levels of post-tensioning
- Over 0.33 million meters of strand
- 29,453 anchors installed

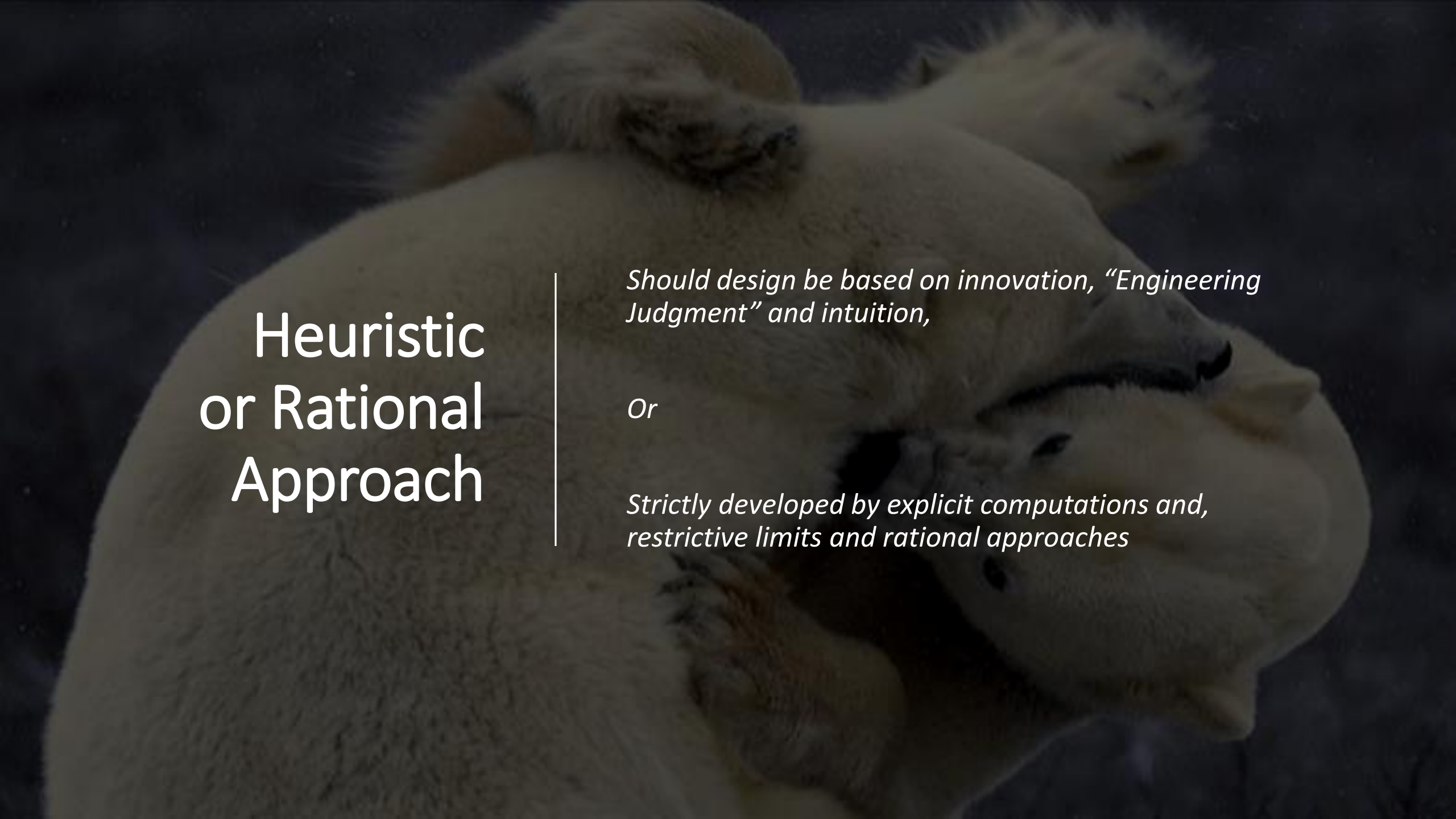
https://www.vsl.net/
http://www.klineengineered.com



Possibility of 3D Printed Concrete – Freedom of Form

3D Printed Structure at UC Berkeley

How to Develop New Systems?

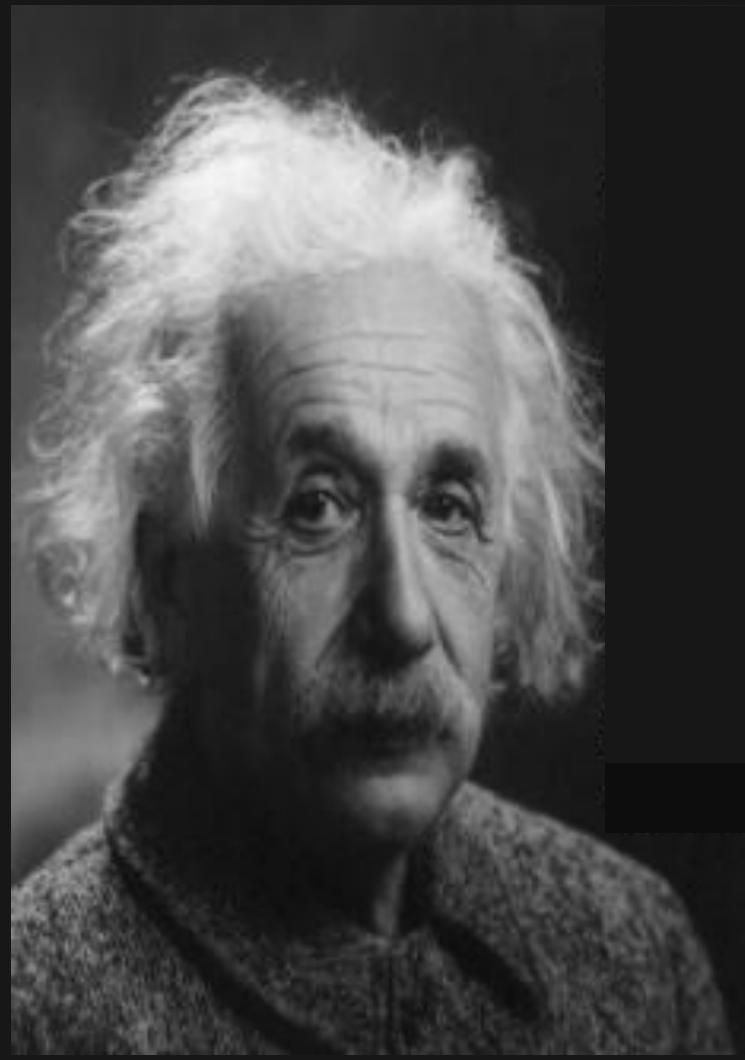


Heuristic or Rational Approach

Should design be based on innovation, "Engineering Judgment" and intuition,

Or

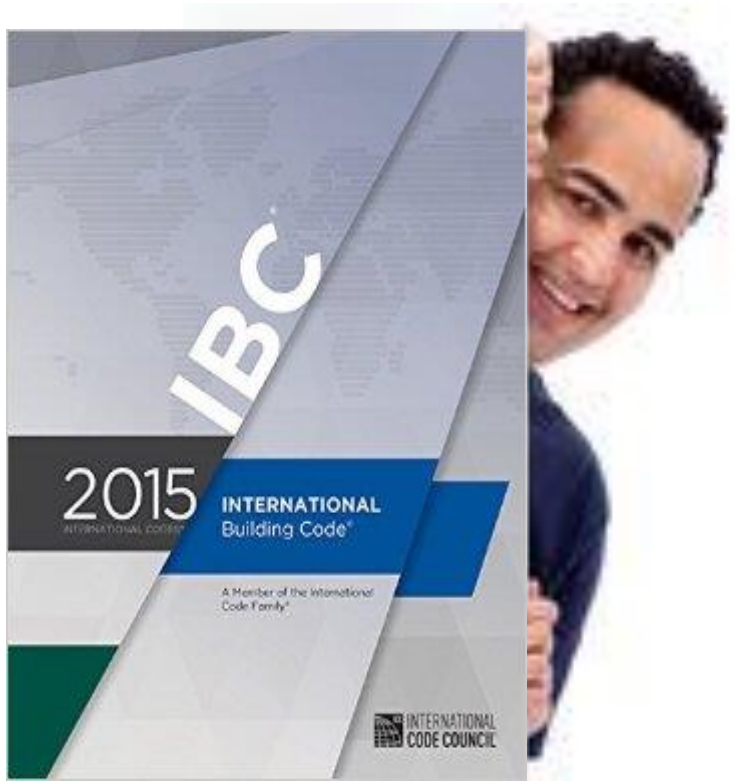
Strictly developed by explicit computations and, restrictive limits and rational approaches



Prescriptive Codes – A Shelter and an Impediment

- Public:
  - *Is my structure safe ?*
- Structural Engineer:
  - *Not sure, but I did follow the "Code"*

As long as engineers follow the code, they can be sheltered by its provisions

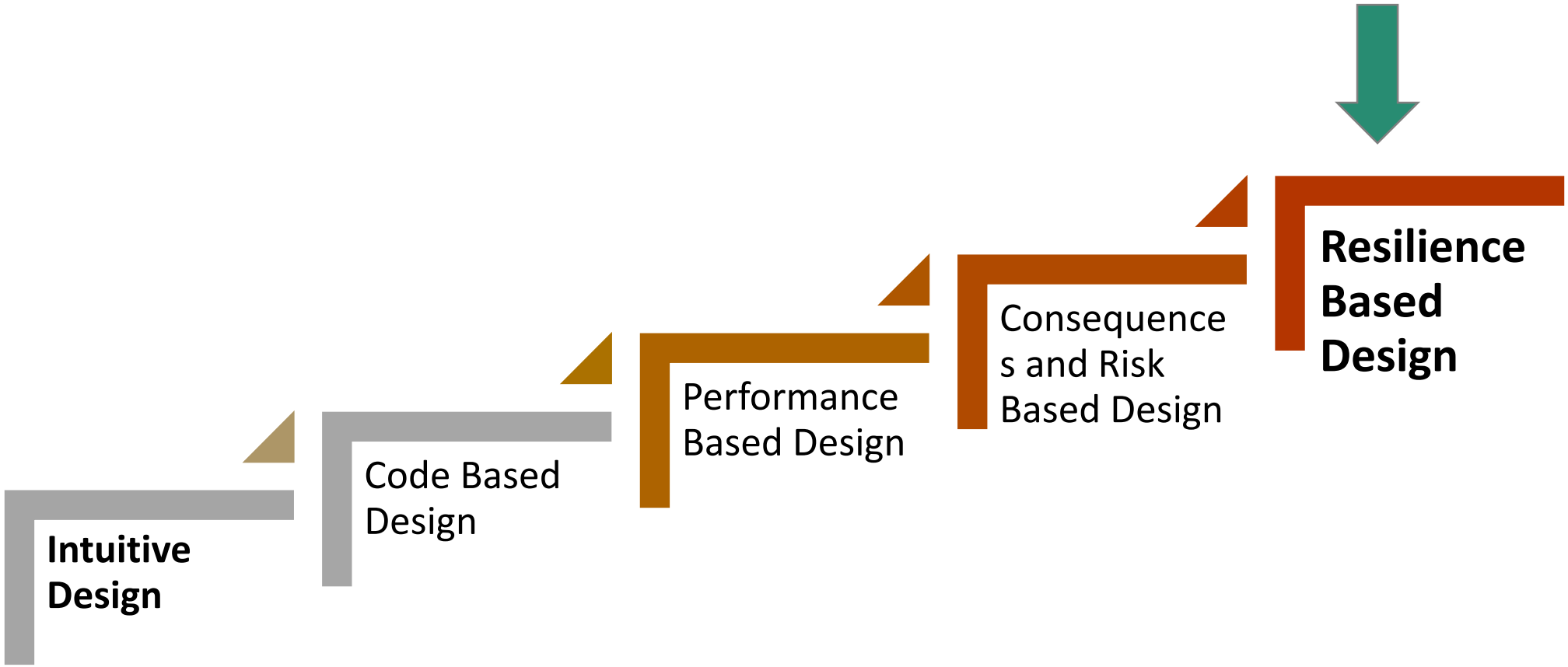


A Move Towards Performance-based Approach

- Prescriptive Codes restrict and discourage innovation

- Performance Based approach encourages and liberates it

Use of New Design Approaches



The P2P Initiative

- P2P > for Prescription-to-Performance
- Initiative of the ready mixed industry through the NRMCA
- Coordinated by P2P Steering Committee under the NRMCA Research, Engineering and Standards Committee
- Members include technical representatives, product suppliers, contractors, engineers, and architects

NRMCA™
NATIONAL READY MIXED CONCRETE ASSOCIATION

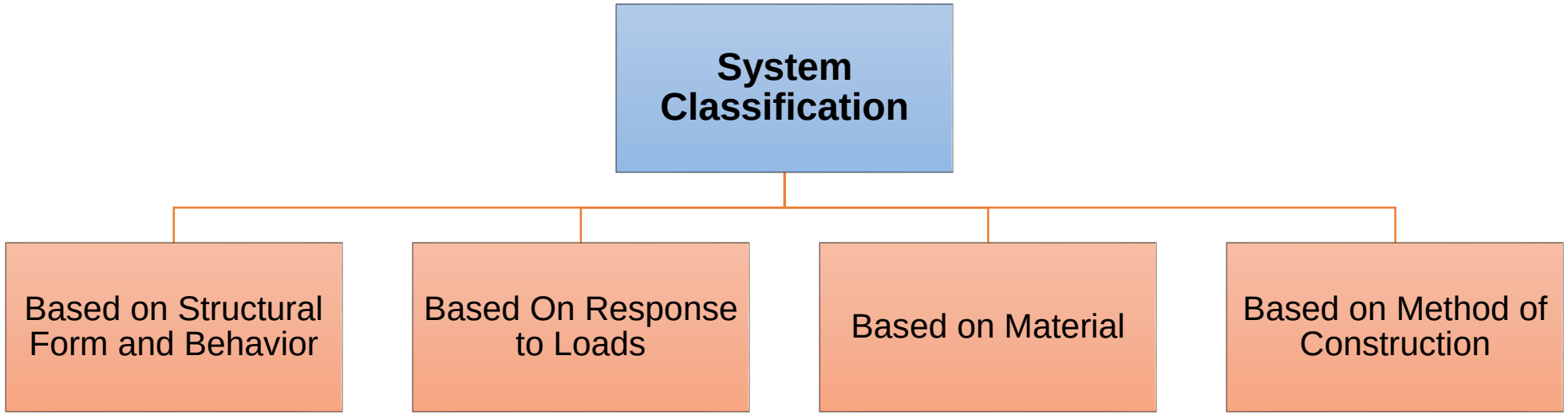
P2P INITIATIVE

Source: www.nrmca.org/P2P

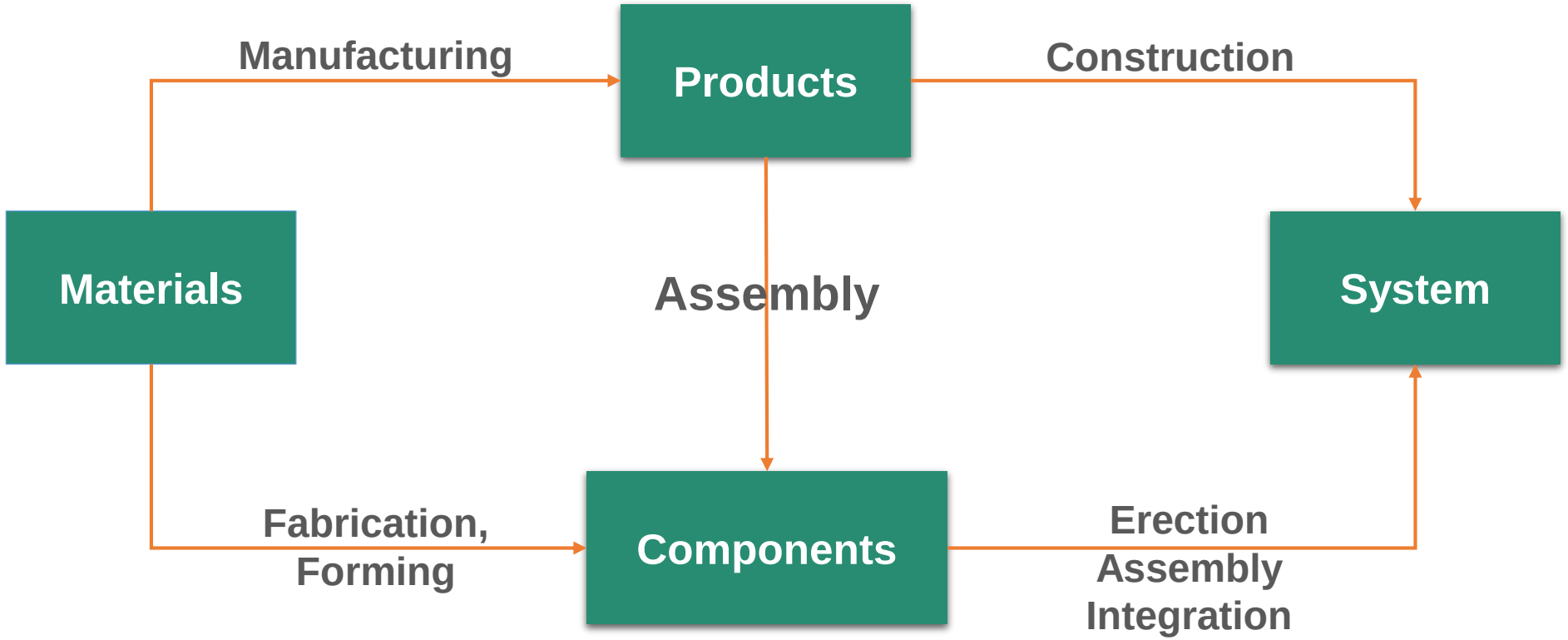
Prescriptive vs. Performance

Approach	Procedure	Outcome
Prescriptive (emphasis on procedures)	Specify “what, and how to do” Make Concrete: 1:2:4	Implicit Expectation (a strength of 21 MPA is expected)
Performance Based Approach (emphasis on Key Performance Indicators)	What ever it takes (within certain bounds)	Explicit Performance Concrete less than 21 MPA is rejected

Using a Systems Approach



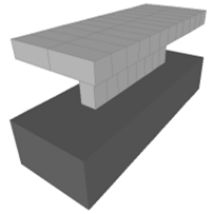
Building/Structural System



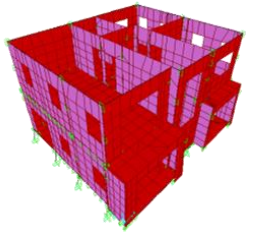
A Rational Approach for Developing New Systems

Experimental Study of Bearing wall Panel and Wall Connections.

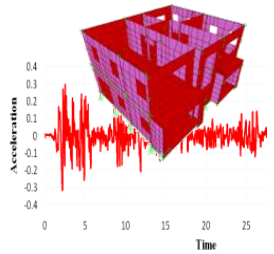
Calibration of Wall Connection for Finite Element Analysis



Full 3D Finite Element Modeling of Typical House

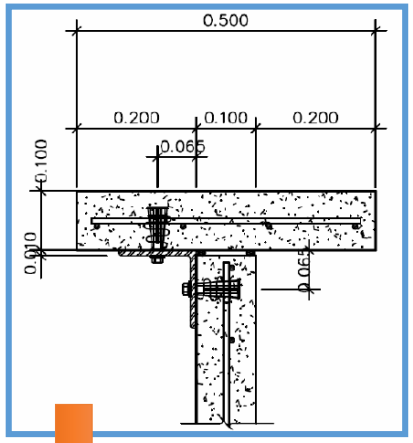


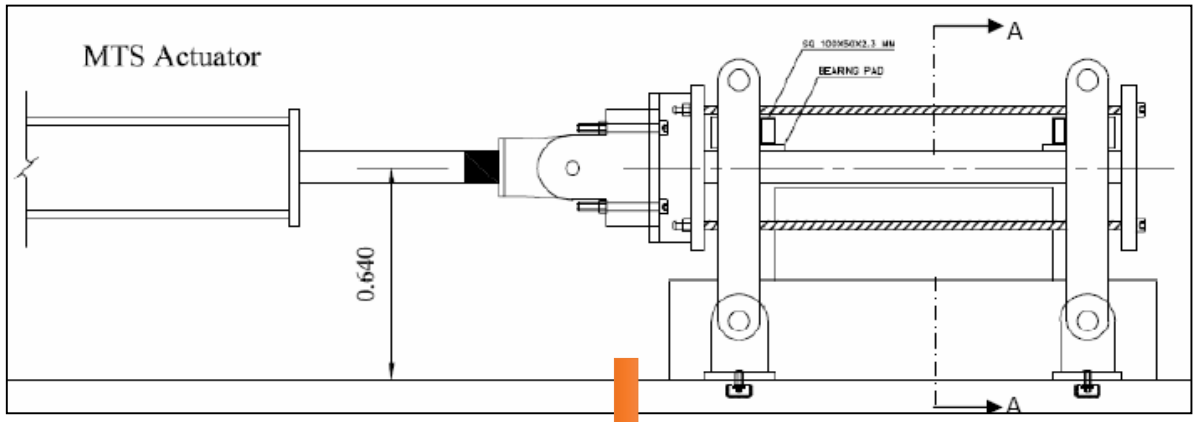
Evaluate the Performance Acceptance



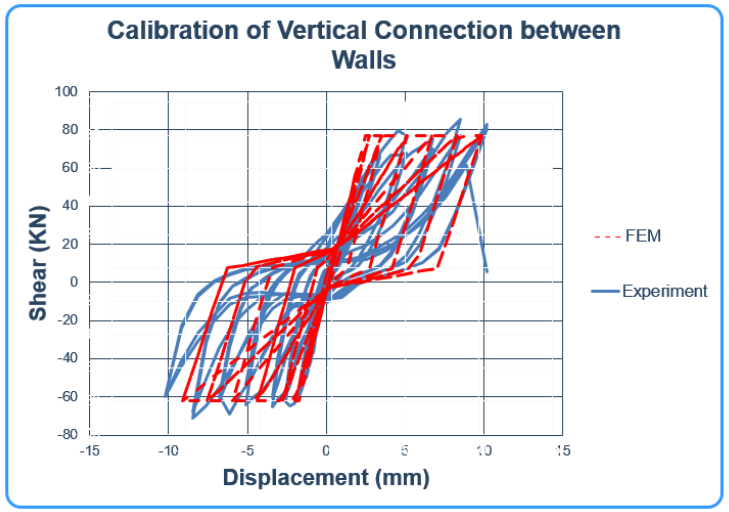
Calibration Process

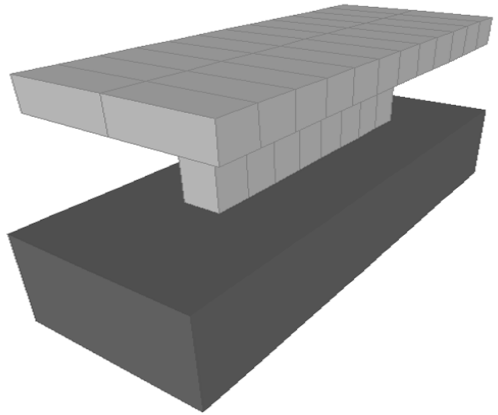
Connection to test



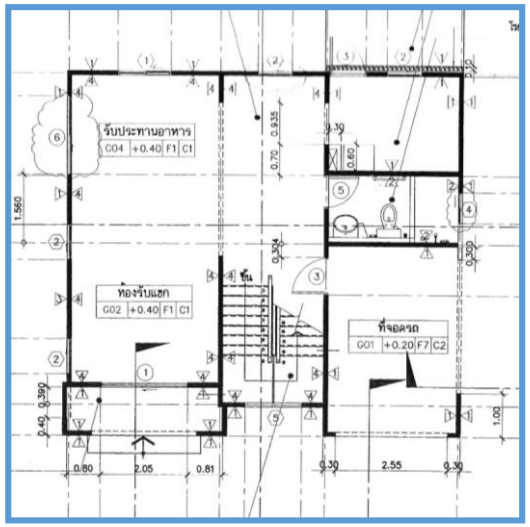


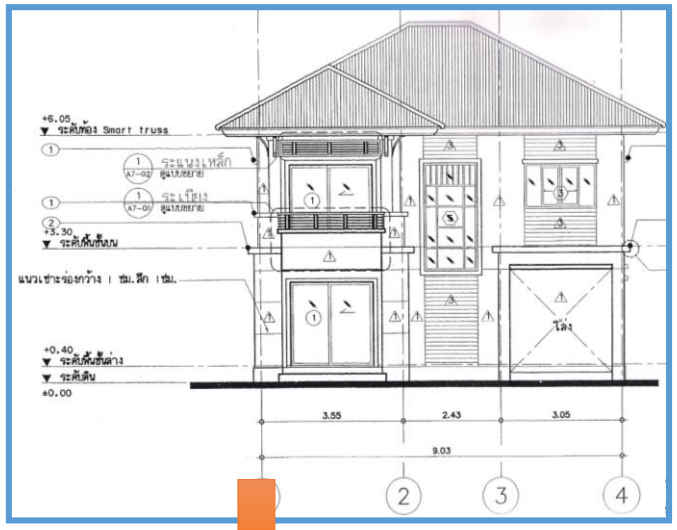
Test Model

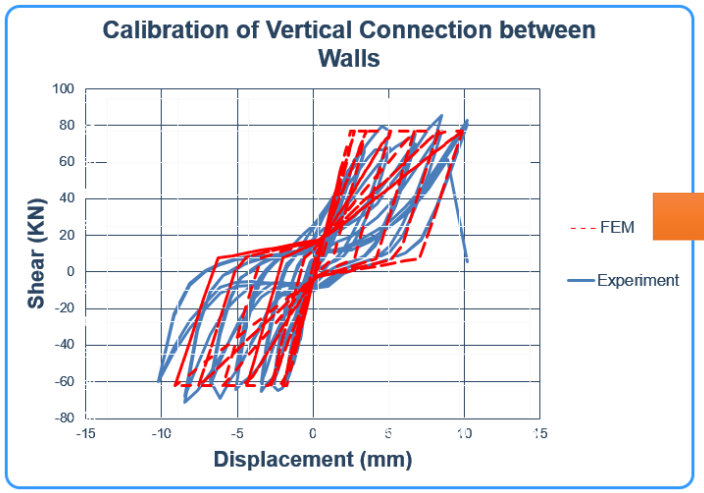


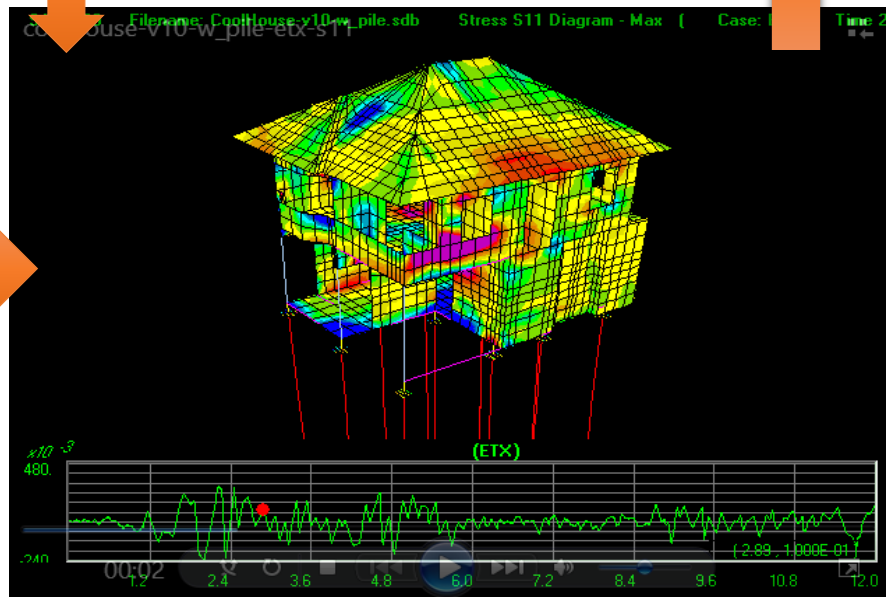


FE Model

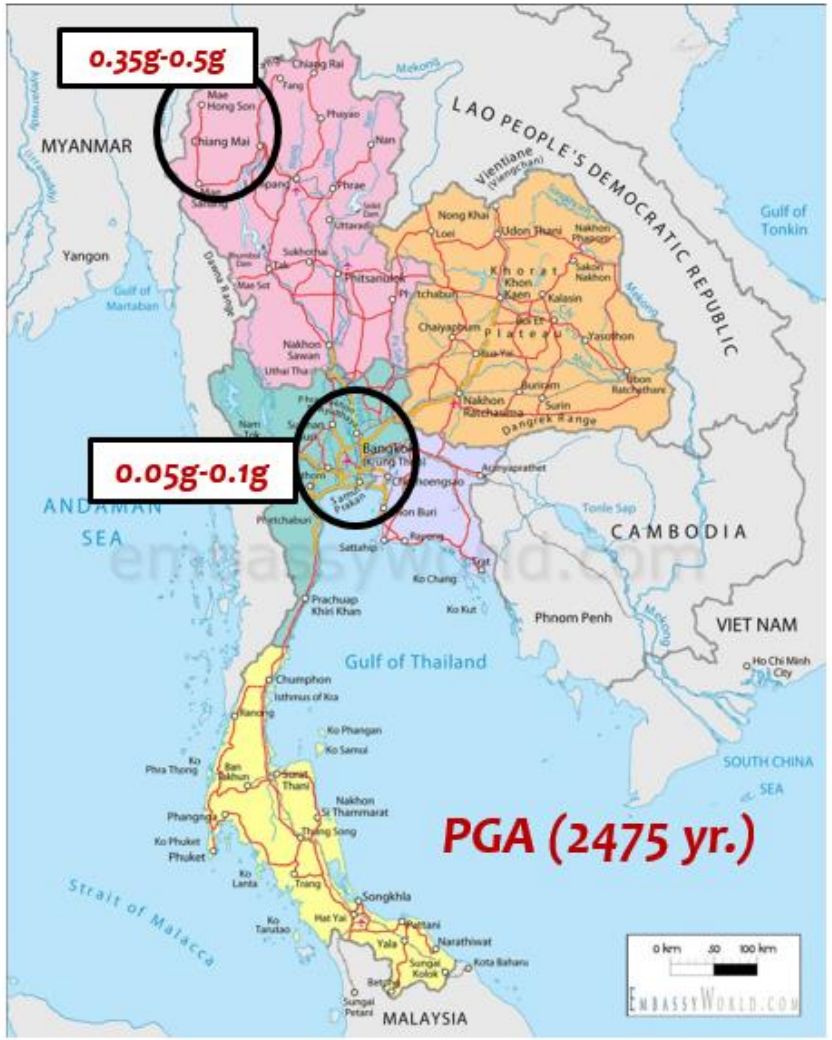

รับประทานอาหาร
ห้องรับแขก
ที่จอดรถ

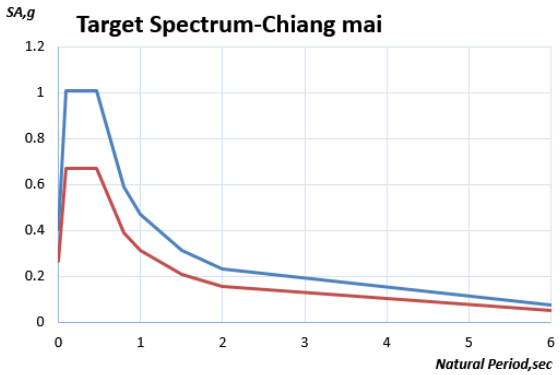

3.55
2.43
3.05
9.03

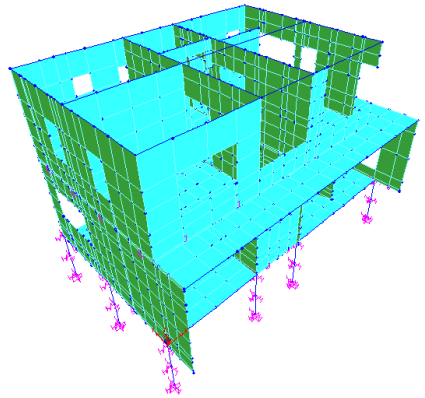

Calibration of Vertical Connection between Walls
Shear (KN)
Displacement (mm)
FEM
Experiment

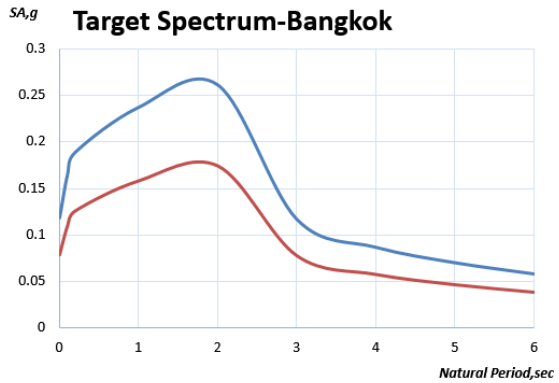

Stress S11 Diagram - Max
(ETX)

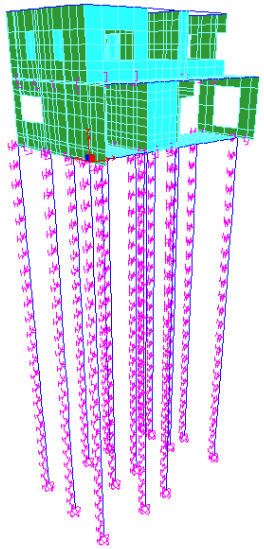
Localization Effects







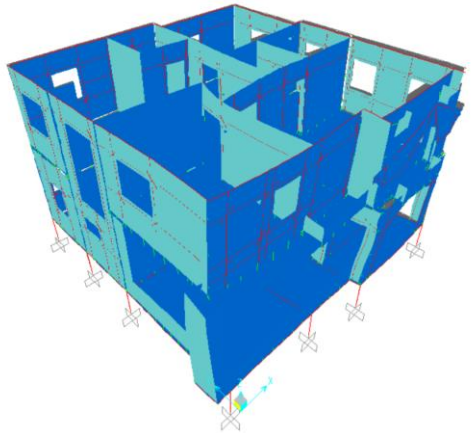


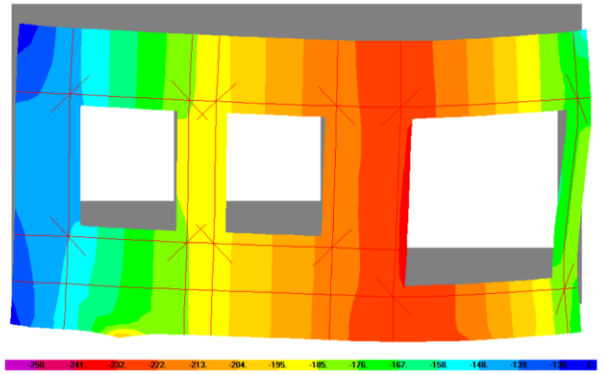


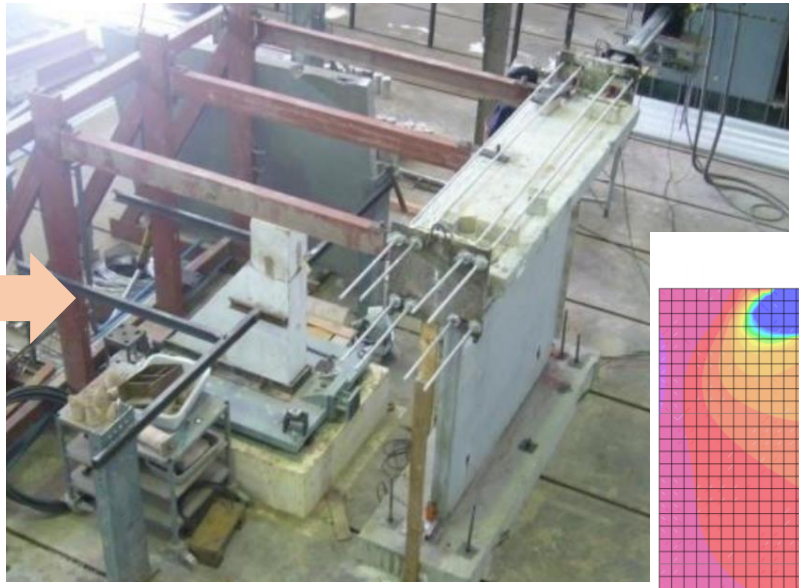
Response Spectrum

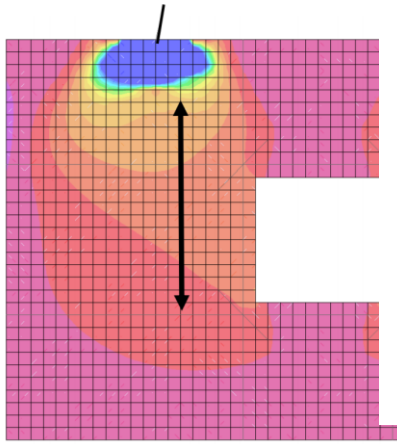
Foundations

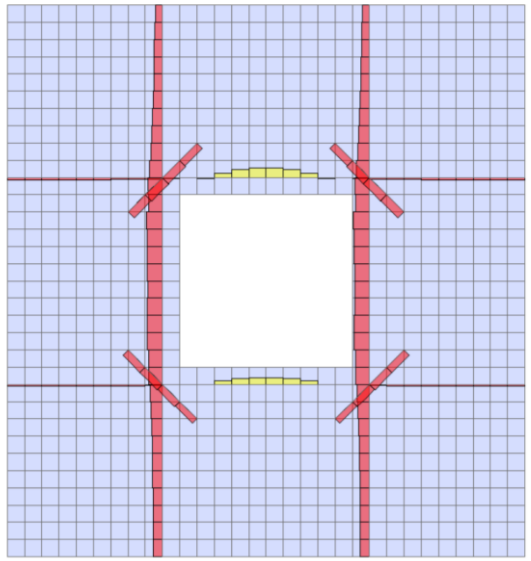
R&D for Systematic Determination of Shortcoming











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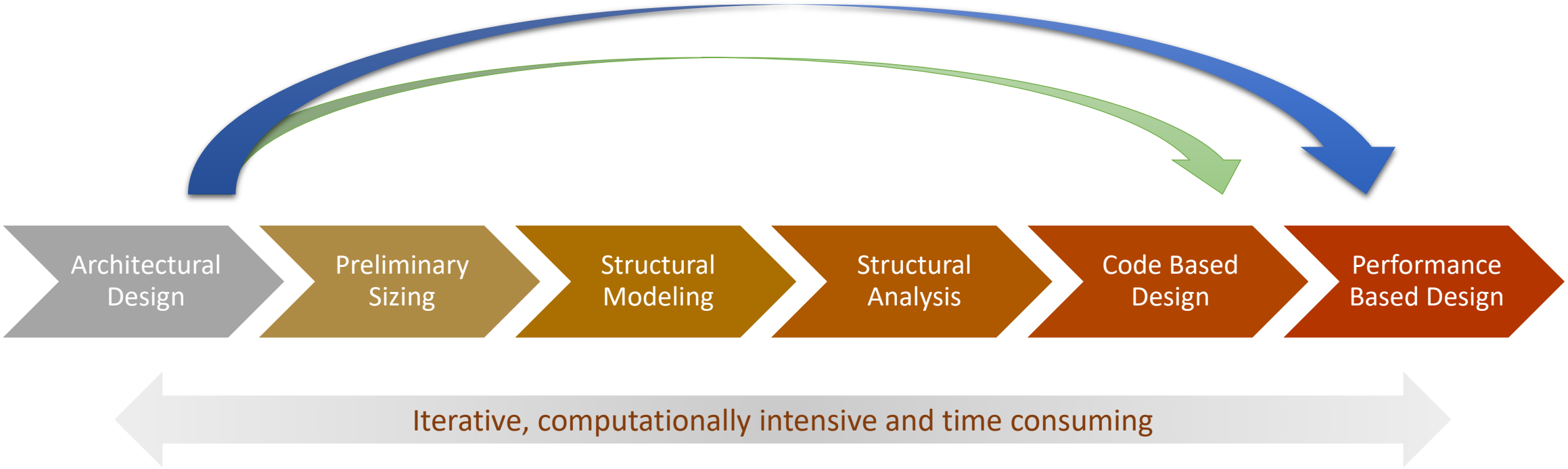
Using Artificial Intelligence

- Rich Pictures
- Analytical Hierarchy Process (AHP)

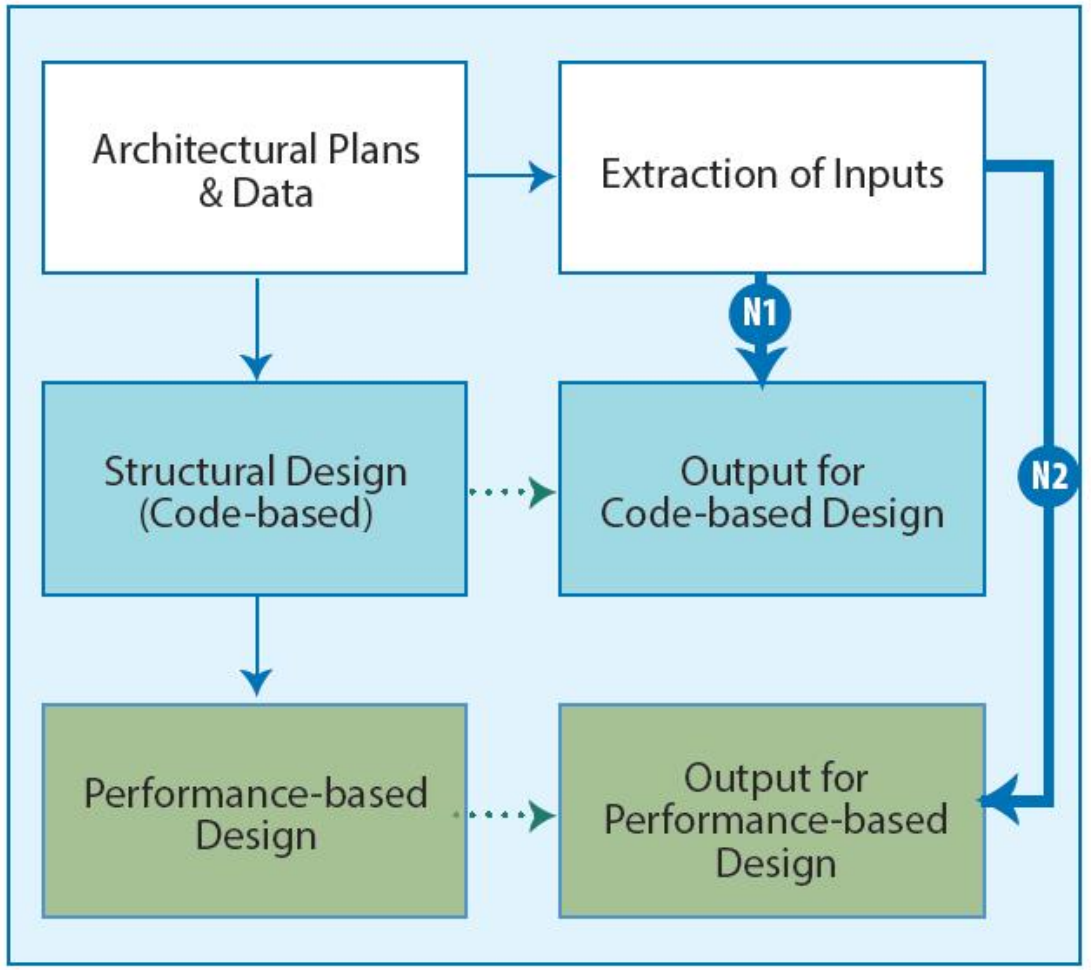
- Artificial Neural Networks (ANN)
- Genetic Algorithms (GA)
- Expert Systems (ES)

- Fuzzy Logic
- Deep Thinking
- Big Data and Data Mining

Using AI in Structural Design Process



Our Approach for Tall Buildings

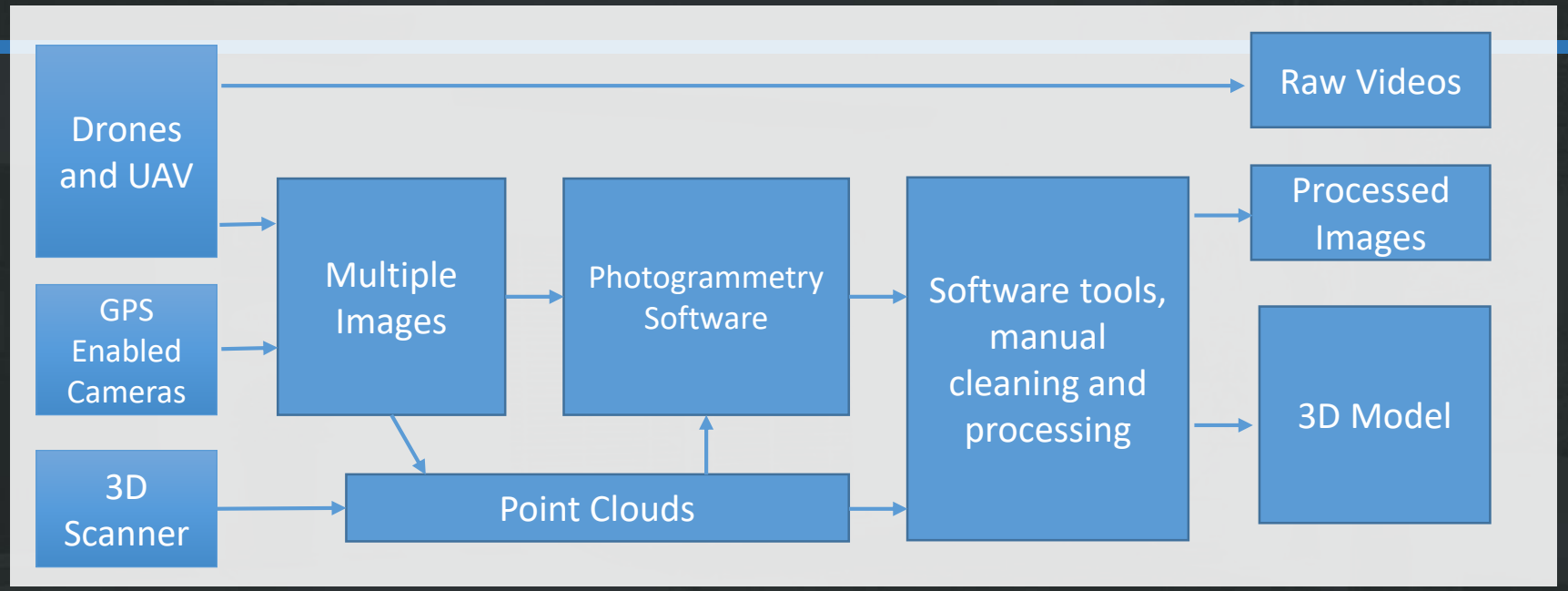


Using Mobile Computing and Apps for Learning and Design

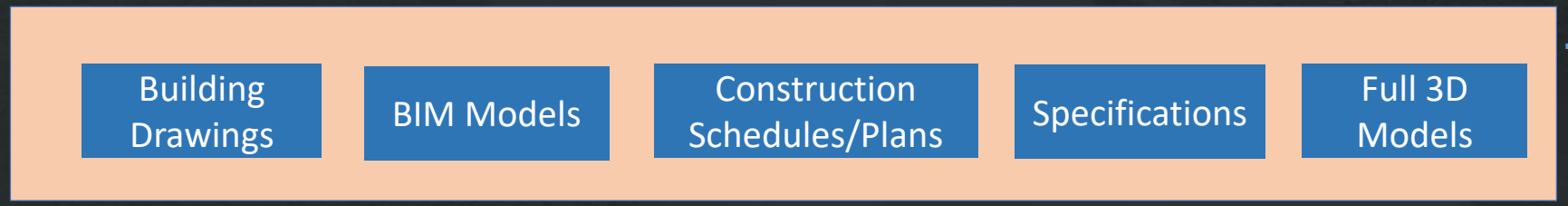
Mobile computing might change how we learn and design

Drone Based Construction Monitoring Solutions

Overall Concept



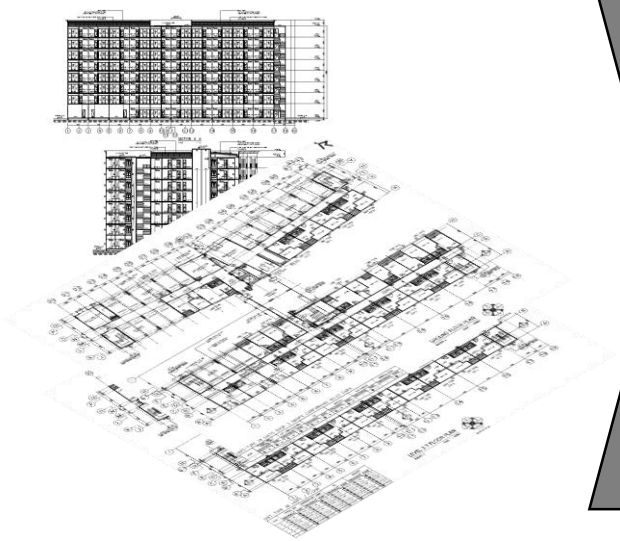
Compare



- **Construction Progress Monitoring**
- **Billing**
- **Verification**
- **Records**
- **Learning**

Case study

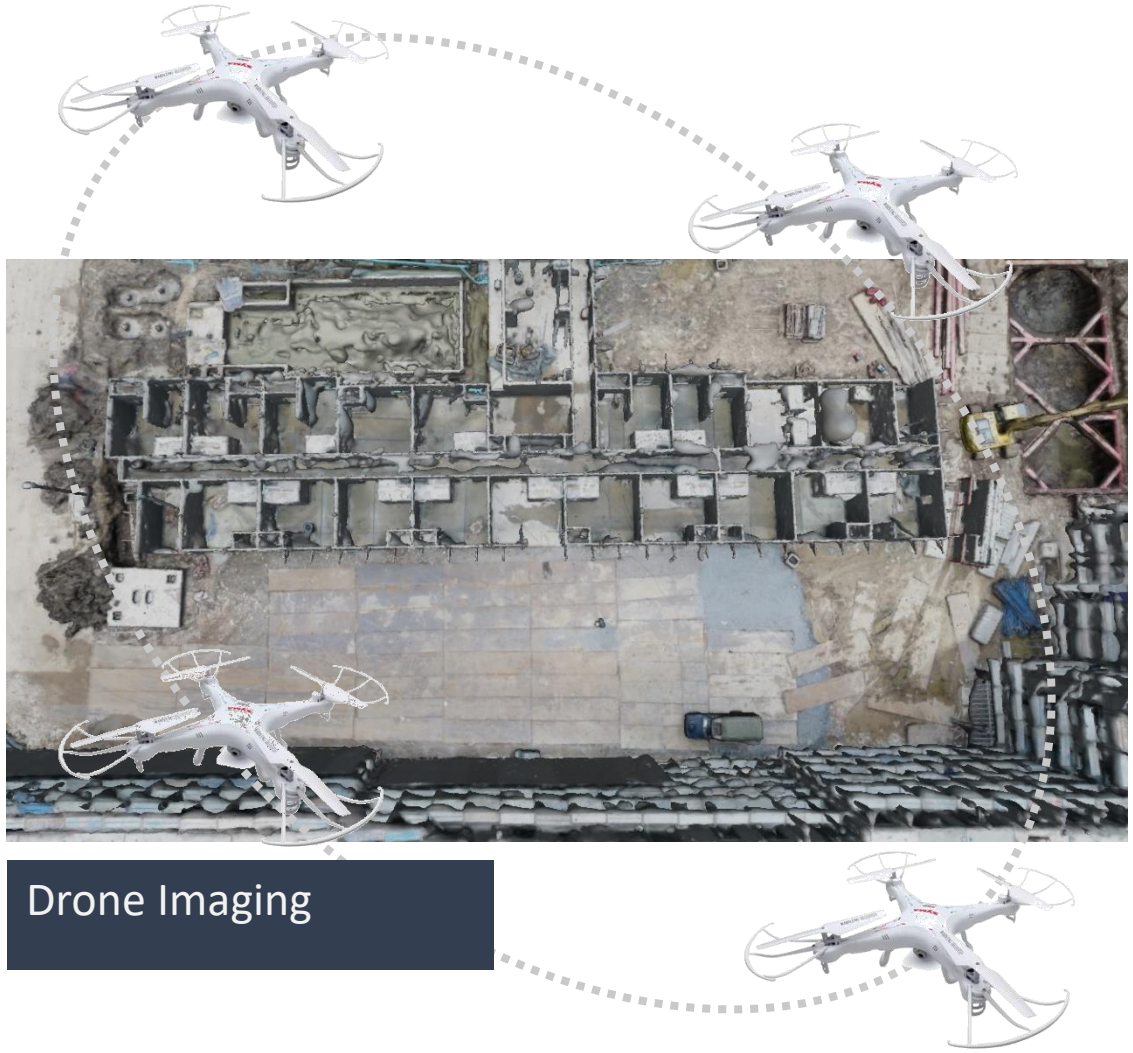
Conceptual and Detail Drawings



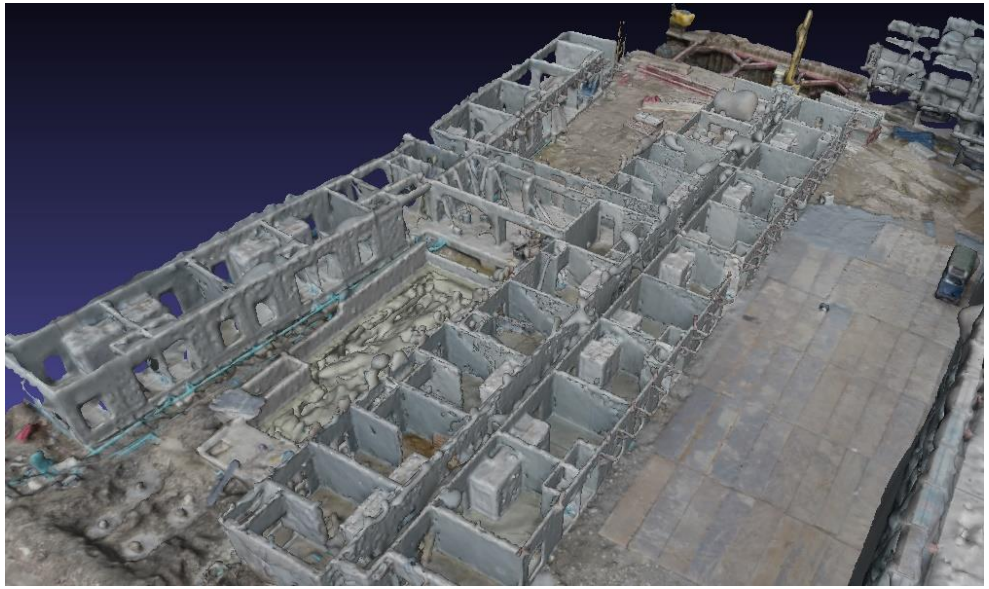
3D Model with all the detail (BIM)

Construction Modeling Trough Drone

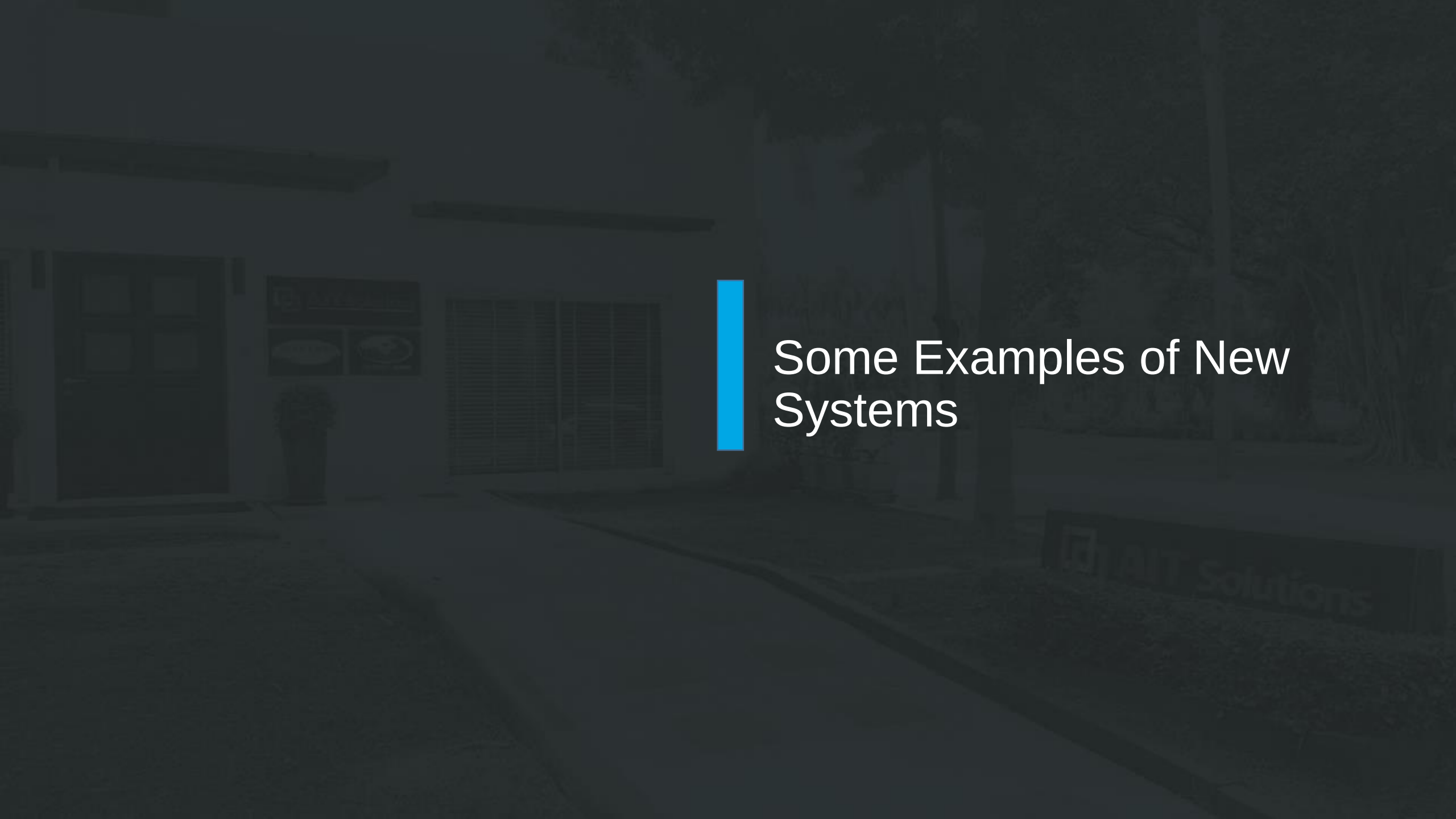
A Sample Project



Drone Imaging

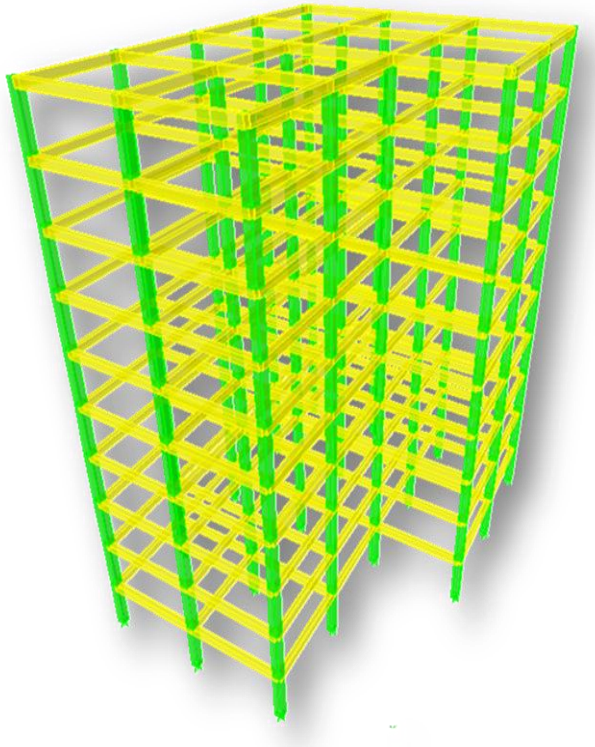


3D Model from drone

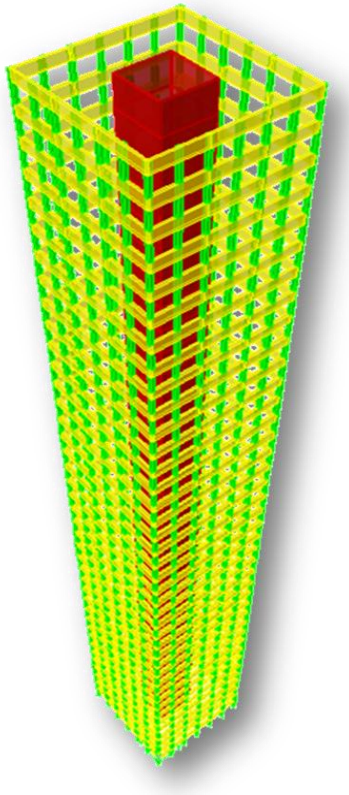


Some Examples of New Systems

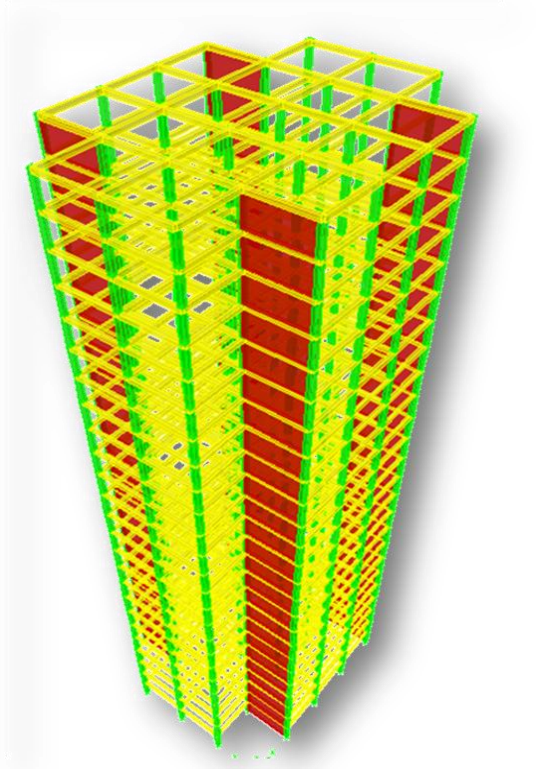
Traditional Systems



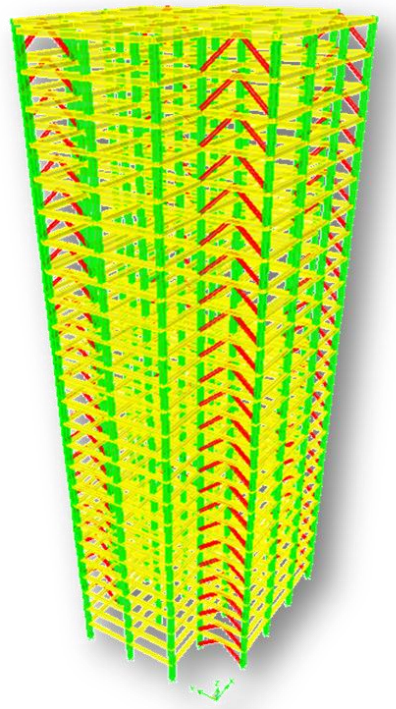
Moment Resisting Frame



Shear Wall and Frame



Shear Wall – Frame Coupled



Braced Frame

Traditional vs. Innovative







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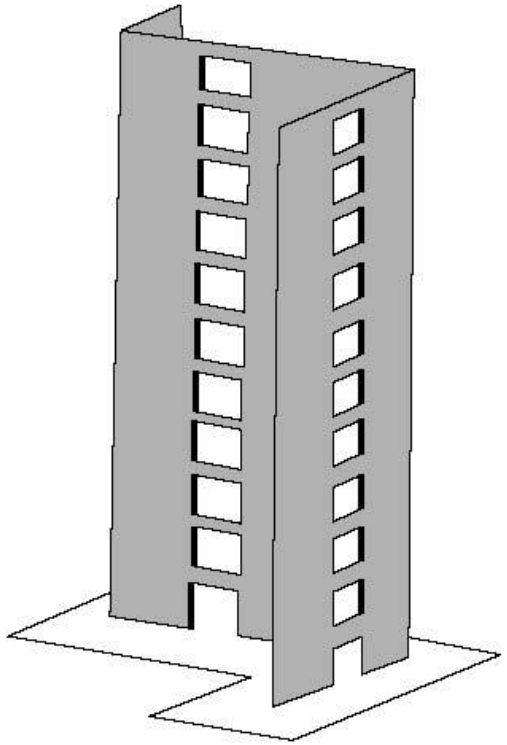
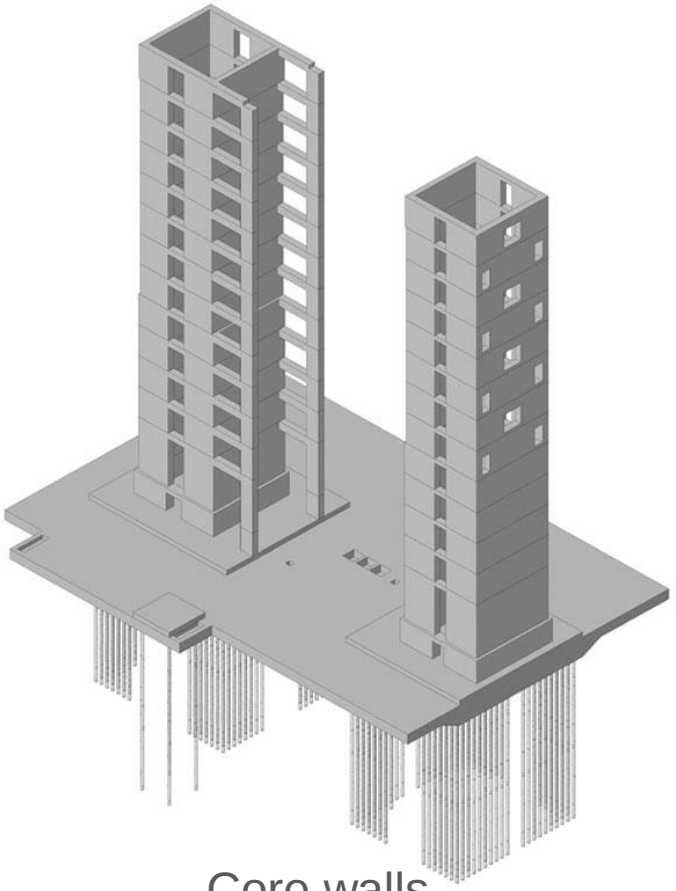
Core Walls



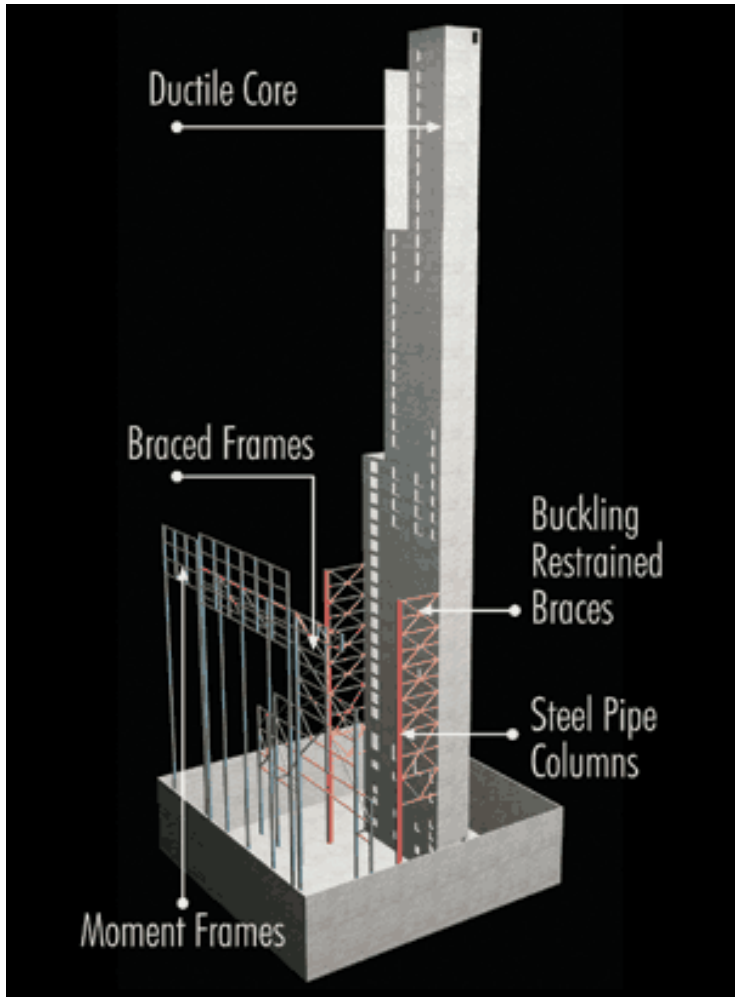
Coupled shear walls

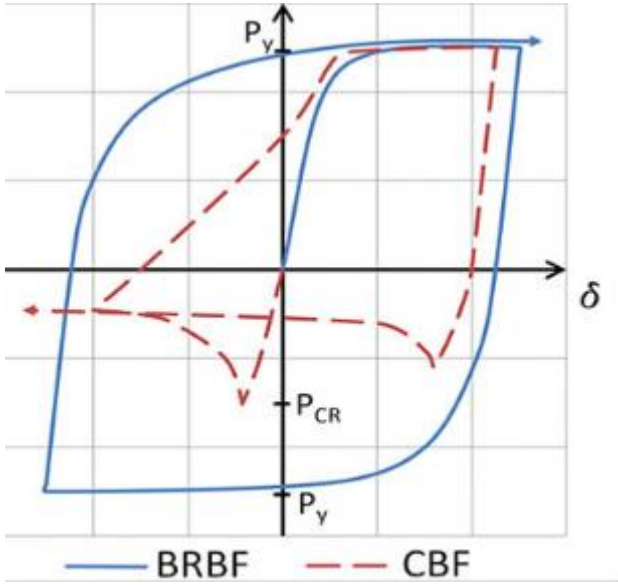


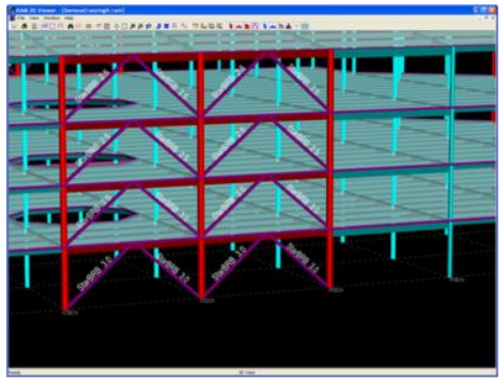
Core walls

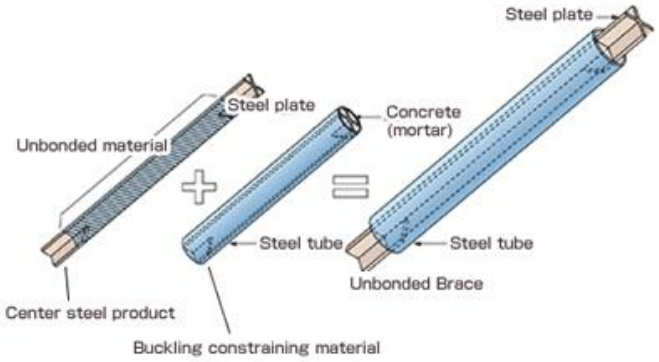
- Capable of transmitting lateral loads in both directions
- Able to resist shear forces and bending moments in two directions
- Able to resist torsion particularly when link beams are provided between the openings
- The shape is typically dictated by the elevator and stair requirements

BRB Based Systems (Braces that Don't Buckle)



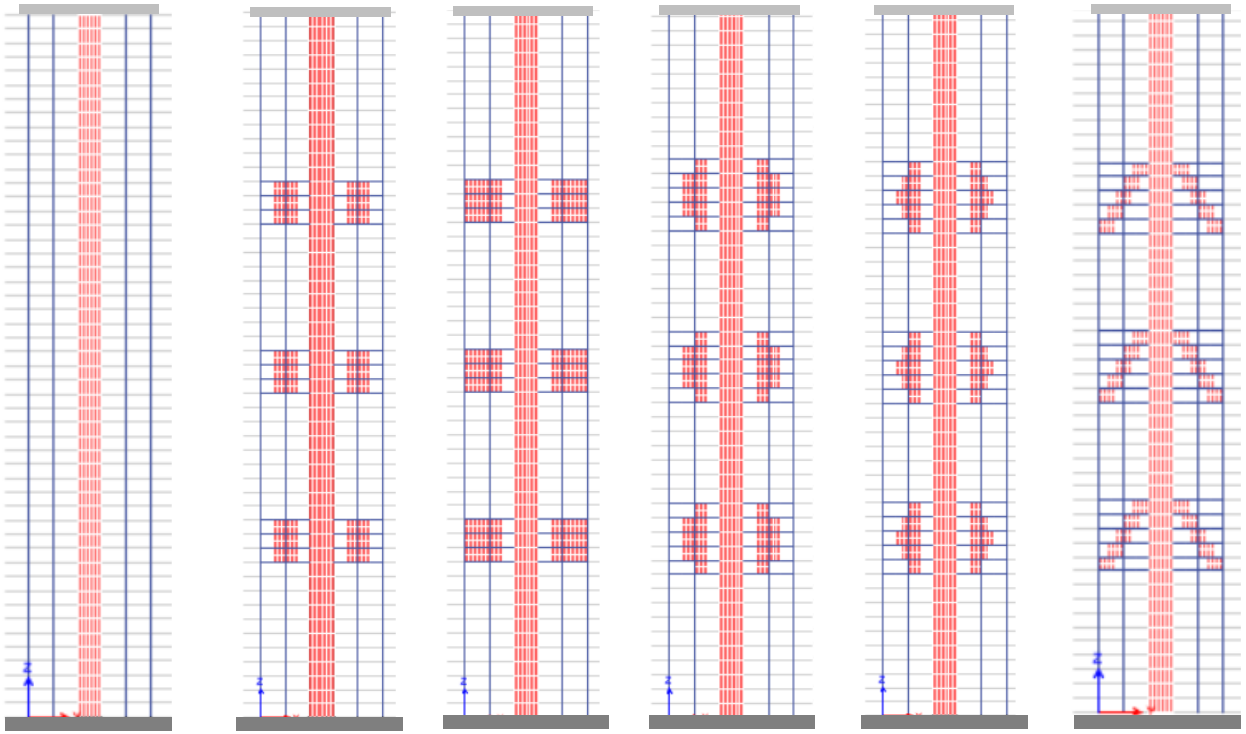






Flag Wall Systems

Partition walls, general made of brick masonry, can be effectively replaced with RC walls and therefore, can be used as structural components.



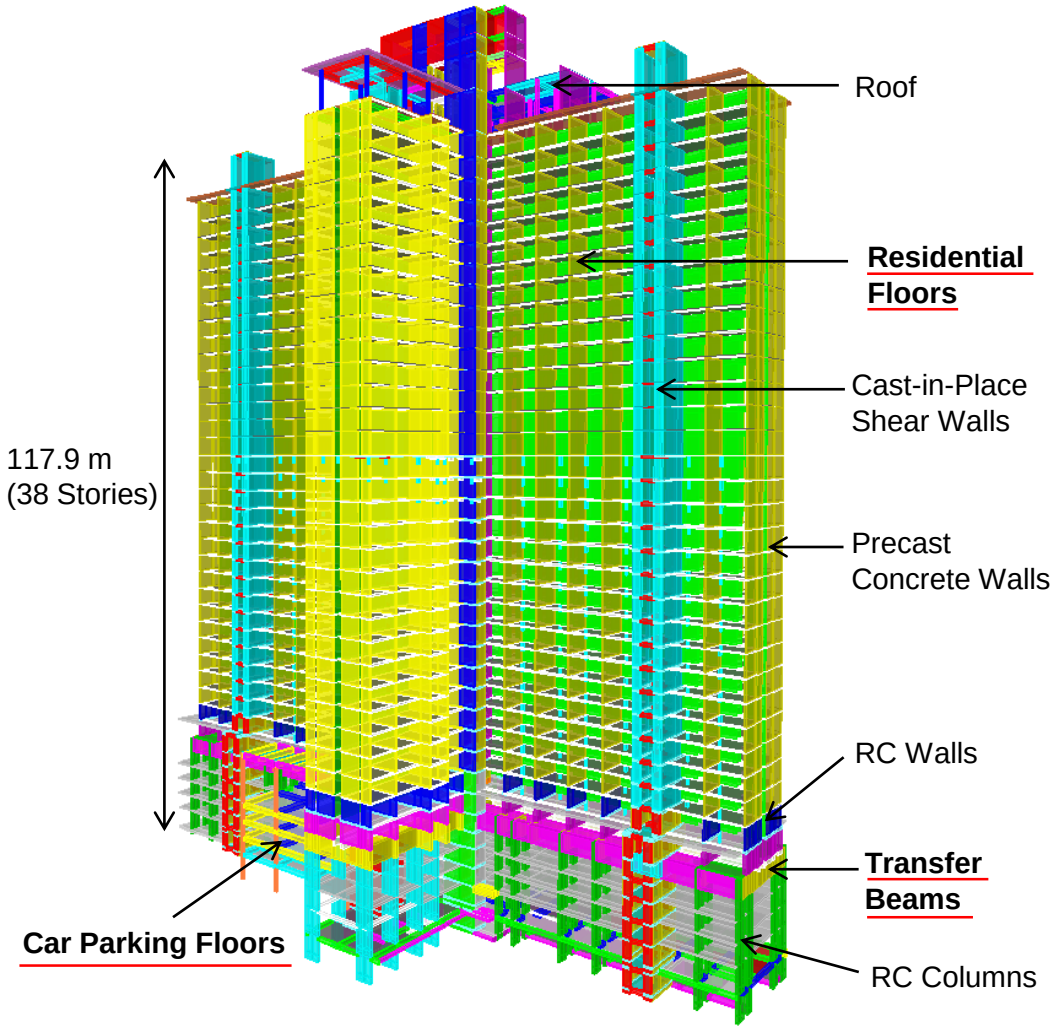
Various configurations of flag walls in a tall building

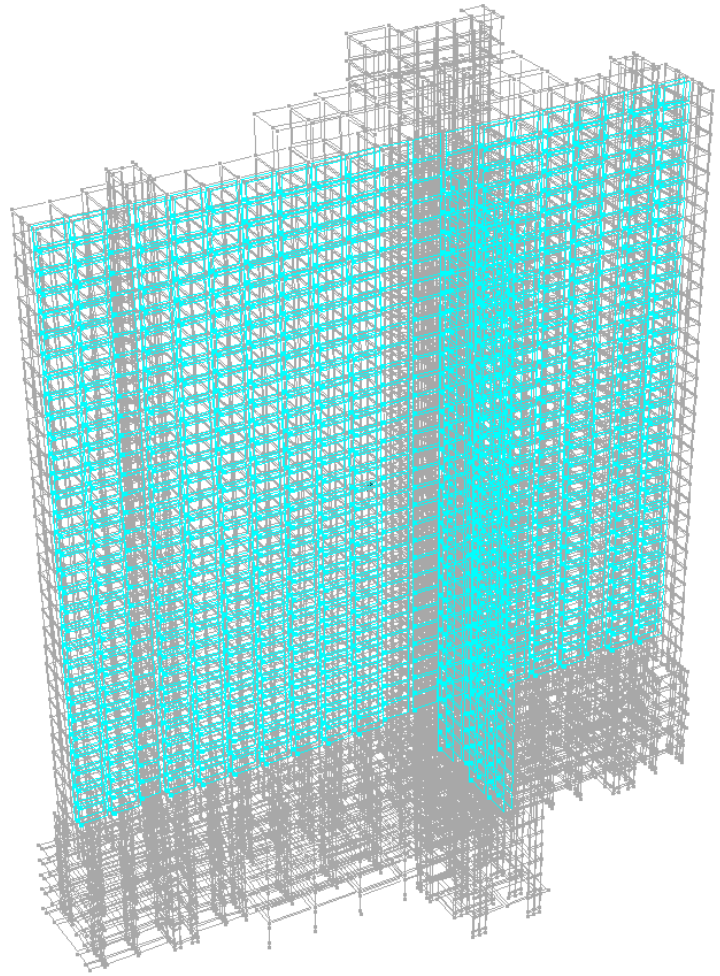
Recent study showed that:

- Flag walls can be used as an alternative to outriggers
- However, they can create local concentration of forces
- Their configuration should be symmetric

PC-RC Hybrid Tall Building in Bangkok

PC-RC Hybrid Tall Building in Bangkok

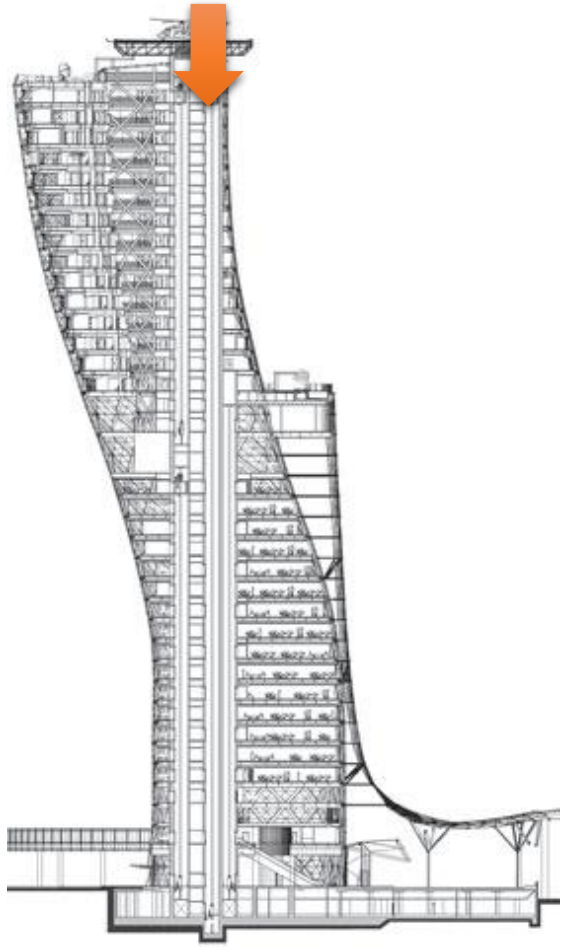




Code Based Design – Linear Model

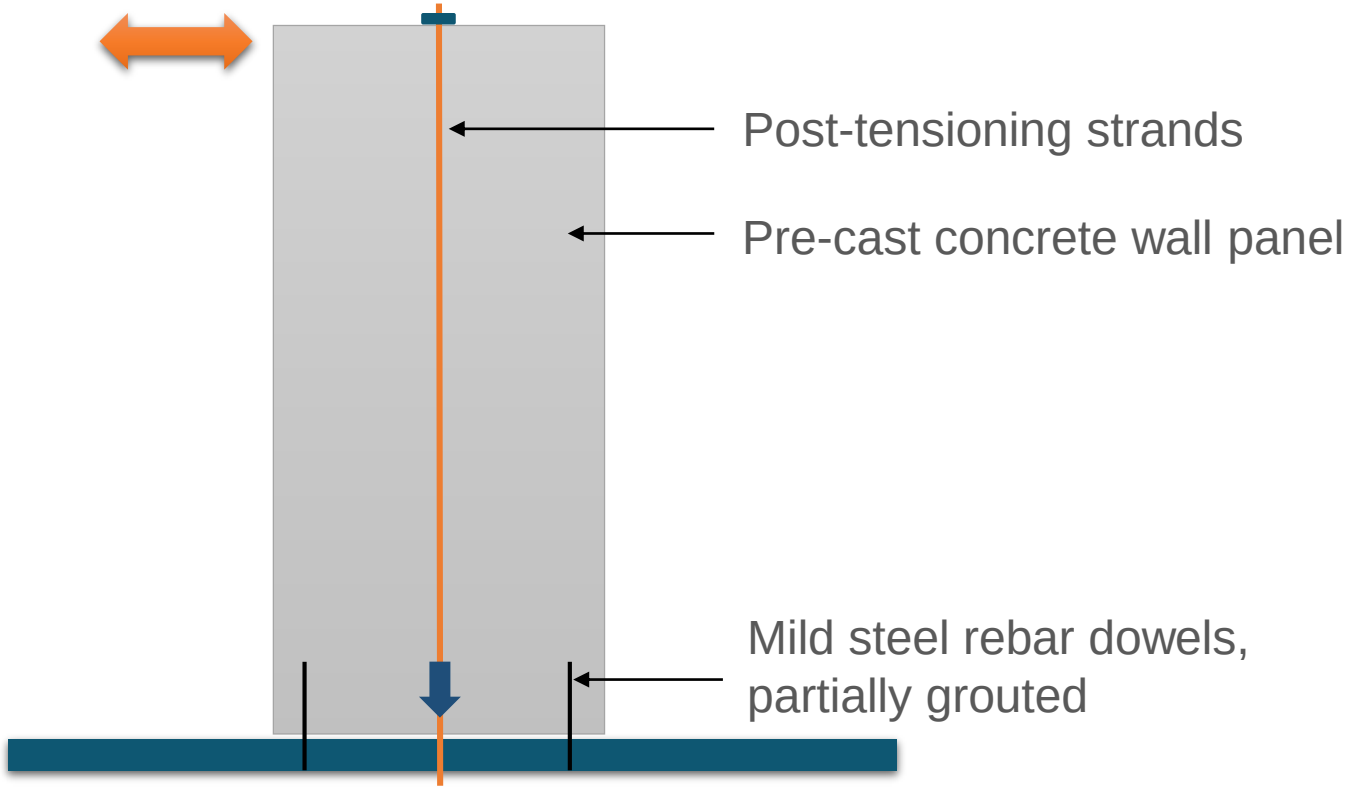
PBD – Nonlinear Model

Capital Gate Tower, Dubai – Vertical Post Tensioning of Walls

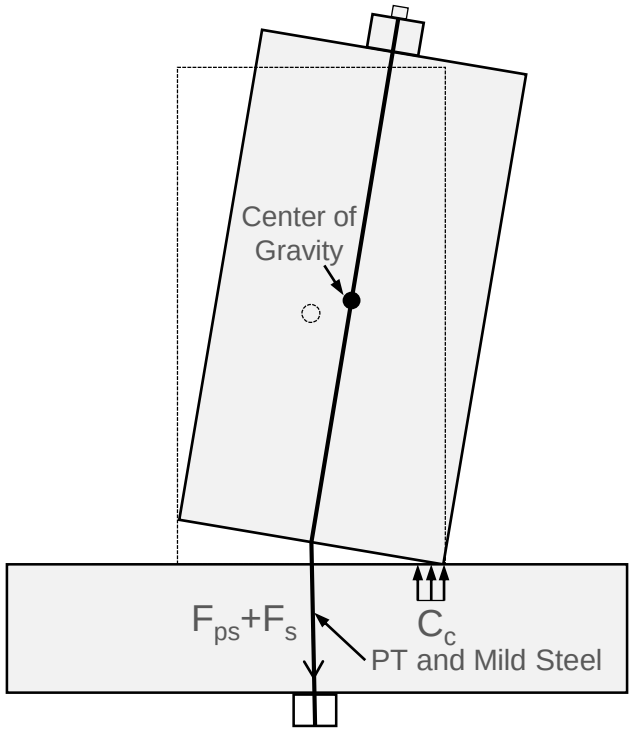


The Rocking PC Walls

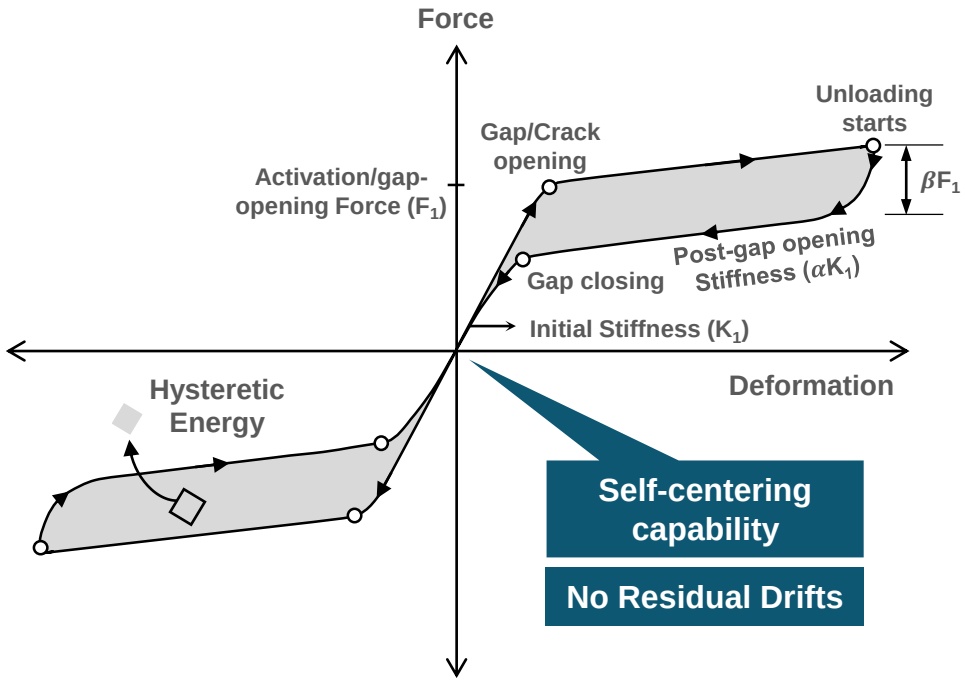
- An innovative solution to resist large, cyclic seismic excitation
  - without damage
  - With re-centering ability (no residual deformations)
  - Providing damping, and energy dissipation
  - Simpler construction



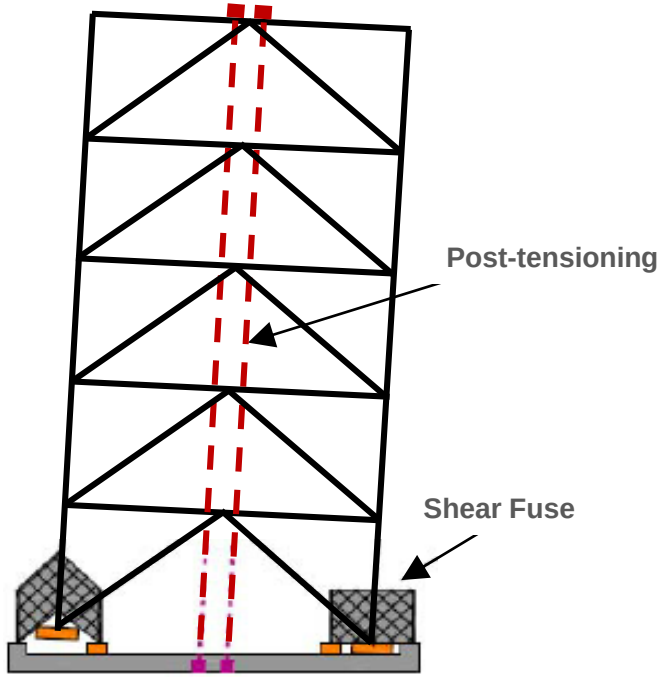
Rocking Wall Systems



A single rocking wall



Cyclic behavior of a rocking wall



A rocking frame with shear fuses

Developing Better Connections

Increasing use of Concrete in Buildings

+

Seismic Risk

+

Failure of pre-fabricated concrete structures caused by failure of joints

↓

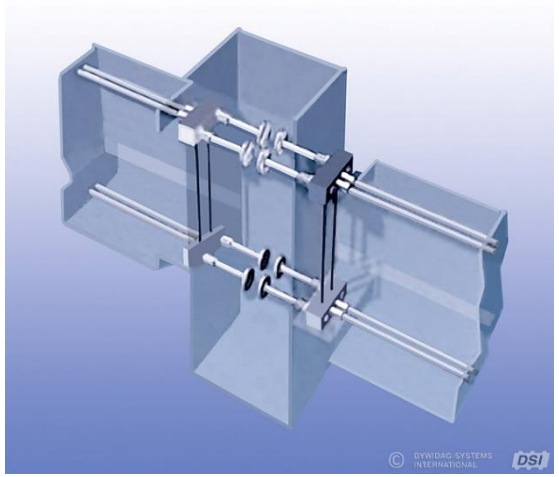
R&D and Testing of RC joints

Cast-in-place

Hybrid connections

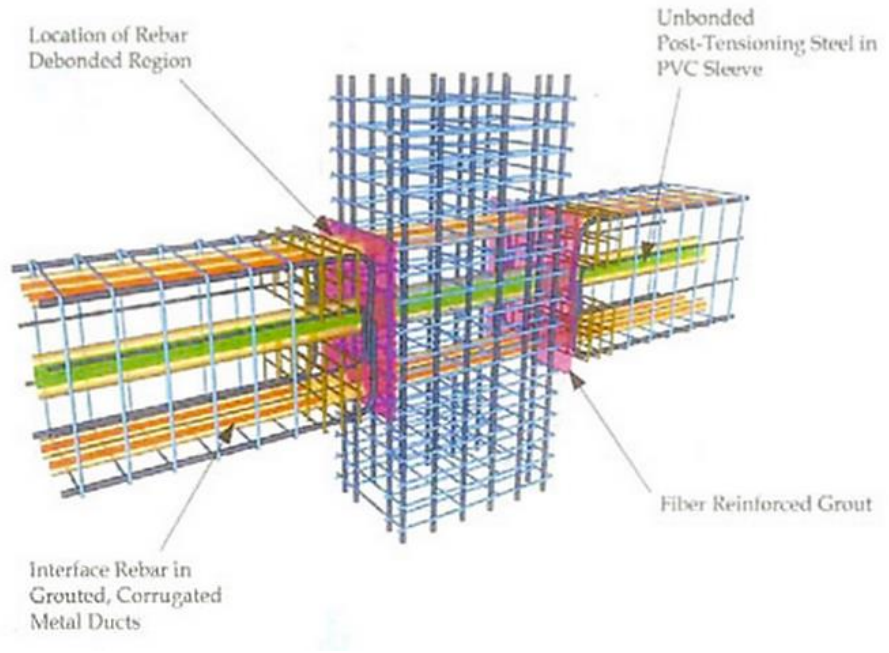
http://failures.wikispaces.com/

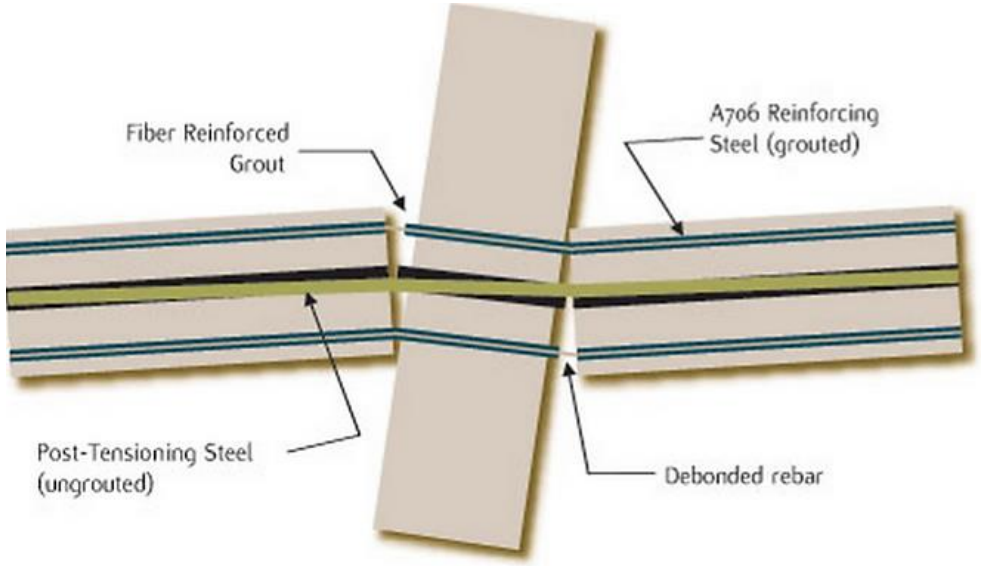
Ductile PC Connections



A Ductile Connection System at Cilacap Oil Refinery, Indonesia

Improved Post Tensioned Frame Connections





An innovative solution to resist large, cyclic seismic excitation without damage
Providing ductility , damping, and energy abortion

http://cenews.com/article/8596/how-the-precast-hybrid-moment-frame-works

http://precast.org/2010/05/defying-mother-nature/

New Systems – A Joint Effort

Design Codes and Guidelines

Peer Review

Basic Design

PBD

Value Engineering

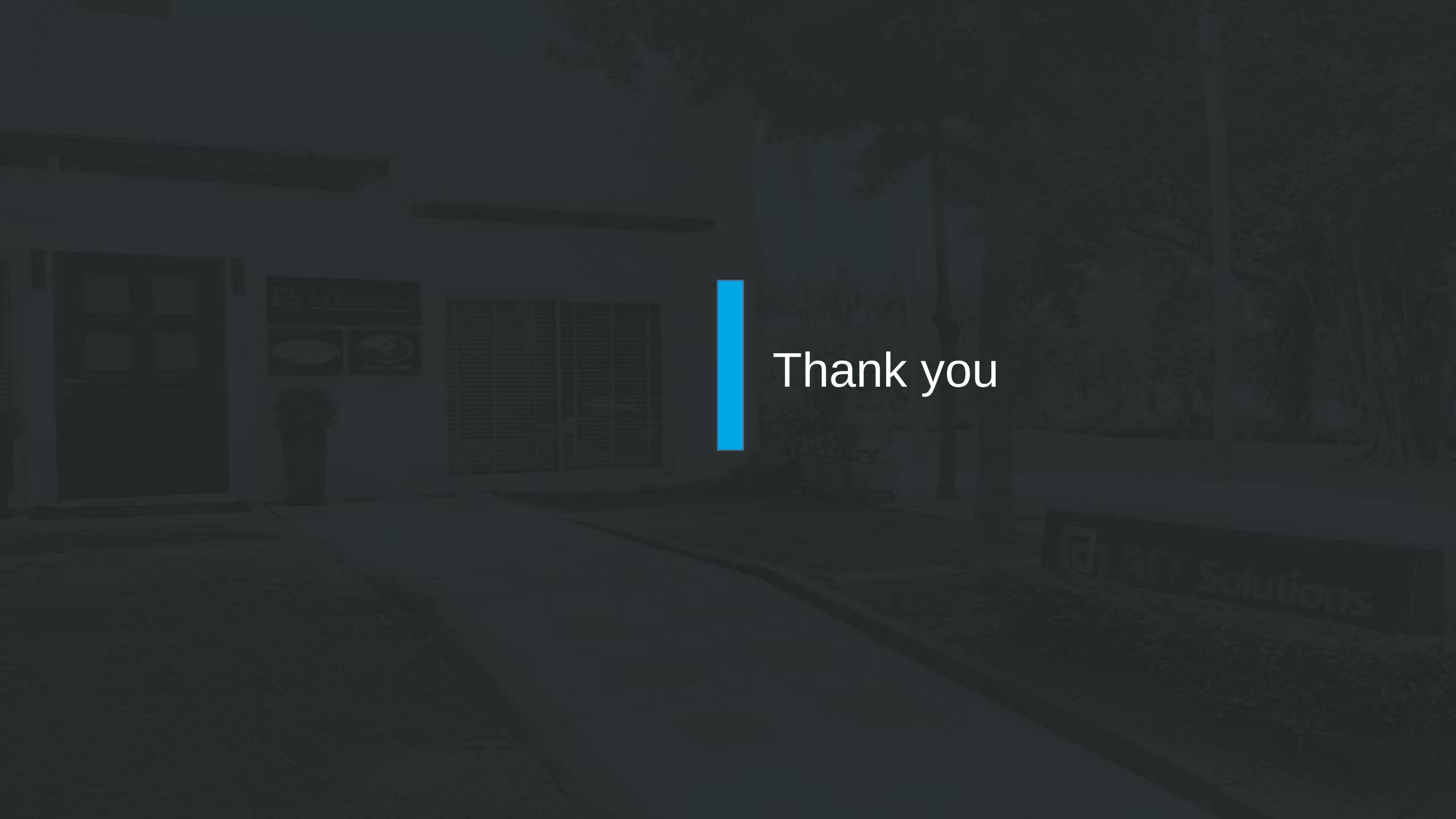
R & D

Client

Innovation

Public Officials

High performance,
Higher safety
higher value,
cost effective
Sustainable



Thank you