# Advanced concrete for Highrise building 2

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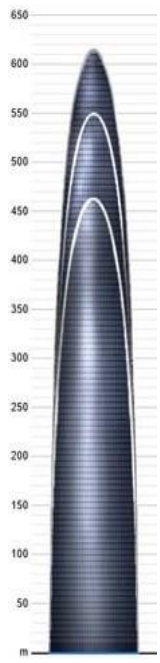


| High(m) | Concrete Application | Slump/Flow (cm) | Required strength (ksc, CY) | Type of concrete |
|---|---|---|---|---|
| 450 - 650 | • Insee high performance<br>• Insee Self compacting<br>• Post - tension | • 65 – 75 cm<br>• 65 – 75 cm<br>• > 25 cm | • 500 ksc<br>• 500 ksc<br>• 320 ksc | • Lift core<br>• Column; Shear wall<br>• Post - Floor |
| 300 - 450 | • Insee high performance<br>• Insee Self compacting<br>• Insee post-tension | • 65 – 75 cm<br>• 65 – 75 cm<br>• 20 – 25 cm | • 800 ksc<br>• 800 ksc<br>• 320 - 450 ksc | • Lift core<br>• Column; Shear wall<br>• Post - Floor |
| 200 - 300 | • Insee high performance<br>• Insee high strength<br>• Insee post-tension | • 65 – 75 cm<br>• 20 – 25 cm<br>• 20 – 25 cm | • 600 - 800 ksc<br>• 600 - 800 ksc<br>• 320 - 450 ksc | • Lift core<br>• Column; Shear wall<br>• Post - Floor |
| 100 - 200 | • Insee high performance<br>• Insee high strength<br>• Insee post-tension | • 65 – 75 cm<br>• 20 – 25 cm<br>• 15 – 20 cm | • 600 - 1000 ksc<br>• 600 - 1000 ksc<br>• 320 - 450 ksc | • Lift core<br>• Column; Shear wall<br>• Post - Floor |
| 0 - 100 | • Insee high performance<br>• Insee high strength<br>• Insee post-tension | • 65 – 75 cm<br>• 15 – 20 cm<br>• 10 - 15 cm | • 800 - 1000 ksc<br>• 800 - 1000 ksc<br>• 320 - 450 ksc | • Lift core<br>• Column; Shear wall<br>• Post - Floor |

21/07/2022

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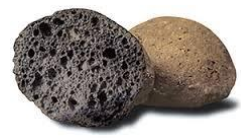
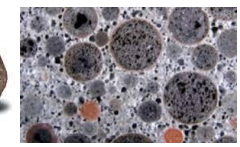
# INSEE Structural Lightweight Concrete

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## Agenda

- Standard Specification for Lightweight Aggregates
- Requirements for Structural Lightweight Concrete
- Performance of Lightweight Concrete
- Simulation for Floor re-sectioning project
- Appendix A
- Summary




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## What is Lightweight concrete?

- This product can be created by the addition of either polystyrene beads (nonstructural) or a lightweight aggregate (structural) or special admixture.
- These products, although both are lightweight have several important differences and these must be noted before using.




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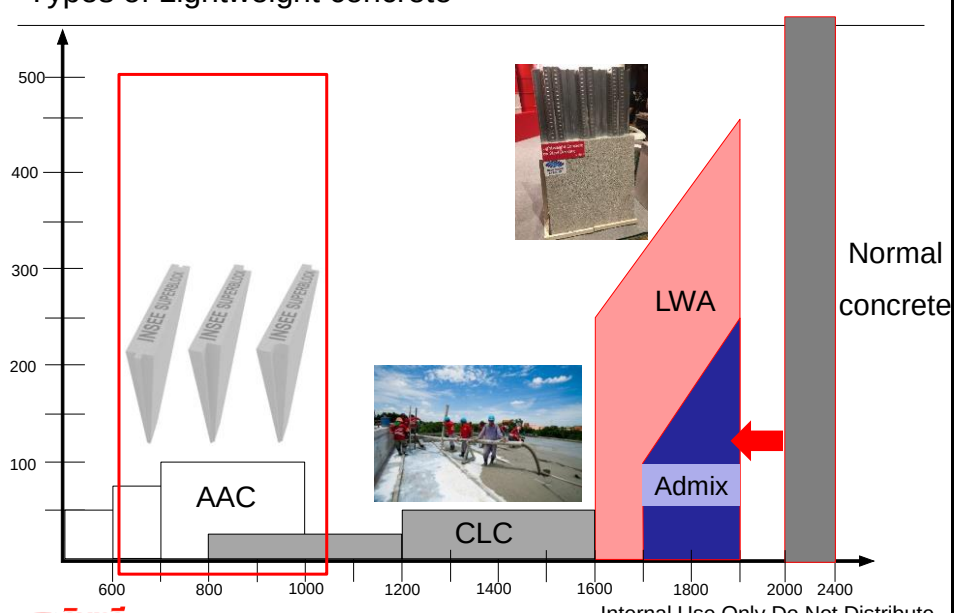
## Types of Lightweight concrete







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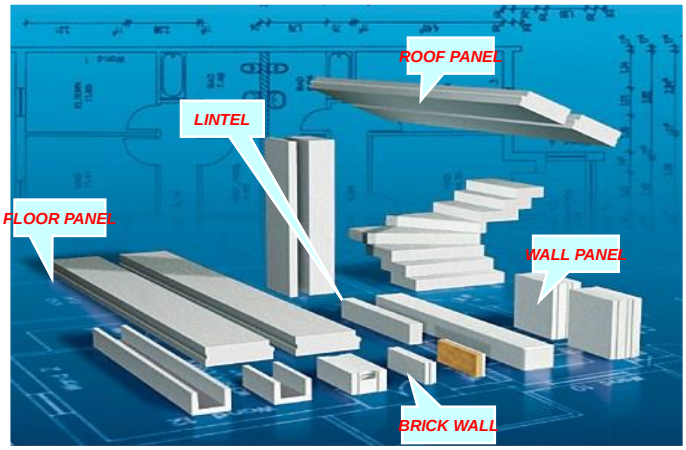
## INSEE SUPERBLOCK




**อิฐมวลเบา อบไอน้ำ**
**Autoclaved Aerated Concrete**

มาตรฐานสากลที่ใช้กำหนดได้แก่ AAC
- DIN 4165
- ASTM-C1386***
- มอก 1505 - 2541

แบ่งชั้นคุณภาพที่ความหนาแน่น กับ การรับแรงอัด





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## INSEE SUPERBLOCK

"DIN 4165-G4-0.7-200 x 600 x 75"
หมายความว่า
"อิฐมวลเบาชนิดอบไอน้ำ ชั้น 4 ความหนาแน่น 500 - 800 kg/m$^3$ ขนาดกว้าง 20 ซม. ความยาว 60 ซม. หนา 7.5 ซม."

<u>การแบ่งเป็นชั้นเกรดคุณภาพ (เป็นเลขคู่) ได้แก่</u>

- ชั้นคุณภาพ 2 ความหนาแน่น 400 – 500 kg/m$^3$ <u>รับแรงอัด 25 ksc</u>
- ชั้นคุณภาพ 4 ความหนาแน่น 500 - 800 kg/m$^3$ <u>รับแรงอัด 50 ksc</u>
- ชั้นคุณภาพ 6 ความหนาแน่น 600 - 800 kg/m$^3$ <u>รับแรงอัด 75 ksc</u>
- ชั้นคุณภาพ 8 ความหนาแน่น 700 - 1,000 kg/m$^3$ <u>รับแรงอัด 100 ksc</u>
- <u>อัตราการดูดกลืนน้ำต้องไม่เกิน 500 kg/m$^3$</u>





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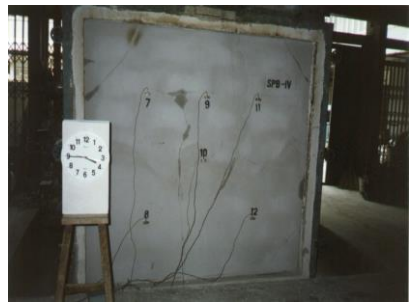
## INSEE SUPERBLOCK



- ส่งผลต่อ คุณสมบัติหลัก
- การดูดซึมน้ำ --ความหนาแน่น ต่ำ จะ ดูดน้ำมาก ปูนฉาบแตกร้าว
- การรับแรงอัดต่ำ ผนังรับแรงด้านข้างน้อย จะต้องเพิ่ม เสา-คานเอ็น
- เกิดผลึกคริสตัลปริมาณน้อย รับแรงดัดต่ำ เกิดรอยร้าวตามช่องเปิด
- ความหนาแน่นต่ำ จะไม่ทนทาน ต่อ การกันไฟไหม้

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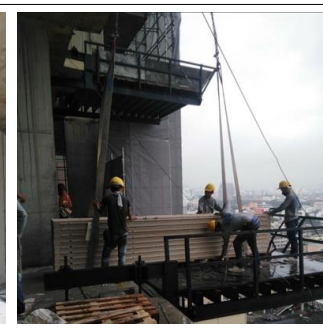
## construction of High ceiling wall & double floor: Height 4.25 – 4.50 m



- Total cost saving in speed of work ,reduce defect, waste of material and repairing work , cleaner jobsite

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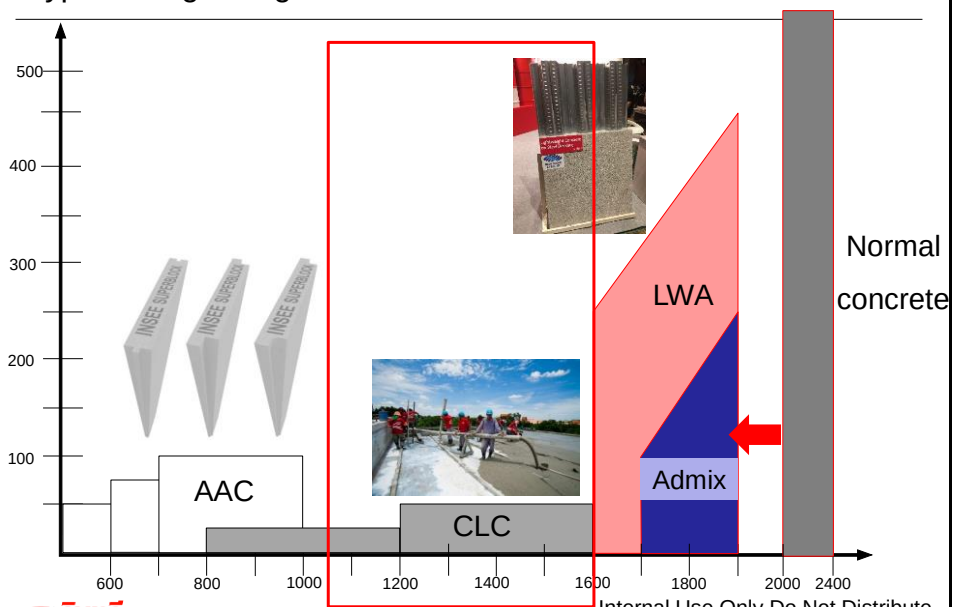
## Types of Lightweight concrete







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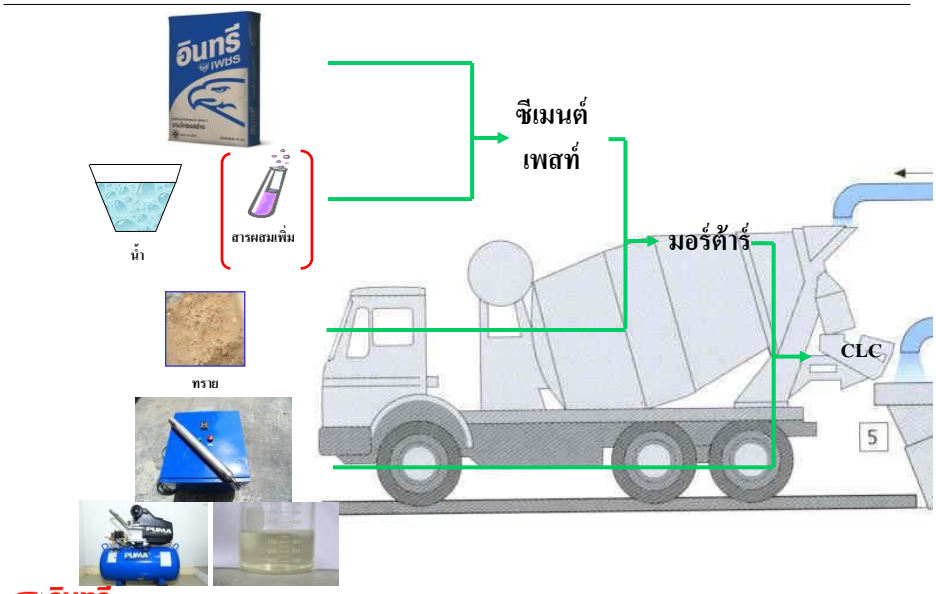
## ซีเมนต์เพสท์ มอร์ต้าร์ และ CLC







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## CLC (Cellular Lightweight Concrete)

- CLC (Cellular Lightweight Concrete) คือ คอนกรีตมวลเบาแบบเติมฟองอากาศ ตาม มอก 2601-2556 หมายถึง คอนกรีตบล๊อกที่มีมวลเบากว่าคอนกรีตบล๊อกที่มีขนาดเดียวกัน มีฟองอากาศเล็กๆแทรกกระจายในเนื้อคอนกรีตอย่างสม่ำเสมอ ฟองอากาศเกิดจากการใช้สารก่อฟอง มี 2 แบบ
- ผิวเรียบข้างร่องเกิดจากการหล่อในโมล
- กับผิวหน้าร่องเกิดจากการตัดด้วยลวด เหมาะสำหรับใช้ก่อผนัง

แบบผิวเรียบ หล่อในโมล

แบบร่องหวี เกิดจากการตัดด้วยลวด




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## Strength classification of CLC and its application

| ชนิดของคอนกรีตบล๊อกมวลเบา | | |
|---|---|---|
| ชนิด | ความหนาแน่นเชิงปริมาตรในสภาพแห้งเฉลี่ย ($kg/m^3$) | |
| C6 | 501 - 600 | > 21 ksc |
| C7 | 601 - 700 | |
| C8 | 701 - 800 | |
| C9 | 801 - 900 | > 26 ksc |
| C10 | 901 - 1000 | |
| C12 | 1001 - 1200 | |
| C14 | 1201 - 1400 | > 51 ksc |
| C16 | 1401 - 1600 | |




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## Water absorption classification of CLC and its application in TIS

| ชนิดของคอนกรีตบล๊อกมวลเบา | | |
|---|---|---|
| ชนิด | ความหนาแน่นเชิงปริมาตรในสภาพแห้งเฉลี่ย ($kg/m^3$) | |
| C6 | 501 - 600 | < 25 % |
| C7 | 601 - 700 | |
| C8 | 701 - 800 | |
| C9 | 801 - 900 | < 23 % |
| C10 | 901 - 1000 | |
| C12 | 1001 - 1200 | |
| C14 | 1201 - 1400 | < 20 % |
| C16 | 1401 - 1600 | |




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## ลักษณะเนื้อคอนกรีตมวลเบา




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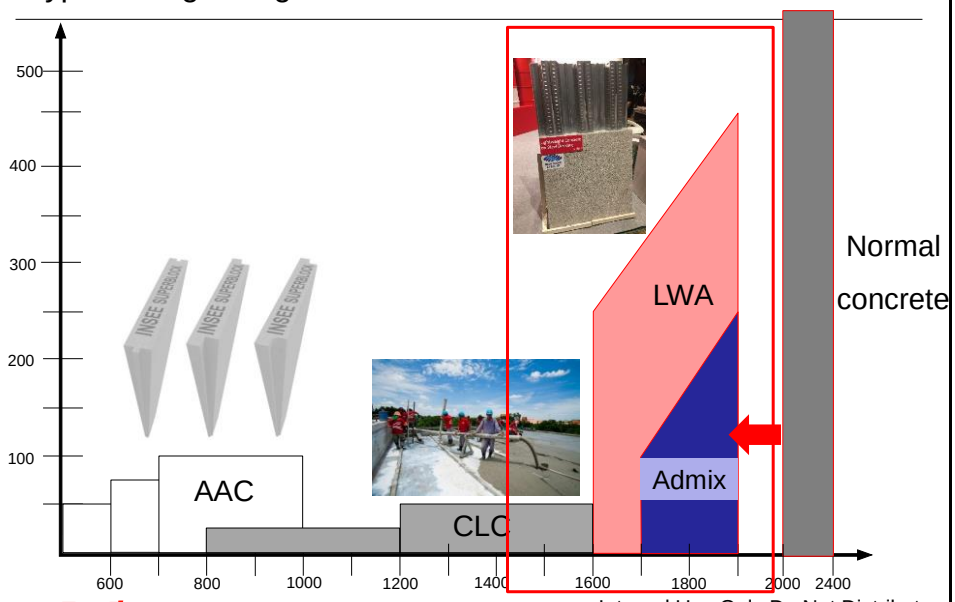
## Types of Lightweight concrete









## Advantage, Benefits of Lightweight Concrete

**(Non-structural)**

- Superior Insulation
- Time savings
- Easier and faster using for Leveling/Screeds
- Cost effective solution

**(Structural)**

- Structural light weight concrete requirements
- Architectural finishes eg. Cladding

## ASTM C330-03 Standard Specification for Lightweight Aggregates for Structural Concrete

- Aggregates that concrete has an equilibrium density in the range of 1,120 – 1,920 kg/m$^3$ are generally considered lightweight, and find application in the production of various types of lightweight concrete.
- Minimum 28-day compressive strength in concrete of 180 ksc


Follow ASTM C330-03 Standard Specification for Lightweight Aggregates for Structural Concrete

ACI 213R-03 Guide for Structural Lightweight-Aggregate Concrete









## ASTM C330-03 Standard Specification for Lightweight Aggregates for Structural Concrete

- Type of lightweight aggregates
  1. Aggregates prepared by expanding, pelletizing, or sintering products
  2. Aggregates prepared by processing natural materials, such as pumice, scoria, or tuff


Follow ASTM C330-03 Standard Specification for Lightweight Aggregates for Structural Concrete

ACI 213R-03 Guide for Structural Lightweight-Aggregate Concrete

## ASTM C330-03 Standard Specification for Lightweight Aggregates for Structural Concrete

- Aggregate Types
  1. Aggregates prepared by expanding, pelletizing, or sintering products such as blast-furnace slag, clay, diatomite, fly ash, shale, or slate
  2. Aggregates prepared by processing natural materials, such as pumice, scoria, or tuff

**Clay**

**Vermiculite**

**Pumice**

**Perlite**

**Slag**

Lightweight aggregates are required to have low density and weight, achieved by using porous materials, but adequate strength.






## Agenda

- Standard Specification for Lightweight Aggregates
- Requirements for Structural Lightweight Concrete
- Performance of Lightweight Concrete
- Simulation for Floor re-sectioning project
- Appendix A
- Summary

## ACI 213R-03 Requirements for Structural Lightweight Concrete

| Requirements for Structural Lightweight Concrete | | |
|---|---|---|
| Calculated Equilibrium density [kg/m$^3$ (lb/ft$^3$)] | 28-day splitting tensile strength min ksc (psi) | 28-day compressive strength ksc (psi) |
| **All lightweight aggregates** | | |
| 1760 (110) | 23 ksc (320) | 280 ksc (4000) |
| 1680 (105) | 22 ksc (300) | 210 ksc (3000) |
| 1600 (100) | 21 ksc (290) | 170 ksc (2500) |
| **Combination of normal sand and lightweight aggregate** | | |
| **1840 (115)** | **24 ksc (330)** | **280 ksc (4000)** |
| 1760 (110) | 22 ksc (310) | 210 ksc (3000) |
| 1680 (105) | 22 ksc (300) | 170 ksc (2500) |

Follow ASTM C330-03 Standard Specification for Lightweight Aggregates for Structural Concrete

ACI 213R-03 Guide for Structural Lightweight-Aggregate Concrete









## Compressive Strength and Cement Content(kg/m$^3$)

| Compressive Strength | All-lightweight cement content | Sanded-lightweight cement content |
|---|---|---|
| 175 ksc | 240 - 305 | 240 - 305 |
| 210 ksc | 260 - 335 | 250 - 335 |
| 280 ksc | 320 - 395 | 290 - 395 |
| 350 ksc | 375 - 450 | **360 - 450** |
| 420 ksc | 440 - 550 | 420 - 500 |

- The compressive strength of lightweight aggregate concrete is usually related to cement content at a given slump rather than to water/cement ratio.
- The compressive strength at a given cement and water content can be increased by reducing the maximum size of coarse aggregate and/or partial replacement of lightweight fine aggregate with a good-quality natural sand.

## Agenda

- Standard Specification for Lightweight Aggregates
- Requirements for Structural Lightweight Concrete
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- Appendix A
- Summary





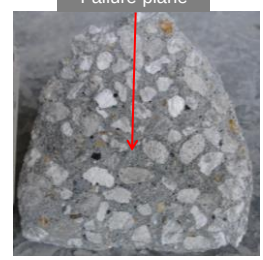

Natural Pumice

## Compressive strength lightweight concrete Pumice

- Density class 1850 kg/m$^3$ gain 320 - 430 ksc Cy of Strength at 28 day
- Density class 1700 kg/m$^3$ gain 250 - 350 ksc Cy of Strength at 28 day

- Failure plane of the sample was occurred at the aggregate. This case showed that the strength limitation at aggregate.

Failure plane



Natural Pumice

## Splitting tensile strength of LW Concrete


Density class 1850 kg/m3





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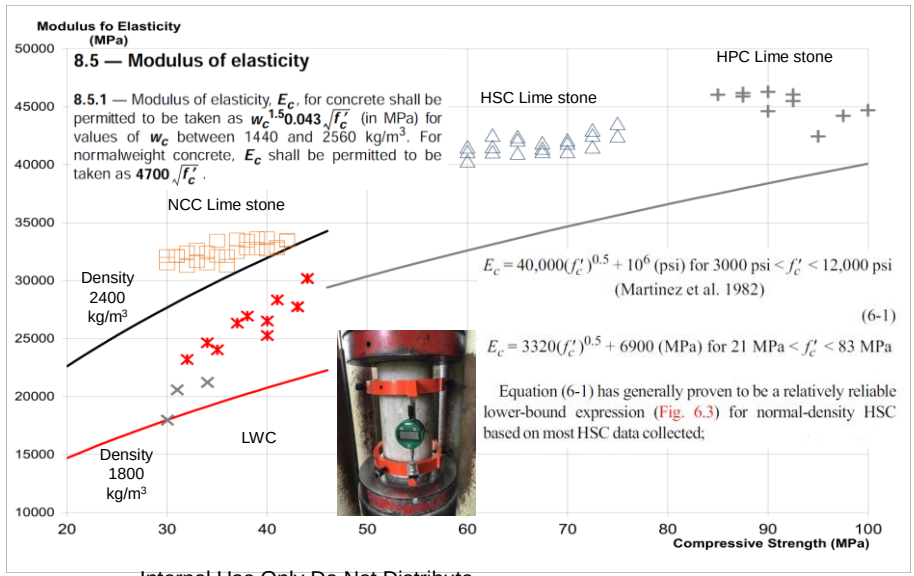
## How we can make sure that High Strength Concrete meet the Quality standard and Specification







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## Agenda

- Standard Specification for Lightweight Aggregates
- Requirements for Structural Lightweight Concrete
- Performance of Lightweight Concrete
- Simulation for Floor re-sectioning project
- Appendix A
- Summary




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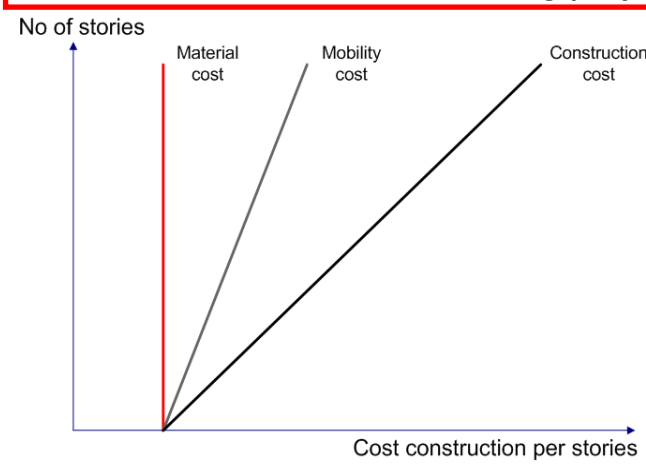
## Simulation for Floor re-sectioning project




- Construction cost depends on the number of stories of the building.
- The number of stories depends on the weight of structure.



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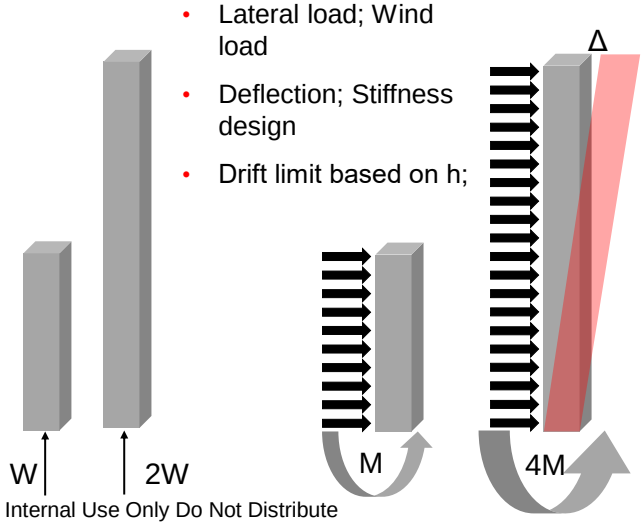
## Effect of Building Design

- Gravity Load
- Lateral load; Wind load
- Deflection; Stiffness design
- Drift limit based on h;







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## Type of floor system

| Type | Post-tension | Two-way Flat slab | One way hollow core | One way Steel decking |
|---|---|---|---|---|
| Thickness cm | 25 | 25 | 15+5 top | **12.5** |
| Span m | 8 | 6 | 4 - 5 | **3.3 - 4.5** |
| DL (2400 kg/m$^3$) | 600 | 600 | 315 | **210** |
| DL (1850 kg/m$^3$) | 460 | 460 | 285 | **180** |
| Allowable Superimposed Load kg/m$^2$ | 520 | 520 | 676 - 340 | **1050 - 480** |




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## Overall Structural system Slender

- Normal density 2,400 kg/m$^3$
- Thickness floor 25 cm
- DL Factor = 1.3
- DL = 1.3 x 600 kg/m$^2$ = 780 kg/m$^2$

Reduce DL 70 %

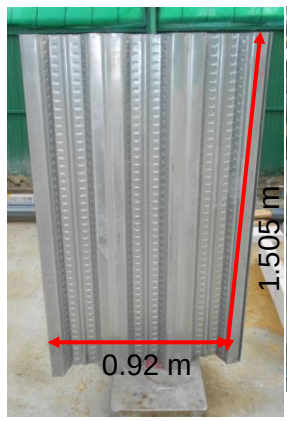
- DL = 1.3 x 180 kg/m$^2$= 234 kg/m$^2$
- LWC density 1,850 kg/m$^3$
- Thickness floor 12.5 cm W shape
- DL Factor = 1.3






## Industrial trial mix at SCCO-RMX Plant

3W Composite Floor Deck Superimposed Load **LWC Mix1**




LWA 17.2% by weight
Density 1,738 kg/m$^3$

- LWA 13.2% by weight
- Density 1,819 kg/m$^3$

## Industrial trial mix at SCCO-RMX Plant

3W Composite Floor Deck Superimposed Load **LWC Mix1 density 1,738 kg/m$^3$**


| | | | | |
|---|---|---|---|---|
| Steel deck Sample 1 | Sample Area | 1.3846 | $m^2$ |
| | Weight of Steel deck (1.2 mm) | 18.15 | kg/sheet |
| | weight/area | 13.11 | $kg/m^2$ |
| LWC 1738 kg/m$^3$ thickness 120 mm | Total weight sample floor | 213.16 | kg |
| | $DL_{floor}$ (Steel+LWC) | 154.0 | $kg/m^2$ |
| | **$DL_{floor}$ (125 mm)** | **160.4** | **$kg/m^2$** |
| | Strength 7 day | 282 | ksc |
| | Strength 28 day | 313 | ksc |
| | Ratio LWA | 17.2 | %/weight |

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## Industrial trial mix at SCCO-RMX Plant

3W Composite Floor Deck Superimposed Load **LWC Mix2 density 1,819 kg/m$^3$**


| | | | | |
|---|---|---|---|---|
| Steel deck Sample 2 | Sample Area | 1.3846 | $m^2$ |
| | Weight of Steel deck (1.2 mm) | 18.11 | kg/sheet |
| | weight/area | 13.08 | $kg/m^2$ |
| LWC 1819 kg/m$^3$ thickness 130 mm | Total weight sample floor | 247.99 | kg |
| | $DL_{floor}$ (Steel+LWC) | 179.1 | $kg/m^2$ |
| | **$DL_{floor}$ (125 mm)** | **172.2** | **$kg/m^2$** |
| | Strength 7 day | 290 | ksc |
| | Strength 28 day | 325 | ksc |
| | Ratio LWA | 13.2 | %/weight |




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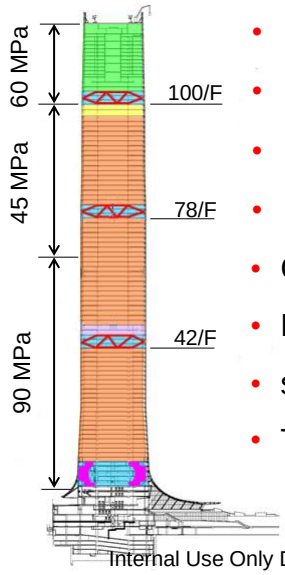
## Construction/Structural Features




- Total 115 floors
- Height of tower structure – 490 m
- Average floor plate area – 3,000 $m^2$
- Total area 280,000 $m^2$
- Concrete 240,000 $m^3$
- Reinforcing bar 98,000 tons Structural
- steel 27,000 tons
- Total Weight of Building = 701,000 tons







## Summary

- Lightweight Aggregate Concrete has 3 density classes; 2,000, 1,850, 1,700 $kg/m^3$
- Lightweight Aggregate Concrete has the same strength classes as INSEE Normal Weight Concrete.
- Lightweight Aggregate Concrete has Elastic modulus lower than Normal Weight Concrete 10 – 35 % depending on concrete density
- Equation model for control Elastic Lightweight aggregate concrete $W_c^{1.5}$ $0.043\sqrt{f_c'}$ in (Mpa) (ACI 318M-11)
- 2,300 $kg/m^3$ = 15,100 $\sqrt{f_c}$ ksc
- 1,850 $kg/m^3$ = 11,000 $\sqrt{f_c}$ ksc

## Summary

- INSEE Structural Lightweight Aggregate Concrete Floor on steel decking thickness 12.5 cm, weight of DL floor 180 kg/$m^2$
- High strength 250 Ksc
- Low density < 1840kg/m3
- Reduce the weight of concrete
- layer on top of ground floor => reduce load for the basement and structure
- Easy for pumping and placing