Case Studies in Construction Failure

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Main Objective of Structural Design

a) Strong ⟺ strength → Ultimit capacity

b) Stifness ⟺ serviceability → Deflection, confined, loading etc

c) Ductile ⟺ survival → Earthquake resistant, deformability

d) Stable ⟺ geometry → Secondary effect

LRFD system:

$$\phi M_n \geq M_u$$

$$\phi P_n \geq P_u$$

$$\phi V_n \geq V_u$$

Requirements of Serviceability

-Deflection

-Time dependent analysis: creep, shrinkage

-Crack width etc

The structure namely ductile if before collapse can be:

a) Large yield deformation

b) Dissipating energy

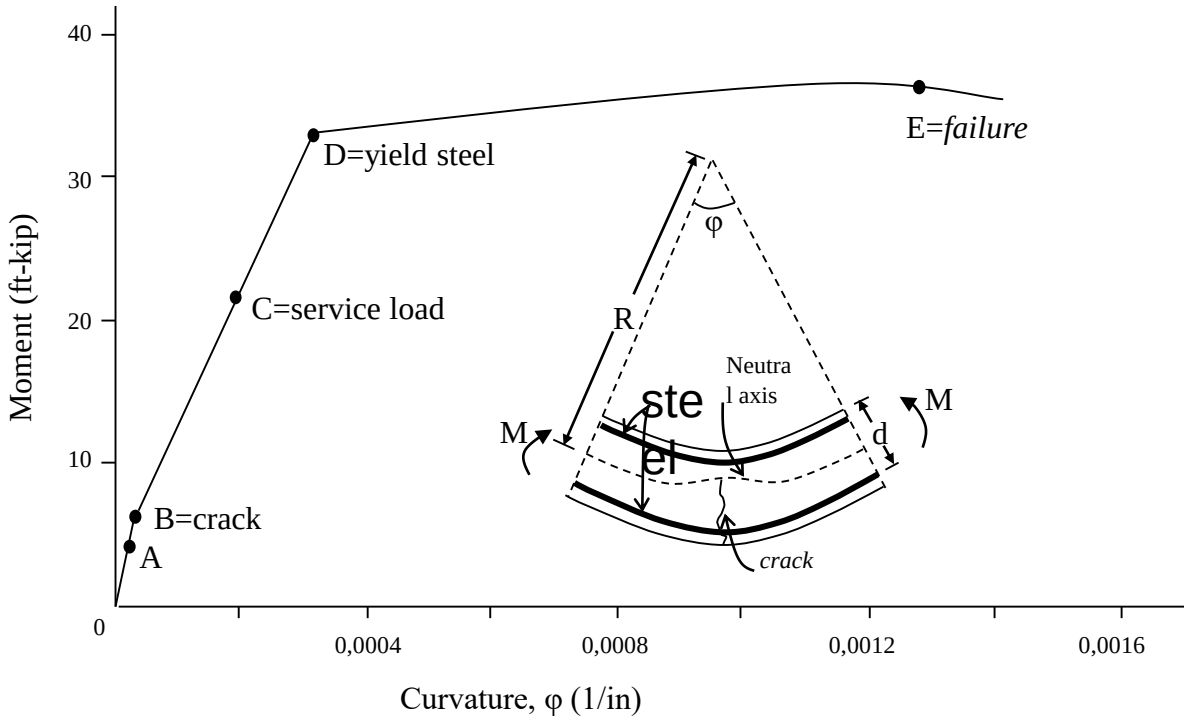
In RC, flexural members defined, i.e. beams. Plastic hinge under flexure can be happened if:

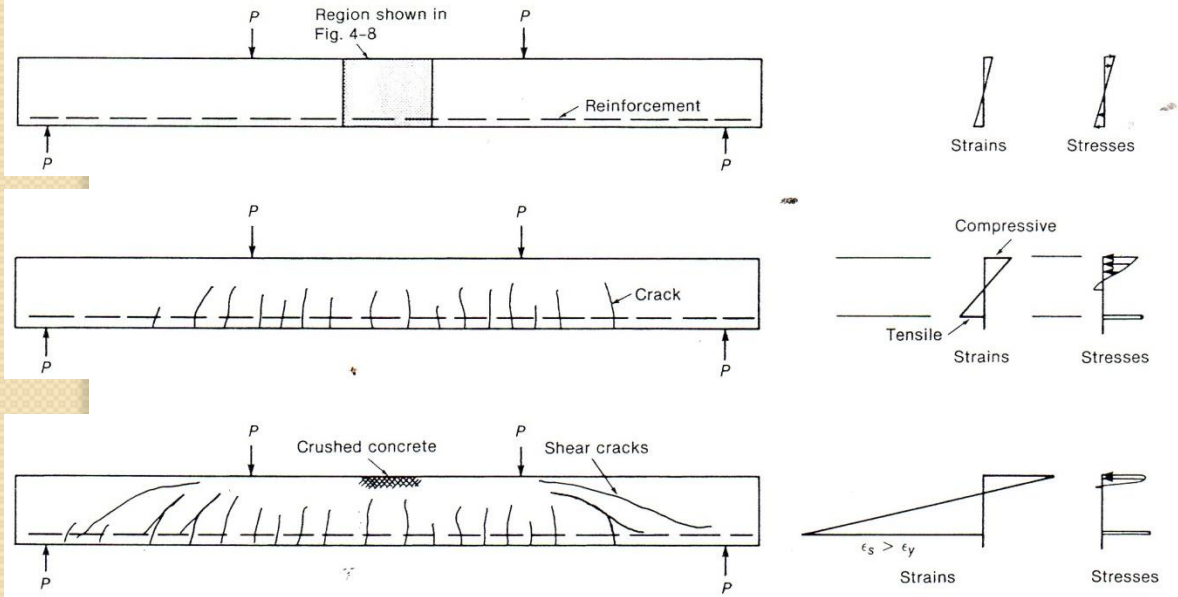
a) Shear Strength > Flexural strength

b) Small shear deformation

c) Not brittle failure both under moment or shear

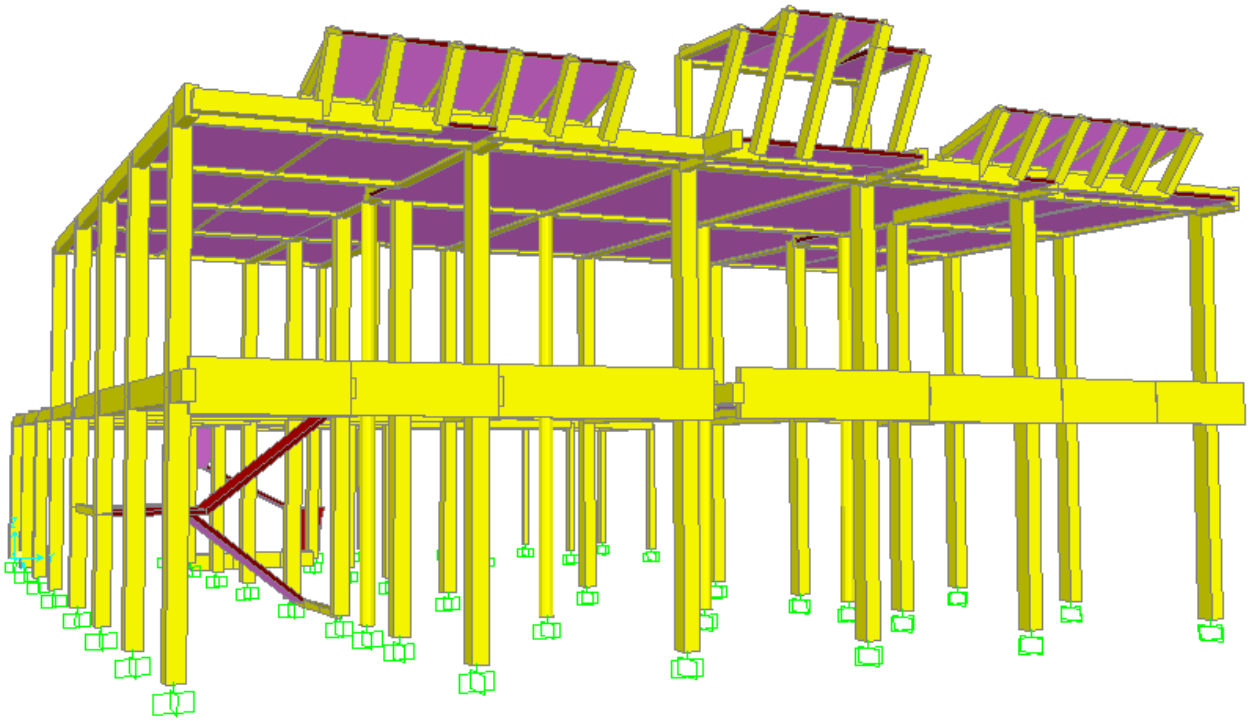
Basic Concept of Flexural RC Members





Case Studies

Building with 2 storey



There are no connection

Under standard

2nd floor vibrating

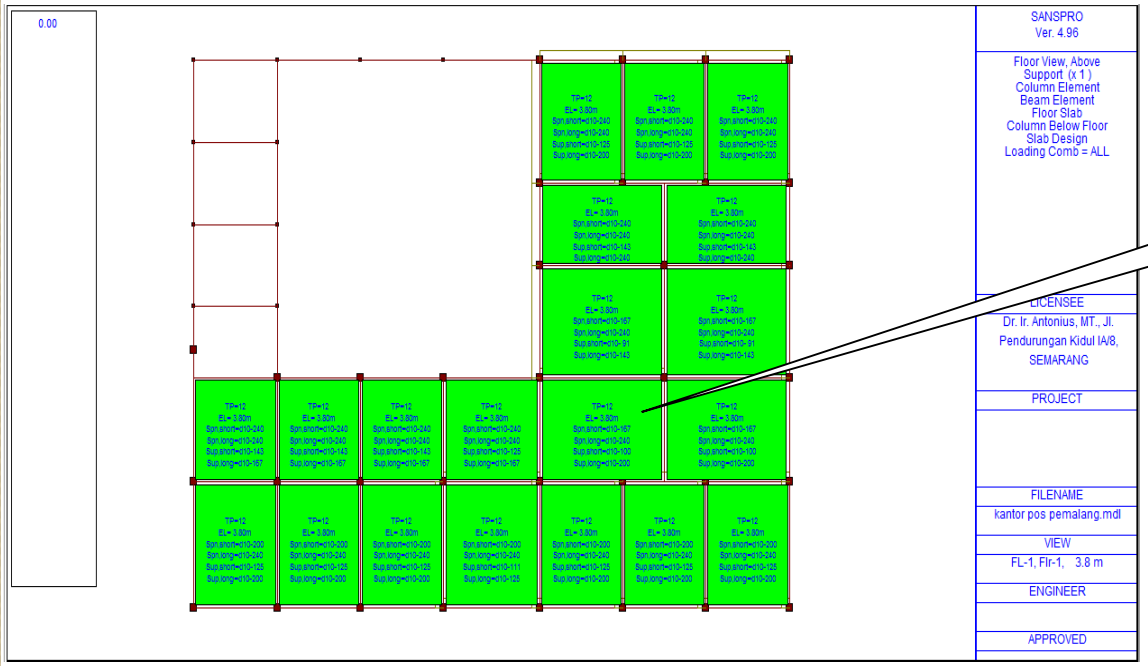
Average concrete strength133 kg/cm2 (K-133)

Thickness of plate 90 mm (core drill test)

Wide crack on wall at 1st floor

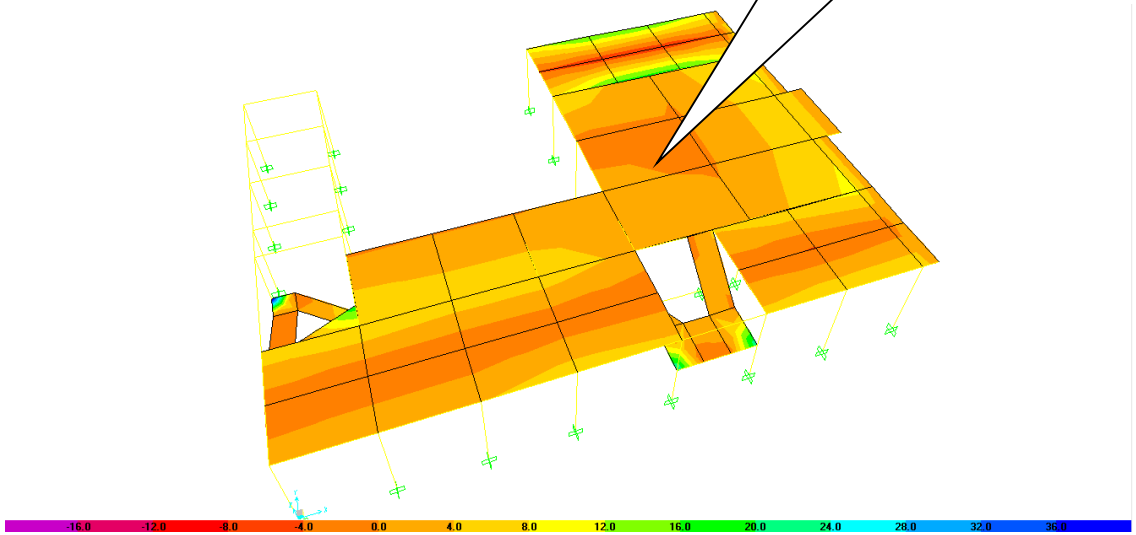
Deflection at 1st floor, Indication of foundation settlement

Analysis of plate

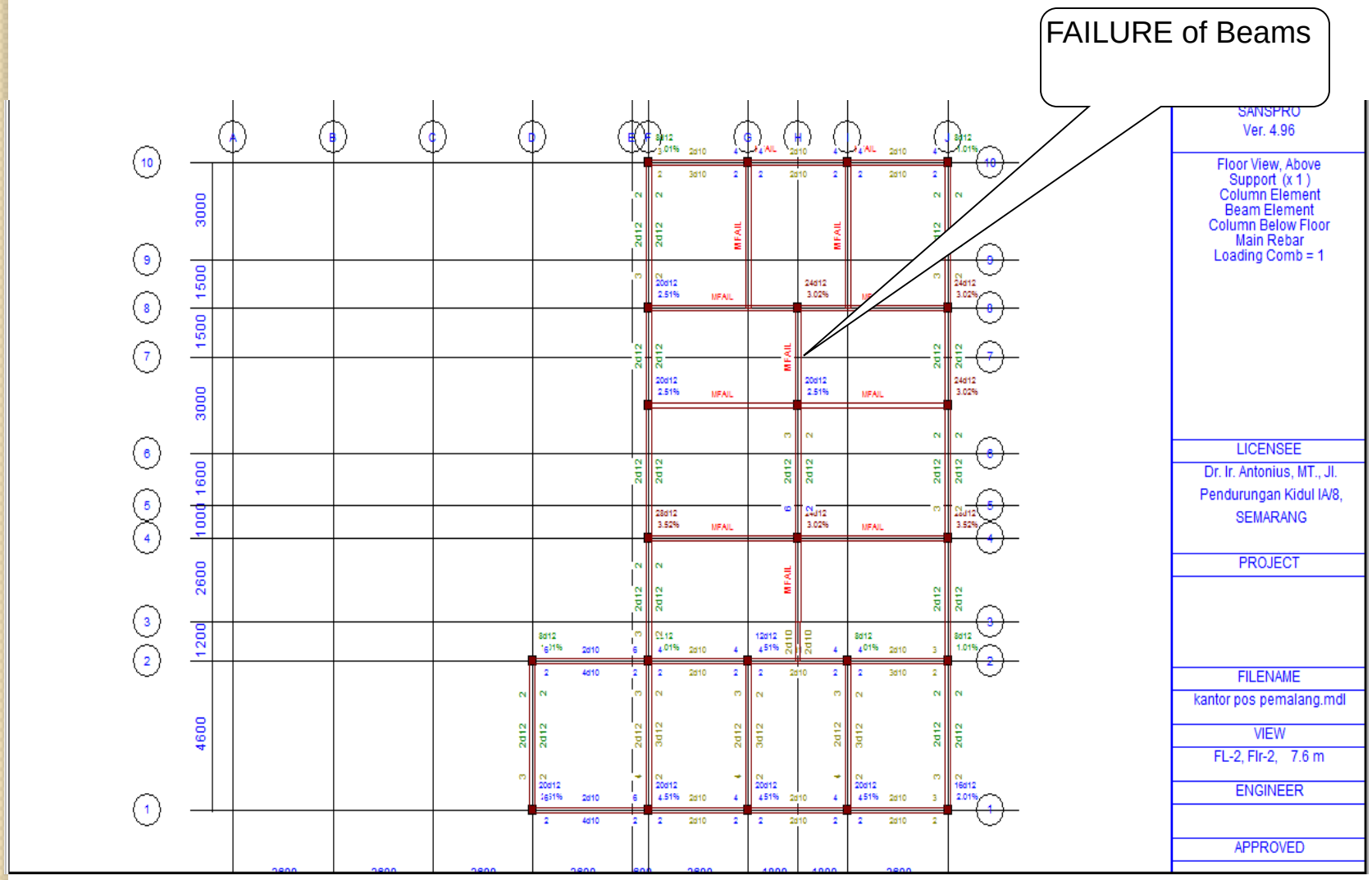


Re-design need more reinforcement ratio

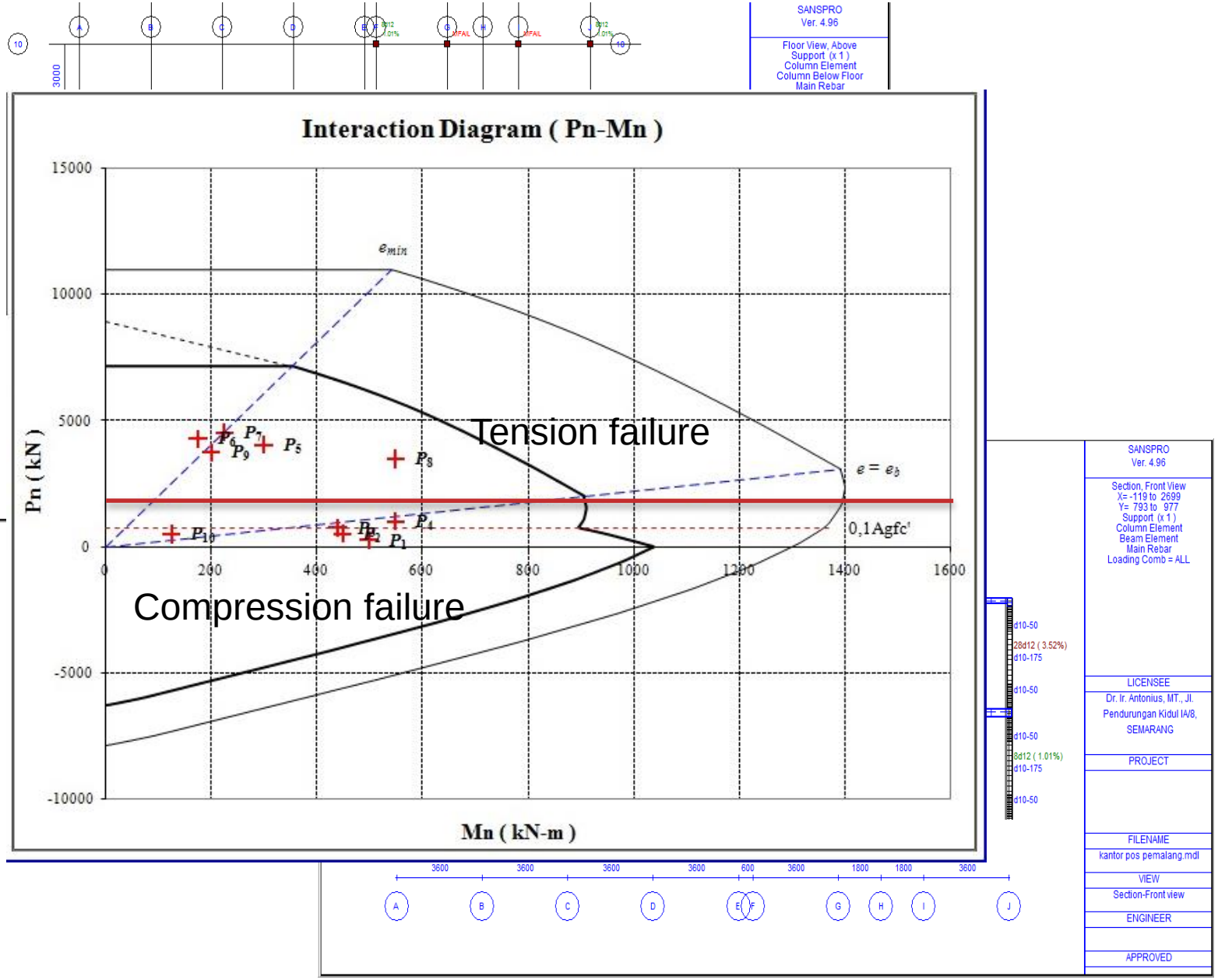
Maxium tensile stress



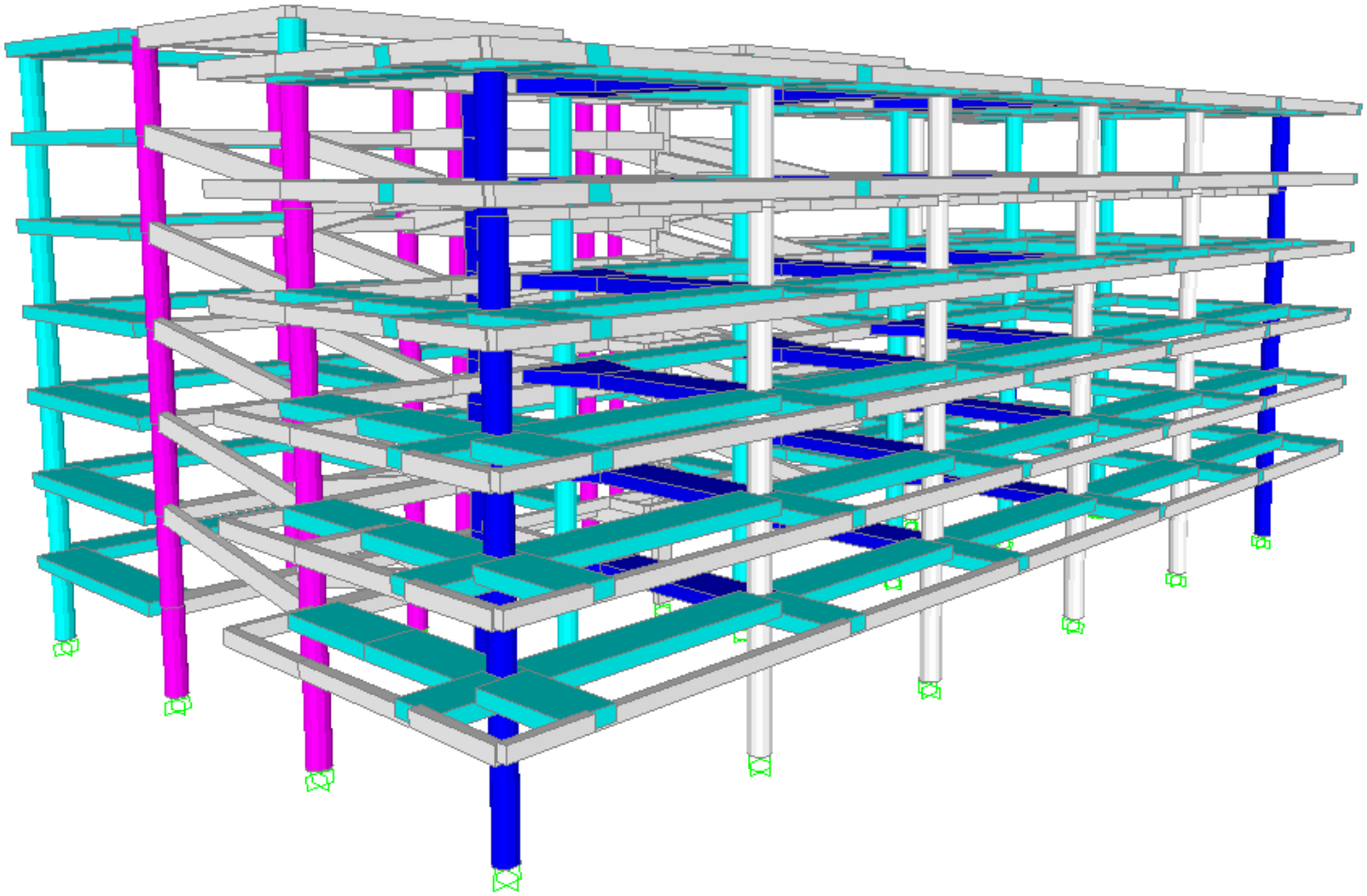
Analysis of Beams



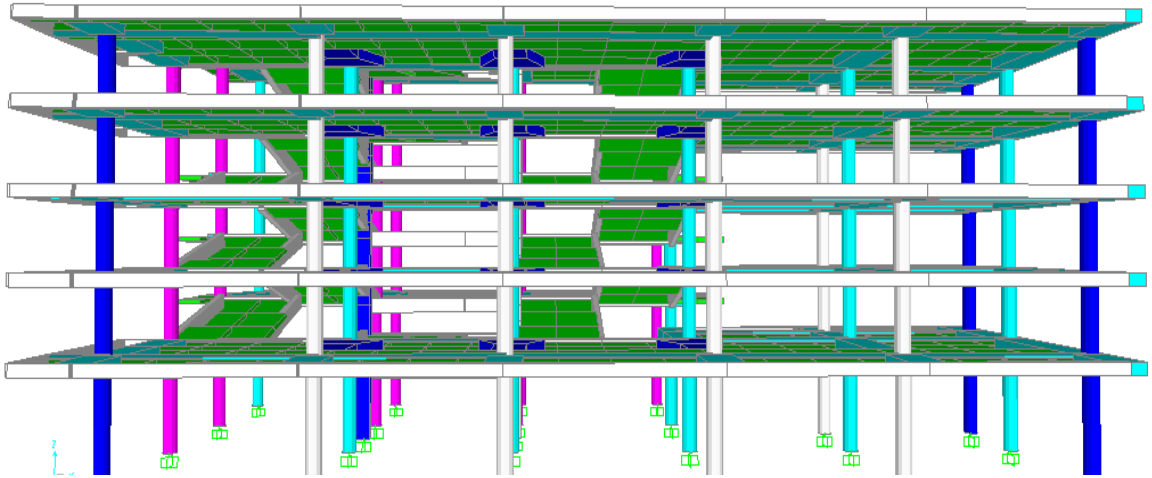
Analysis of Columns

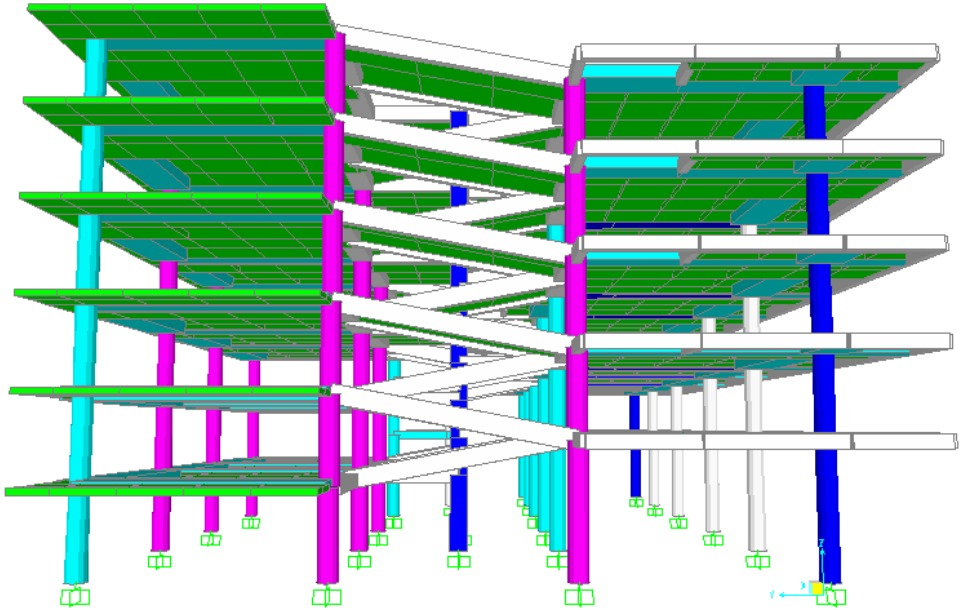


Case study of Park Building, 8 Storey



Frame structure





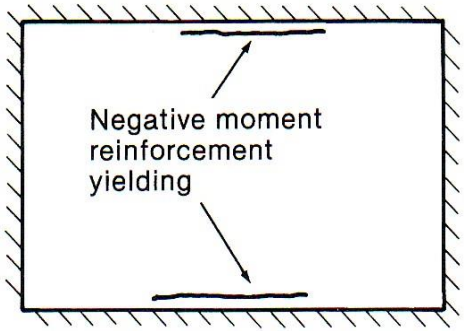
Exixting plates condition

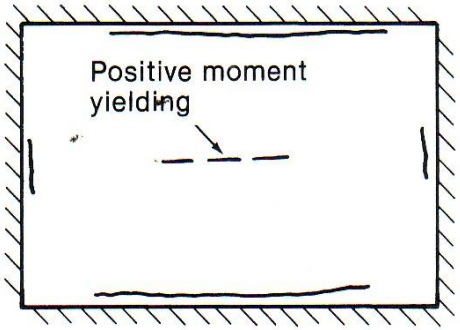
Objective

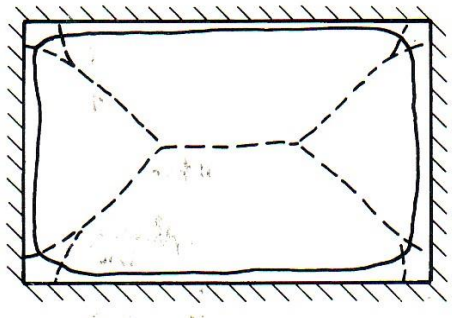
Melakukan pemeriksaan teknis kemampuan layan bangunan gedung terutama pada Lantai 6 di sebelah selatan. Evaluasi yang akan dilakukan adalah :

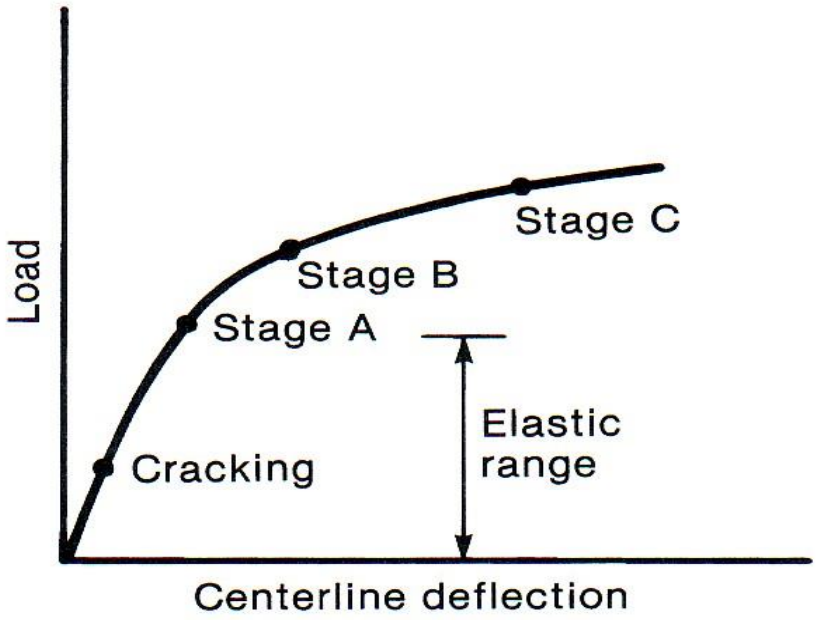
- Evaluation of concrete strength exixting (f'_c or K)
- Capacity of plate existing by Loading Test
- Recommendation for repair and strengthening.

Two Way Slab

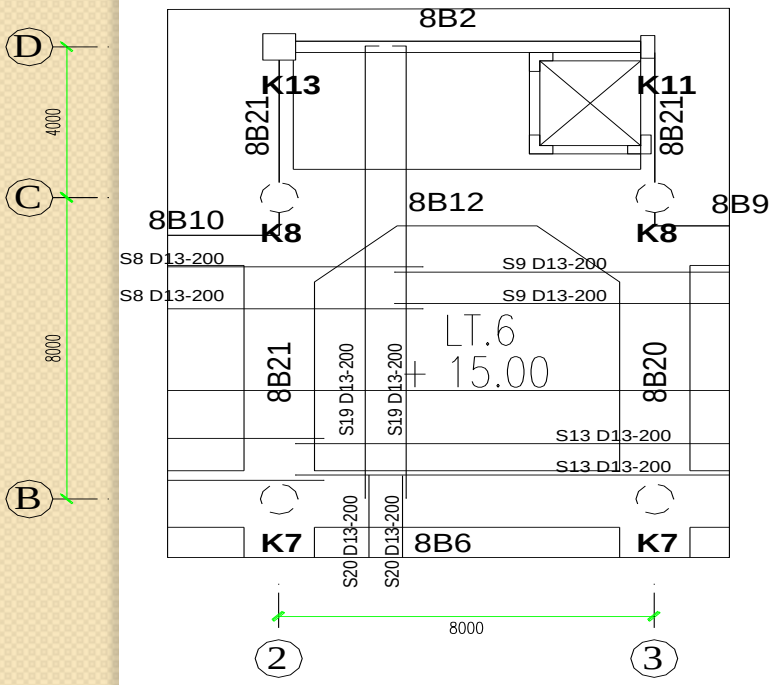

Negative moment
reinforcement
yielding

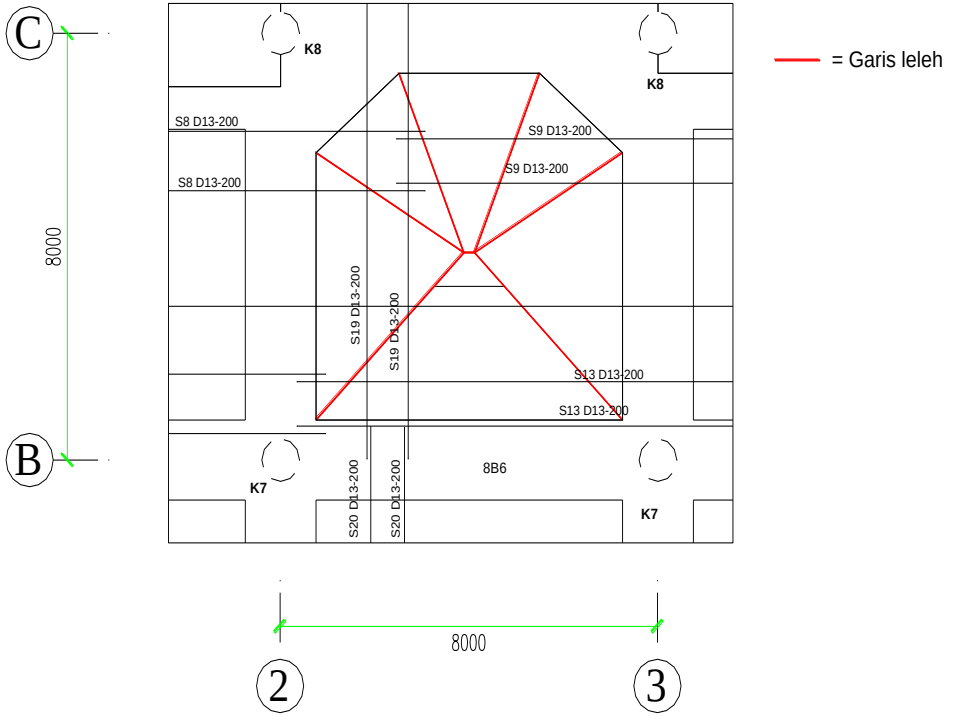

Positive moment
yielding



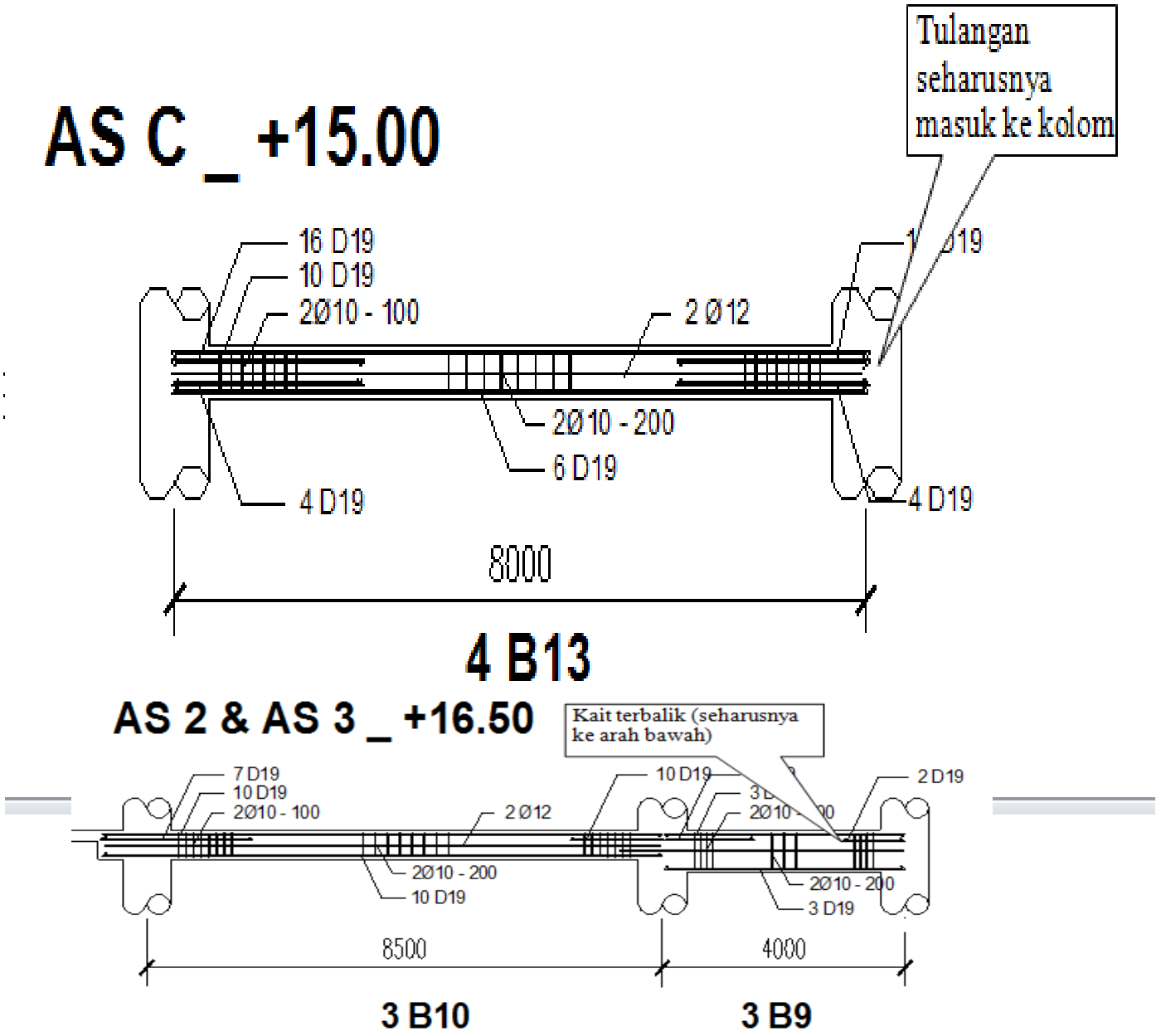

Load
Stage C
Stage B
Stage A
Cracking
Elastic
range
Centerline deflection

Detail Evaluation of Plate Design





Evaluation Design of Beam

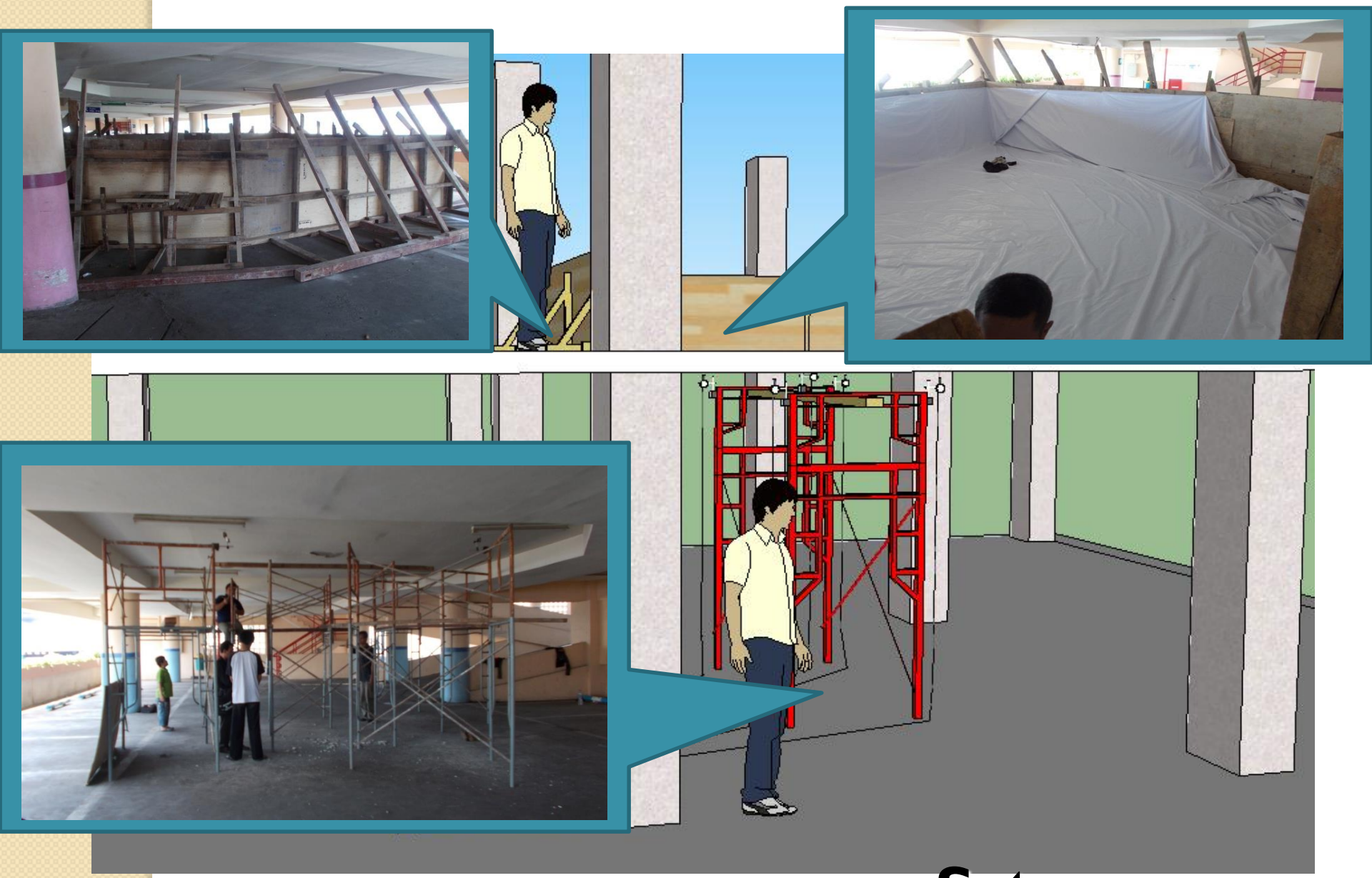


Gambar 4.5. Penulangan balok As-2 dan As-3

Non-destructive test

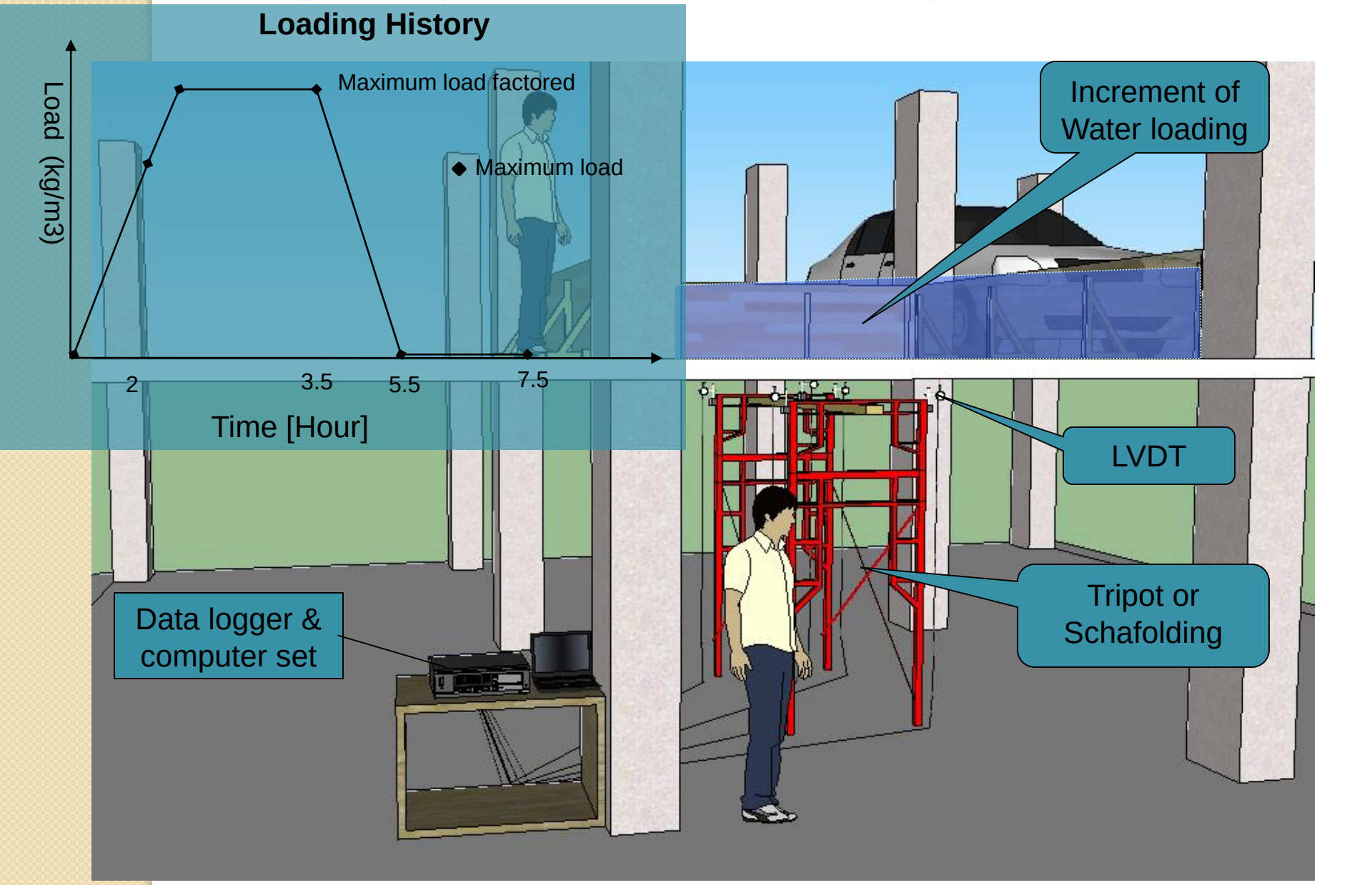
Concrete compressive strength characteristics for plate on 6th floor = K177 or f'_c=14,7 MPa.

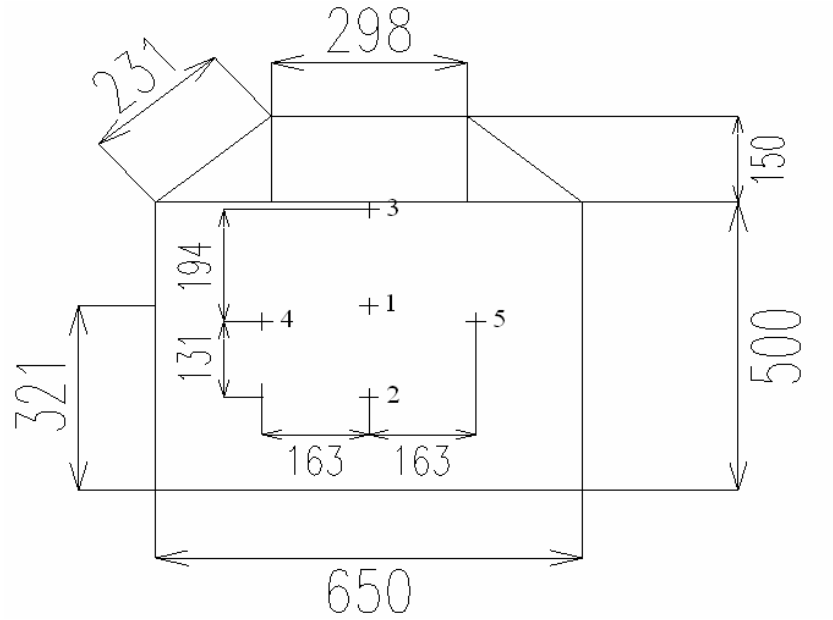
Loading test (Semi Destructive Test)



Set-up

Loading test (Semi Destructive Test)

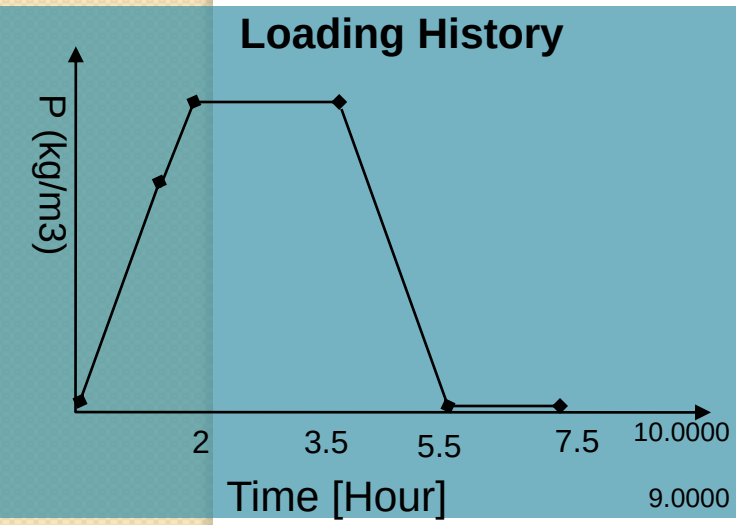


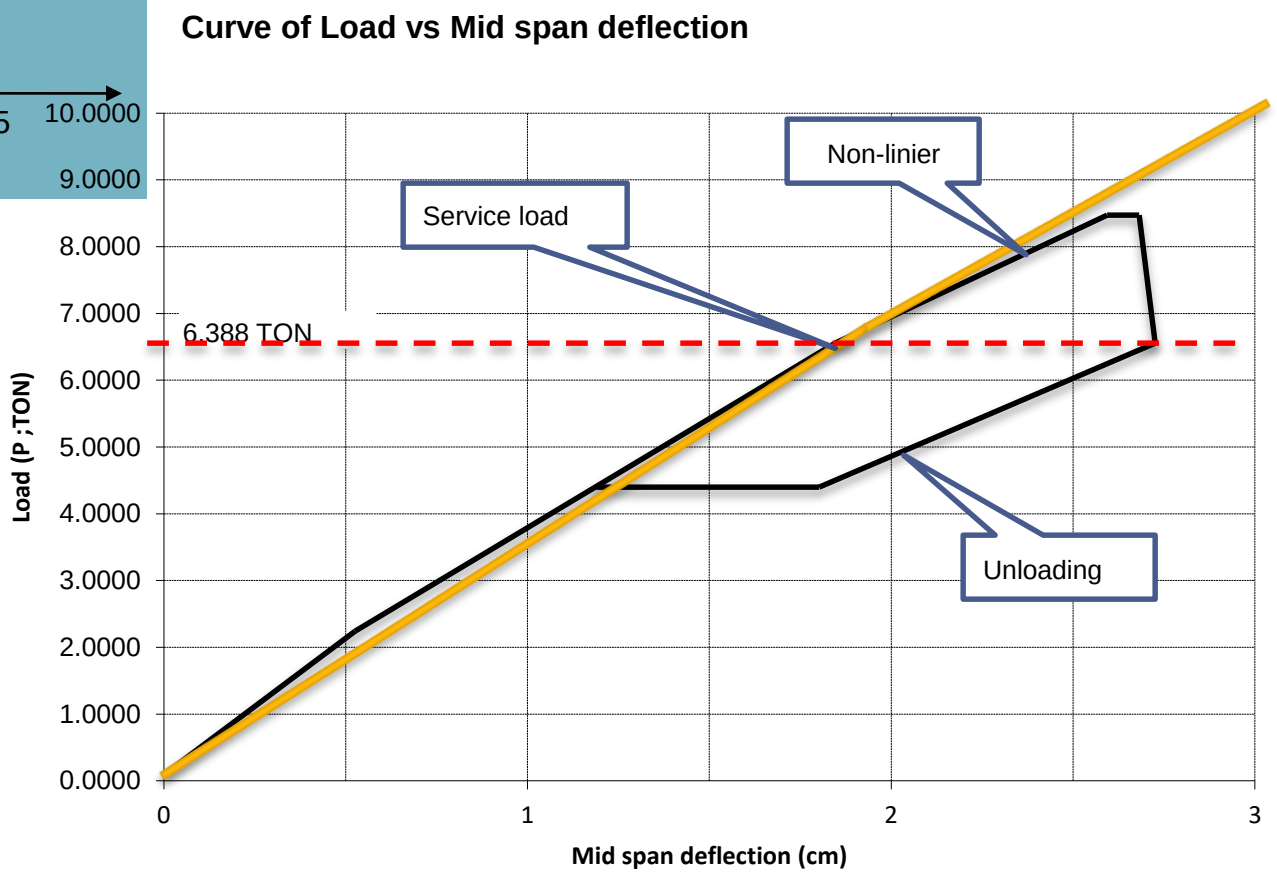


Installation of LVDT and Dial gauge on plat

LVDT at mid span of plate

Result of Loading Test





Stress of Existing Plate

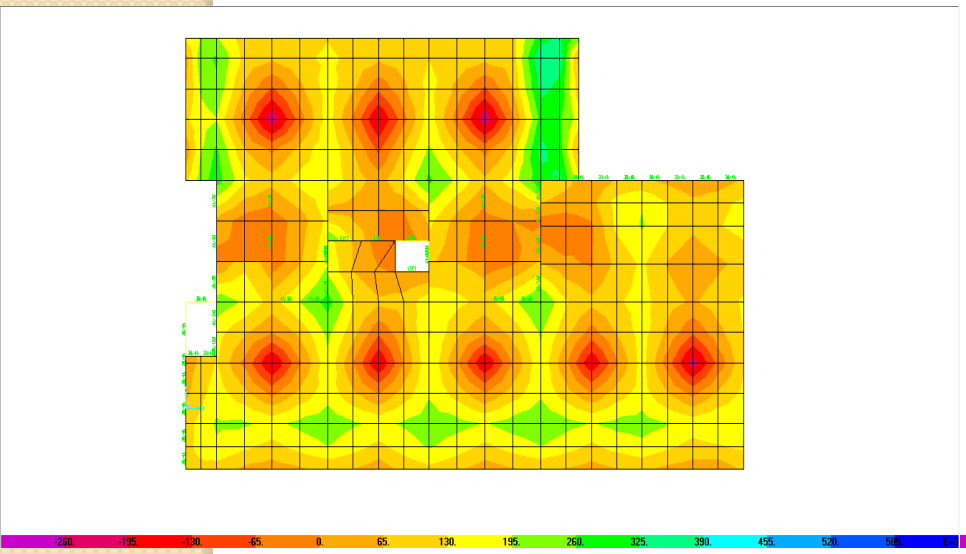


Diagram of flexural stress

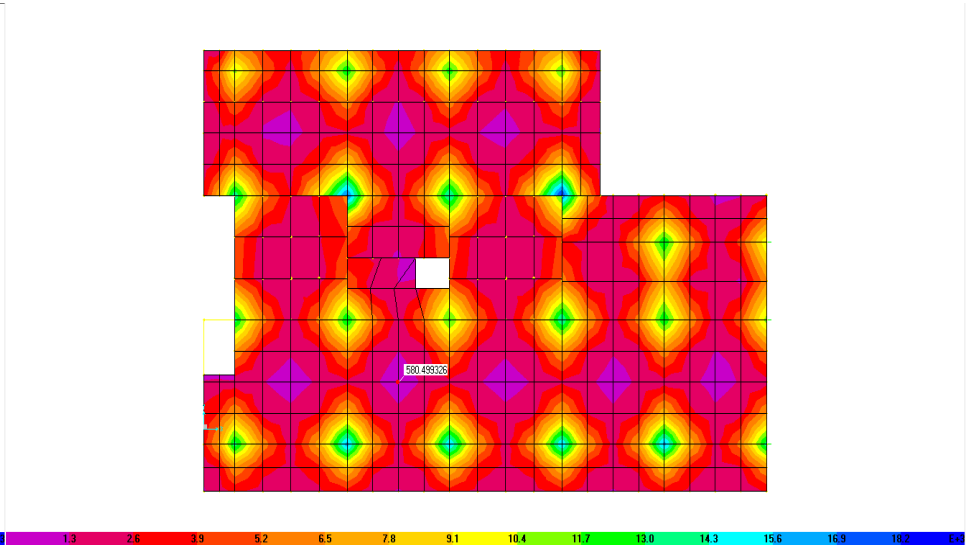


Diagram of shear stress

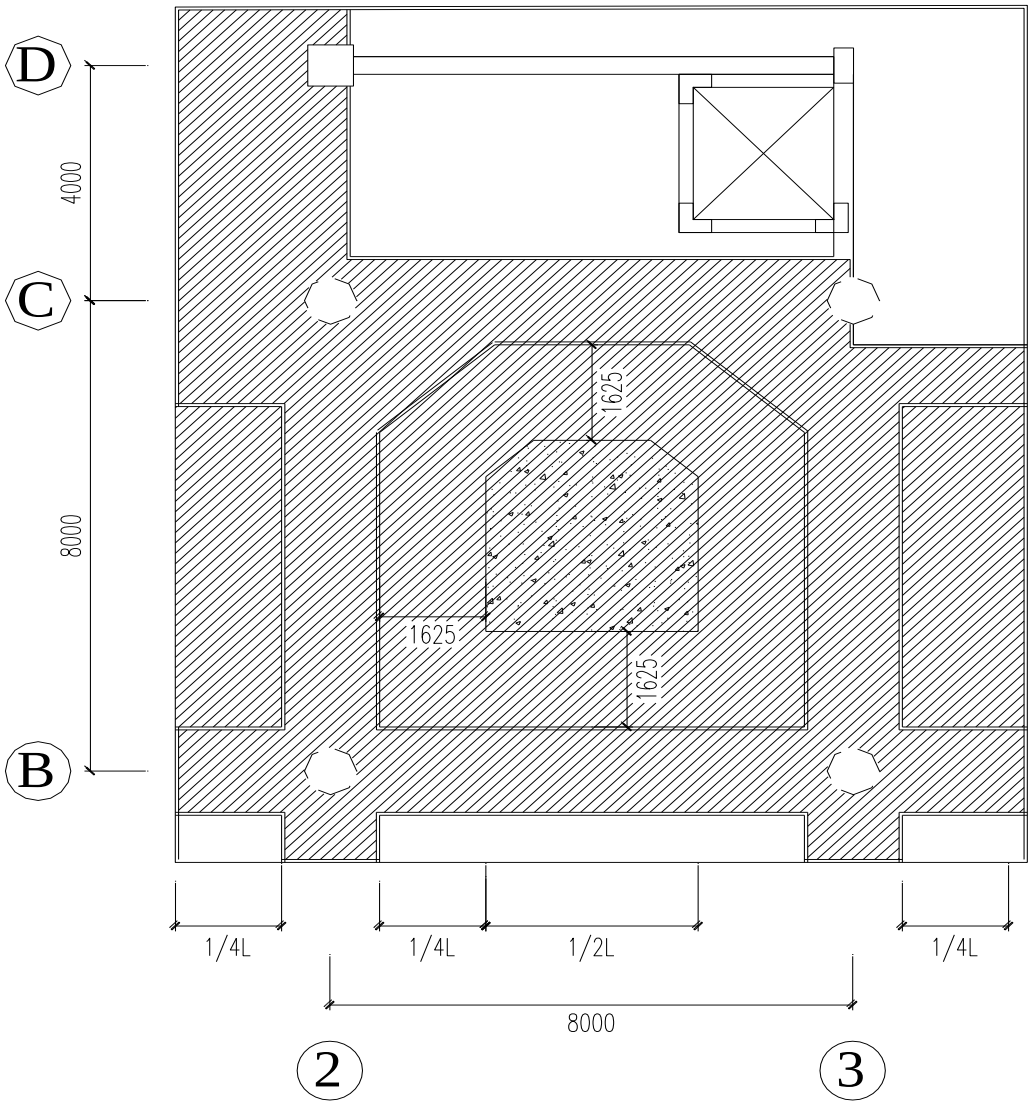
CONCLUSIONS & RECOMENDATION

Properties	Analysis	Loading Test
Service load (ton)	6,393	**6,338**
Live load (kg/m^2)	**150,42**	**195**

Main Conclusion :

•Plate on 6th floor (As 2-3 and As B-C) underestimate for live load, so the plate to reconstruction.

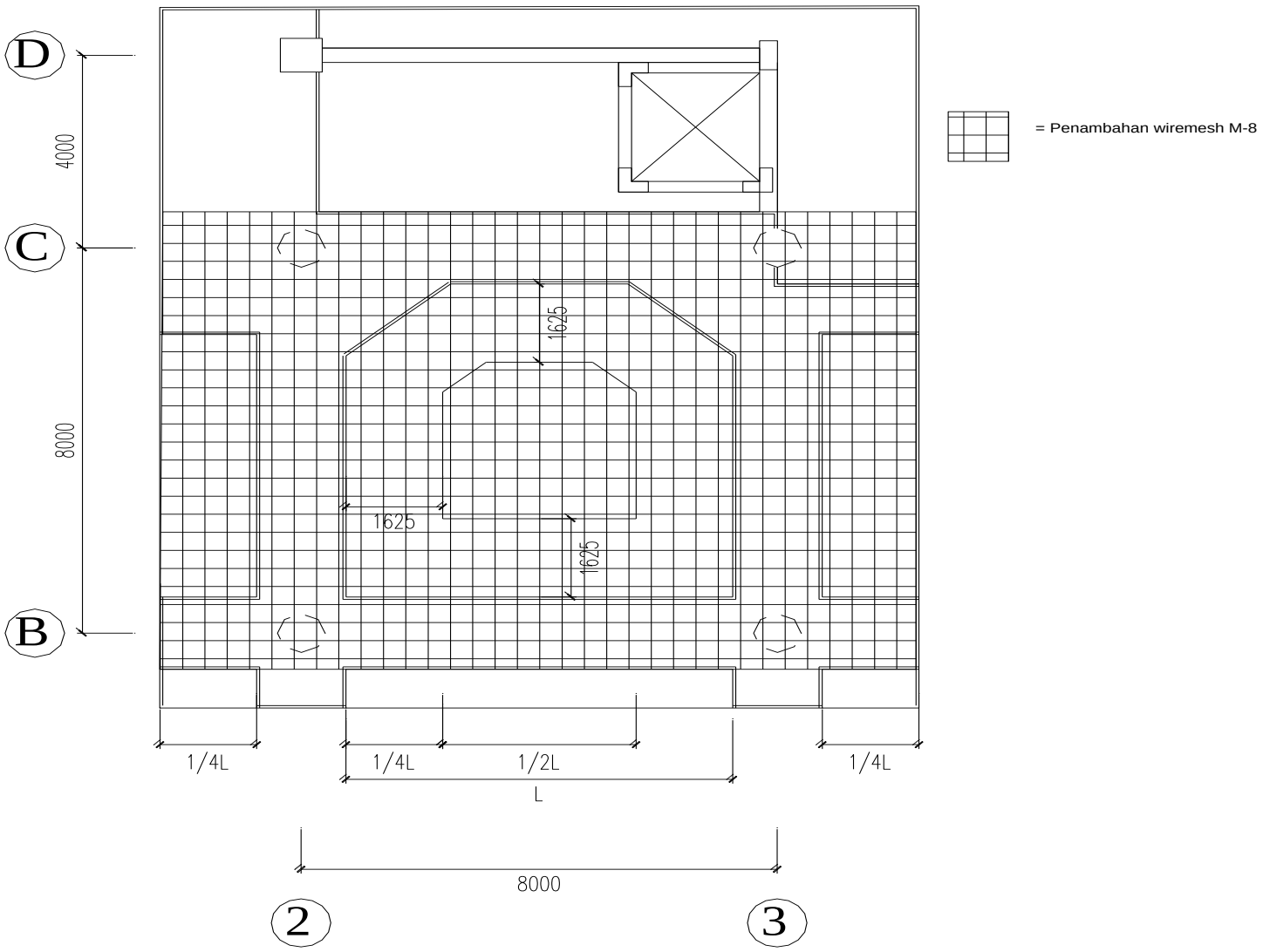
•Other plat must strengthening



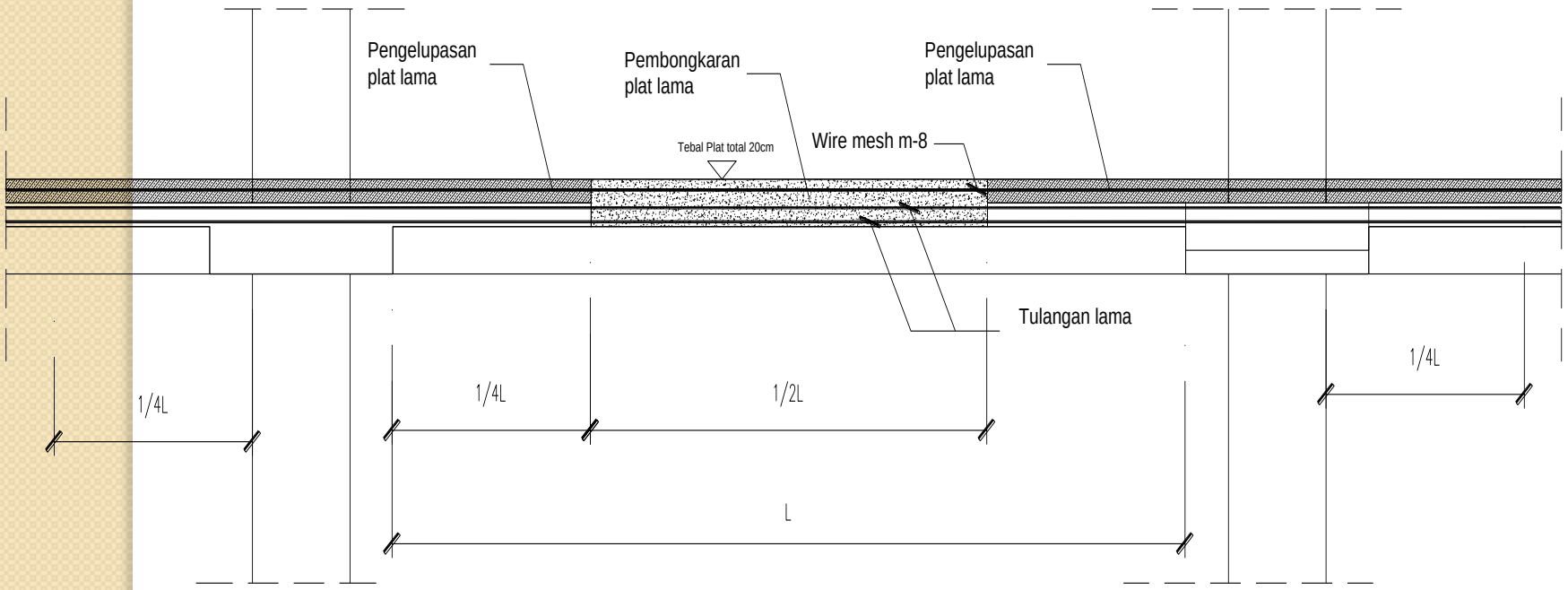
= Pengelupasan selimut beton

= Pembongkaran plat beton

Thicker of Plate



Added of Reinforcement

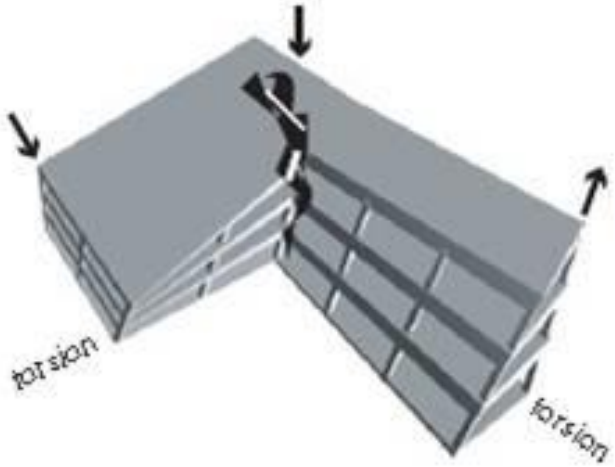


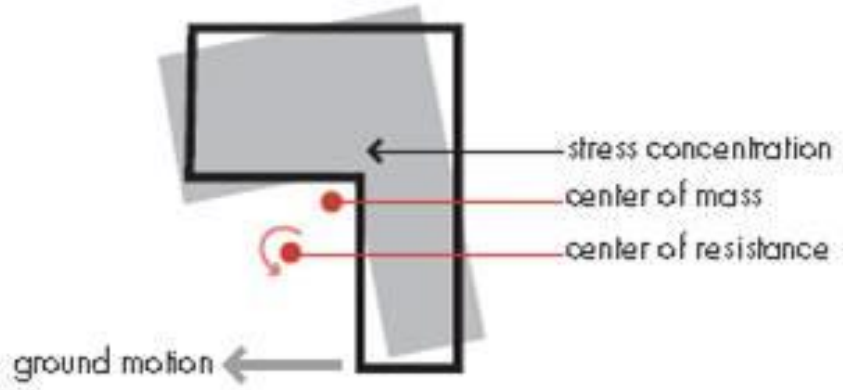
Design section

Structural characteristics that result in behavior are less well against earthquakes

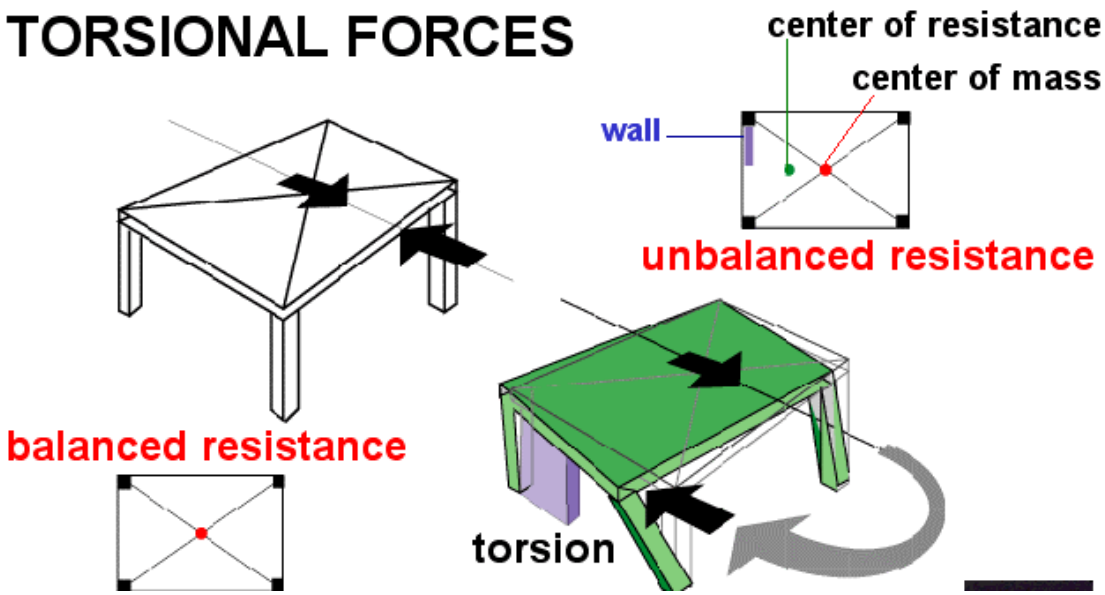
- Short columns
- Configuration of structure, regular vs irregular
- Soft storey
- Strong beam – column weak
- Un-uniform of stiffness distribution, both vertical and horizontal
- Non-structural component
- Unreinforced Masonry

TORSIONAL FORCES and STRESS CONCENTRATION





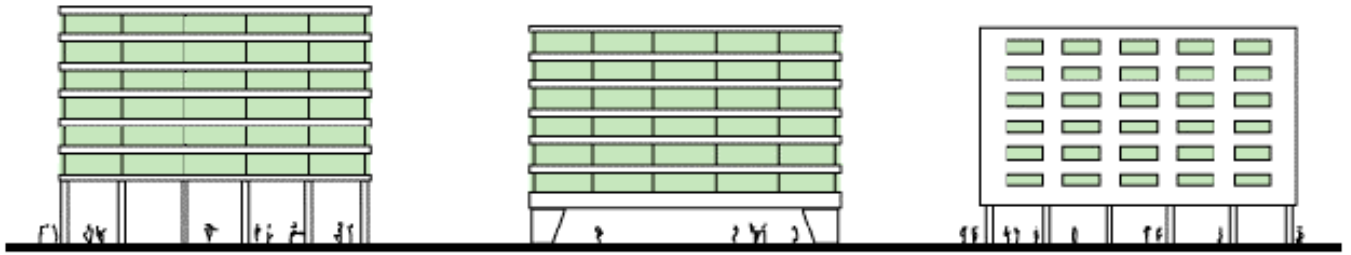
Eccentricity



Soft Story

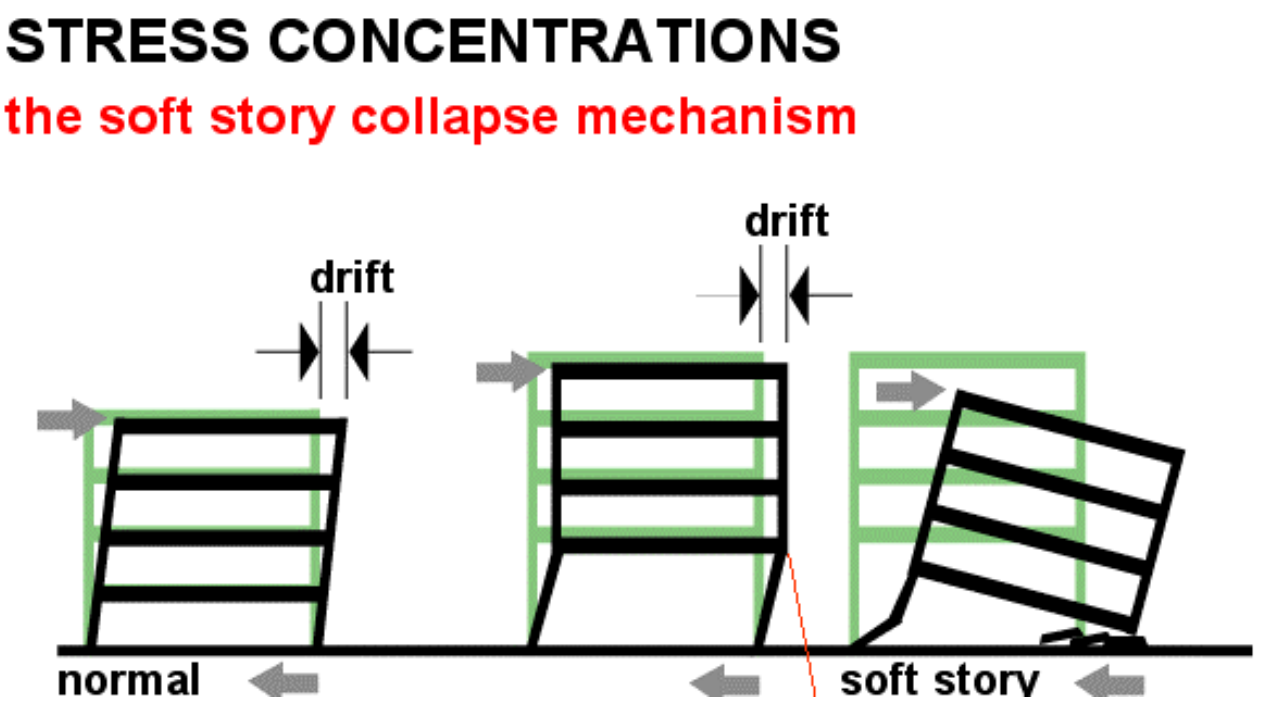
STRESS CONCENTRATIONS

The most serious condition of vertical irregularity is the soft or weak story, in which one story, usually the first with taller, fewer columns, is significantly weaker or more flexible than the stories above.



flexible 1st floor | discontinuity | heavy superstructure

Failure of Soft Story



soft stories

Failure of Structures under Soft Storey Effect

Padang Earthquake 2009

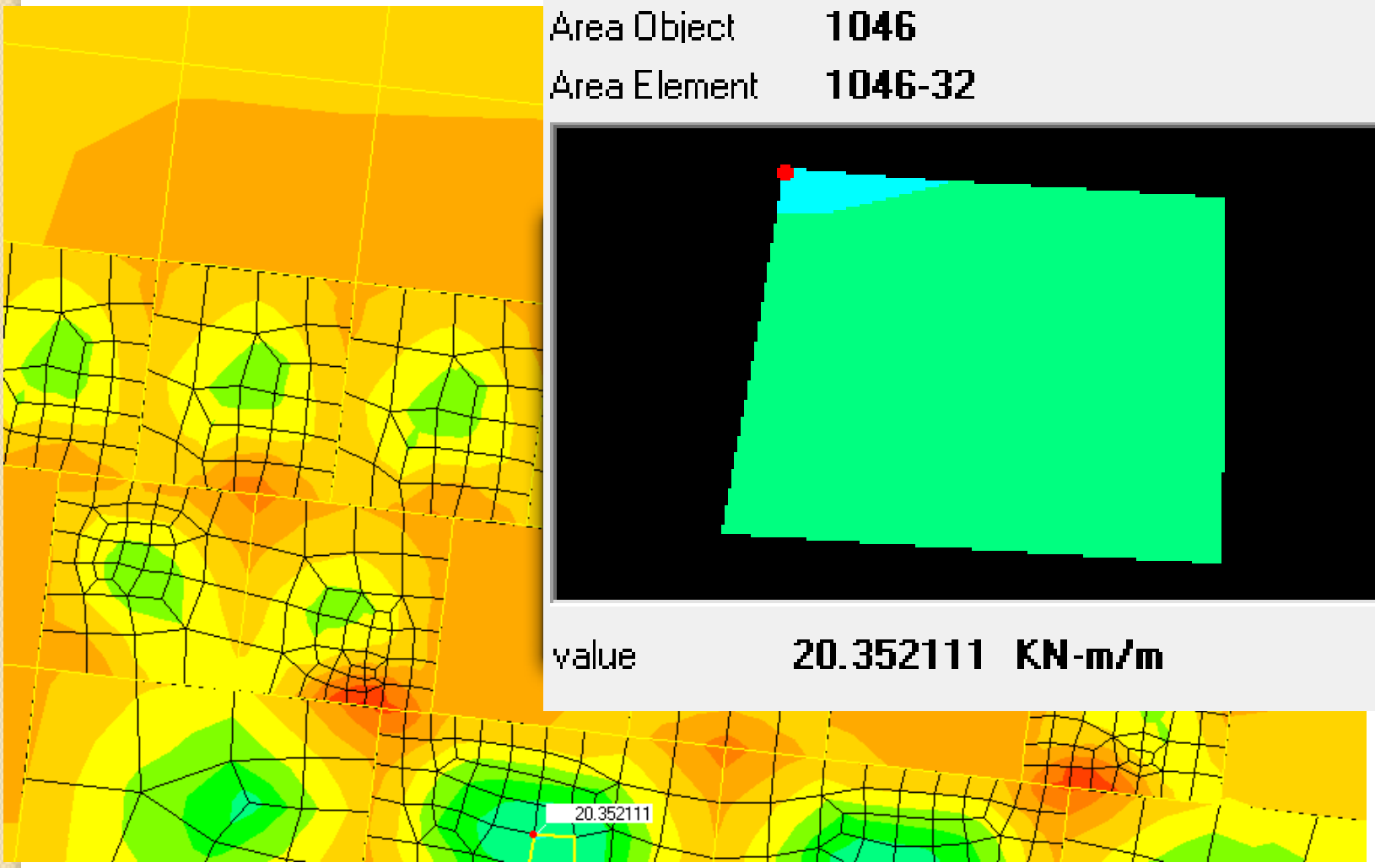
STRENGTHENING OF STRUCTURES

AFTER FIRING

Large deflection of plates

Large deflection of beams

PERKUATAN PLAT LANTAI



Material Pro
B. BAHAN

Mutu betor
Kuat tekan
Mutu baja
Untuk baja
Tegangan l
Untuk baja
Tegangan l

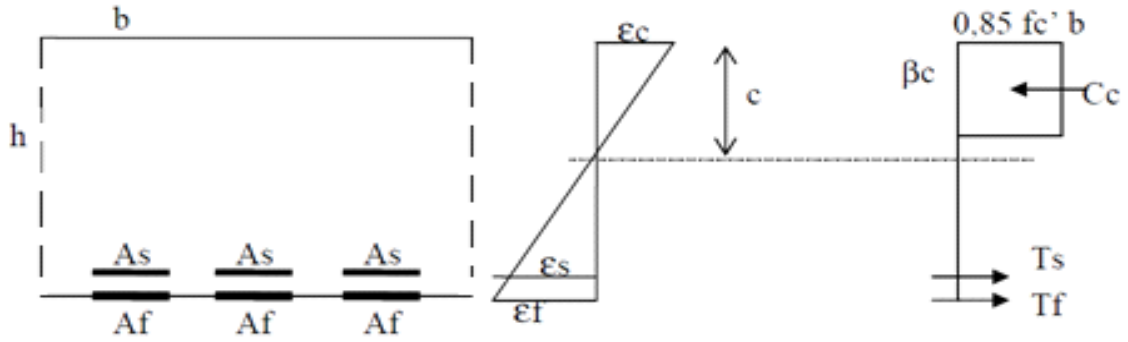
Jumlah Tula

Carbodur F
Type
Cross Secti
Modulus Ela
Tensile Stre
Ultilate Srai

Composite

Tensile Forces in ULS
Reinforcement

Carbodur Plate
Jumlah Carbodure



Momen nominal,
"Kapasitas momen ultimit"

Σ H =0
Σ M =0

Gaya internal tarik Sika Carbodur,

JARAK CARBODURE

Zs = As * fy = 108.52 kN

n = 8

ZL = As * El *(ἐL/KL) = 792 kN

Z = 908.518 KN

Mn = As * fy * (d - a / 2) * 10^{-6} = 4.341 kNm

ϕ * Mn = 3.690 kNm

> Mu 20.352 kNm

Failure

Tf =ἐL*Ef*Af = 554400 N

Cc = Ts + Kl * Tf = 496598.4 N

M Carbodure = Kl * Tf * (h-0.5*β1*c) = 20.76 kNm

MN = ϕ * (Mn + M carbodure) = 21.339 kNm

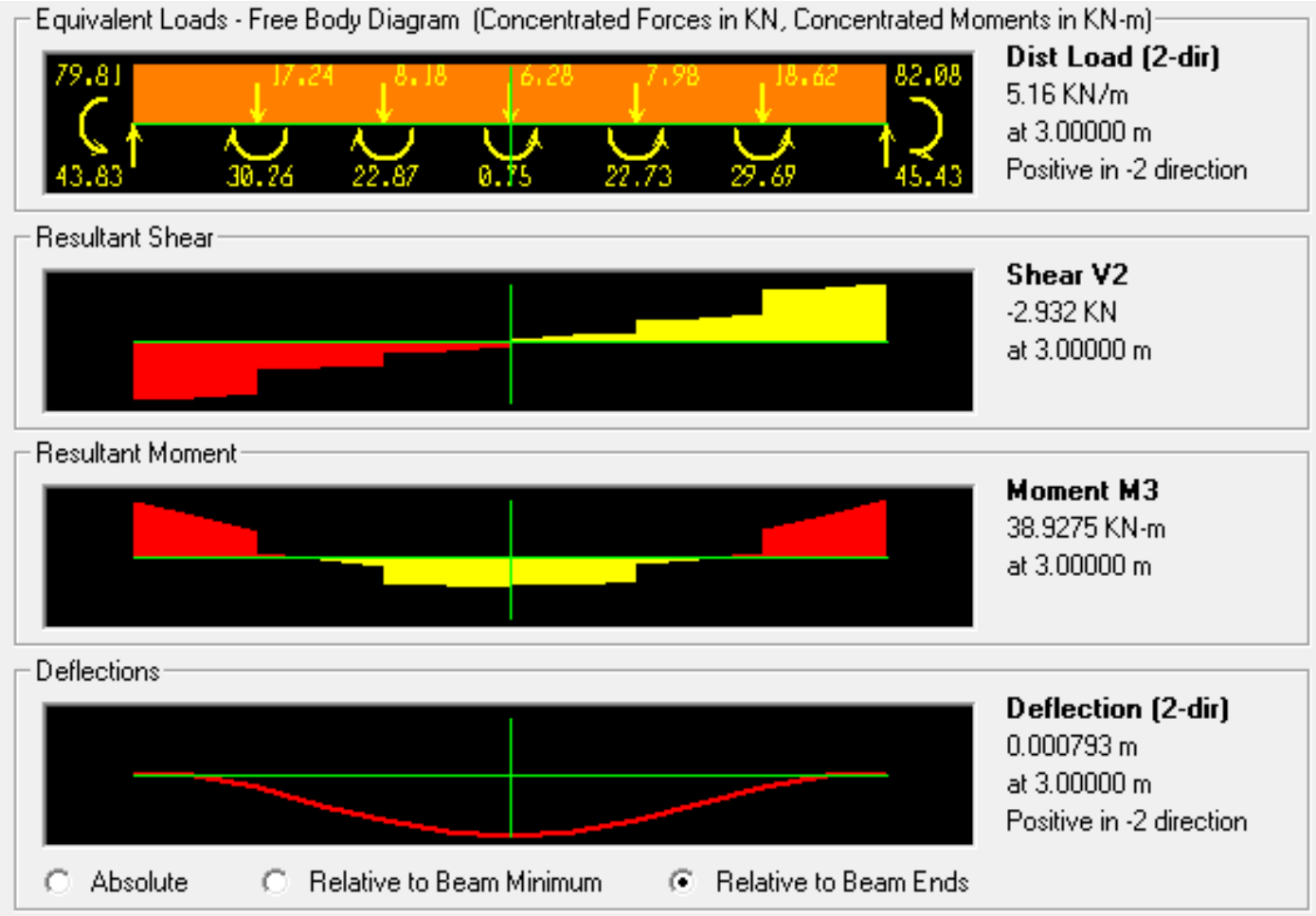
> Mu 20.35

OK

1000 MM = 125 MM

Strengthening of Plates

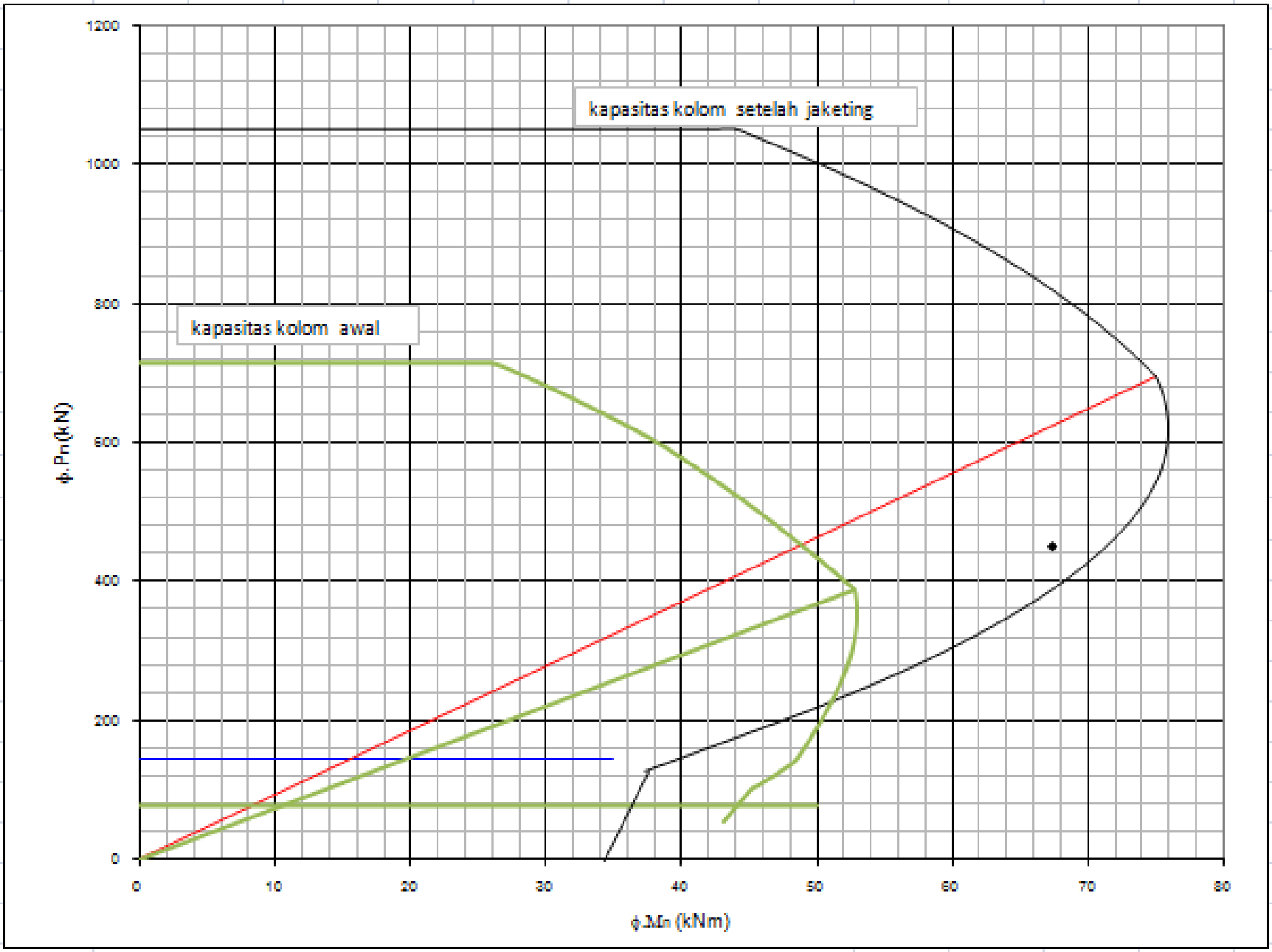
Strengthening of Beams



INSTALLATION

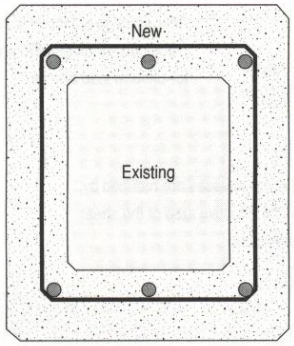
Strengthening of Flexure

Strengthening of Shear

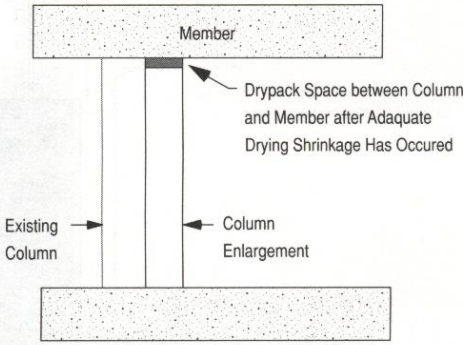


ANALISIS KOLOM DENGAN DIAGRAM INTERAKSI

Colomn jacketing



Method C



Elevation view of Method A