

Prediction and Measurement of Slab Construction Load of Wall-type Residential Building



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1. Introduction
2. Basic Concept of Load Transfer during Construction
3. Construction Load Prediction Model
4. Structural Safety Assessment of Slab
5. Structural Safety Assessment Software

1. Introduction

✓ Gwangju

Residential Building Collapse Accident



✓ Incheon

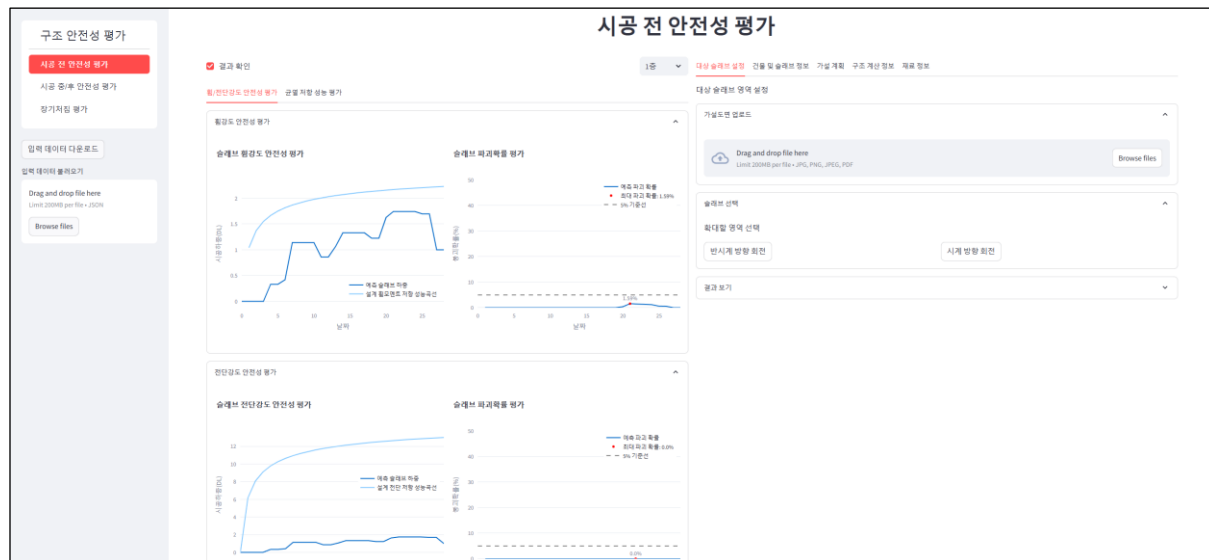
Parking Garage Collapse Accident



1. Introduction

✓ Development of Structural Safety Assessment Software

- Construction load model
- Verification of model through comparison with field measurement
- Cracking and load resistance of early-aged slab during construction
- Failure probability prediction of early-aged slab during construction



2. Basic Concept of Load Transfer during Construction

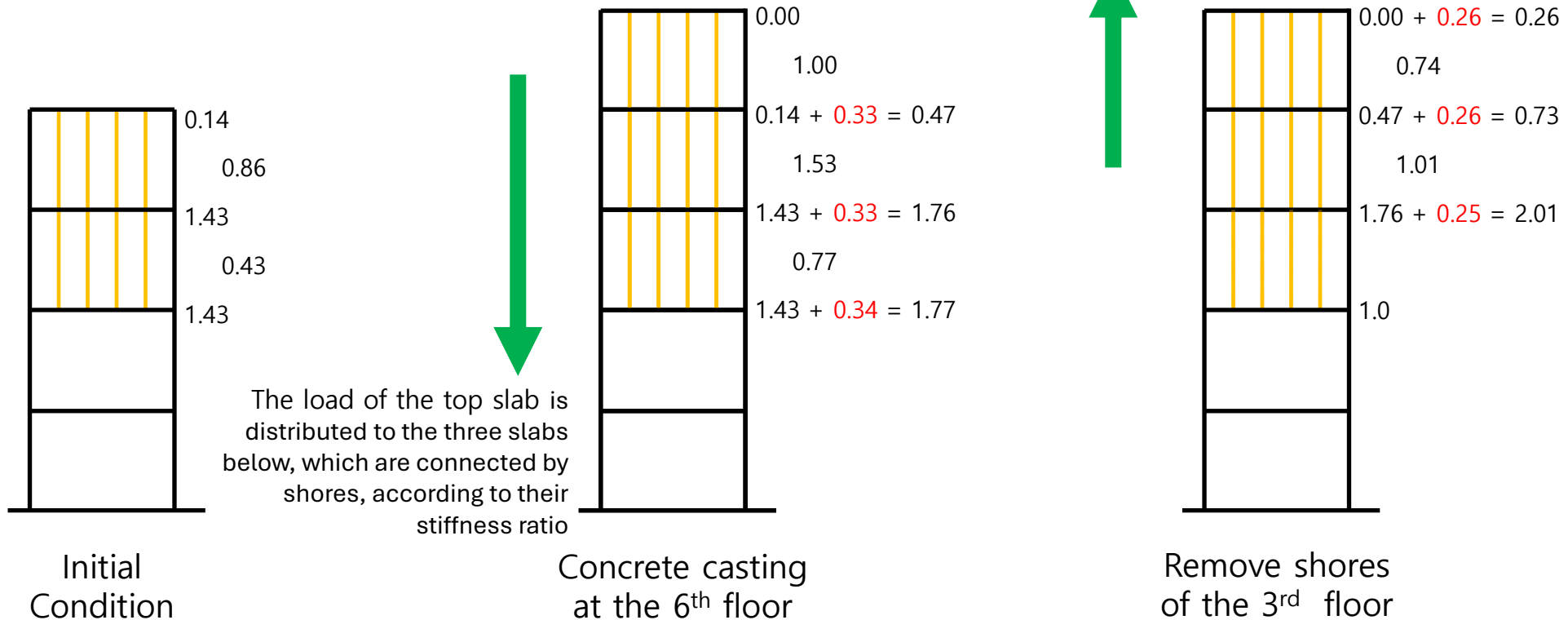
✓ Construction Load?

: Slab load transferred through form shores that support upper slab weight

* Assumption:
same slab stiffness
three levels of shores

The load previously supported by the 2nd floor shores is redistributed to the top three slabs according to their stiffness ratio

||| : shoring

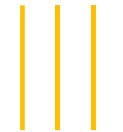


3. Construction Load Prediction Model

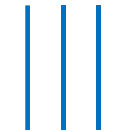
✓ Verification Site Information

Planned Construction Schedule

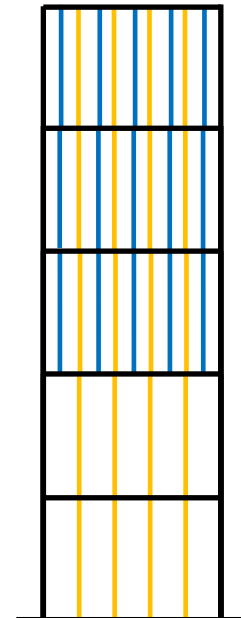
- Construction cycle of each floor : 7 days
- Number of floors supported by shores : 3 floors
- Removal of temporary support : 4 days after casting the top floor
- Removal of regular support : 5 days after pouring the top floor



: Regular support



: Temporary support



Cast 6th floor

Remove temporary supports
in 5th floor

Remove temporary supports
in 4th floor

Remove regular supports
in 3rd floor

Remove regular supports
in 2nd floor

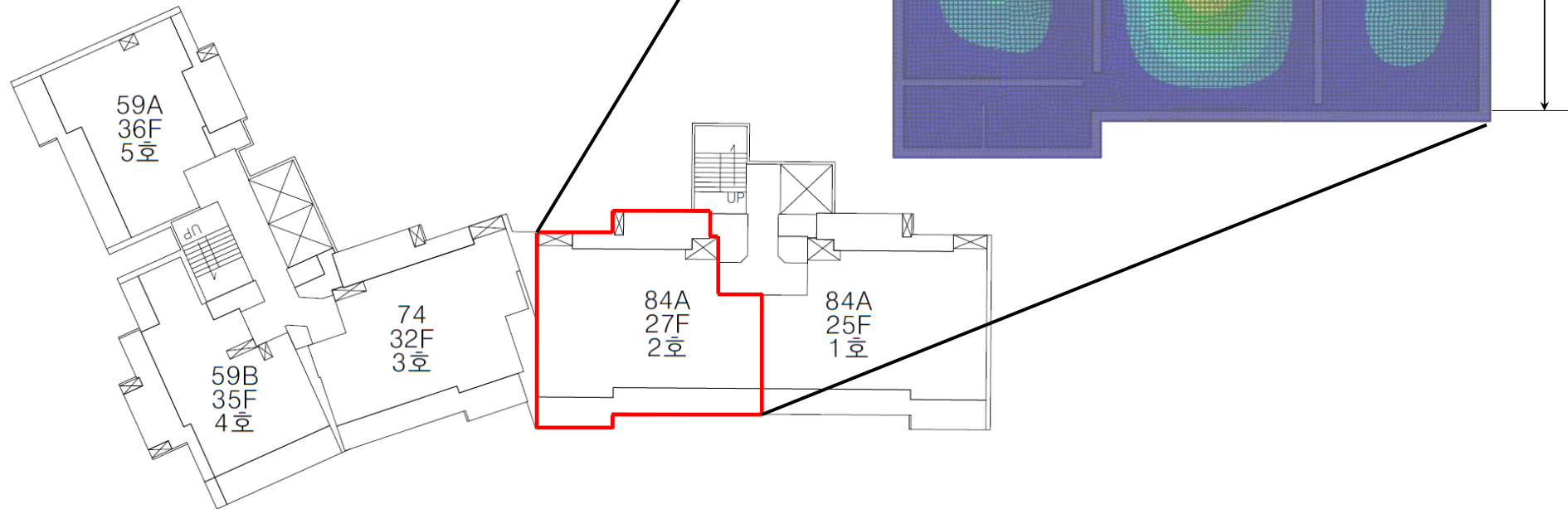
Remove regular supports
in 1st floor

3. Construction Load Prediction Model

✓ Measurement of Construction Loads

Site Information

- Reinforced concrete wall structure
- Specified concrete strength: 40 MPa
- Rebar yield strength: 500 MPa



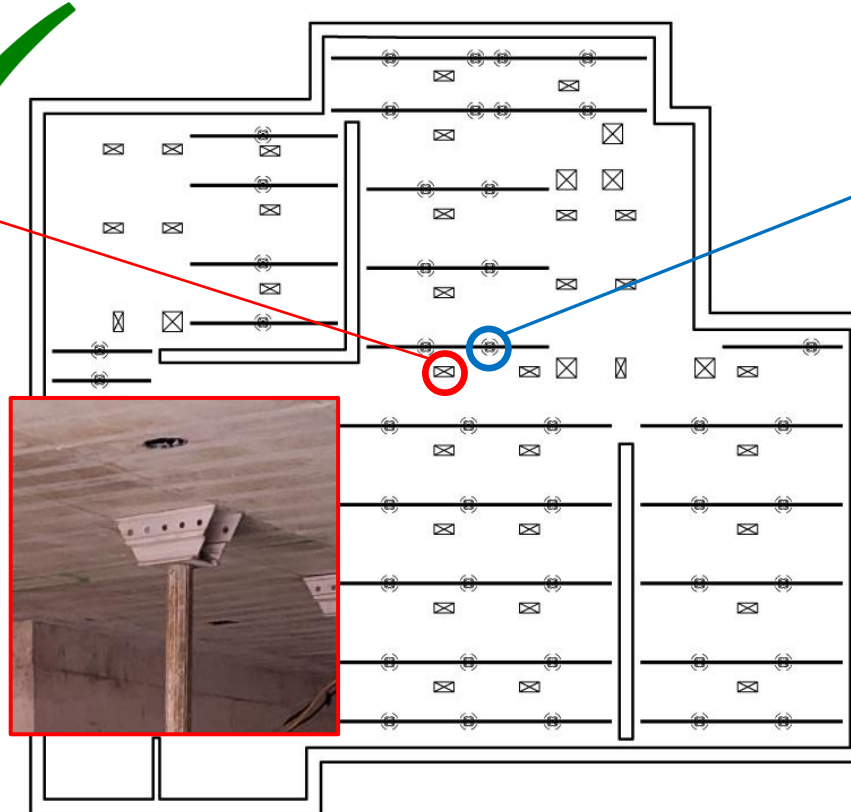
3. Construction Load Prediction Model

✓ Measurement of axial shore force

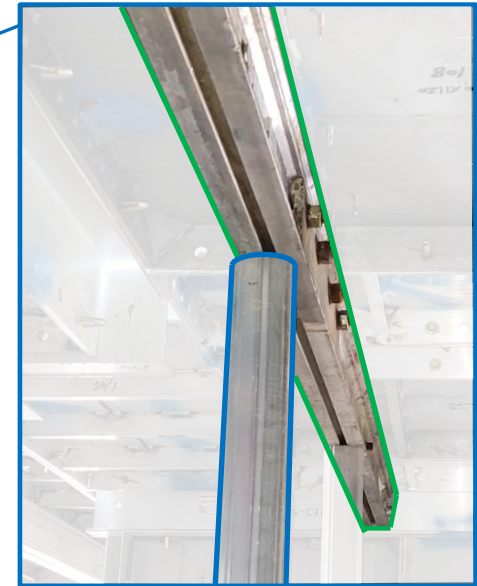
Regular support



- Supporting the upper slab
- Remains in place even after removing the slab formwork



Temporary support



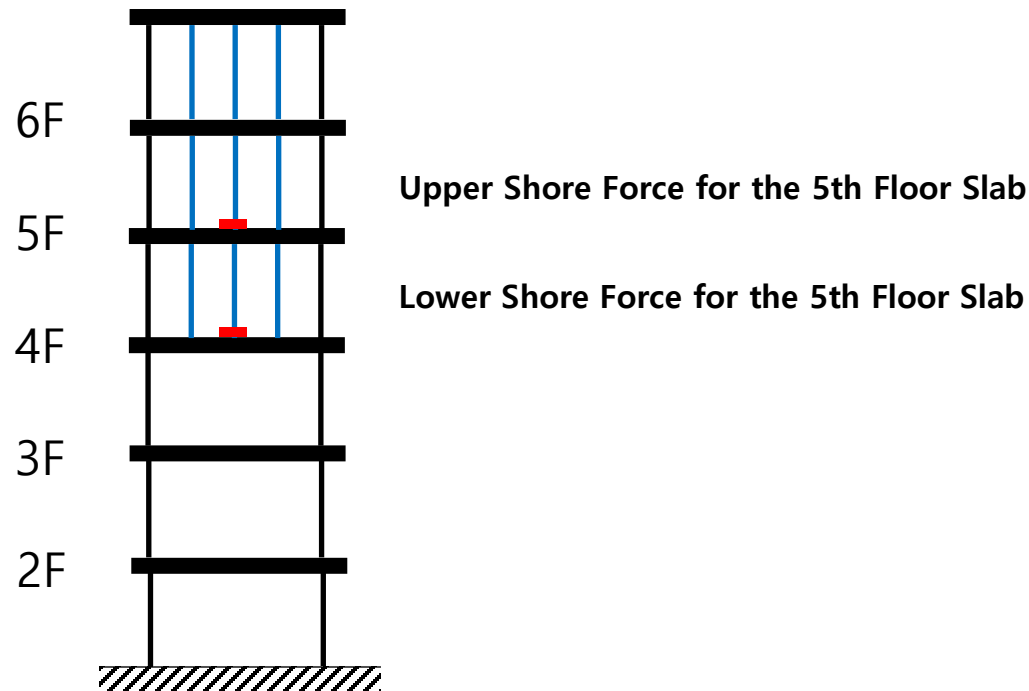
- Supporting the rail that supports the slab formwork
- Removed together when removing the slab formwork

3. Construction Load Prediction Model

✓ Conversion to Construction Load

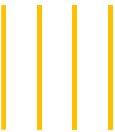
Construction Load = Upper shore force + Self-weight of slab – Lower shore force

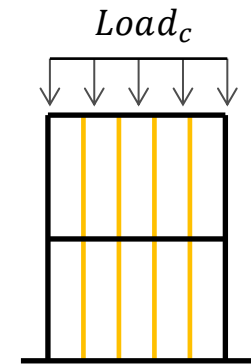
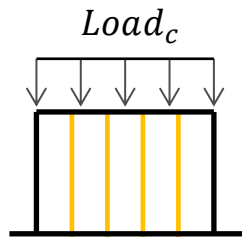
* At this time, the shore force should be converted to DL (Dead Load) units for calculation



3. Construction Load Prediction Model

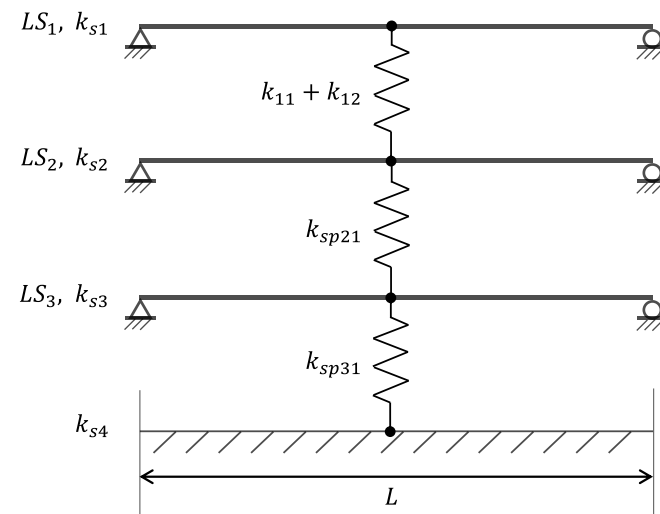
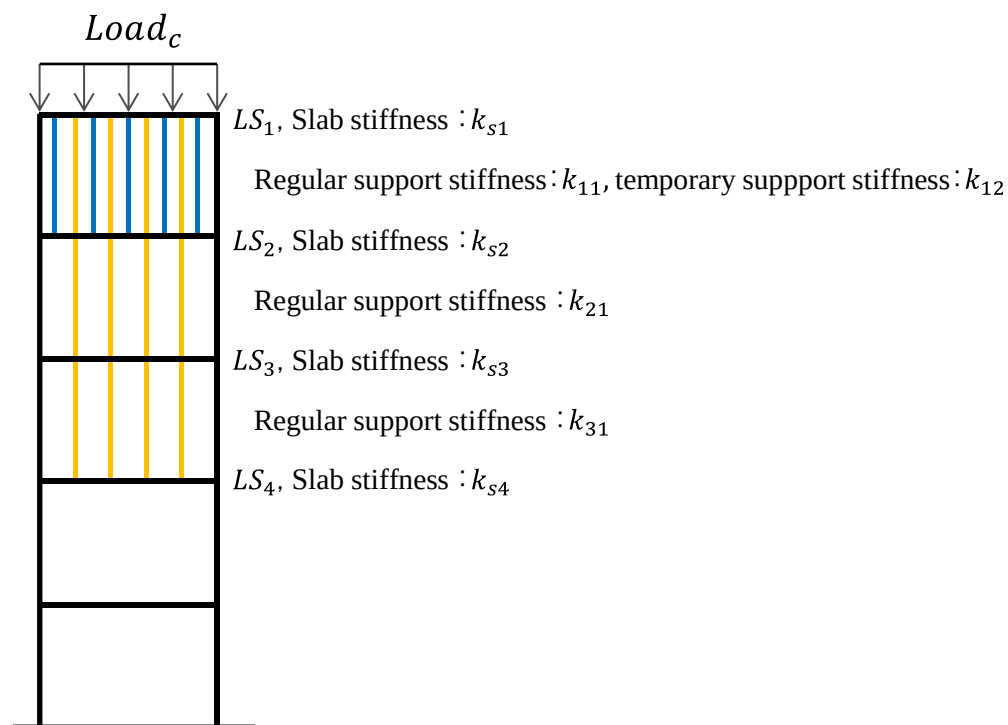
✓ Calculation of Construction Load for Lower Floors

 : Regular support



3. Calculation of Construction Load

✓ Concrete casting of slab



$$\begin{pmatrix} DL + LL \\ 0 \\ 0 \end{pmatrix} = [K_{ff}] \begin{pmatrix} v_2 \\ v_3 \\ v_4 \end{pmatrix}, \quad \begin{pmatrix} LS_2 \\ LS_3 \\ LS_4 \end{pmatrix} = [K_{fsl}] \begin{pmatrix} v_2 \\ v_3 \\ v_4 \end{pmatrix}$$

$$\begin{pmatrix} LS_2 \\ LS_3 \\ LS_4 \end{pmatrix} = [K_{fsl}] \begin{pmatrix} v_2 \\ v_3 \\ v_4 \end{pmatrix} = [K_{fsl}] [K_{ff}]^{-1} \begin{pmatrix} DL + LL \\ 0 \\ 0 \end{pmatrix}$$

$$[K_{fsl}] = \begin{bmatrix} k_{s2} & 0 & 0 \\ 0 & k_{s3} & 0 \\ 0 & 0 & k_{s4} \end{bmatrix} \quad [K_{ff}] = \begin{bmatrix} k_{s2} + k_{21} & -k_{21} & 0 \\ -k_{21} & k_{s3} + k_{21} + k_{31} & -k_{31} \\ 0 & -k_{31} & k_{s4} + k_{31} \end{bmatrix}$$

3. Calculation of Construction Load

✓ Removal of temporary supports

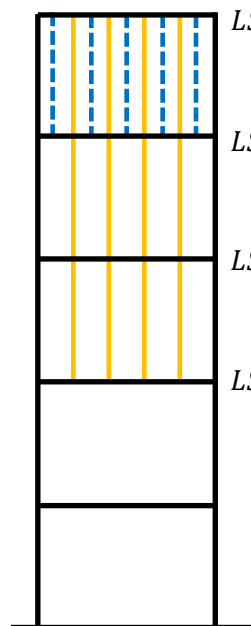
STEP 1.



: Regular support



: Removed temporary support



LS_1 , Slab stiffness : k_{s1}

Regular support stiffness: k_{11} , temporary support stiffness: k_{12}

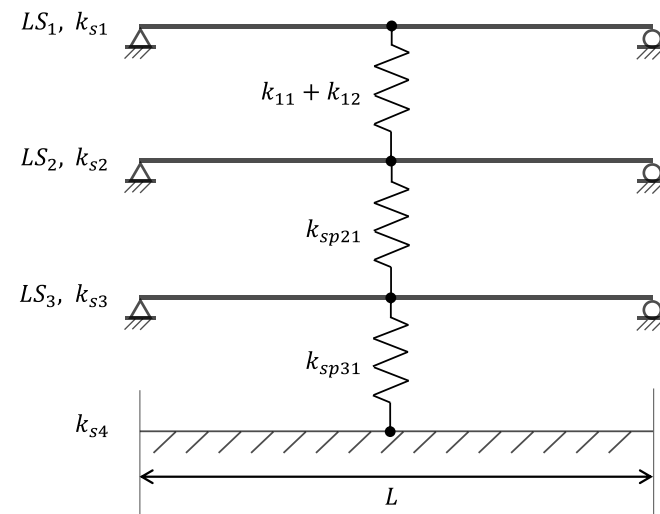
LS_2 , Slab stiffness : k_{s2}

Regular support stiffness : k_{21}

LS_3 , Slab stiffness : k_{s3}

Regular support stiffness : k_{31}

LS_4 , Slab stiffness : k_{s4}



$$\begin{pmatrix} LS_2 \\ LS_3 \\ LS_4 \end{pmatrix} = [K_{fsl}] \begin{pmatrix} v_2 \\ v_3 \\ v_4 \end{pmatrix} = [K_{fsl}] [K_{ff}]^{-1} \begin{pmatrix} -(DL \left(\frac{k_{12}}{k_{11} + k_{12}} \right) + LL) \\ 0 \\ 0 \end{pmatrix}$$

$$[K_{fsl}] = \begin{bmatrix} k_{s2} & 0 & 0 \\ 0 & k_{s3} & 0 \\ 0 & 0 & k_{s4} \end{bmatrix} \quad [K_{ff}] = \begin{bmatrix} k_{s2} + k_{21} & -k_{21} & 0 \\ -k_{21} & k_{s3} + k_{21} + k_{31} & -k_{31} \\ 0 & -k_{31} & k_{s4} + k_{31} \end{bmatrix}$$

3. Calculation of Construction Load

✓ Removal of temporary supports

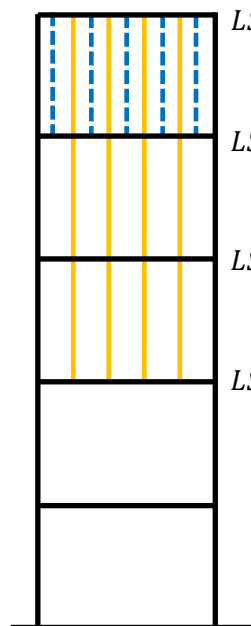
STEP 2.



: Regular support



: Removed temporary support



LS_1 , Slab stiffness : k_{s1}

Regular support stiffness: k_{11} , temporary support stiffness: k_{12}

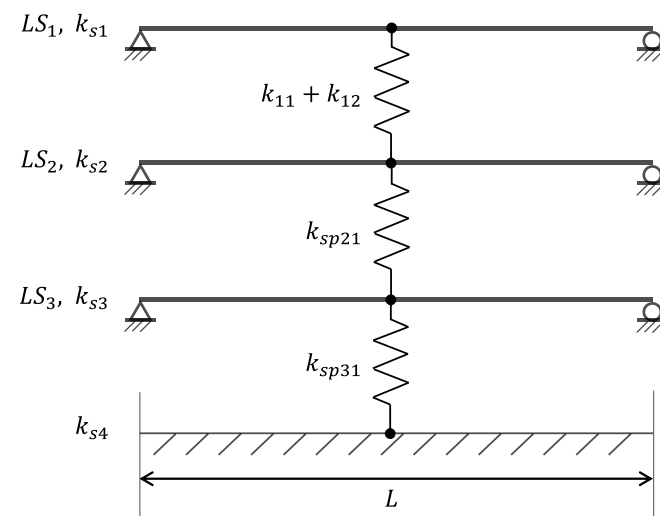
LS_2 , Slab stiffness : k_{s2}

Regular support stiffness : k_{21}

LS_3 , Slab stiffness : k_{s3}

Regular support stiffness : k_{31}

LS_4 , Slab stiffness : k_{s4}



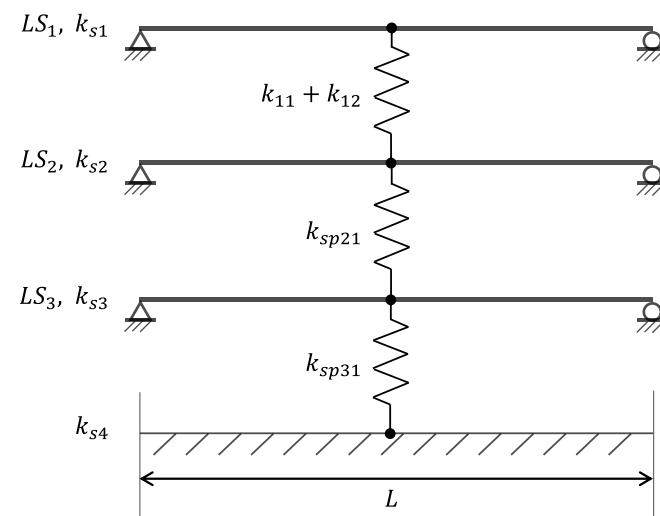
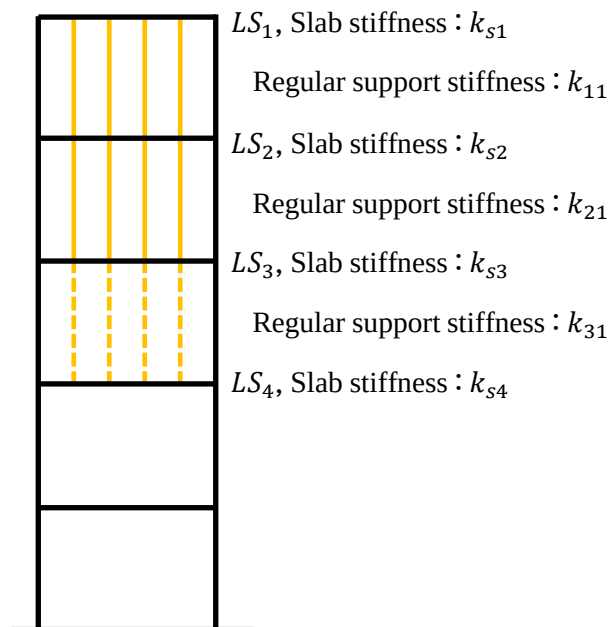
$$\begin{pmatrix} LS_1 \\ LS_2 \\ LS_3 \\ LS_4 \end{pmatrix} = [K_{fsl}] \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} = [K_{fsl}] [K_{ff}]^{-1} \begin{pmatrix} DL \left(\frac{k_{12}}{k_{11} + k_{12}} \right) \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

$$[K_{fsl}] = \begin{bmatrix} k_{s1} & 0 & 0 & 0 \\ 0 & k_{s2} & 0 & 0 \\ 0 & 0 & k_{s3} & 0 \\ 0 & 0 & 0 & k_{s4} \end{bmatrix}$$

$$[K_{ff}] = \begin{bmatrix} k_{s1} + k_{11} & -k_{11} & 0 & 0 \\ -k_{11} & k_{s2} + k_{11} + k_{21} & -k_{21} & 0 \\ 0 & -k_{21} & k_{s3} + k_{21} + k_{31} & -k_{31} \\ 0 & 0 & -k_{31} & k_{s4} + k_{32} \end{bmatrix}$$

3. Calculation of Construction Load

✓ Removal of regular supports



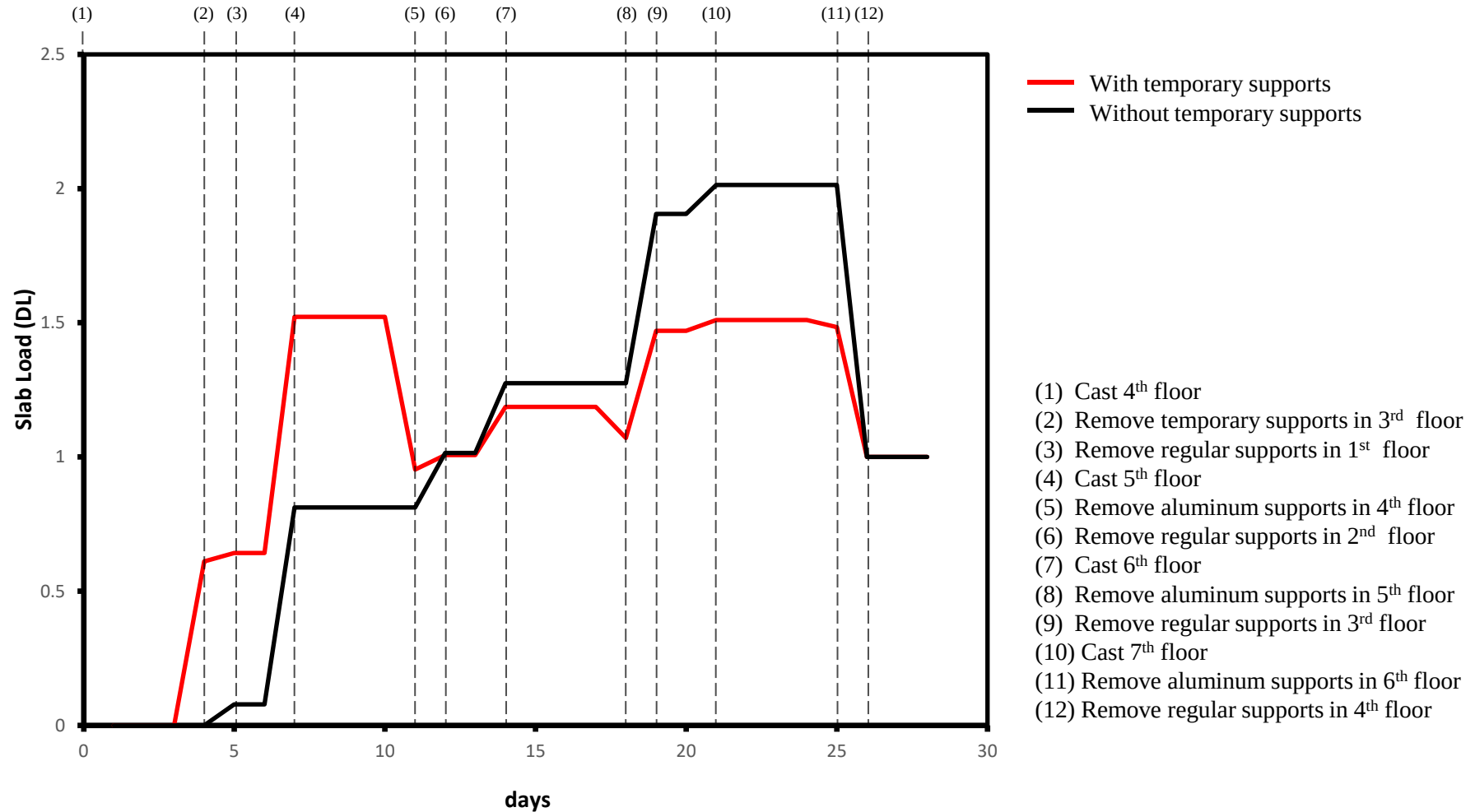
$$\begin{pmatrix} LS_1 \\ LS_2 \\ LS_3 \end{pmatrix} = [K_{fsl}] \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix} = [K_{fsl}] [K_{ff}]^{-1} \begin{pmatrix} 0 \\ 0 \\ Load_{sh} \end{pmatrix}$$

$$[K_{fsl}] = \begin{bmatrix} k_{s1} & 0 & 0 \\ 0 & k_{s2} & 0 \\ 0 & 0 & k_{s3} \end{bmatrix}$$

$$[K_{ff}] = \begin{bmatrix} k_{s1} + k_{11} & -k_{11} & 0 \\ -k_{11} & k_{s2} + k_{11} + k_{21} & -k_{21} \\ 0 & -k_{21} & k_{s3} + k_{21} \end{bmatrix}$$

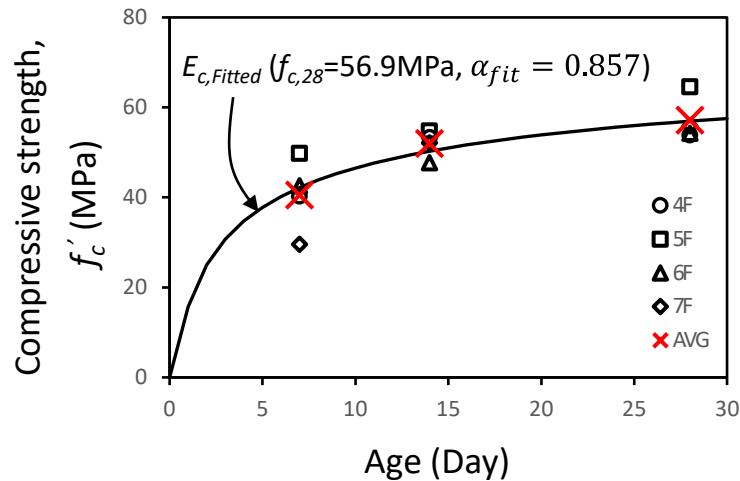
3. Calculation of Construction Load

✓ Prediction result



3. Calculation of Construction Load

✓ Prediction result



$$f_c(t) = \exp \left\{ \alpha_{fit} \cdot 0.35 \left(1 - \sqrt{\frac{28}{t}} \right) \right\} f_{c28}$$

$$4F: f_{c28} = 56 \text{ MPa}, \alpha_{fit} = 0.75$$

$$5F: f_{c28} = 65 \text{ MPa}, \alpha_{fit} = 0.90$$

$$6F: f_{c28} = 54 \text{ MPa}, \alpha_{fit} = 0.85$$

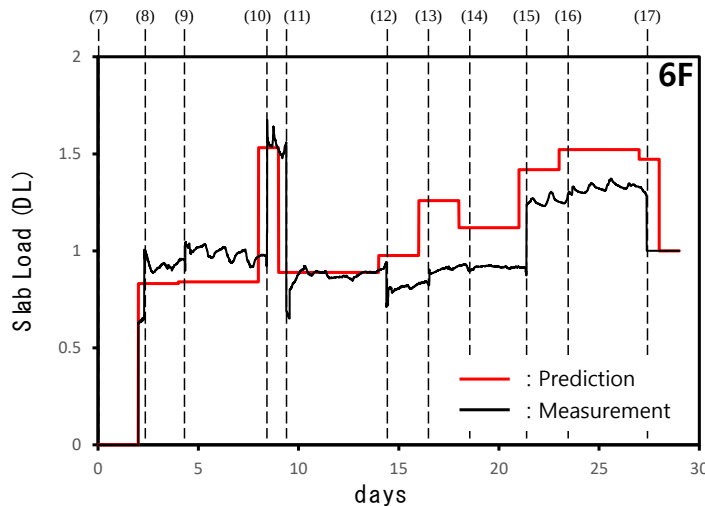
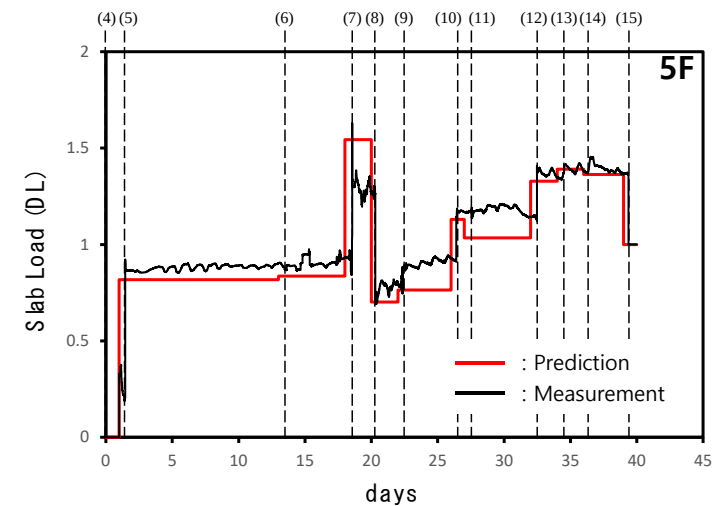
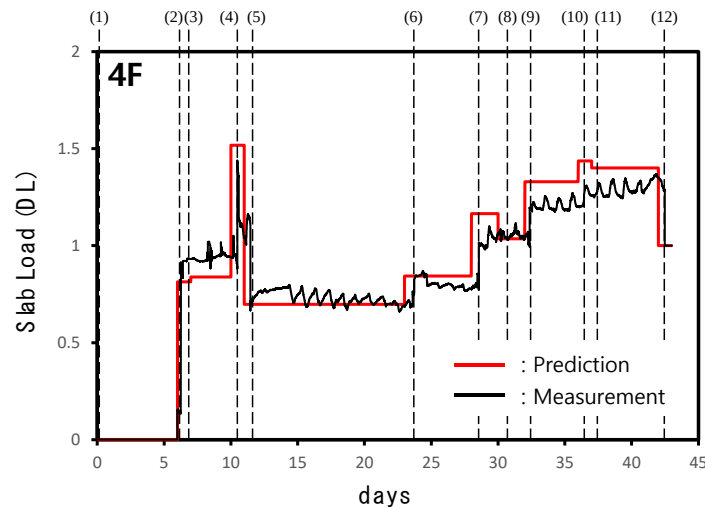
$$7F: f_{c28} = 56 \text{ MPa}, \alpha_{fit} = 1.00$$

Construction schedule for concrete casting and shoring

Floor	Concrete casting	Installation		Removal	
		Regular	Temporary	Regular	Temporary
3F	-	Aug 22	Aug 22	09/24	Aug 29
4F	Aug 23	Aug 30	Aug 30	Oct 05	Sep 3
5F	Sep 2	Sep 16	Sep 16	Oct 11	Sep 22
6F	Sep 20	Sep 26	Sep 26	Oct 27	Sep 29
7F	Sep 28	-	-	-	-

3. Calculation of Construction Load

✓ Comparison of results



- (1) Cast 4th floor
- (2) Remove temporary supports in 3rd floor
- (3) Remove regular supports in 1st floor
- (4) Cast 5th floor
- (5) Remove temporary supports in 4th floor
- (6) Remove regular supports in 2nd floor
- (7) Cast 6th floor
- (8) Remove temporary supports in 5th floor
- (9) Remove regular supports in 3rd floor

- (10) Cast 7th floor
- (11) Remove temporary supports in 6th floor
- (12) Remove regular supports in 4th floor
- (13) Cast 8th floor
- (14) Remove temporary supports in 7th floor
- (15) Remove regular supports in 5th floor
- (16) Cast 9th floor
- (17) Remove temporary supports in 8th floor
Remove regular supports in 6th floor

4. Structural Safety Assessment of Slab

✓ Load corresponding to slab strength development during construction (Capacity)

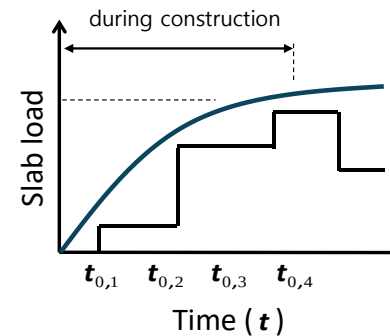
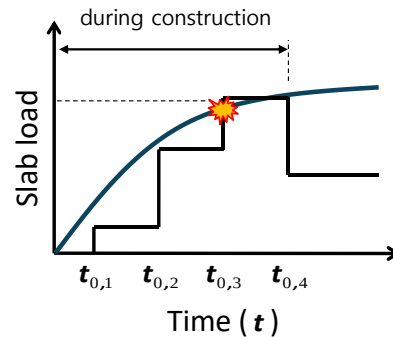
$$\phi_c R_s \geq \gamma_c C_t, \quad R_s = R_n(t), \quad R_n(t) = \alpha(t) \frac{\gamma_D D + \gamma_L L}{\phi}$$

$$\rightarrow \frac{C_t}{D} \leq \frac{\phi_c}{\phi} \frac{\alpha(t)}{\gamma_c} \left(\gamma_D + \gamma_L \frac{L}{D} \right)$$

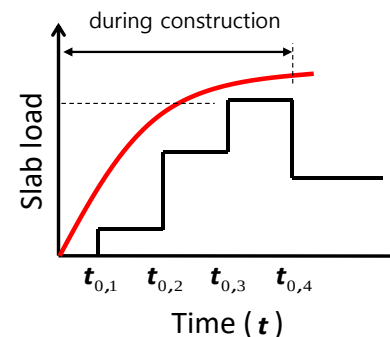
$$\text{ex) } \alpha(t) = \frac{\phi M_n(t)}{M_u}$$

* M_u is the value according to $1.2DL + 1.6LL$

Construction collapse
due to delayed
strength development
during construction



Reduction and delay in
construction load
through construction
plan modification

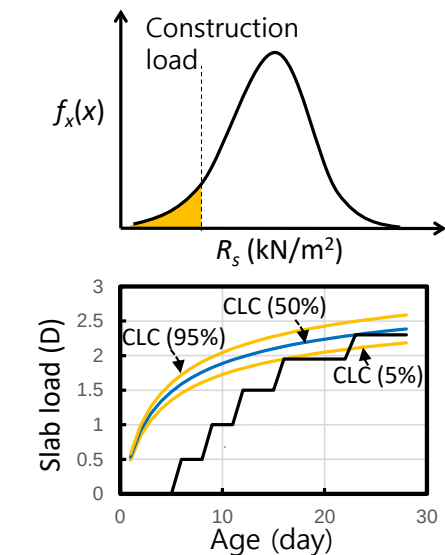


Early strength
development of
concrete

4. Structural Safety Assessment of Slab

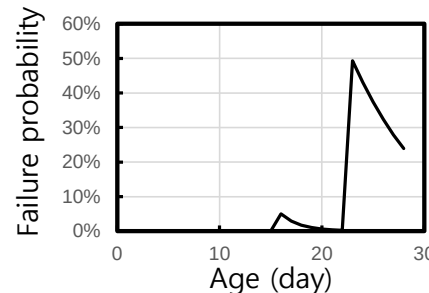
✓ Failure probability

Cumulative distribution addressing construction errors of 1) concrete cover and 2) design models



$$P\left(R_s \leq \frac{C_t}{D}\right) = \int_{-\infty}^{C_t/D} f_x(x) dx$$

$$R_s \sim N(m_p(R_s), \sigma_p(R_s)^2)$$



- Mean and Standard Deviation for Calculating Flexural Strength Failure Probability

$$m(\alpha(t)) = \frac{\phi A_s f_y (d - m_d - 0.5a(t))}{M_u} \quad \sigma(\alpha(t)) = \sqrt{\frac{(\phi A_s f_y)^2 \sigma_d^2}{(M_u)^2}}$$

$$m(R_s) = \frac{\phi_c}{\phi} m(\alpha(t)) (1.2 + 1.6 \frac{L}{D}) \quad \sigma(R_s) = \frac{\phi_c}{\phi} \sigma(\alpha(t)) (1.2 + 1.6 \frac{L}{D})$$

$$m_p(R_s) = m(R_s) \times m_p \quad \sigma_p(R_s) = \left[\left(\frac{\sigma(R_s)}{m(R_s)} \right)^2 + \left(\frac{\sigma_p}{m_p} \right)^2 \right]^{0.5} \times m_p(R_s)$$

- Mean and Standard Deviation for Calculating Shear Strength Failure Probability

$$m_p(R_s) = R_s \times m_p \quad \sigma_p(R_s) = R_s \times \sigma_p$$

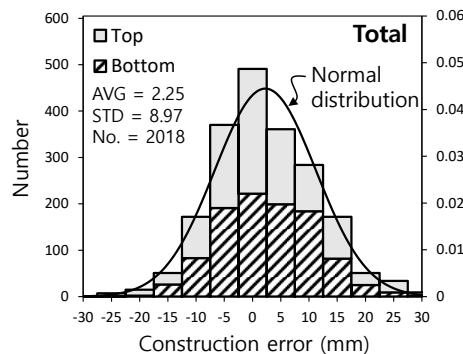


Table 8—Statistical parameters of professional factor

Item	λ	V
Beam, flexure	1.02	0.06
Beam, shear	1.075	0.10
Slab	1.02	0.06
Column, tied	1.00	0.08
Column, spiral	1.05	0.06
Plain concrete	1.02	0.06

Calibration of Design Code for Buildings (ACI 318) Part I
— Statistical Models for Resistance
Anderzej S. Nowak and Maria M. Szafer

✓ Consideration Variables for Flexural Strength Failure Probability

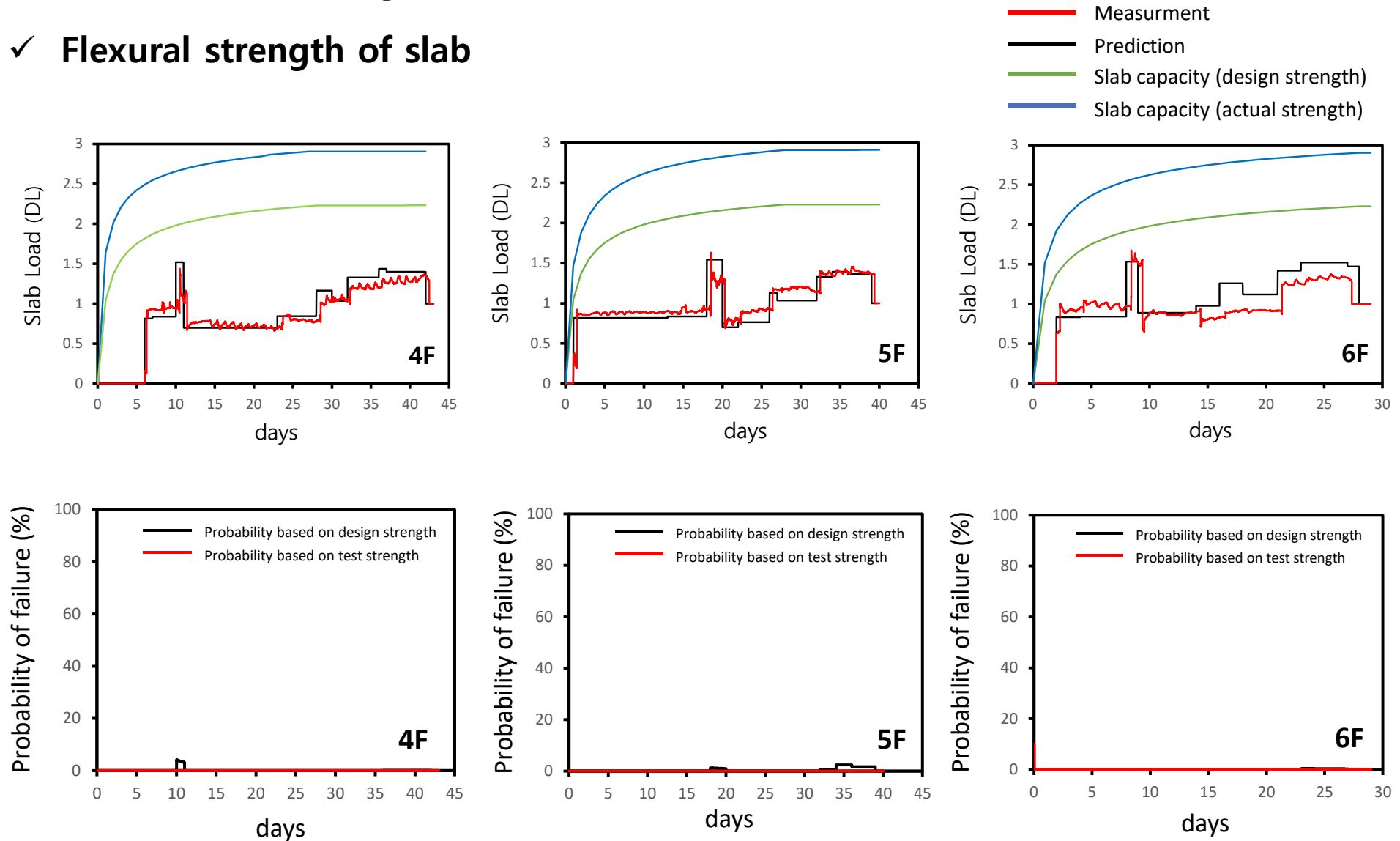
- Construction Error in Cover Thickness ($m_d = 2.25$, $\sigma_d = 8.97$)
- Error in Experiment/Prediction ($m_p = 1.02$, $\sigma_p = 0.06$)

✓ Consideration Variables for Shear Strength Failure Probability

- Error in Experiment/Prediction ($m_p = 1.43$, $\sigma_p = 0.246$)

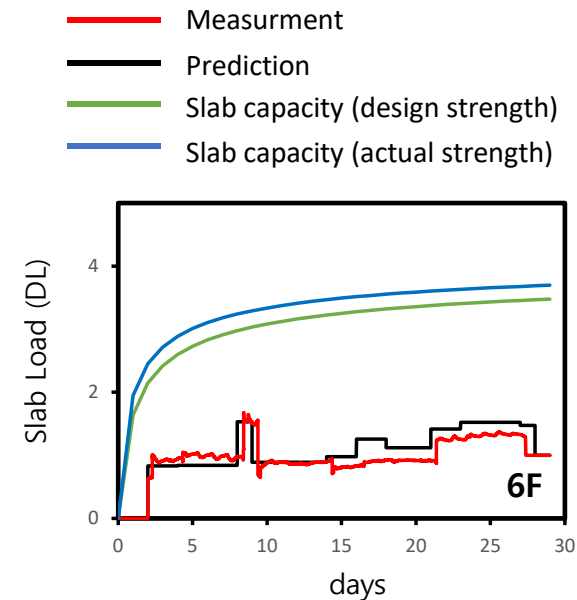
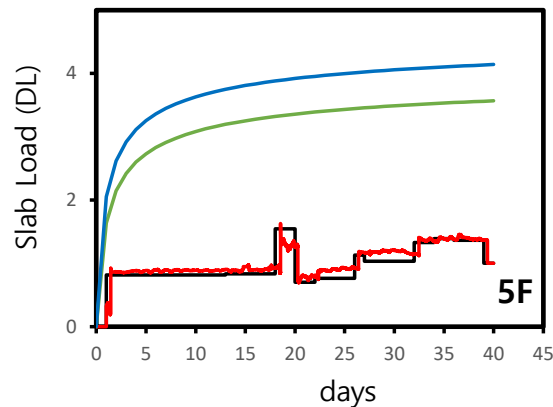
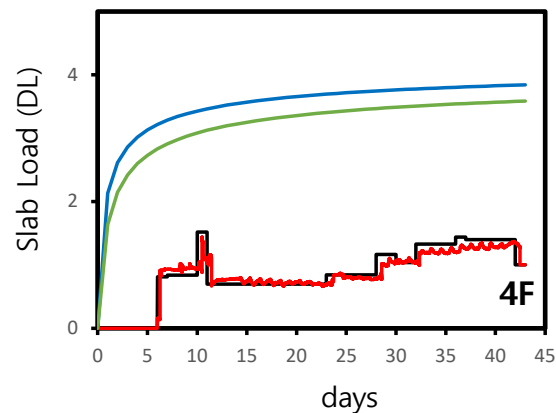
4. Structural Safety Assessment of Slab

✓ Flexural strength of slab

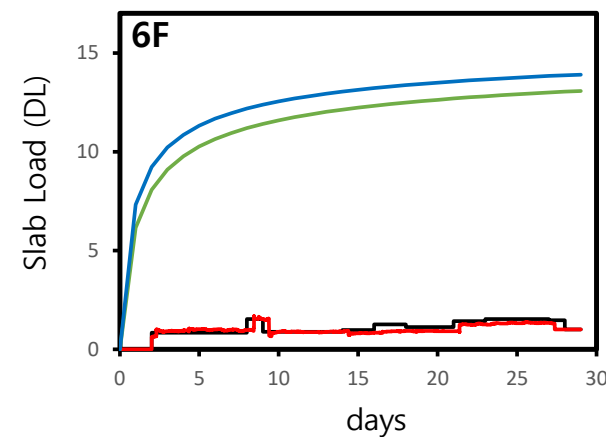
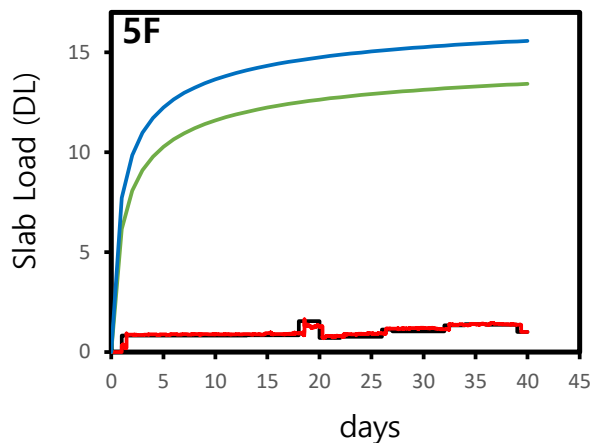
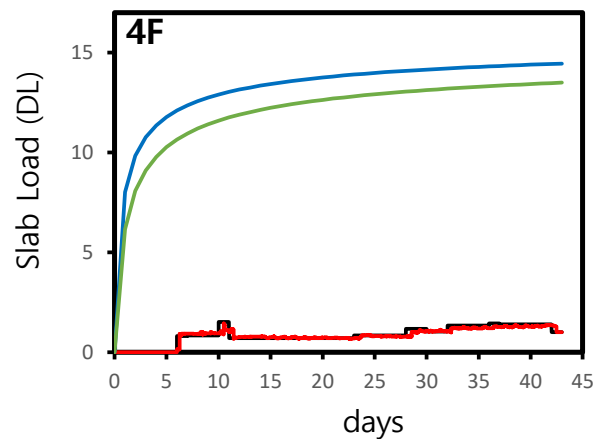


4. Structural Safety Assessment of Slab

✓ Cracking resistance of slab

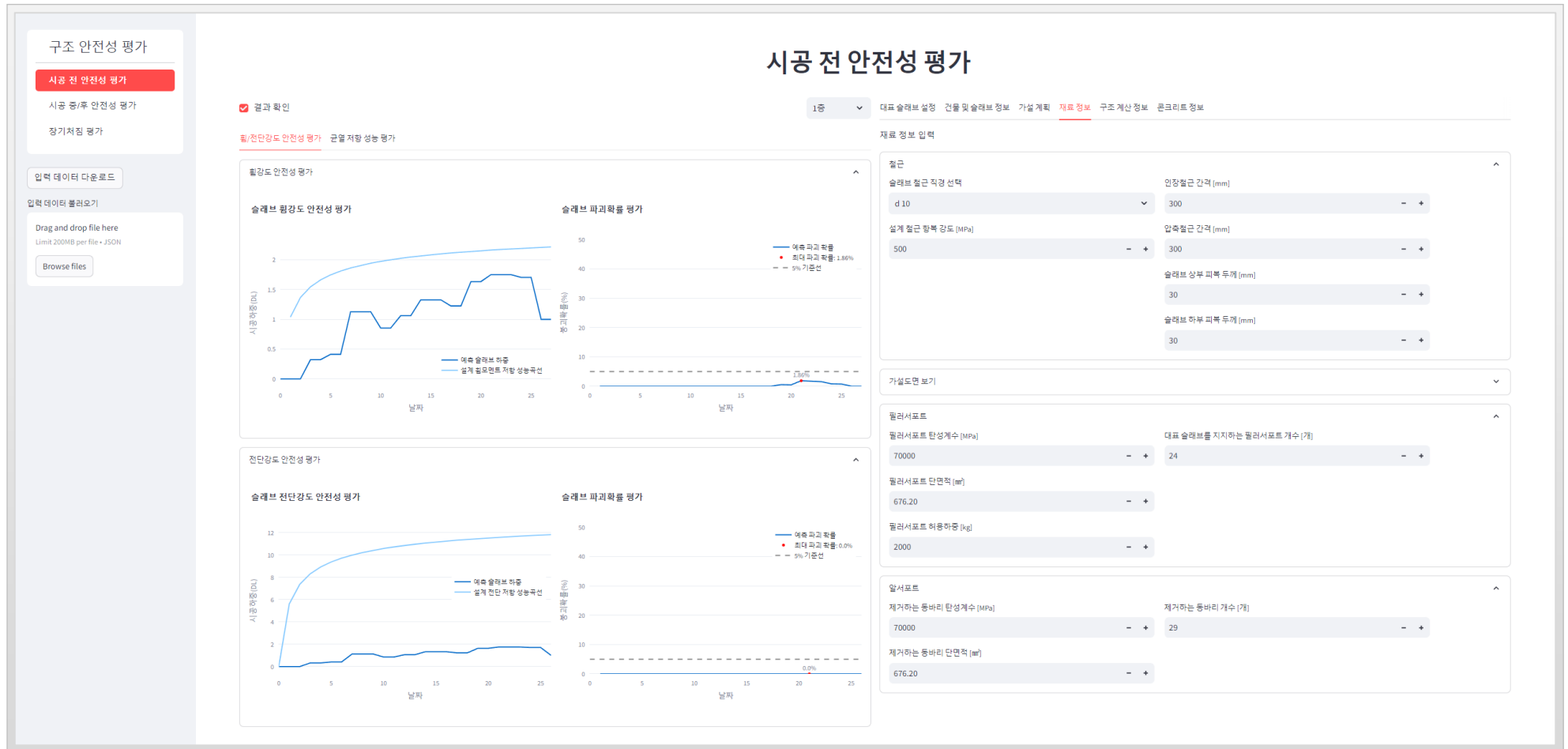


✓ Shear strength of slab



5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment



5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

대표 슬래브 설정 건물 및 슬래브 정보 가설 계획 구조 계산 정보 재료 정보

대표 슬래브 영역 설정

가설도면 업로드

Drag and drop file here
Limit 200MB per file • JPG, PNG, JPEG, PDF

Browse files

슬래브 선택

확대할 영역 선택

반시계 방향 회전 시계 방향 회전

결과 보기

대표 슬래브 설정 건물 및 슬래브 정보 가설 계획 구조 계산 정보 재료 정보

건물 및 슬래브 정보

슬래브 종류 선택 1방향 슬래브의 스펀

1방향 슬래브 스펀: 평면에서 x방향 또는 y방향으로 center to center 스펀이 가장 긴 곳 (대각방향이 아님)

슬래브 높이 [m] 슬래브의 높이: 기둥 혹은 내력벽 중심선 기준의 대상 슬래브의 높이

53.37

스판 [mm]

5220

슬래브 두께 [mm]

210

유효 스펀 계수 유효스판계수

0.80

Boundary condition Effective length factor ψ

Continuous on both ends	$\psi = 0.6$ $0.67 M_1$ $0.33 M_2$
Continuous on one end, Pinned on the other end	$\psi = 0.8$ $0.75 M_1$ $0.25 M_2$
Pinned on both ends	$\psi = 1.0$ M_1 M_2

중고 [mm] (바닥부터 천장까지의 높이)

2820

전체 층수 (층)

27

• Middle strip의 슬래브 두께, Drop panel에 의한 두께 제외

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

- Determination of Effective Span

대표 슬래브 설정 건물 및 슬래브 정보 가설 계획 구조 계산 정보 재료 정보

건물 및 슬래브 정보

슬래브 종류 선택 1방향 슬래브의 스펠

1방향 슬래브 스펠: 평면에서 x방향 또는 y방향으로

슬래브 길이 [m] 슬래브의 길이: 기둥 중심 간 거리

53.37 - +

스판 [mm]

5220 - +

슬래브 두께 [mm]

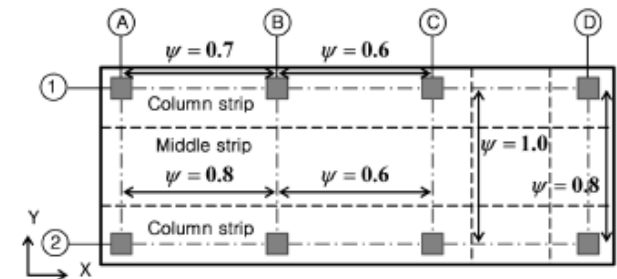
210 - +

유효 스펠 계수 유효 스펠 계수

0.80 - +

Boundary condition

Boundary condition	Effective length factor ψ
Continuous on both ends	$\psi = 0.6$
Continuous on one end, Pinned on the other end	$\psi = 0.8$
Pinned on both ends	$\psi = 1.0$



Determination of Effective Span

$$\Rightarrow L_{eff} = \psi \cdot L$$

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

대표 슬라브 설정 건물 및 슬라브 정보 **가설 계획** 구조 계산 정보 재료 정보

가설 계획

동바리 지지 층수 (층)

3 - +

중량 시공 주기 (일)

7 - +

필러서포트 제거 시점 (일)

5 - +

일부동바리 제거 시점 (일)

3 - +

☒ 일부 동바리 제거 여부

☐ 포스트텐션 여부

Ex)

동바리 지지 층수: 3개 층

5층 타설
5층 재형 0일

5층 벽체 거푸집 제거
5층 재형 2일

5층 슬라브 거푸집 및
알서포트 제거
5층 재형 3일

2층 필러서포트 제거
5층 재형 5일

6층 타설
5층 재형 7일

알서포트 제거 시점: 3일

필러서포트 제거 시점: 5일

시공 추가: 7일

가설도면 보기

필러서포트

필러서포트 탄성계수 [MPa]

70000 - +

대표 슬라브를 지지하는 필러서포트 개수 [개]

24 - +

필러서포트 단면적 [㎡]

676.20 - +

필러서포트 허용하중 [kg]

2000 - +

대표 슬라브 설정 건물 및 슬라브 정보 **가설 계획** **구조 계산 정보** 재료 정보

구조 계산 정보 입력 (구조 계산서 참고)

중력 하중 정보 입력

고정하중 [N/㎡]

D 5.04 - +

γ_D 고정하중의 하중조합계수 (default = 1.2)

1.20 - +

활하중 [N/㎡]

L 2.50 - +

γ_L 활하중의 하중조합계수 (default = 1.6)

1.60 - +

시공하중 정보 입력

시공하중의 하중조합계수 (default = 1.0)

γ_C 1.00 - +

ϕ_c (시공하중 안전율, default = 1.0)

1.00 - +

설계 부재력 입력

단위 설계 정모멘트 [kN · m/m]

M_u 18.45 - +

ϕ (휨강도 안전율, 강도감소계수)

0.85 - +

단위 설계 전단력 [kN/m]

V_u 23.17 - +

ϕ_V (전단강도 안전율, 강도감소계수)

0.75 - +

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

- Shoring stiffness for a single floor

대표 슬래브 설정 건물 및 슬래브 정보 가설 계획 재료 정보 구조 계산 정보

건물 및 슬래브 정보

슬래브 종류 선택
1방향 슬래브

슬래브 넓이 [m²]
53.37

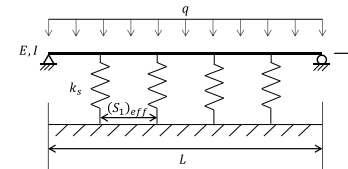
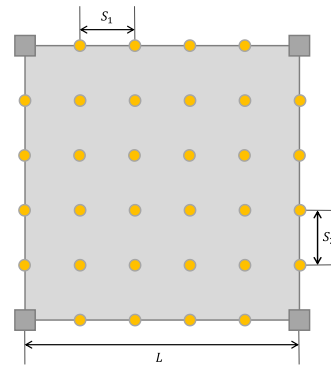
슬래브 두께 [mm]
210

스팬 [mm]
5330

유효 스펀 계수
0.80

중고 [mm]
2820

중수 [종]
27



✓ Effective supporting area

$$\rightarrow A_{eff} = \frac{A_{slab}}{n_{sh}}$$

✓ Effective Shoring Spacing

$$\rightarrow (S_1)_{eff} = \sqrt{A_{eff}}$$

✓ Stiffness of a Single Spring

$$\rightarrow (k_s)_{eff} = \frac{A_s \cdot E_s}{(S_1)_{eff} \cdot H}$$

$$v = \frac{q}{k_s} \left[1 - \frac{2 \sin \frac{\beta L}{2} \cdot \sinh \frac{\beta L}{2}}{\cos \beta L + \cosh \beta L} \cdot \sin \beta x \cdot \sinh \beta x - \frac{2 \cos \frac{\beta L}{2} \cdot \cosh \frac{\beta L}{2}}{\sin \beta L + \sinh \beta L} \cdot \cos \beta x \cdot \cosh \beta x \right],$$

$$\beta = \sqrt[4]{\frac{k_s}{4EI}}$$

$$L_{sp} = S_1 k_s \sum_{i=1}^{n_s} v_i, \quad L_{sl} = qL - L_{sp}$$

$$K = \frac{L_{sl}}{L_{sp}} \rightarrow K = \frac{L_{sl}}{L_{sp}} = \frac{k_{sl}}{k_{sp}} \rightarrow k_{sp} = \frac{k_{sl}}{K} = \frac{E(t)I}{K}$$

원리서포트

원리서포트 탄성계수 [MPa]
70000

원리서포트 단면적 [m²]
676.20

원리서포트 허용하중 [kg]
2000

대표 슬래브를 지지하는 원리서포트 개수 [개]
24

원리서포트

제거하는 등배리 탄성계수 [MPa]
70000

제거하는 등배리 단면적 [m²]
676.20

제거하는 등배리 개수 [개]
29

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

- Construction schedule



Construction Schedule Generation Based on the 1st Floor Slab Casting Date

✓ Pouring Schedule	✓ Temporary Support Removal Schedule	✓ Regular Support Removal Schedule
1F: day 0	1F: day 10	1F: day 27
2F: day 7	2F: day 17	2F: day 34
3F: day 14	3F: day 24	3F: day 41
4F: day 21	4F: day 31	4F: day 48
⋮	⋮	⋮

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

대표 슬래브 설정 건물 및 슬래브 정보 가설 계획 구조 계산 정보 **재료 정보**

재료 정보 입력

슬래브 주철근 정보 입력

슬래브 철근 직경 선택

d 10

인장철근 간격 [mm]

300

설계 철근 항복 강도 [MPa]

500

압축철근 간격 [mm]

300

슬래브 상부 피복 두께 [mm]

30

슬래브 하부 피복 두께 [mm]

30

콘크리트 정보 입력

28일 콘크리트 설계 강도 [MPa]

32

(기준에 의하여 계산시에는 입력값에 8 MPa가 더해진다.)

28일 실제 콘크리트 강도를 맞추는 경우 설계 강도에서 8MPa를 뺀 값을 입력

예) 28일 실제강도 30MPa인 경우 22MPa로 입력해야 계산시 30MPa로 인식

강도발현식 선택

KDS

양상 방법 선택

습윤 양생

시멘트 종류 선택

1종 시멘트

콘크리트 탄성 계수식 선택

보정식

탄성계수 보정 계수 (recommended value = 4100)

4100

콘크리트 강도발현식 확인

$$f_c(t) = \exp \left\{ 0.35 \left(1 - \sqrt{\frac{28}{t}} \right) \right\} f_{c28}$$

콘크리트 탄성 계수식 확인

$$E_c = a_E \cdot (f_{c28})^{\frac{1}{3}}, \quad a_E = 4100$$

콘크리트 강도 발현 곡선

탄성계수 곡선



5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

- Concrete strength development

콘크리트 정보 입력

28일 콘크리트 설계 강도 [MPa]

32

강도 발현식 선택

KDS

양생 방법 선택

습윤 양생

시멘트 종류 선택

1종 시멘트

콘크리트 탄성 계수식 선택

보정식

콘크리트 강도 발현식 확인

$$f_c(t) = \exp \left\{ 0.35 \left(1 - \sqrt{\frac{28}{t}} \right) \right\} f_{c,28}$$

콘크리트 강도 발현 곡선

KDS

$$\rightarrow f_c(t) = \exp \left\{ \beta_{sc} \left(1 - \sqrt{\frac{28}{t}} \right) \right\} f_{c,28}$$

→ Wet Curing

$$\rightarrow \text{Type I} : \beta_{sc} = 0.35$$

$$\rightarrow \text{Type II} : \beta_{sc} = 0.40$$

$$\rightarrow \text{Type III} : \beta_{sc} = 0.25$$

→ Steam Curing

$$\rightarrow \text{Type I} : \beta_{sc} = 0.15$$

$$\rightarrow \text{Type II} : \beta_{sc} = 0.40$$

$$\rightarrow \text{Type III} : \beta_{sc} = 0.12$$

ACI 209

$$\rightarrow f_c(t) = \frac{t}{\alpha + \beta \cdot t} f_{c,28}$$

→ Wet Curing

$$\rightarrow \text{Type I} : \alpha = 4, \beta = 0.85$$

$$\rightarrow \text{Type II, III} : \alpha = 2.3, \beta = 0.92$$

→ Steam Curing

$$\rightarrow \text{Type I} : \alpha = 1, \beta = 0.95$$

$$\rightarrow \text{Type II, III} : \alpha = 0.7, \beta = 0.98$$

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

- Elastic modulus of concrete

콘크리트 정보 입력

28일 콘크리트 설계 강도 [MPa]

32

(기준에 의하여 계산시에는 입력값에 8 MPa이 더

28일 실제 콘크리트 강도를 맞추는 경우 설계 강도

예) 28일 실제강도 30MPa인 경우 22MPa로 입력하

강도 발현식 선택

KDS

양생 방법 선택

습윤 양생

시멘트 종류 선택

1종 시멘트

콘크리트 탄성 계수식 선택

보정식

탄성계수 보정 계수 (recommended value = 4100)

4100

콘크리트 강도 발현식 확인

$$f_c(t) = \exp \left\{ 0.35 \left(1 - \sqrt{\frac{28}{t}} \right) \right\} f_{c28}$$

콘크리트 탄성 계수식 확

E_c

콘크리트 강도 발현 곡선

탄성계수 곡선

KDS & CEB-FIP 1990

$$\rightarrow E_c = 8500 * \sqrt[3]{f_c(t)}$$

ACI 209

$$\rightarrow E_c = 4700 * \sqrt{f_c(t)}$$

Modified

$$\rightarrow E_c = a_E * \sqrt{f_c(t)}$$

5. Structural Safety Assessment Software

✓ Pre-Construction Safety Assessment

구조 안전성 평가

시공 전 안전성 평가

시공 중/후 안전성 평가

장기치짐 평가

입력 데이터 다운로드

입력 데이터 불러오기

Drag and drop file here

Limit 200MB per file • JSON

Browse files

결과 확인

필/전단강도 안전성 평가

균열 저항 성능 평가

휨강도 안전성 평가

전단강도 안전성 평가

시공 전 안전성 평가

1층

대상 슬래브 설정 건물 및 슬래브 정보 가설 계획 구조 계산 정보 재료 정보

대상 슬래브 영역 설정

가설도면 업로드

Drag and drop file here

Limit 200MB per file • JPG, PNG, JPEG, PDF

Browse files

슬래브 선택

확대할 영역 선택

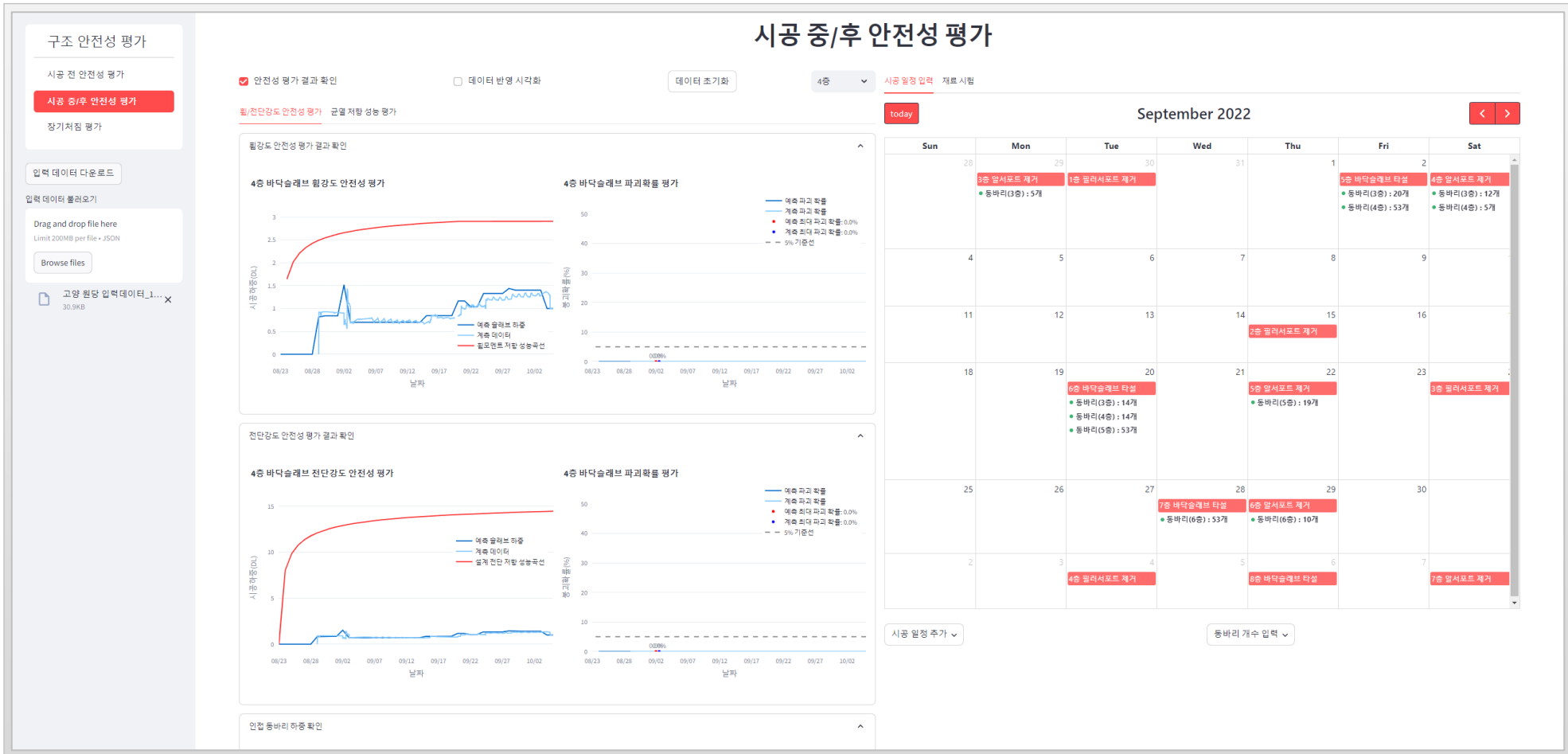
반시계 방향 회전

시계 방향 회전

결과 보기

5. Structural Safety Assessment Software

✓ During and Post-Construction Safety Assessment



5. Structural Safety Assessment Software

✓ During and Post-Construction Safety Assessment

구조 안전성 평가

시공 전 안전성 평가

시공 중/후 안전성 평가

장기치짐 평가

입력 데이터 다운로드

입력 데이터 불러오기

Drag and drop file here

Limit 200MB per file • JSON

Browse files

시공 중/후 안전성 평가

☐ 안전성 평가 결과 확인
 ☐ 데이터 반영 시각화

데이터 초기화

1층

시공 일정 입력

재료 시험

월/연단강도 안전성 평가

균열 저항 성능 평가

today

October 2024

< >

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	1	2	3	4	
6	7	8	9	10	11	
13	14	15	16	17	18	
20	21	22	23	24	25	
27	28	29	30	31	1	
3	4	5	6	7	8	

시공 일정 추가

동바리 개수 입력

시공 일정 자동 생성

Conclusions

1. Construction load : at early-aged slab concrete
2. Critical to slab cracking & load resistance
3. Prediction model of construction load
4. Prediction of failure probability of slab under construction
5. Structural Safety Assessment Software