Deformation of Concrete

Fall 2010

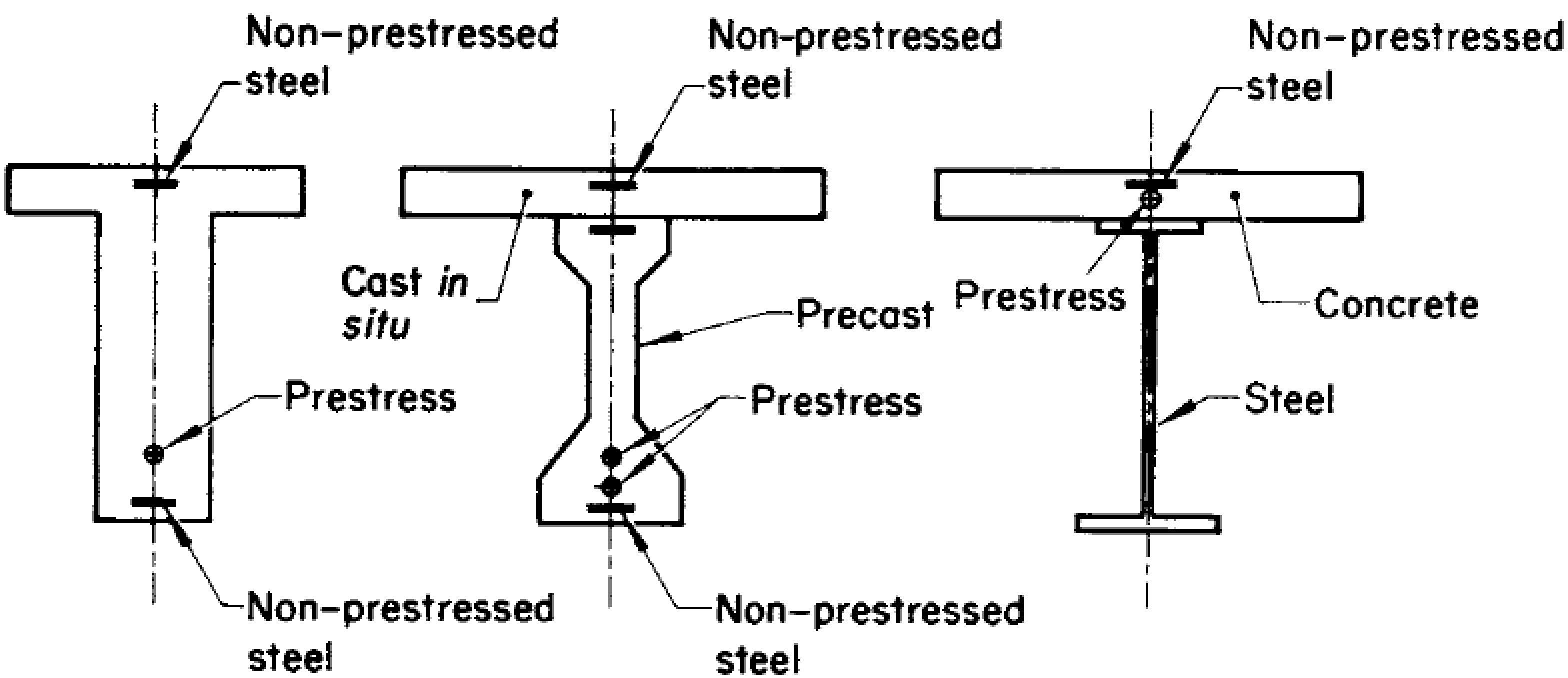
Dept of Architecture
Seoul National University

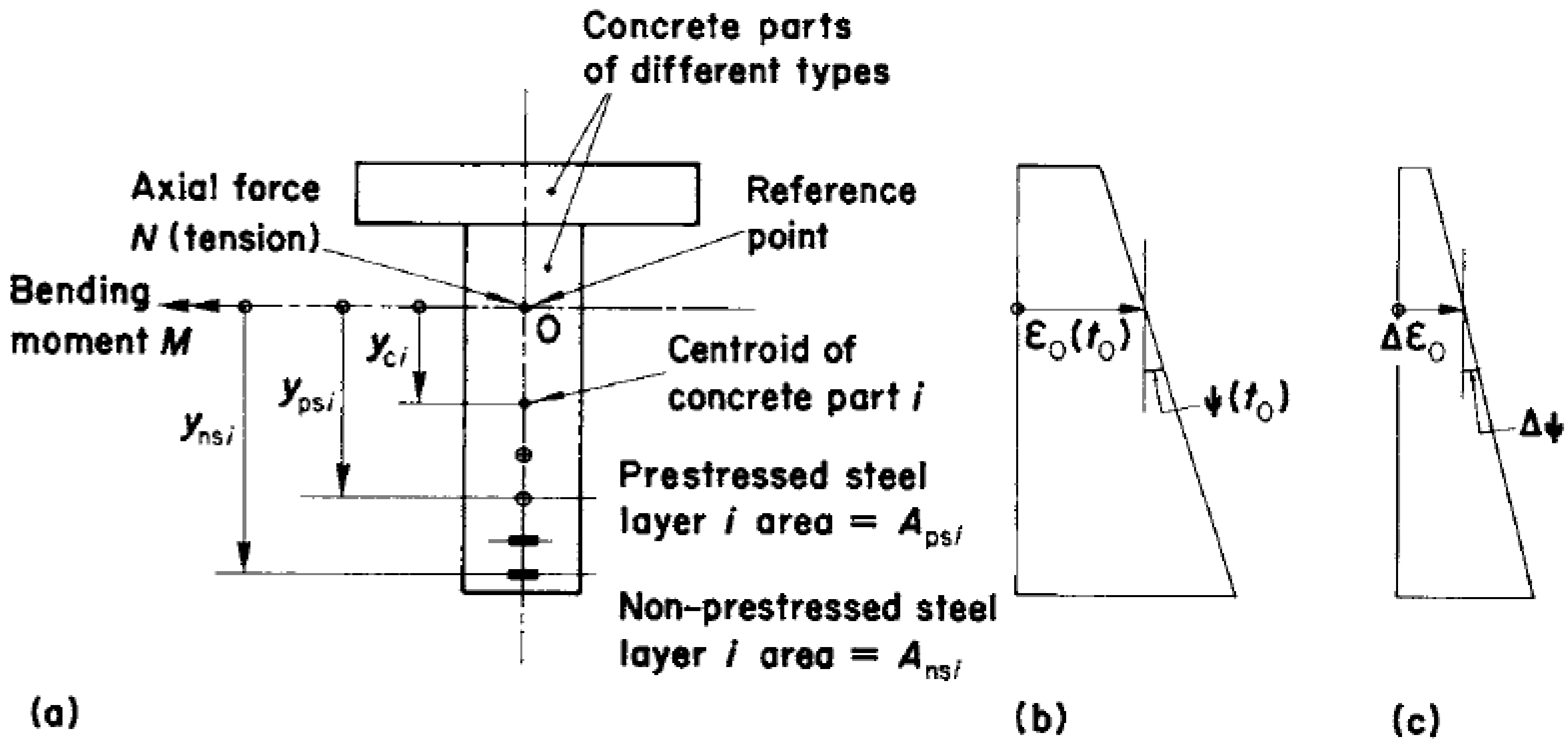
5^{th} week

Time-dependent stress and strain in composite sections

2.5 Time dependent s-s in composite section

2.5.1 Instantaneous stress and strain
2.5.2 Change in s-s during period





Concrete parts
of different types
Axial force
N (tension)
Reference
point
Bending
moment M
O
y_{ci}
y_{psi}
y_{nsi}
Centroid of
concrete part i
Prestressed steel
layer i area = A_{psi}
Non-prestressed steel
layer i area = A_{nsi}
(a)
$\varepsilon_O(t_0)$
$\psi(t_0)$
(b)
$\Delta\varepsilon_O$
$\Delta\psi$
(c)

2.5.1 Instantaneous stress and strain

1)Equivalent Forces= load + prestressing force

2) $\varepsilon_o(t_0)$ and $\psi(t_0)$

	ε	σ
concrete	$\varepsilon_c(t) = \varepsilon_o + \psi_0 y$	$\sigma_c = E_c(t_o)\left[\varepsilon_o(t_o) + \psi(t_o)y\right]$
Normal reinforcing bars	$\varepsilon_{ns}(t_o) = \varepsilon_o(t_o) + \psi(t_o)y_{ns}$	$\sigma_{ns}(t_0) = E_s\left[\varepsilon_o(t_0) + \psi(t_0)y_{ns}\right]$
prestressing	$\varepsilon_{ps}(t_0) = \varepsilon_o(t_0) + \psi(t_0)y_{ps}$	$\sigma_{ps}(t_0) = (\sigma_{ps})_{initial} + E_{ps}\left[\varepsilon_o(t_0) + \psi(t_0)y_{ps}\right]$

2.5.2 Change in s-s

The change of strain due to creep and shrinkage of concrete and relaxation of prestressed steel is first artificially restrained by application of axial force and bending moment.

$$\begin{Bmatrix} \Delta\varepsilon_o \\ \Delta\psi \end{Bmatrix} = \frac{1}{\bar{E}_c\left(\bar{A}\bar{I}-\bar{B}^2\right)}\begin{bmatrix} \bar{I} & -\bar{B} \\ -\bar{B} & \bar{A} \end{bmatrix}\boxed{\begin{Bmatrix} -\Delta N \\ -\Delta M \end{Bmatrix}}$$

The restraining forces

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix} = \begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{creep} + \begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{shrinkage} + \begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{relaxation}$$

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{creep} = -\sum_{i=1}^{m}\left\{\bar{E}_c\begin{bmatrix} A_c & B_c \\ B_c & I_c \end{bmatrix}\varphi\begin{Bmatrix} \varepsilon_o(t_0) \\ \psi(t_0) \end{Bmatrix}\right\}_i$$

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{shrinkage} = -\sum_{i=1}^{m}\left\{\bar{E}_c\begin{bmatrix} A_c & B_c \\ B_c & I_c \end{bmatrix}\begin{Bmatrix} \varepsilon_{cs} \\ 0 \end{Bmatrix}\right\}_i$$

$$\begin{Bmatrix} \Delta N \\ \Delta M \end{Bmatrix}_{\text{prestressing}} = \sum\begin{Bmatrix} A_{ps}\Delta\bar{\sigma}_{pr} \\ A_{ps}y_{ps}\Delta\bar{\sigma}_{pr} \end{Bmatrix}_i$$

$$\bar{E}_c(t,t_0) = \frac{E_c(t_0)}{1+\chi\varphi(t,t_0)}$$

Change of strains due to creep and shrinkage and relaxation

Restrained forces due to creep, shrinkage and relaxation

Restrained stress in concrete

Change in stresses in concrete, reinforcing bars and prestressing steel

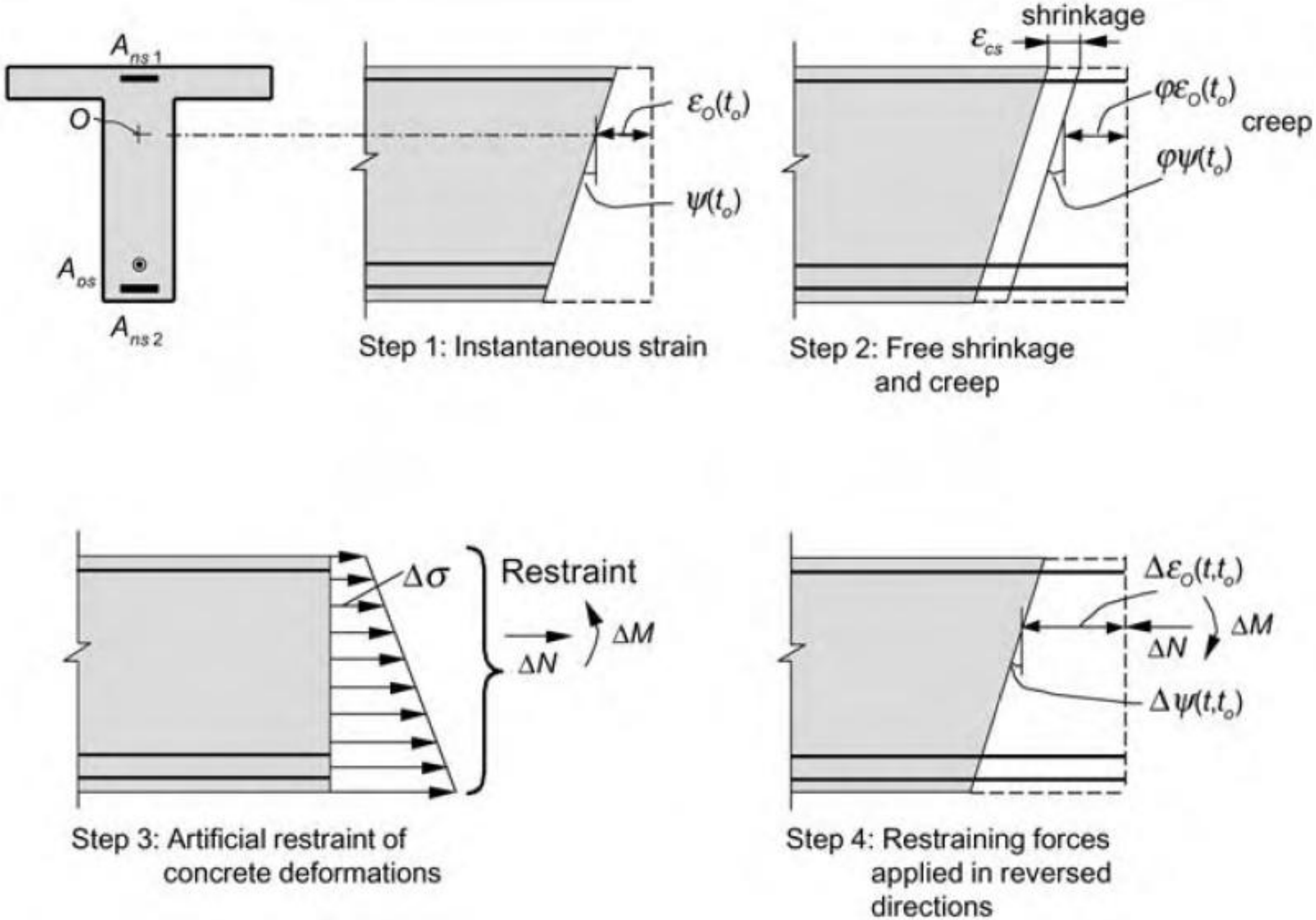
Think about free strain due to temperatu

$$\sigma_{c,restrained} = -\bar{E}_c(t,t_0)\left[\varphi(t,t_0)\varepsilon_c(t_0)+\varepsilon_{cs}\right]$$

$$\Delta\sigma_c = \sigma_{restrained} + \bar{E}_c(t,t_0)\left[\Delta\varepsilon_o + y\Delta\psi\right]$$

$$\Delta\sigma_{ns} = E_{ns}\left[\Delta\varepsilon_o + y_{ns}\Delta\psi\right]$$

$$\Delta\sigma_{ps} = \Delta\bar{\sigma}_{pr} + E_{ps}\left[\Delta\varepsilon_o + y_{ps}\Delta\psi\right]$$



A_{ns1}
O
A_{ps}
A_{ns2}
$\varepsilon_o(t_o)$
$\psi(t_o)$
Step 1: Instantaneous strain
shrinkage
ε_{cs}
$\varphi\varepsilon_o(t_o)$
creep
$\varphi\psi(t_o)$
Step 2: Free shrinkage and creep
$\Delta\sigma$
Restraint
ΔN
ΔM
Step 3: Artificial restraint of concrete deformations
$\Delta\varepsilon_o(t,t_o)$
ΔN
ΔM
$\Delta\psi(t,t_o)$
Step 4: Restraining forces applied in reversed directions