Seismic Design of Urban Infrastructures
都市施設の耐震設計

(4-3) Strength an d Ductility Capacity of RC Structural Members
⑷-3⑴ RC構造物の動的耐力･変形性能

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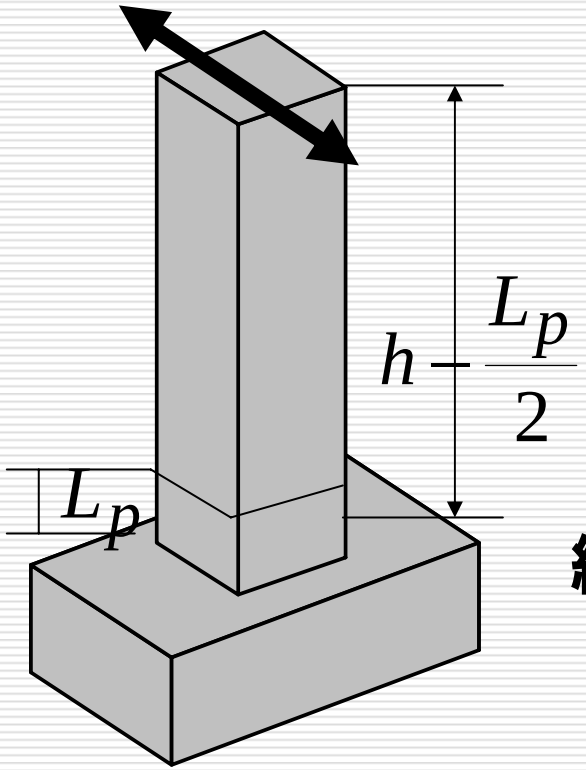
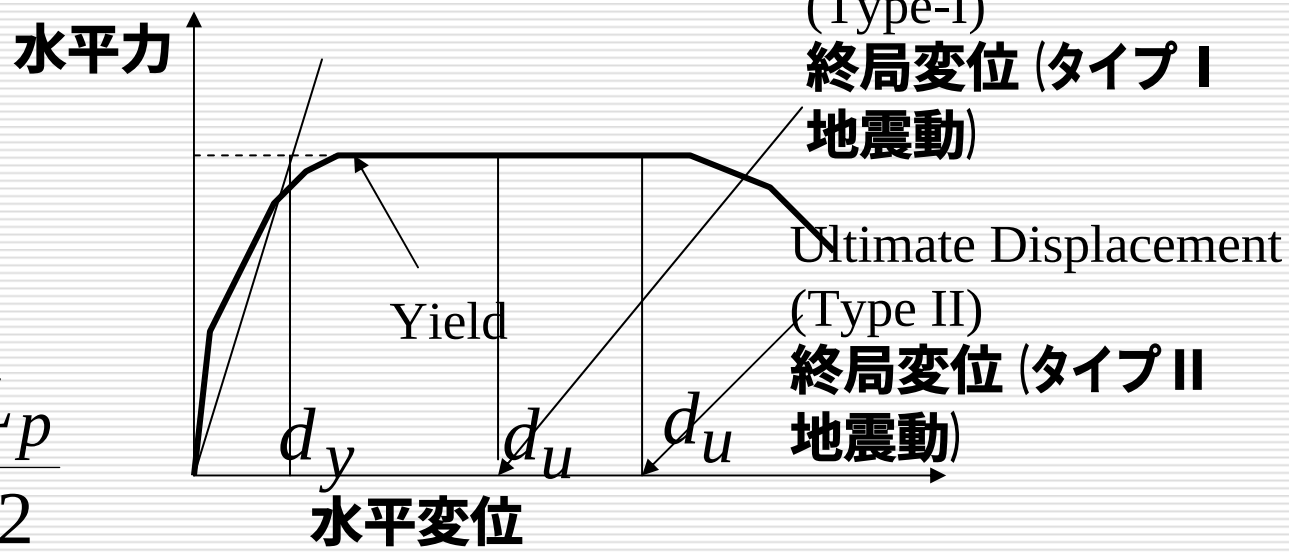
(10) Evaluation of Ultimate Displacement depending on Loading Type

（１０）載荷履歴に依存した終局変位の定義





終局変位Ultimate Displacement

$$d_u = d_y + (\phi_u - \phi_y)(h - \frac{L_p}{2})L_p$$

設計変位Design Displacement

$$d_a = d_y + \frac{d_u - d_y}{\alpha}$$

(11) Design Displacement
(12) 設計変位

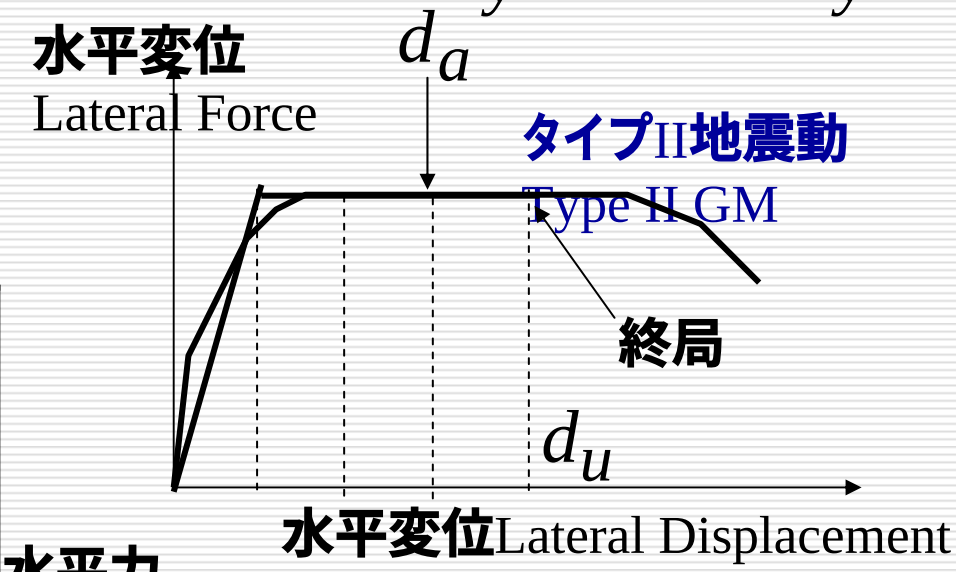
設計変位
Design Displacement

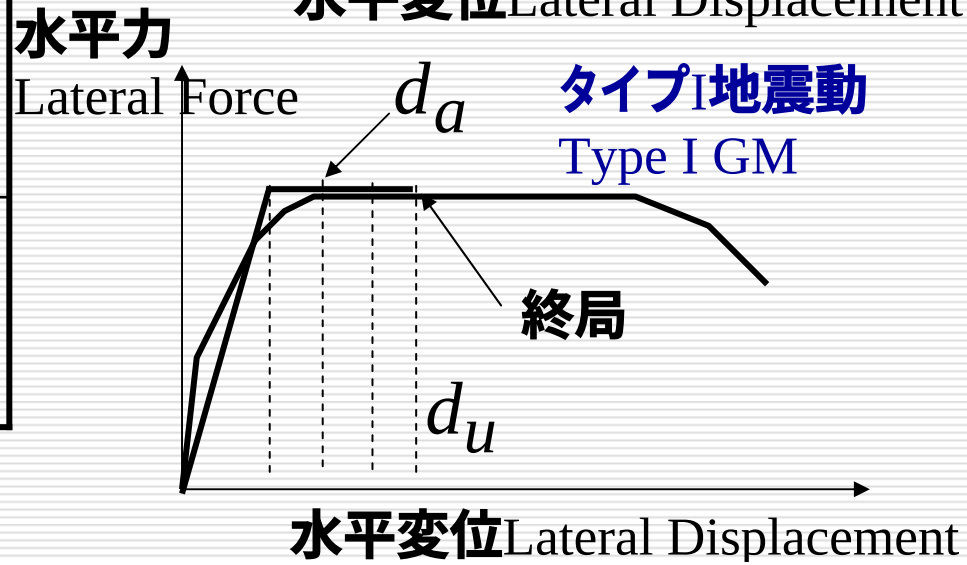
$$d_a = d_y + \frac{d_u - d_y}{\alpha}$$

地震動 GMs	タイプI Type I	タイプII Type II
重要な橋 Important	3.0	1.5
標準的な橋 Standard	2.4	1.2

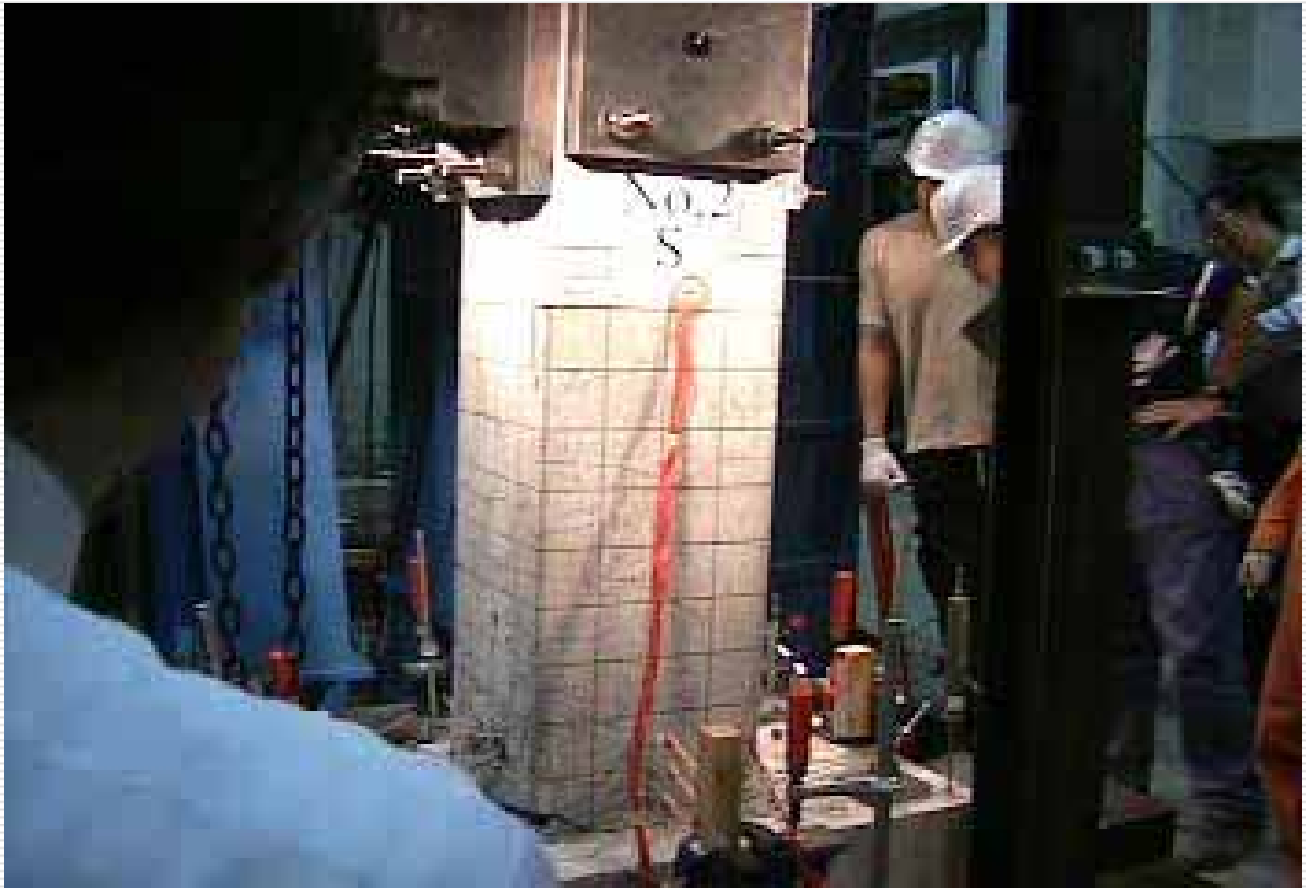
設計変位じん性率
Design Ductility Factor

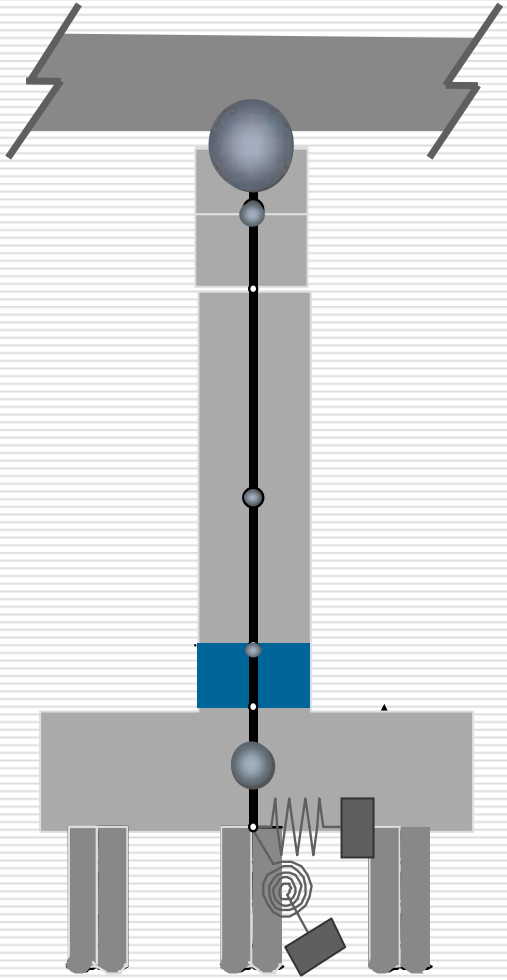
$$\mu_a = \frac{d_a}{d_y} = 1 + \frac{d_u - d_y}{\alpha d_y}$$



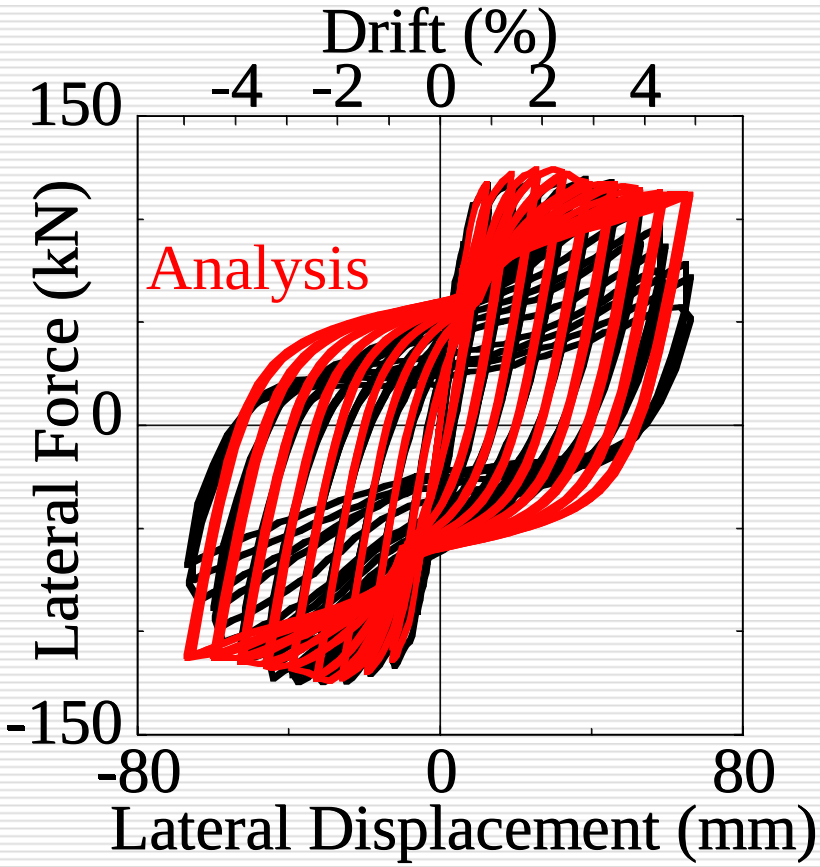


(12) Example of implementation of fiber element analysis

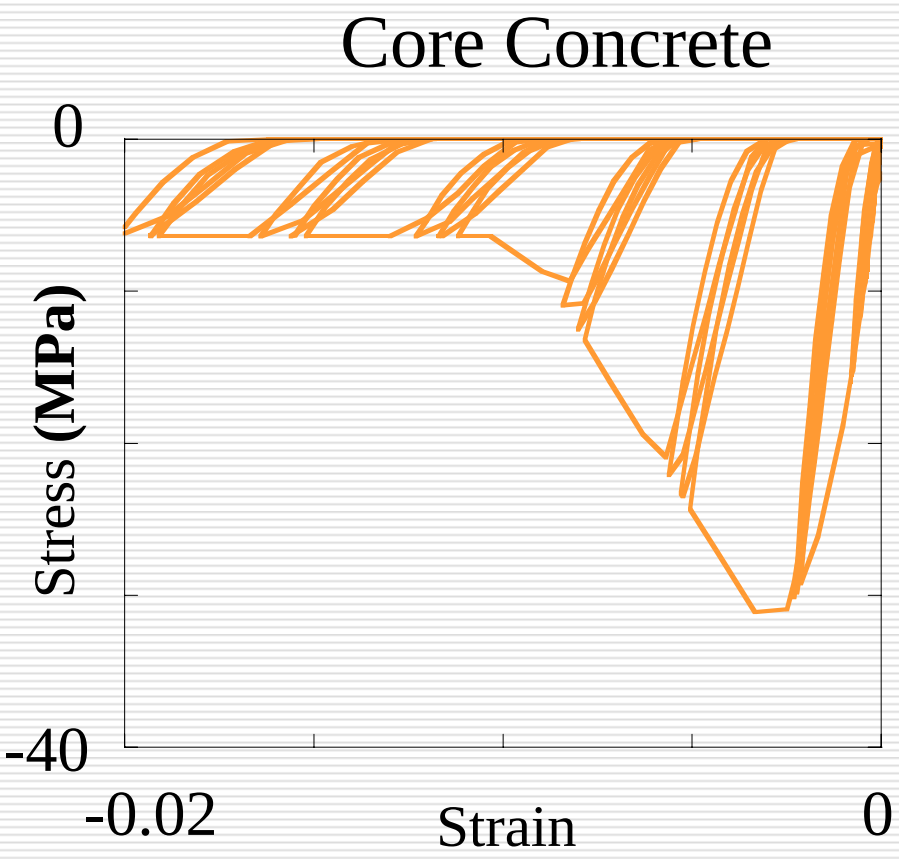


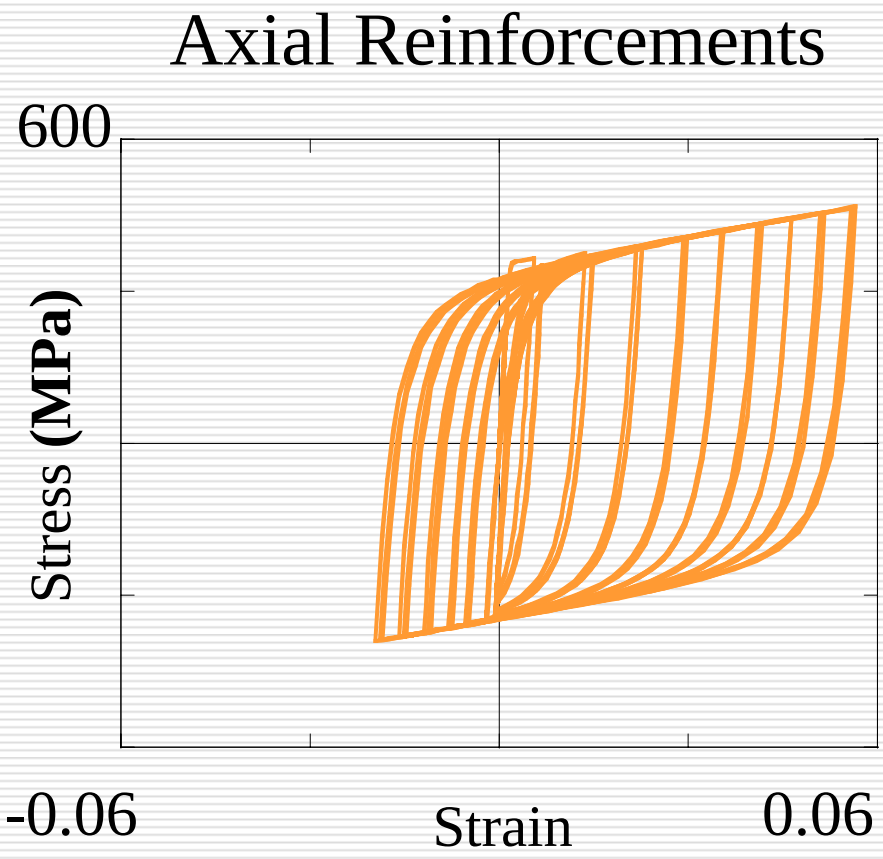


Experimental Hysteresis of Lateral Force vs. Lateral Displacement



Hysteresis of Core Concrete and Longitudinal Bars





４．６　RC橋脚のせん断耐力の評価

4.6 Evaluation of Shear Strength of Concrete Columns

1) Various equations are used.

- Seismic Design Specification, Japan Road association
- Japan Society of Civil Engineers
- ASCE-ACI
- New Zealand Design Specifications
- Priestley, N. M. J.

2) Evaluation of shear strength based on Design Specifications of Highway Bridges, 2002

$$V_d = V_c + V_s$$

$$V_c = c_c \cdot c_e \cdot c_{pt} \cdot \tau_c \cdot bd$$

c_c : modification coefficient for type of ground motion

c_c=0.6 for Type-I GM and =0.8 for Type-II GM

c_e : modification coefficient for effective height

c_e =1.0 for w<1m, 0.3 for w=3m, 0.6 for w=5m and 0.5 for w>10m

c_{pt} : modification coefficient for longitudinal reinforcement ratio pt

c_{pt} =0.9 for pt < 0.2%, 1.0 for pt1.0%, 1.2 for pt=1.2%, 1.5 for pt > 1.0%

$$V_d = V_c + V_s$$

$$V_c = c_c \cdot c_e \cdot c_{pt} \cdot \tau_c \cdot bd$$

τ_c : standard shear strength

τ_c =0.33MPa for f_c' =21MPa, 0.35MPa for f_c' =24 MPa, 0.39MPa for f_c' =27MPa, 0.37MPa for f_c' =30MPa and 0.41MPa for f_c' =40MPa

b: width

d: height

Shear Strength

Design Specifications of Highway Bridges,
Japan Road Association,2002

$$V_d = V_c + V_s$$

$$V_s = \frac{A_v f_y d(\sin\theta + \cos\theta)}{1.15a}$$

A_v =sectional area of a tie

f_y = strength of ties

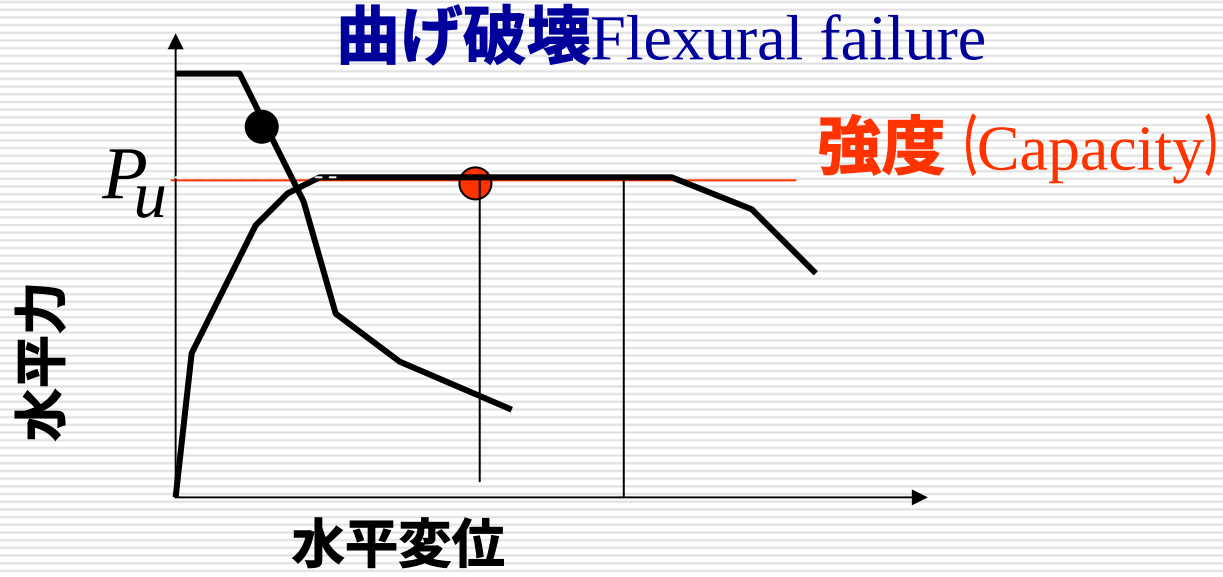
d = effective height

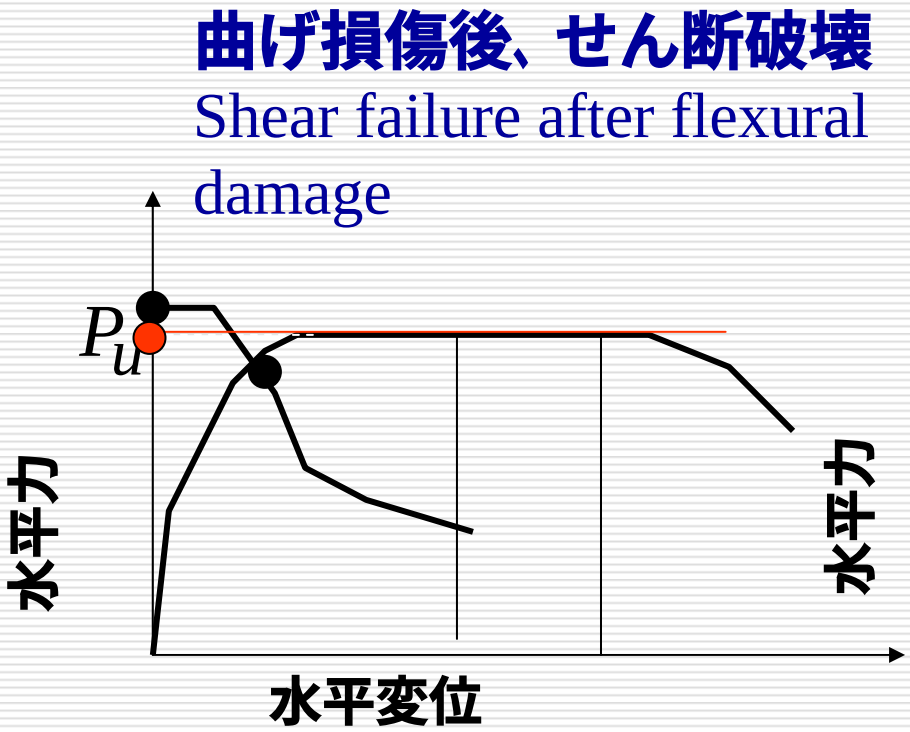
θ = angle between ties and vertical axis

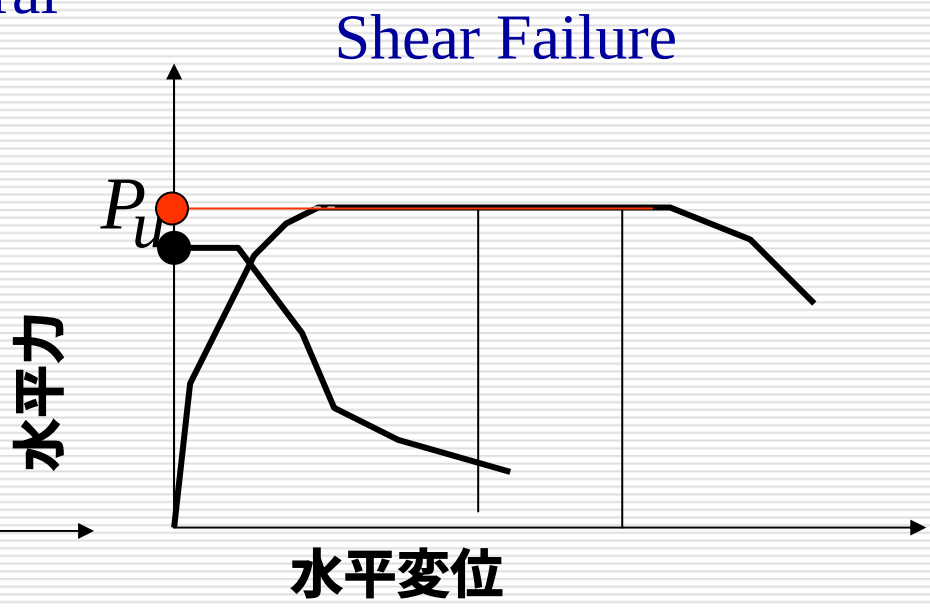
a = interval of ties

4．7　破壊形態の評価

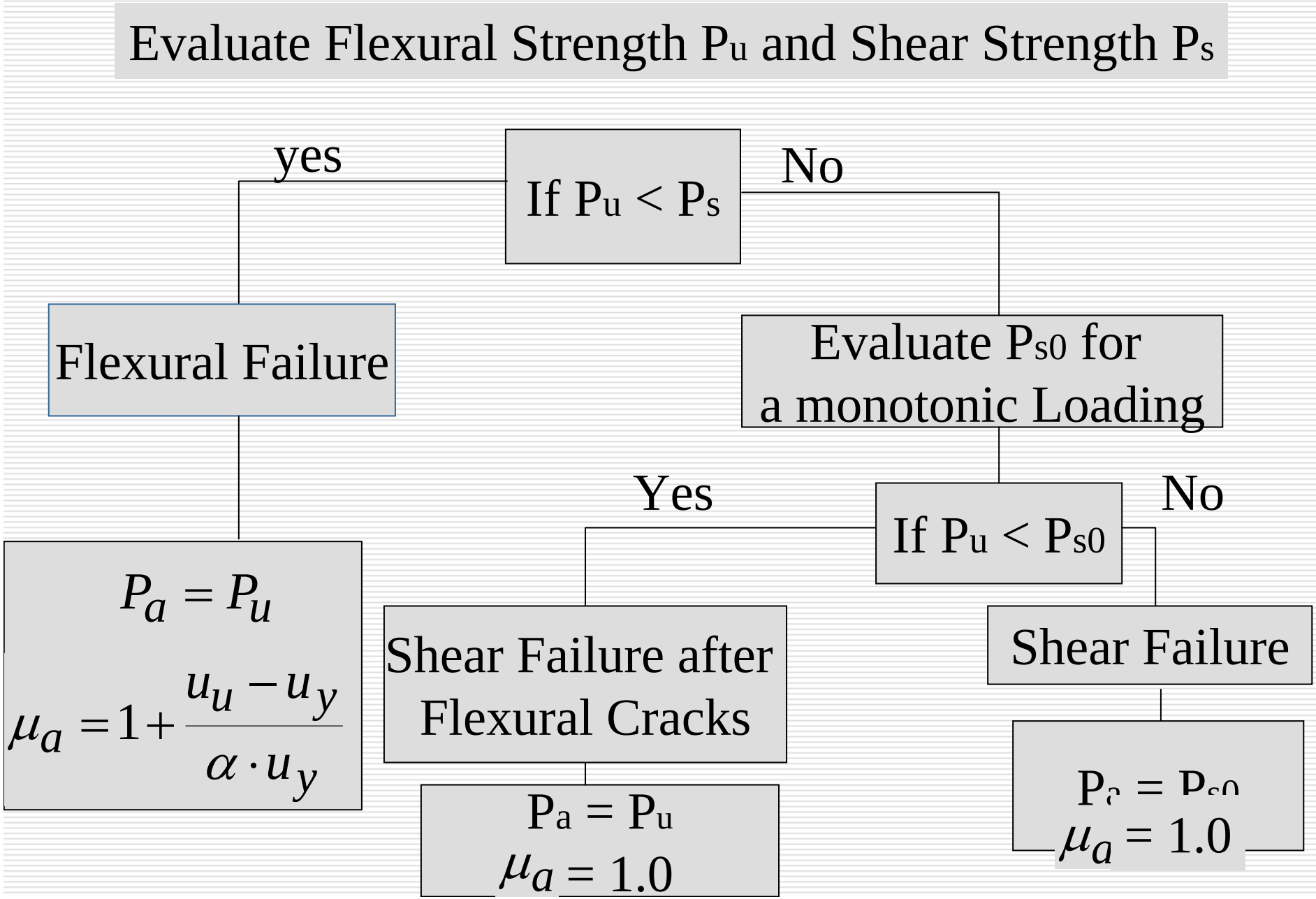
47 Evaluation of Failure Modes







破壊形態の評価の流れEvaluation of Damage Modes



設計強度と設計変位じん性率

$$P_a = \begin{cases} P_u & \cdots\cdots\cdots \text{ flexural failure + shear failure after flexural damage} \\ P_{s0} & \cdots\cdots\cdots \text{shear failure} \end{cases}$$

$$\mu_a = \begin{cases} 1 + \dfrac{d_u - d_y}{\alpha \cdot d_y} \cdots\cdots\cdots \text{flexural failure} \\ 1 \cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{shear failure after flexural damage + shear failure} \end{cases}$$

(6.26)