Architectural Structures: Form, Behavior, and Design

ARCH 331

Dr. Anne Nichols

Summer 2014

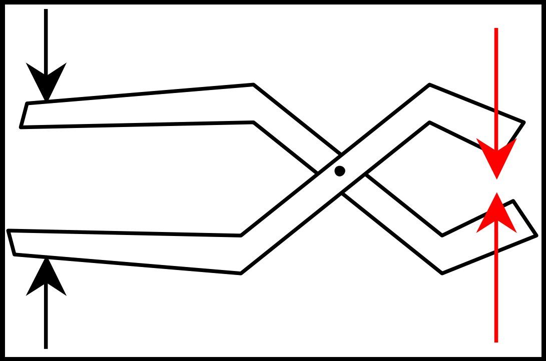
lecture nine

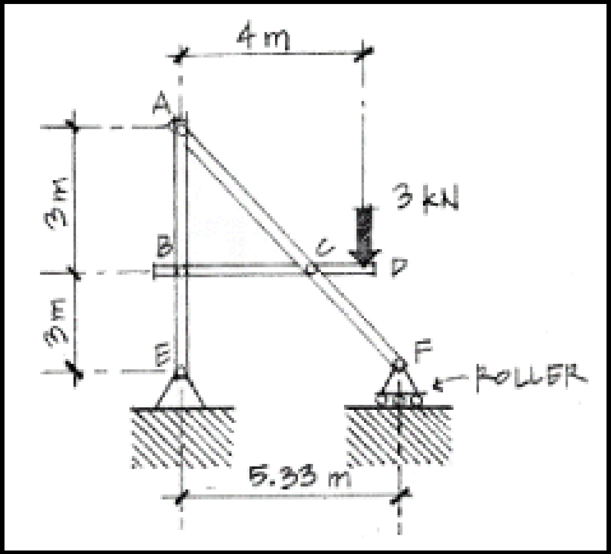
other beams & pinned frames

Continental train platform, Grimshaw 1993

Pinned Frames

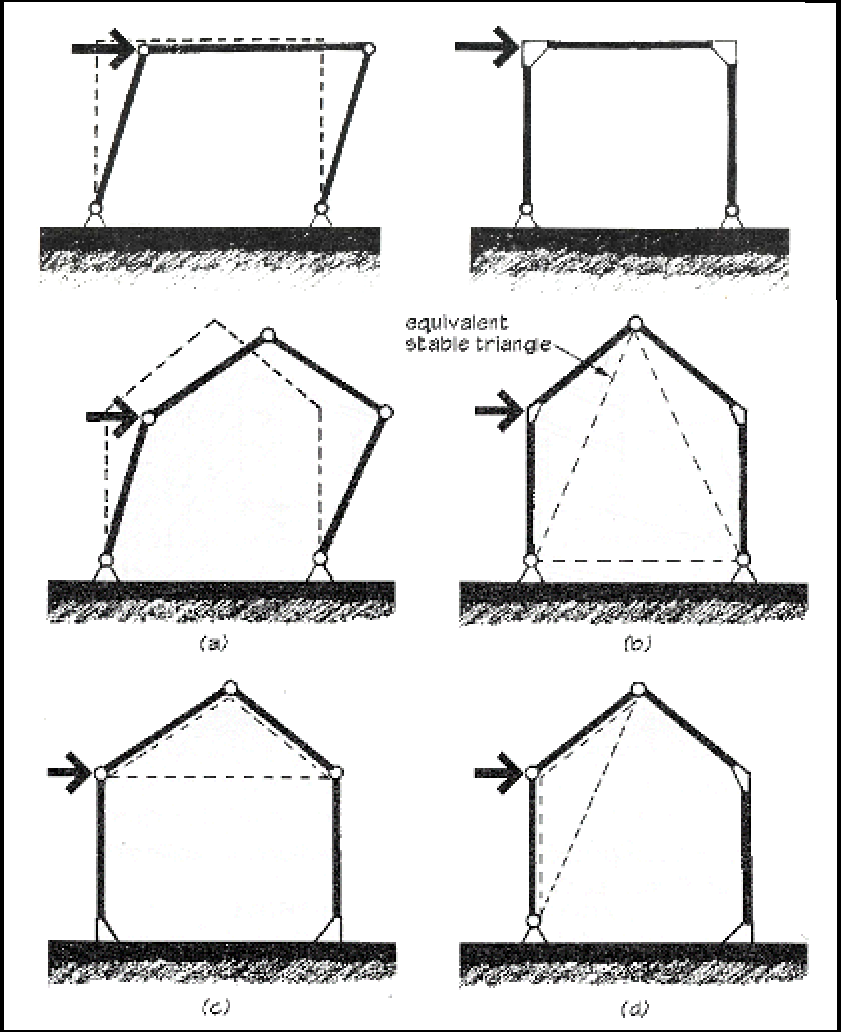
- *structures with at least one 3 force body*
- *connected with pins*
- *reactions are equal and opposite*
  - *non-rigid*
  - *rigid*





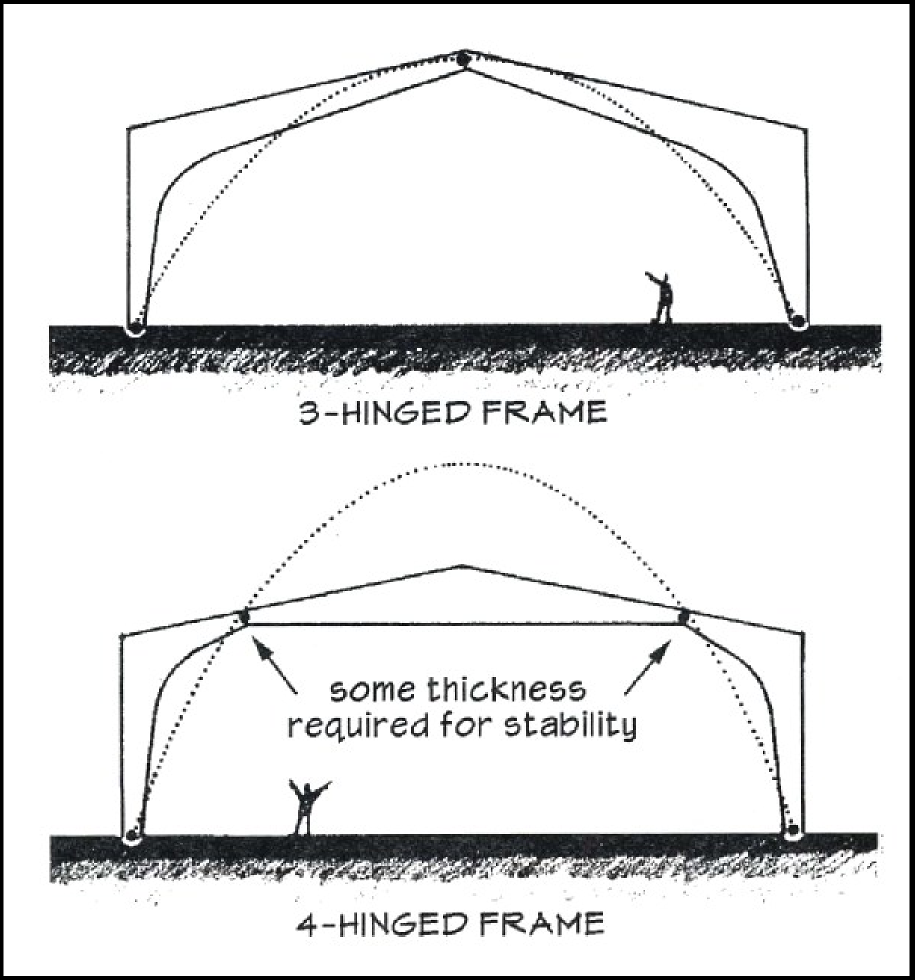
Rigid Frames

- *<u>rigid</u> frames have no pins*
- *frame is all one body*
- *typically statically indeterminate*
- *types*
  - *portal*
  - *gable*



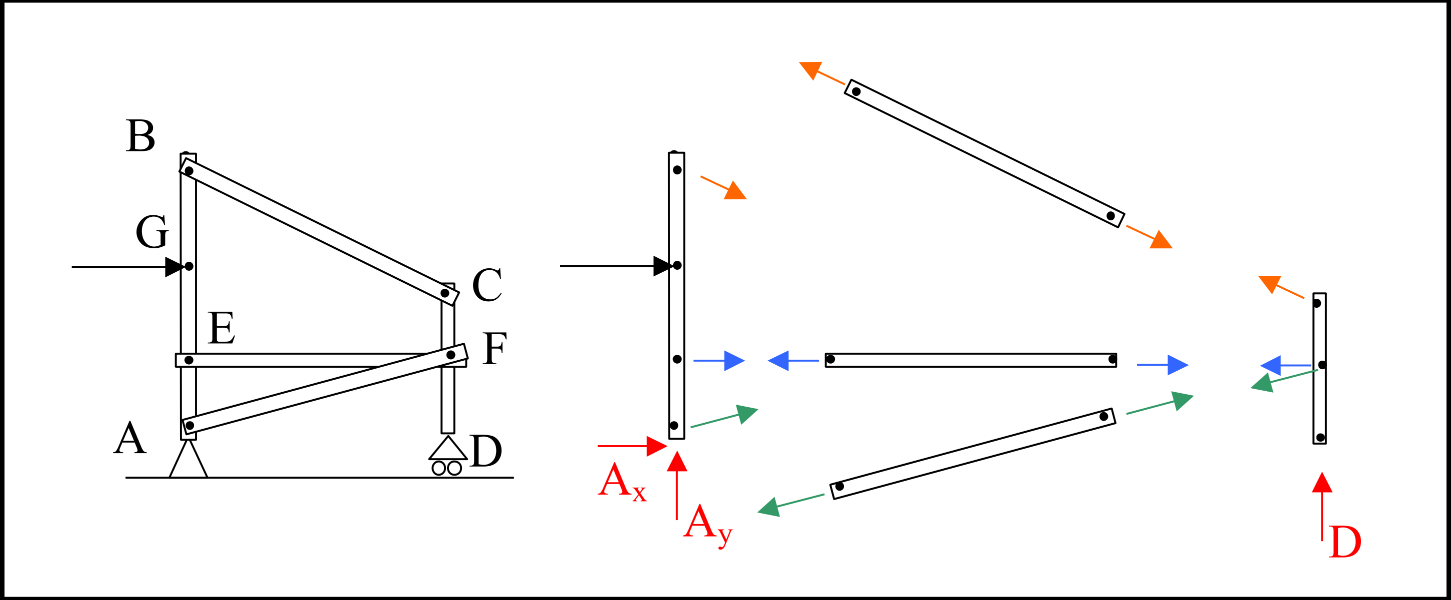
Rigid Frames with PINS

- *frame pieces with connecting pins*
- *not necessarily symmetrical*



Internal Pin Connections

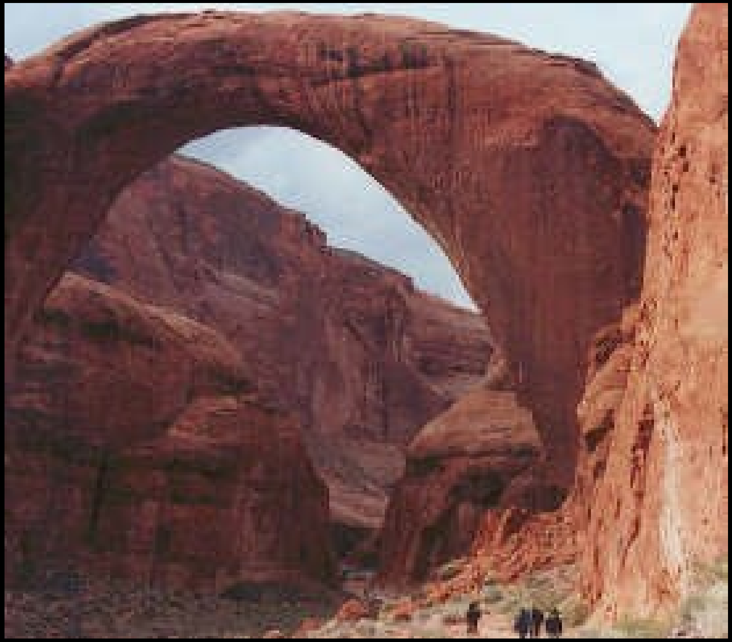
- statically determinant
  - 3 equations per body
  - 2 reactions per pin + support forces



Arches

- ancient
- traditional shape to span long distances

Packhorse Bridge, UK

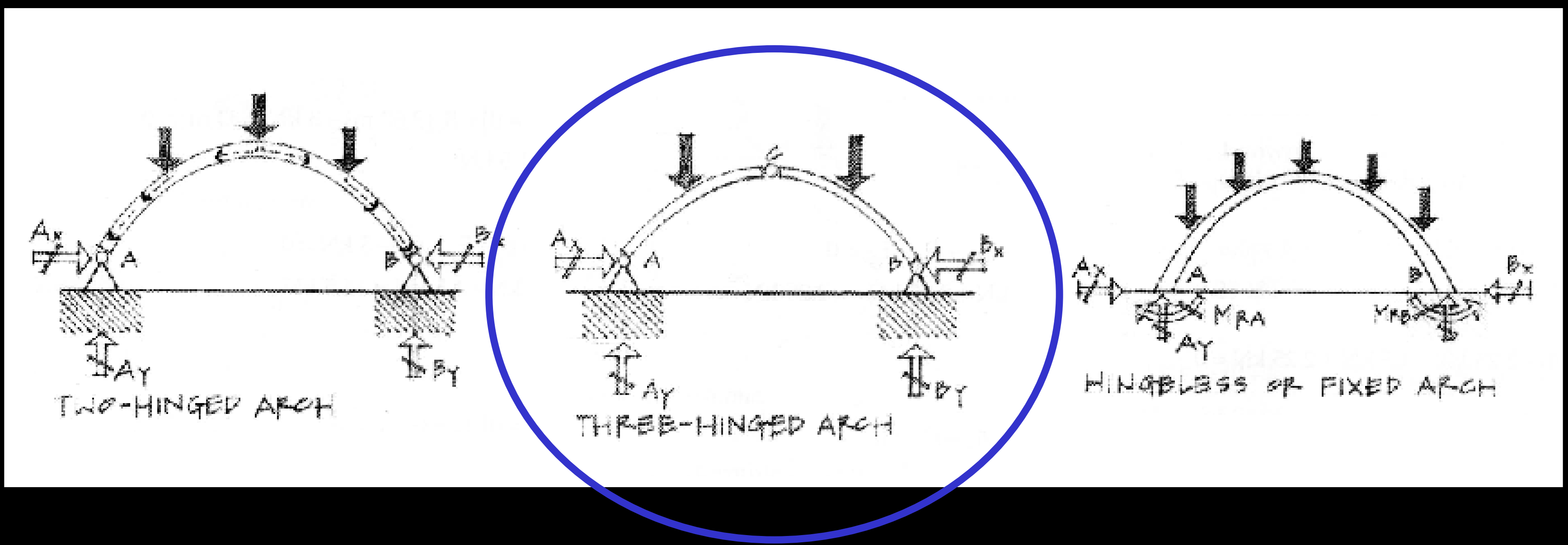


Rainbow Bridge National Monument

Roman Aquaducts

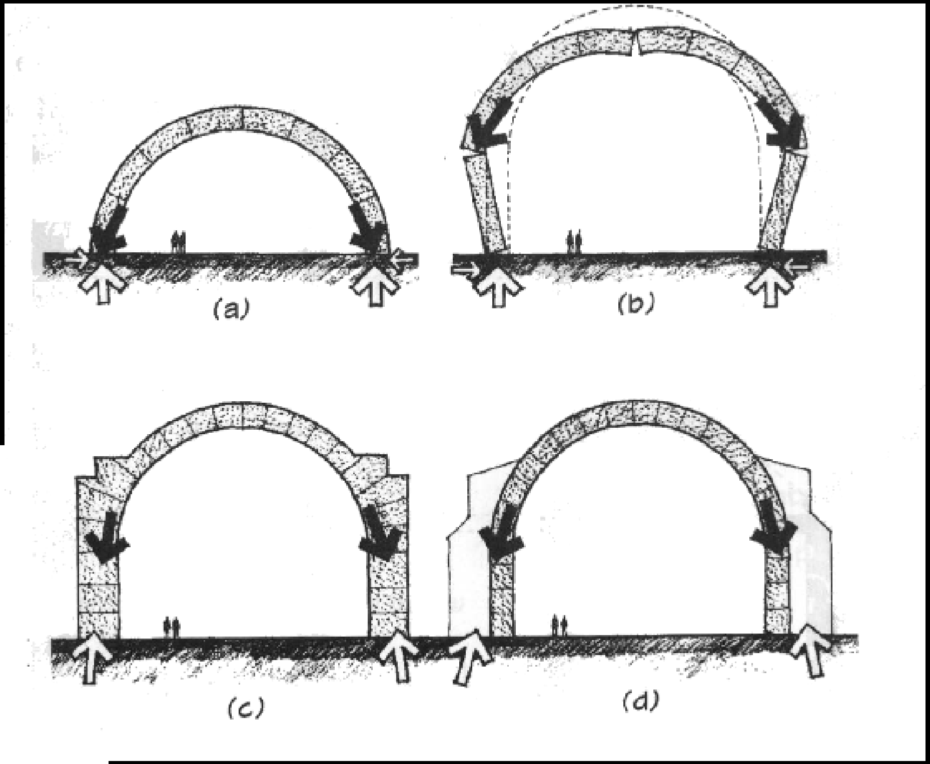
Arches

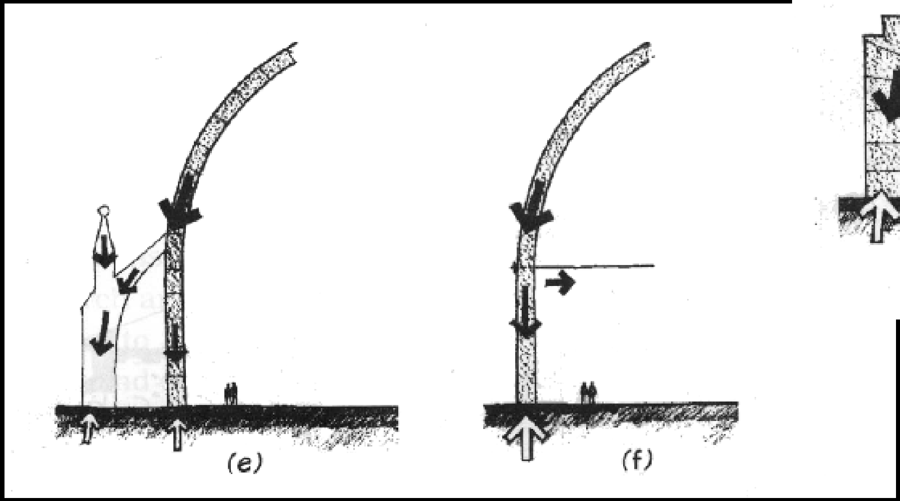
- *primarily sees compression*
- *a brick "likes an arch"*



Arches

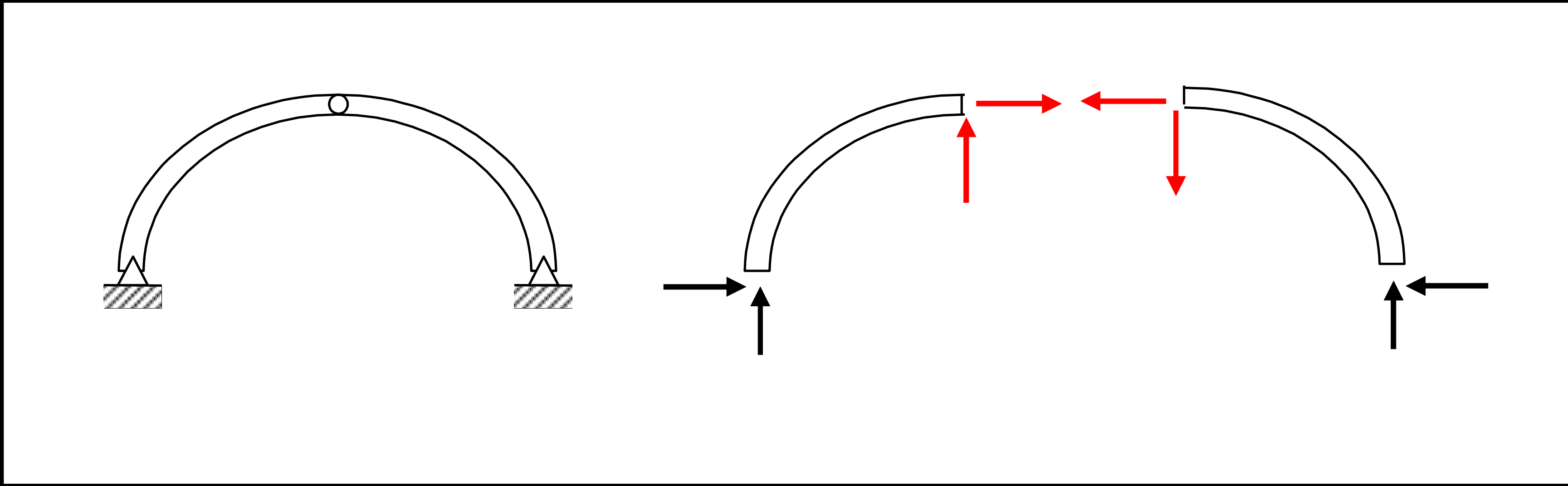
- *behavior*
  - *thrust related to height to width*





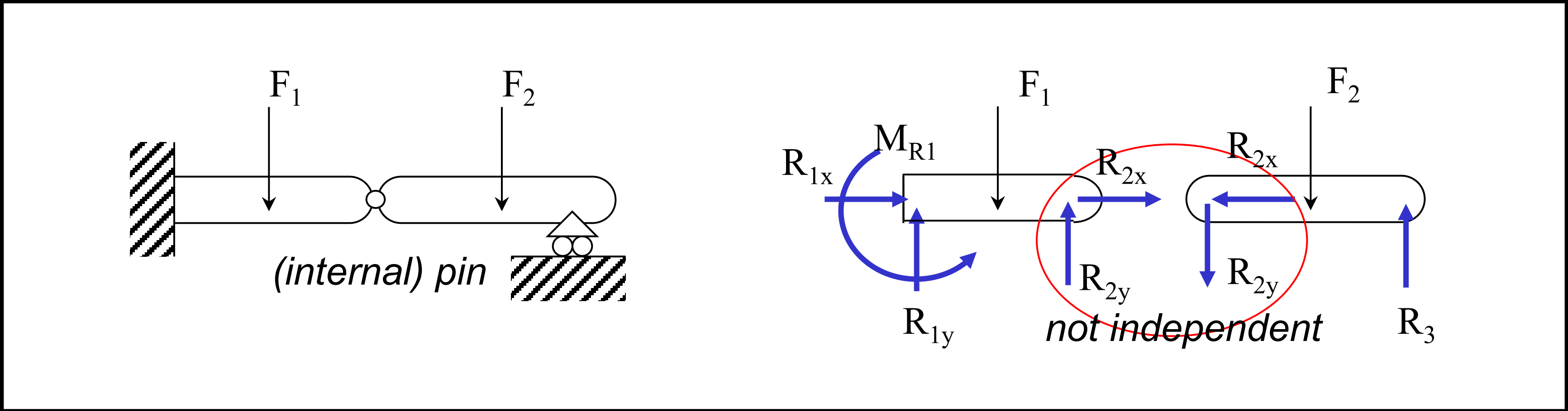
Three-Hinged Arch

- statically determinant
  - 2 bodies, 6 equilibrium equations
  - 4 support, 2 pin reactions (= 6)



Compound Beams

- *statically determinant when*
  - *3 equilibrium equations per link =>*
  - *total of support & pin reactions (properly constrained)*
- *zero moment at pins*

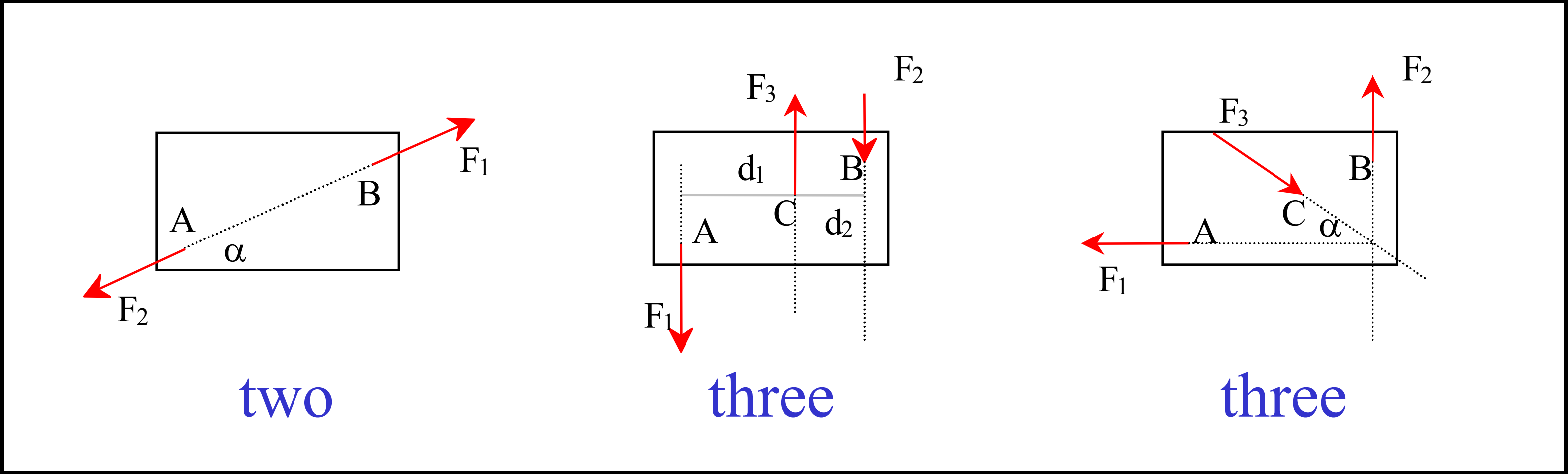


Procedure

- *solve for all support forces you can*
- *draw a FBD of each member*
  - *pins are integral with member*
  - *pins with loads should belong to 3+ force bodies*
  - *pin forces are equal and opposite on connecting bodies*
  - *identify 2 force bodies vs. 3+ force bodies*
  - *use all equilibrium equations*

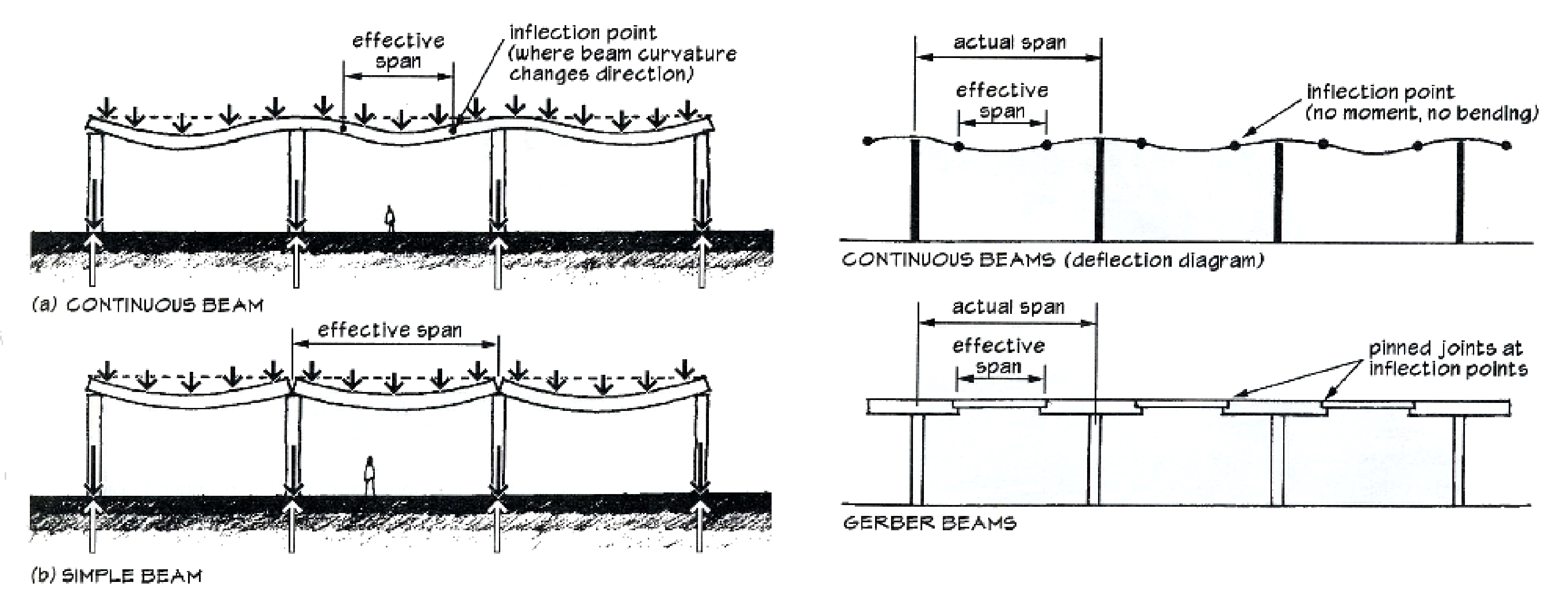
Rigid Body Types

- *two force bodies*
  - *forces in line, equal and opposite*
- *three force bodies*
  - *concurrent or parallel forces*



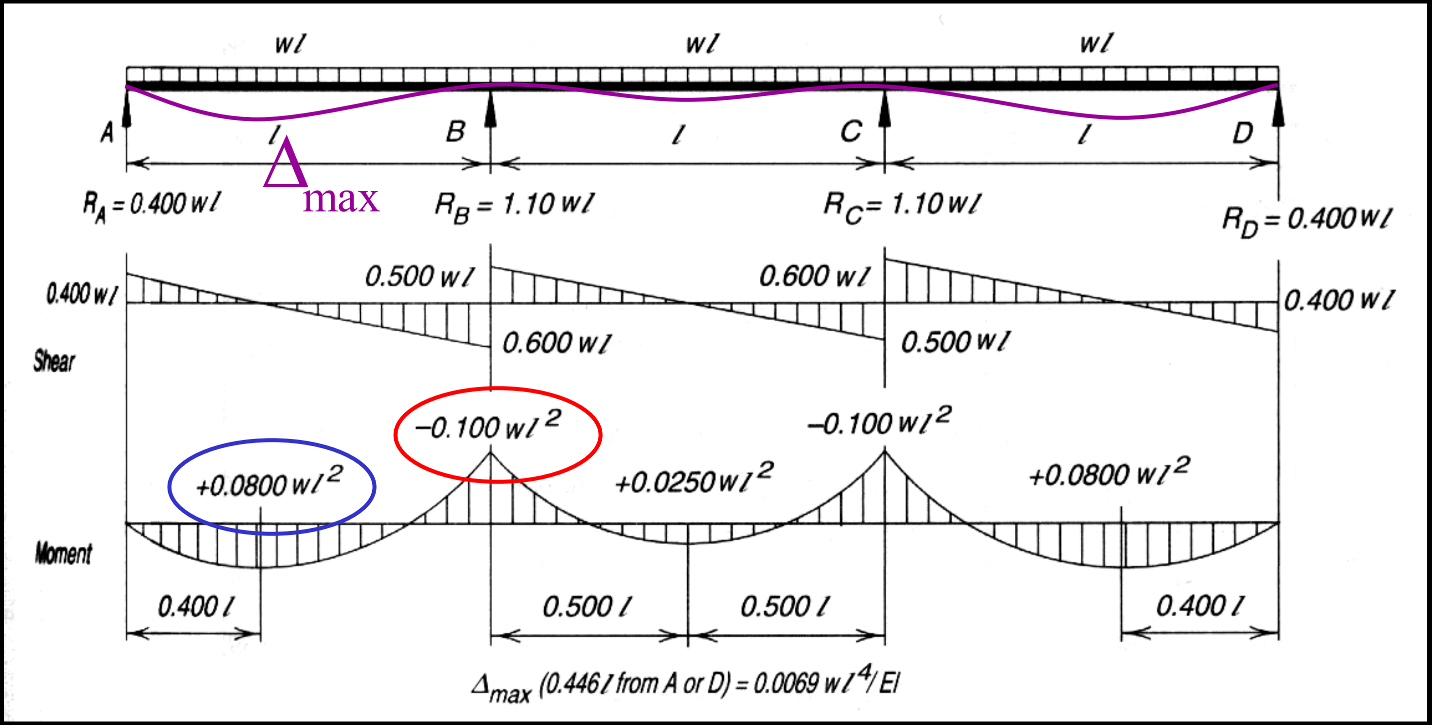
Continuous Beams

- *statically indeterminate*
- *reduced moments than simple beam*



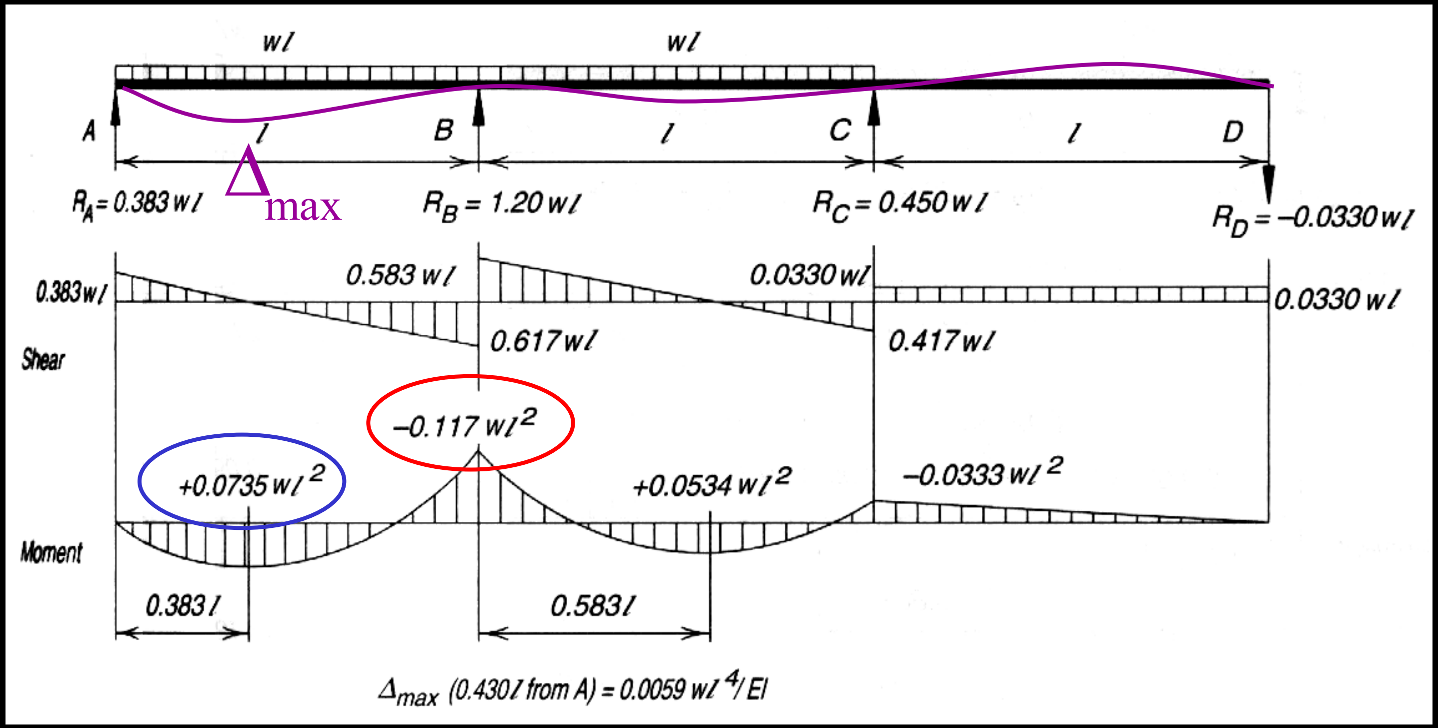
Continuous Beams

- *loading pattern affects*
  - *moments & deflection*



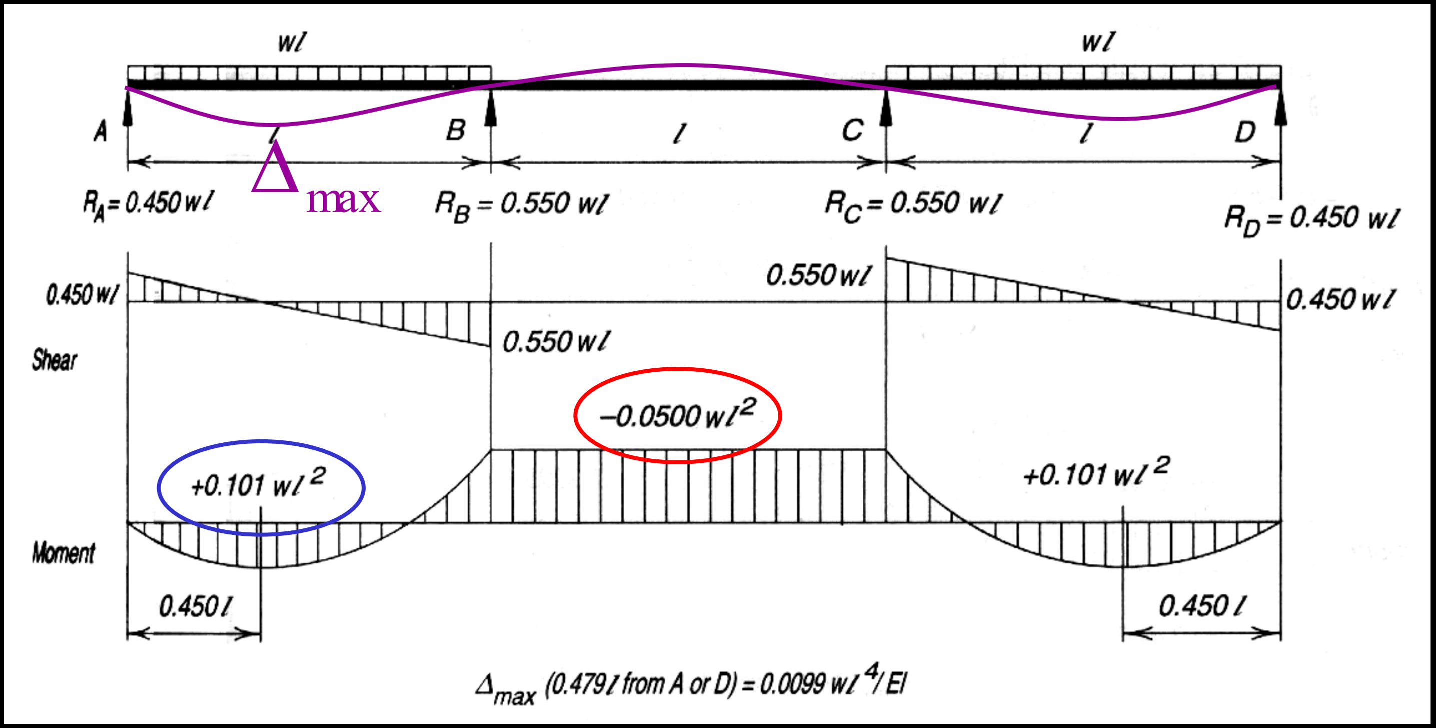
Continuous Beams

- *unload end span*



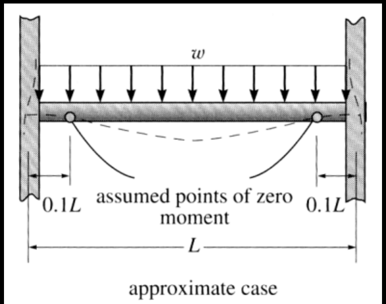
Continuous Beams

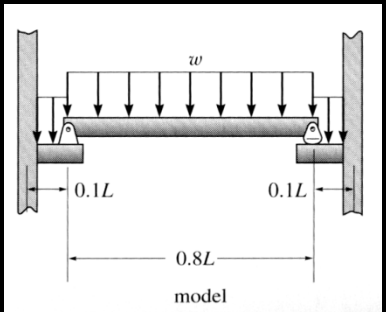
- *unload middle span*



Analysis Methods

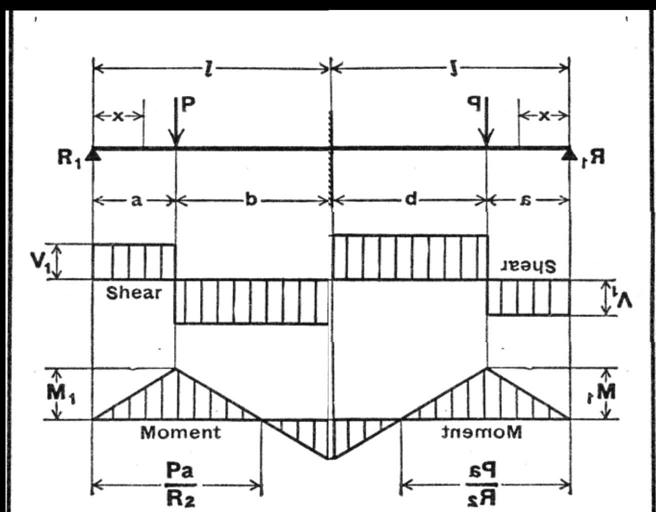
- *Approximate Methods*
  - *location of inflection points*
- *Force Method*
  - *forces are unknowns*
- *Displacement Method*
  - *displacements are unknowns*

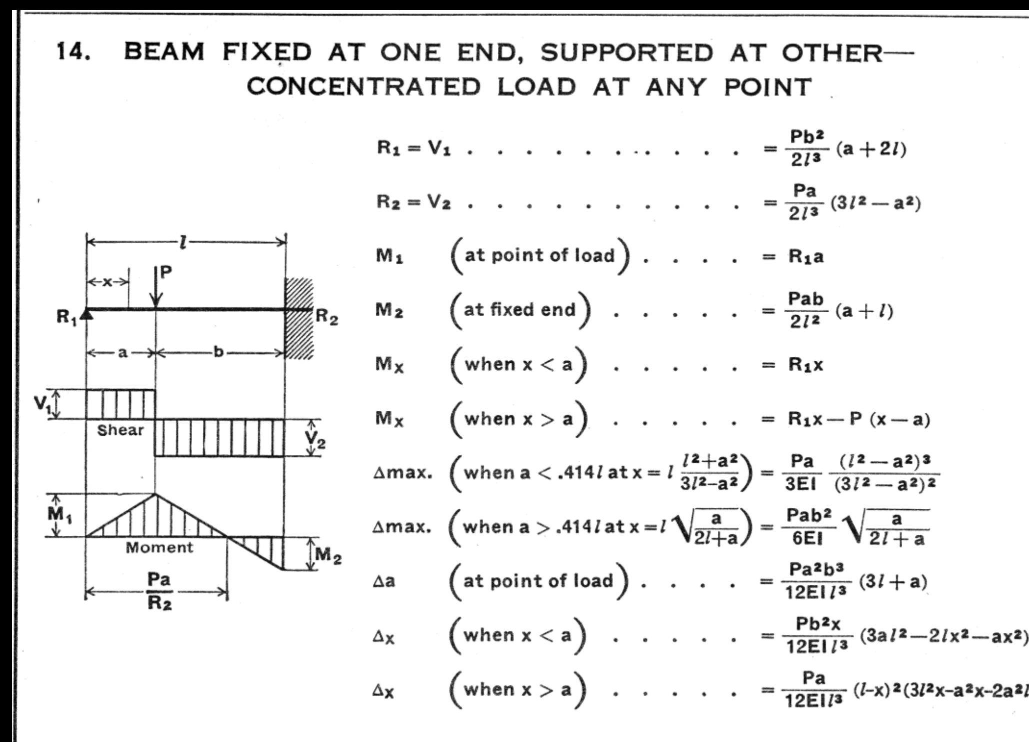




Two Span Beams & Charts

- *equal spans & symmetrical loading*
- *middle support as flat slope*




14. BEAM FIXED AT ONE END, SUPPORTED AT OTHER—
CONCENTRATED LOAD AT ANY POINT

$R_1 = V_1$ . . . . $= \frac{Pb^2}{2l^3}(a + 2l)$

$R_2 = V_2$ . . . . $= \frac{Pa}{2l^3}(3l^2 - a^2)$

M_1 (at point of load) . . . . . $= R_1 a$

M_2 (at fixed end) . . . . . . $= \frac{Pab}{2l^2}(a + l)$

M_x (when $x < a$) . . . . . . $= R_1 x$

M_x (when $x > a$) . . . . . . $= R_1 x - P(x - a)$

$\Delta max.$ (when $a < .414l$ at $x = l\frac{l^2+a^2}{3l^2-a^2}$) $= \frac{Pa}{3EI}\frac{(l^2 - a^2)^3}{(3l^2 - a^2)^2}$

$\Delta max.$ (when $a > .414l$ at $x = l\sqrt{\frac{a}{2l+a}}$) $= \frac{Pab^2}{6EI}\sqrt{\frac{a}{2l + a}}$

Δa (at point of load) . . . . $= \frac{Pa^2b^3}{12EIl^3}(3l + a)$

Δx (when $x < a$) . . . . . . $= \frac{Pb^2x}{12EIl^3}(3al^2 - 2lx^2 - ax^2)$

Δx (when $x > a$) . . . . . . $= \frac{Pa}{12EIl^3}(l-x)^2(3l^2x - a^2x - 2a^2l)$