Pros and Cons of Det. And Ind. Str.

Statically Determinate Structures

- No. of unknowns are equal to the number of available equilibrium conditions.
- SDS does not transfer deformation of one part to the other. For e.g. in case of differential settlement, no extra stresses will be produced in the structure. However in SIS it will result in extra force in the structure.
- Similarly temperature Stresses will not be transferred from roof truss to the columns on which the truss is rested if it is simply supported. Hence no temperature analysis is required for such trusses.
- In SIS temperature analysis is essential to avoid buckling of members

Statically Indeterminate Structrues

- No. of unknown are more than available conditions of equilibrium
- Generally majority of the structures are indeterminate. Indeterminacy has advantages as well as disadvantages.
- Indeterminacy produces less deflections in the structure for similar conditions. For e.g. A simply supported beam produces $M_{max} = \frac{PL}{4}$ however in case of fixed ended beam it is only $M_{max} = \frac{PL}{8}$
- SIS can redistribute loads to the stronger portion of the structure in case of faulty design or over loadings specially in case of lateral loadings hence avoiding the collapse of structure up to certain extent.

FORCE METHOD

Method of analysis

- During analysis of SIS structures following are required
  - Equilibrium satisfaction
  - Compatibility satisfaction
  - & Force displacement forces
- Equilibrium is satisfied when the reactive forces hold the structure at rest.
- Compatibility is satisfied when various segments of the structure fit together without intentional breaks or overlaps.
- Force displacement relationship depends upon the way on which material behaves. Since our material is elastic or we are developing the equations for elastic limit of our structure.

FORCE METHOD

Back Ground of Force method

- Originally Developed by James Clerk Maxwell in 1864 and later refined by Mohr and Heinrich.
- It was the first method of analysis for SIS structures.
- Since compatibility forms the basis of this method hence it is also known as compatibility method or method of consistent deformations or displacements.

FORCE METHOD

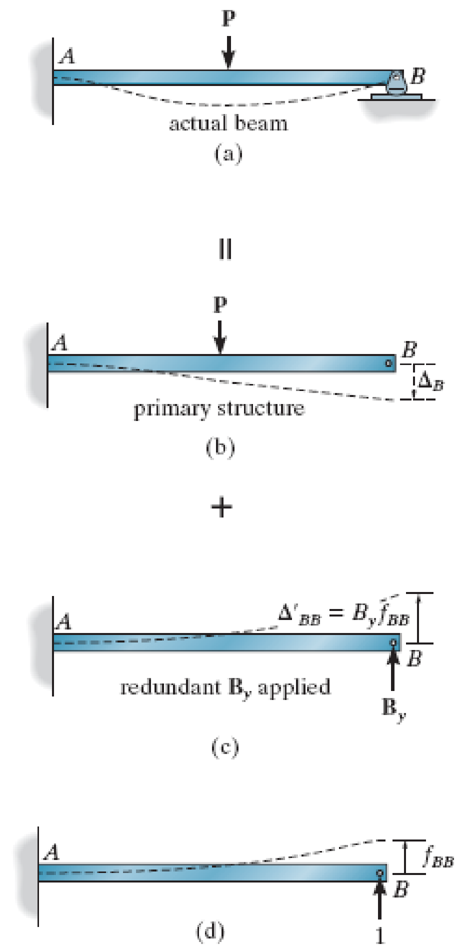
Force Method

- This method includes at first writing force-displacement relationship and then satisfying the equilibrium requirements for the structure.
- The unknowns in the equations are displacements.
- Once displacements are obtained, the forces are determined from force-displacement and compatibility equations.

FORCE METHOD

General Procedure for vertical force as redundant

- Consider the beam shown in figure (a)
- There are four unknown reactions.
- The beam has DOI=4-3 = 1°
- In order to analyze this structure principle of superposition will be used as follows.
- Choose one of the unknown reaction as redundant and temporarily remove its effect from the beam to make it Statically determinate structure as shown in figure-(b) and termed as "Primary structure".
- When the support is removed at joint B, it will cause deflection "Δ_B" or δ_{BB}
- On the other hand when the redundant force "B_y" is applied as shown in fig-(c) it will cause upward deflection "Δ'_{BB}" i.e. deflection at joint "B" due to redudant force at "B".
- $P = KD \Rightarrow D = \frac{P}{K} => fP, \qquad Hence\ \Delta'_{BB} = fBB_{By}$



FORCE METHOD

General Procedure for vertical force as redundant

- Using figures "b" and "c", the compatibility condition at support "B" can be written as follows

$$0 = -\Delta_{BB} + \Delta'_{BB}$$

- Where $\Delta'_{BB} = By\, x\, fBB$

- The first equation can be modified as follows

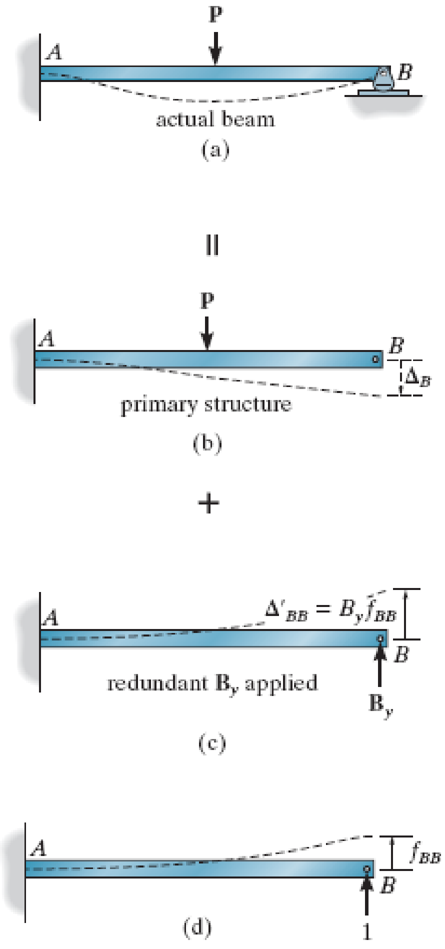
$$0 = -\Delta_{BB} + By\, x\, fBB$$

- Where f_{BB} is a measure of deflection per unit force obtained using figure – d using unit force method.

$$\Delta'_{BB} = fB_{BBy} \qquad since\ By = 1\ for\ figure - d$$

Therefore $f_{BB} = \Delta'_{BB}$

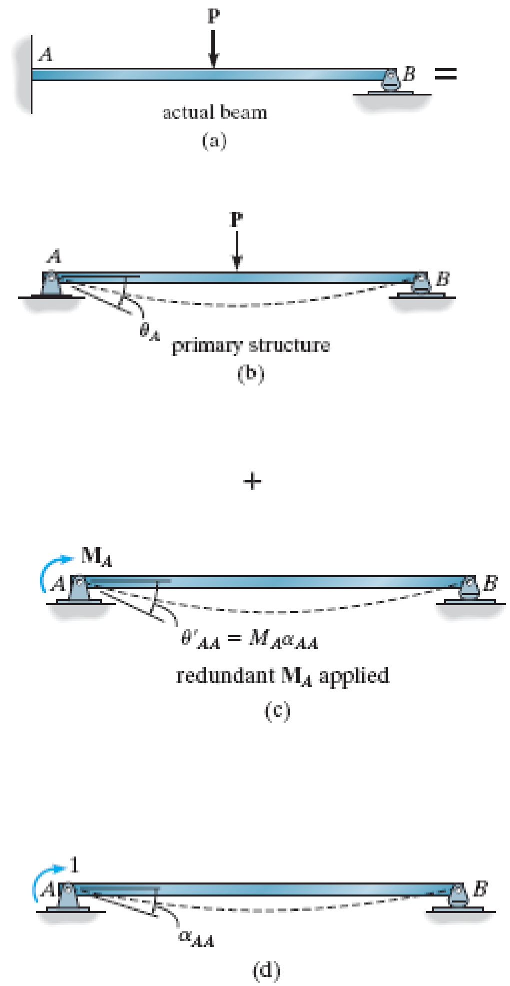
- Hence the unknown force will be obtained using above equation in the following form.
  - $B_y = \frac{\Delta_{BB}}{f_{BB}}$ where $\Delta_{BB} = \int_0^L \frac{Mm\, dx}{EI}$ & $f_{BB} = \int_0^L \frac{m^2\, dx}{EI}$



FORCE METHOD

General Procedure for Moment Redundant

- Consider the beam shown in figure (a)
- There are four unknown reactions.
- The beam has DOI=4-3 = 1°
- In order to analyze this structure principle of superposition will be used as follows.
- Choose one of the unknown reaction as redundant and temporarily remove its effect from the beam to make it Statically determinate structure as shown in figure-(b) and termed as "Primary structure".
- When the fixed support is removed at joint A, it will cause rotation under load "P" as "θ_A"
- On the other hand when the redundant force "M_A" is applied as shown in fig-(c) it will cause CCW rotation "θ'_{AA}" i.e. rotation at joint "A" due to redudant moment at "A".
- $P = KD \Rightarrow D = \frac{P}{K} => fP, \quad Hence\ \theta'_{AA} = \alpha_{AA} M_A$



FORCE METHOD

General Procedure for Moment Redundant

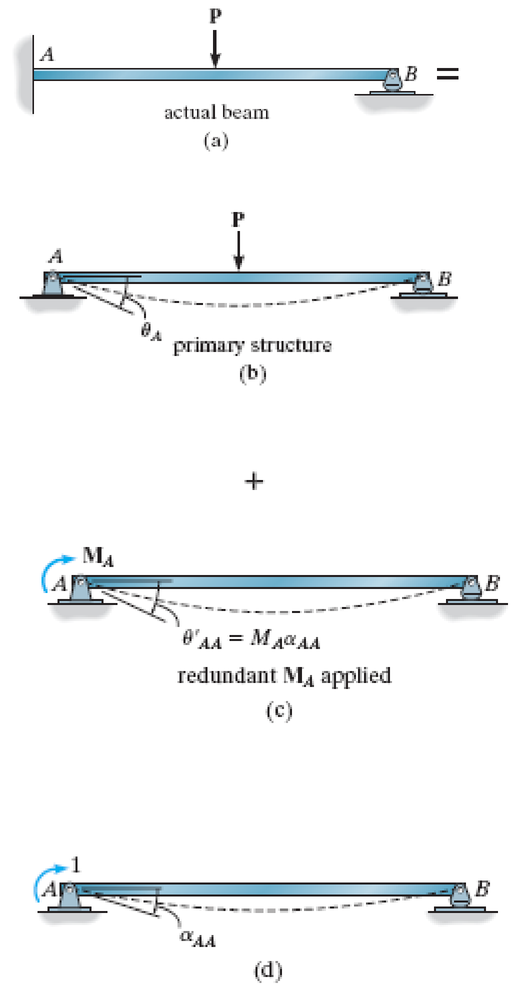
- Using figures "b" and "c", the compatibility condition at support "B" can be written as follows

$$0 = +\theta_{BB} + \theta'_{BB}$$

- Where $\theta'_{AA} = \alpha_{AA} M_A$

- The first equation can be modified as follows
- $$0 = \theta_{BB} + \alpha_{AA} M_A$$
- Where α_{BB} is a measure of angular displacement per unit moment obtained using figure – d using unit force method.
- Hence the unknown force will be obtained using above equation in the following form.

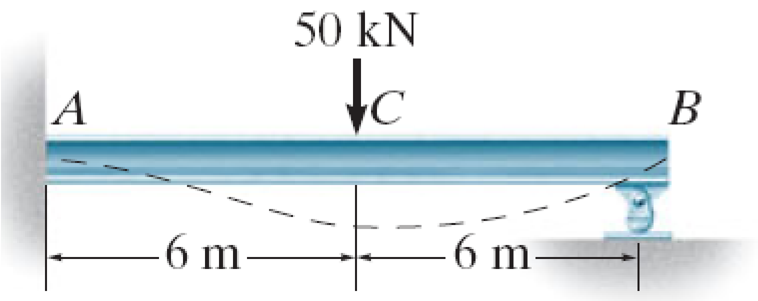
  - $$M_A = -\frac{\theta_{BB}}{\alpha_{BB}}$$



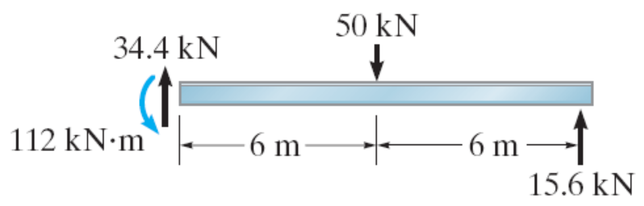
FORCE METHOD

Problem-1

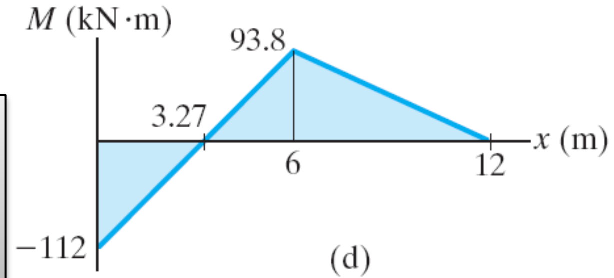
- Analyze the given beam using Redundant at “B”. Also draw the shear force and the bending moment diagrams.



actual beam



(c)



(d)

Note:- Either assume the direction of unknown force and write compatibility condition by yourself and use absolute values for Δ_{BB} or f_{BB}

Or consider all the deformations in the positive direction and let the sign of Δ_{BB} or f_{BB} to decide about the direction of reaction.

FORCE METHOD

Problem-2

- Analyze the given beam using Redundant at “A”. Also draw the shear force and the bending moment diagrams.