

Structural Analysis II
構造力学第二
(1)

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Structures that support human activities

人間の生活と生産活動を支える構造物

Beam or Lintel(梁(はり))



Parthenon

Column or post (柱)



Stone Hange, UK

A structure at the early days



Timber truss bridge at Cambridge University



Truss structure(トラス構造)

Rainbow Bridge under construction

Suspension bridge
吊橋 (つり橋)

Tower (主塔)

Cables (ケーブル)

Girder (桁)



Arch Structures



Seine River



Venezia, Italy



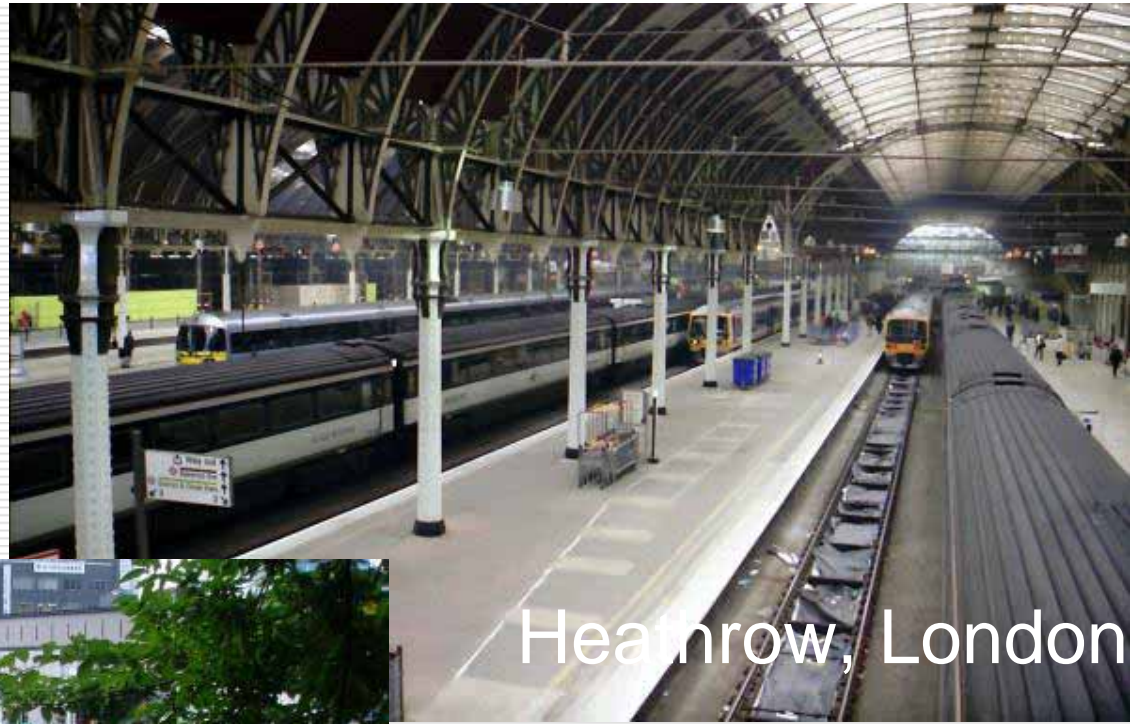
Pavia, Italy

Eiffel Tower



Bird Nest Beijing





Heathrow, London



Yotsuya Bridge, Tokyo

Fuji River Bridge



City which is formed by various civil engineering structures



SCHEDULE

- 1st: April 9 (M)
- 2nd: April 16 (M)
- 3rd: April 23 (M)
- 4th: May 7 (M)-----Mid-term examination
- 5th: May 14 (M)
- 6th: May 21 (M)
- 7th: May 28 (M)
- 8th: June 4 (M)-----Final Examination

All classes are provided at 13:20-14:50.

Text Book

Harry, H. W. and Louis, F.
G., Professors, The
Pennsylvania State
University

Fundamentals of Structural
Analysis, John Wiley &
Sons

ME
HARRY H. WEST
LOUIS F. GESCHWINDNER

FUNDAMENTALS OF STRUCTURAL ANALYSIS SECOND EDITION

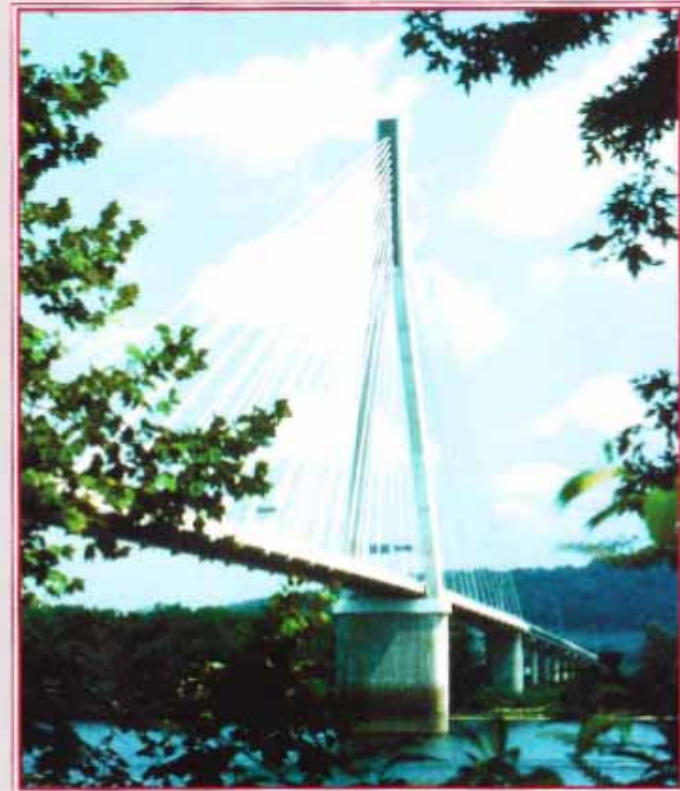


Table of Contents of the Text Book

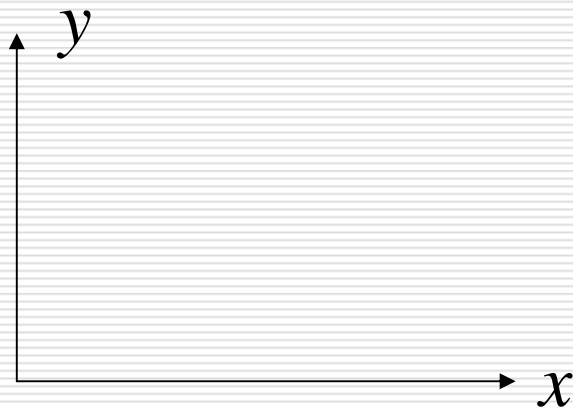
- Part I Orientation
- Part II Analysis of Statically Determinate Structures(静定構造)
- Part III Elastic Deflections of Structures(弾性たわみ) < - > (非弾性たわみ)
- Part IV Analysis of Statically Indeterminate Structures(不静定構造)
- Part V Matrix Methods of Analysis (マトリックス構造解析)

CHAPTER 9 MORE BASIC CONCEPTS OF STRUCTURAL ANALYSIS

9.1 REQUIREMENTS AND LIMITATIONS OF EQUILIBRIUM(つり合い)

- Statically determinate structures(静的構造物)

For planar structures(2次元平面構造), equilibrium is ensured by satisfying the three equations of static equilibrium (静的つり合い式) as



$$\sum P_x = 0$$

$$\sum P_y = 0$$

$$\sum M_z = 0$$

●According to Section 3.3, representing the total number of unknown reaction components of a planar structure as r_a , the structure can be classified into three categories;

✓ $r_a < 3$; structure is statically unstable externally
(外的静的に不安定)

✓ $r_a = 3$; structure is statically determinate externally
(外的静的に静定)

✓ $r_a > 3$; structure is statically indeterminate externally
(外的静的に不静定)

●In the Structural Analysis II, analytical methods of externally statically indeterminate structures are studied.

Consider the beam shown in Fig. 9.1.

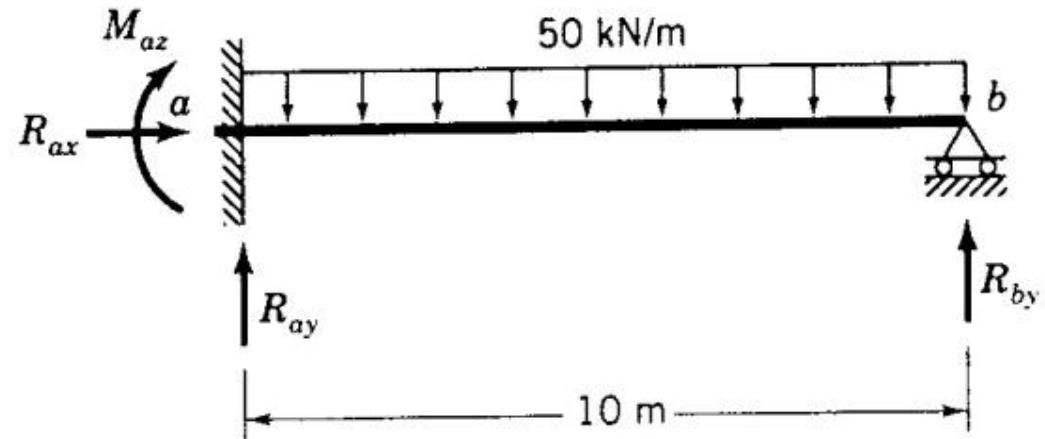


Fig. 9.1

- this beam is statically indeterminate externally because $r_a = 4$.

- A unique solution for the reactions is not possible in this case because there are four unknown reactions while we have only three equilibrium equations as

$$R_{ax} = 0$$

$$R_{ay} + R_{by} = 500 \quad (9.1)$$

$$M_{az} - 10R_{by} = -2500$$

- There is an infinite number of solutions. Each results in values for R_{ay} and M_{az} that satisfy the equilibrium requirements along with assigned value of R_{by} .
- There is a limitation that equilibrium considerations alone give no clue regarding which one of the infinite array of possible equilibrium solutions is the correct one

9.2 STATIC INDETERMINANCIES (静的不静定); REDUNDANCIES (静的不静定次数)

1) External and internal indeterminacy

- All criteria involve a comparison between the number of independent unknown force components (未知力の数) and the number of independent equations of equilibrium (つり合い方程式の数) that are available for the solution of these unknowns.
- The criteria always take the following form:
 - ✓ If there are more equations than there are unknowns, the structure is statically unstable.
 - ✓ If there is the same number of equations as unknowns, the structure is statically determinate.
 - ✓ If there are fewer equations than unknowns, the structure is statically indeterminate.

- The unknown force quantities must be arranged so as to ensure the stability of the structure
- A structure is statically indeterminate when there are more reaction force components available and/or member forces present than are necessary for stability of the structure.
- The degree of external indeterminacy is equal to the number of reaction components that are available in excess of the number that is required for external stability. These excess reaction components are called **redundants (不静定次数)** because they are unnecessary for the stability of the structure.

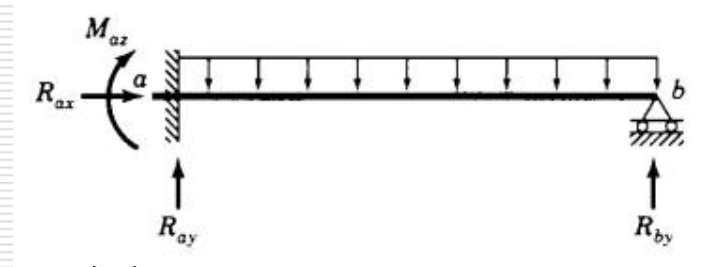
- The degree of internal indeterminacy is given by the number of internal force components that are present in excess of those that are needed for internal stability. These are also called **redundants (不静定次数)** since they are not required for a stable structure.

2) Primary structure (基本構造)

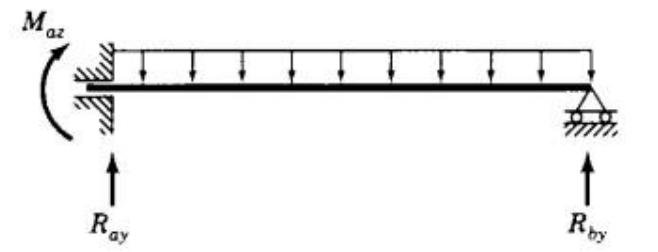
- In certain methods of statically indeterminate analysis, it is necessary to identify explicitly the reaction components or internal force components that they wish to select as the redundants.
- These are then conceptually removed from the structure, and the statically determinate structure that remains is called **the primary structure**.
- It is essential that the redundant be selected so that the primary structure is stable.

3) Example of Primary Structure

- Consider the beam which is **statically indeterminate externally to the first degree (1次の不静定はり)**
- There is one redundant, or unnecessary, reaction component.
- If R_{ax} is selected as the redundant, the primary structure becomes as shown in (b).
- This structure is both unstable and indeterminate.



(a) statically indeterminate structure

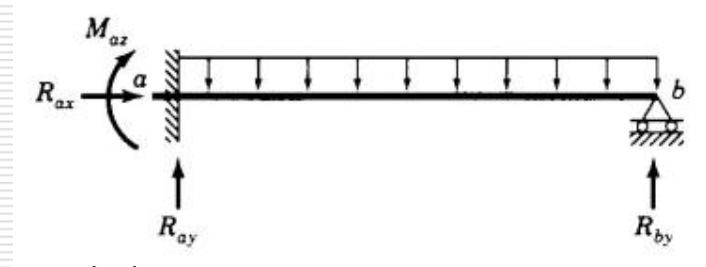


(b) Unstable and statically primary structure

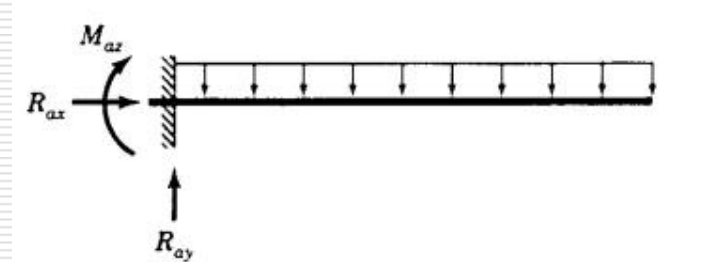
Fig. 9.3 Selection of redundant reaction

- However, if R_{by} is taken as the redundant as shown in (c)

- then the primary structure is stable and statically determinate.



(a) statically indeterminate structure



(c) Stable and statically determinate primary structure

Fig. 9.3 Selection of redundant reaction