PUBLISHED BY STUCOR

DEPARTMENT OF CIVIL ENGINEERING

QUESTION BANK

DEPARTMENT: CIVIL **SEMESTER: V**

SUBJECT CODE / Name: CE8502 / STRUCTURAL ANALYSIS-I

UNIT 1- STRAIN ENERGY METHOD

1. **State and explain the princ**

(AUC Apr/May 2012 & 2011, Nov/Dec 2012 & 2013, May/June 2014)

The principle of virtual work is based on the conservation of energy for a structure which implies that work done on a structure by external loads is equal to workdone on a structure by internal loads.

2. **Write down the Castigliano's first theorem.** **(AUC Nov/Dec 2010)**

The partial derivative of the total strain energy with respect to an applied force or moment gives the displacement or rotation at the point of application of the force and in the direction of application of the force.

3. **What is the significance of unit load method?** **(AUC Apr/May 2012)**

The external load is removed and the unit load is applied at the point, where the deflection or rotation is to found.

4. **State the basic unit load formula.** **(AUC Nov/Dec 2010)**

i) Find the forces P1, P2, ……. in all the members due to external loads.
ii) Remove the external loads and apply the unit vertical point load at the joint if the vertical deflection is required and find the stress.
iii) Apply the equation for vertical and horizontal deflection.

5. **Explain Mohr's correction.** **(AUC Apr/May 2011)**

The Williot diagram does not give the true deflection of the joints but the same can be modified and correlated to the true deflection by applying certain correction is known as Mohr's correction.

6. **Differentiate perfect and imperfect frame.** **(AUC Nov/Dec 2012)**

A structural frame that is stable under loads imposed upon it from any direction is known as perfect frame.

A structural frame is unstable if one of its members were removed or one of its fixed ends became hinged is known as imperfect frame.

7. **State Maxwell's Reciprocal theorem?**

This theorem states that 'work done by the forces of the first state on the corresponding displacements of the second state is equal to the work done by the forces of the second state on the corresponding displacements of the first state'.

8. **Determine the free end slope of a cantilever beam having length 'L' due to an applied moment 'M' at free end using the principle of virtual work?**

$$\Delta = \int_0^l \frac{mM}{EI} dx$$

Here m = - x and M = $-\frac{wx^2}{2}$

$$\Delta = \frac{wl^2}{8}$$

9. **Distinguish between pin jointed and rigidly jointed structures.**

Pin jointed structures:

i) The joints permit change of angle between connected members.
ii) The joints are incapable of transferring any moment to the connected members and Vice versa.
iii) The pins transmit forces between connected members by developing shear.

Rigidly jointed structures:

i) The members connected at a rigid joint will maintain the angle between them even under deformation due to loads.
ii) Members can transmit both forces and moments between themselves through the joint.
iii) Provision of rigid joints normally increases the redundancy of the structures.

10. **What are the assumptions made in the analysis of pin jointed trusses?**

i) All the members are pin jointed.
ii) External loads are transmitted to the structure only at the joint.
iii) Pins do not transfer any moment to any of the connected members.
iv) Pins allow the connected members to change the angles between them.

11. **Explain Williot's diagram.**

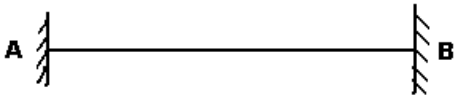
A graphical method used to determining the deflection of a framed structure under the load is known as Williot's diagram.

12. **Give the equation that is used for the determination of deflection at a given point in truss and frames?**

For truss, $\Delta = \frac{\Sigma kFl}{AE}$

For frames, $\Delta = \int_0^l \frac{mM}{EI} dx$

13. Find the static indeterminacy of below figure.



Static indeterminacy = No. of unknowns – No. of conditions

= 6 – 3

= 3

14. Define internally and externally indeterminate structures.

Internally indeterminate structures:

In a pin jointed frames redundancy caused by too many members is called internally indeterminate structures or internal redundancy.

Externally indeterminate structures:

In a pin jointed frames redundancy caused by too many supports is called externally indeterminate structures or external redundancy.

15. Define degree of freedom.

In a structure the number of independent joint displacement that the structures can undergo are known as degree of freedom. It is also known as kinematic indeterminacy.

16. Write any two important assumptions made in the analysis of trusses?

i) All the members are pin jointed.
ii) External loads are transmitted to the structure only at the joint.

17. State the difference between strain energy method and unit load method in the determination of deflection of structures?

In the unit load method, one has to analyze the frame twice to find the load and deflection.

While in the strain energy method, only one analysis is needed to find the load and deflection.

18. Name any four methods used for computation of deflection in structures?

Double integration method, Macaulay's method, Conjugate beam method, Moment area method, Method of elastic weights, Virtual work method- Dummy unit load method, Strain energy method and Williot Mohr diagram method.

19. Define static indeterminacy of structures. (AUC Nov/Dec 2013)

If the conditions of statics i.e. $\sum H = 0$, $\sum V = 0$ and $\sum M = 0$ alone are not sufficient to find either external reactions or internal forces in a structure. The structure is called static indeterminacy of structures.

20. Define static determinate structures. (AUC Nov/Dec 2013)

If the conditions of statics i.e. $\sum H = 0$, $\sum V = 0$ and $\sum M = 0$ alone are sufficient to find either external reactions or internal forces in a structure. The structure is called static determinacy of structures.

PUBLISHED BY STUCOR

DEPARTMENT OF CIVIL ENGINEERING

QUESTION BANK

DEPARTMENT: CIVIL **SEMESTER: V**

SUBJECT CODE / Name: CE8502 / STRUCTURAL ANALYSIS-I

UNITII – SLOPE DEFLECTION METHOD

PART - A (2 marks)

1. **What are the assumptions made in slope-deflection method?**

(AUC Apr/May 2012, Nov/Dec 2013)

i) Between each pair of the supports the beam section is constant.

ii) The joint in structure may rotate or deflect as a whole, but the angles between the members meeting at that joint remain the same.

2. **What is the limitation of slope-deflection equations applied in structural analysis?**

(AUC Apr/May 2012)

i) It is not easy to account for varying member sections.

ii) It becomes very cumbersome when the unknown displacements are large in number.

3. **Mention the causes for sway in portal frames.** **(AUC Nov/Dec 2012, May/June 2014)**

Because of sway, there will be rotations in the vertical members of a frame. This causes moments in the vertical members. To account for this, besides the equilibrium, one more equation namely shear equation connecting the joint-moments is used.

4. **Explain the use of slope deflection method.** **(AUC Nov/Dec 2012)**

i) It can be used to analyze statically determinate and indeterminate beams and frames.

ii) In this method it is assumed that all deformations are due to bending only.

iii) In other words deformations due to axial forces are neglected.

iv) The slope-deflection equations are not that lengthy in comparison.

5. **Compute the rotation at middle support of a two equal span continuous beam fixed at the ends and carrying UDL of 10 kN/m over the entire beam span 5 m. Take EI = 60000 kNm^2.**

(AUC Apr/May 2011)

θ_B = 0.00155 mm and

θ_C = 0.0062 mm

6. **Write down the slope deflection equation for a beam AB fixed at A and B subjected to a settlement δ at B.** **(AUC Apr/May 2011, May/June 2014)**

$$M_{AB} = M_{FAB} + \frac{2EI}{L}\left(2\theta_A + \theta_B + \frac{3\delta}{L}\right)$$

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left(\theta_A + 2\theta_B + \frac{3\delta}{L}\right)$$

7. **Mention two assumptions made in slope deflection method.** **(AUC Nov/Dec 2010)**

   i) Between each pair of the supports of the beam is constant.

   ii) The joint in a structure may rotate or deflect as a whole, but the angles between the members meeting at that joint remain the same.

8. **Write down the fundamental equation of slope deflection method. (AUC Nov/Dec 2010, 2013)**

$$M_{AB} = M_{FAB} + \frac{2EI}{L}\left(2\theta_A + \theta_B + \frac{3\delta}{L}\right)$$

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left(\theta_A + 2\theta_B + \frac{3\delta}{L}\right)$$

9. **How many slope deflection equations are available for a two span continuous beam?**

   There will be 4 Nos. of slope deflection equations, two for each span.

10. **What is the moment at a hinged end of a simple beam?**

    Moment at the hinged ends of a simple beam is zero.

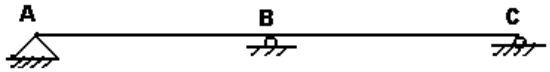
11. **What are the quantities in terms of which the unknown moments are expressed in slope deflection method?**

    In slope-deflection method, unknown moments are expressed in terms of

    (i) Slopes (θ) and

    (ii) Deflections (Δ)

12. **The beam shown in figure is to be analyzed by slope deflection method. What are the unknowns and to determine them, what are the conditions used?**



Unknowns are θ_A, θ_B and θ_C

Equilibrium equations used:

(i) $M_{AB} = 0$

(ii) $M_{BA} + M_{BC} = 0$

(iii) $M_{CB} = 0$

13. Mention any three reasons due to which sway may occur in portal frames.

Sway in portal frames may occur due to

i) Unsymmetry in geometry of the frame
ii) Unsymmetry in loading or
iii) Settlement of one end of a frame.

14. Write down the general slope deflection equations and state what each term represents.

$$M_{AB} = M_{FAB} + \frac{2EI}{L}\left(2\theta_A + \theta_B + \frac{3\delta}{L}\right)$$

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left(\theta_A + 2\theta_B + \frac{3\delta}{L}\right)$$

Where, M_{AB}, M_{BA} = fixed end moments at A and B due to given loading.

θ_A, θ_B = slopes at A and B.

Δ = Sinking of support A with respect to B.

15. A rigid frame is having totally 10 joints including support joints. Out of slope deflection and moment distribution methods, which method would you prefer for analysis? Why?

Moment distribution method is preferable.

If we use slope-deflection method, there would be 10 (or more) unknown displacements and an equal number of equilibrium equations. In addition, there would be 2 unknown support moments per span and the same number of slope-deflection equations. Solving them is difficult.

PUBLISHED BY STUCOR

DEPARTMENT OF CIVIL ENGINEERING

QUESTION BANK

DEPARTMENT: CIVIL **SEMESTER: V**

SUBJECT CODE / Name: CE8502 / STRUCTURAL ANALYSIS-I

UNIT III – MOMENT DISTRIBUTION METHOD

PART – A (2 marks)

1. **Differentiate between distribution factors and carry over factor. (AUC Apr/May 2012)**

Distribution factor:

When several members meet at a joint and a moment is applied at the joint to produce rotation without translation of the members, the moment is distributed among all the members meeting at that joint proportionate to their stiffness.

Distribution factor = Relative stiffness / Sum of relative stiffness at the joint

Carry over factor:

A moment applied at the hinged end B "carries over" to the fixed end A, a moment equal to half the amount of applied moment and of the same rotational sense.

C.O =0.5

2. **Define point of contra flexure with an example. (AUC Apr/May 2012, Nov/Dec 2013)**

In a bending moment diagram, where the sign changes from positive to negative or negative to positive that place is called point of contra flexure.

3. **Write the equation for final moments in moment distribution method.(AUC Nov/Dec 2012)**

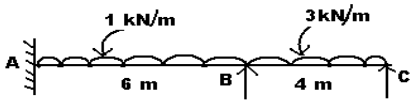


Fig.

For the above figure the final moments are

M_{AB}; M_{BA} = - M_{BC}; M_{CB};

4. **Define flexural rigidity. (AUC Nov/Dec 2012)**

The product of young's modulus (E) and moment of inertia (I) is called Flexural Rigidity (EI) of Beams. The unit is N / mm^2.

5. **What is sway correction? Explain.** **(AUC Apr/May 2011)**

Sway correction is defined as the removal of lateral movement in the beams or frames by correction factor is multiplied by corresponding sway moment.

$$\text{Correction factor} = \frac{Nonswayforce}{swayforce}$$

6. **What is distribution factor? Explain. (AUC May/June 2014, Apr/May 2011, Nov/Dec 2013)**

When several members meet at a joint and a moment is applied at the joint to produce rotation without translation of the members, the moment is distributed among all the members meeting at that joint proportionate to their stiffness.

7. **What is distribution factor, as applied in moment distribution method?**

(AUC Nov/Dec 2010)

Distribution factor = Relative stiffness / Total stiffness

8. **What is stiffness of a prismatic member?** **(AUC Nov/Dec 2010, May/June 2014)**

The stiffness of a prismatic member is 4EI / L.

9. **Explain the relative stiffness factor.** **(AUC Nov/Dec 2013)**

Relative stiffness is the ratio of stiffness to two or more members at a joint.

10. **What is the difference between absolute and relative stiffness?**

Absolute stiffness

Absolute stiffness is represented in terms of E, I and *L*, such as 4EI / L.

Relative stiffness

Relative stiffness is represented in terms of I and L, omitting the constant E. Relative stiffness is the ratio of stiffness to two or more members at a joint.

11. **In a member AB, if a moment of -10 kNm is applied at A. What is the moment carried over to B?**

Carry over moment = Half of the applied moment

Carry over moment to B = -10/5 = -5 KNm

12. **Explain carry over factor with a sketch.**

A moment applied at the hinged end B “carries over” to the fixed end A, a moment equal to half the amount of applied moment and of the same rotational sense. C.O =0.5

13. **What is the sum of distribution factors at a joint?**

Sum of distribution factors at a joint = 1.

14. **Define the term sway.**

Sway is the lateral movement of joints in a portal frame due to the unsymmetry in dimensions, loads, moments of inertia, end conditions, etc.

15. What are the situations wherein sway will occur in portal frames?

- Eccentric or unsymmetric loading
- Unsymmetrical geometry
- Different end conditions of the columns
- Non-uniform section of the members
- Unsymmetrical settlement of supports
- A combination of the above

16. What are symmetric and antisymmetric quantities in structural behavior?

When a symmetrical structure is loaded with symmetrical loading, the bending moment and deflected shape will be symmetrical about the same axis. Bending moment and deflection are symmetrical quantities.

PUBLISHED BY STUCOR

DEPARTMENT OF CIVIL ENGINEERING

QUESTION BANK

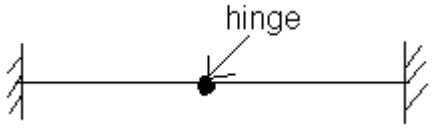
DEPARTMENT: CIVIL **SEMESTER: V**

SUBJECT CODE / Name: CE8502 / STRUCTURAL ANALYSIS- I

UNIT IV - FLEXIBILITY METHOD

PART - A (2 marks)

1. **Find degree of indeterminacy of the following. (AUC Apr/May 2011)**



Degree of indeterminacy = No. of reactions – No. of condition equations
= (3 + 2 + 3) – 3
= 5

2. **Define kinematic redundancy. (AUC Apr/May 2011)**

When a structure is subjected to loads, each joint will undergo displacements in the form of translations and rotations. Kinematic redundancy of a structure means the number of unknown joint displacement in a structure.

3. **Give the mathematical expression for the degree of static indeterminacy of rigid jointed plane frames. (AUC Nov/Dec 2011)**

Degree of static indeterminacy = (No. of closed loops x 3) – No. of releases

4. **What are the properties which characterize the structure response by means of force-displacement relationship? (AUC Nov/Dec 2011)**

- Each element of a flexibility matrix represents a displacement at a coordinate (i) due to a force at a coordinate (j).
- If the matrix of the structure is known, we know the behaviour of the structure.

5. **What are the conditions to be satisfied for determinate structures and how are indeterminate structures identified? (AUC May/June 2012)**

Determinate structures can be solving using conditions of equilibrium alone (H = 0; V = 0; M = 0). No other conditions are required.

Indeterminate structures cannot be solved using conditions of equilibrium because (H ≠ 0; V ≠ 0; M ≠ 0). Additional conditions are required for solving such structures.

6. **Write down the equation for the degree of static indeterminacy of the pin-jointed frames, explaining the notations used. (AUC May/June 2012)**

Total indeterminacy = External indeterminacy + Internal indeterminacy
External indeterminacy = No. of reactions – No. of equilibrium equations
Internal indeterminacy = $m - (2j - 3)$

7. Differentiate pin-jointed plane frame and rigid jointed plane frame. (AUC May/June 2013)

S.No	Pin jointed plane frame	Rigid jointed plane frame
1	The joints permit change of angle between connected members.	The members connected at a rigid joint with maintain the angle between them even under deformation due to loads.
2	The joints are incapable of transferring any moment to the connected members and vice-versa.	Members can transmit both forces and moments between themselves through the joint.
3	The pins transmit forces between connected members by developing shear.	Provision of rigid joints normally increases the redundancy of the structures.

8. Mention any two methods of determining the joint deflection of a perfect frame.
(AUC May/June 2013)

- Unit load method
- Virtual work method
- Slope deflection method
- Strain energy method

9. What are the requirements to be satisfied while analyzing a structure?

The three conditions to be satisfied are:

(i) Equilibrium condition
(ii) Compatibility condition
(iii) Force displacement condition

10. What is meant by force method in structural analysis?

A method in which the forces are treated as unknowns is known as force method.

The following are the force methods:

- Flexibility matrix method
- Consistent deformation method
- Claypeyron's 3 moment method
- Column analogy method

11. Define flexibility coefficient.

It is defined as the displacement at coordinate i due to unit force at coordinate j in a structure. It makeup the elements of a flexibility matrix.

12. Why is flexibility method also called as compatibility method or force method?

Flexibility method begins with the superposition of forces and is hence known as force method. Flexibility method leads to equations of displacement compatibility and is hence known as compatibility method.

13. Define the Force Transformation Matrix.

The connectivity matrix which relates the internal forces Q and the external forces R is known as the force transformation matrix. Writing it in a matrix form,

$$\{Q\} = [b]\ \{R\}$$

Where, Q = member force matrix/vector; b = force transformation matrix
R = external force/load matrix/ vector

14. State any two methods of matrix inversion.

- Adjoint method
- The gauss-jordan method (by linear transformation)
- The Choleski method (by factorization)
- Partitioning method

15. Define Degree of Freedom and explain its types.

Degree of freedom is defined as the least no of independent displacements required to define the deformed shape of a structure.

There are two types of DOF: (a) Nodal type DOF and (b) Joint type DOF.

a) Nodal type DOF:

This includes the DOF at the point of application of concentrated load or moment, at a section where moment of inertia changes, hinge support, roller support and junction of two or more members.

b) Joint type DOF:

This includes the DOF at the point where moment of inertia changes, hinge and roller support and junction of two or more members.

16. Define a primary structure.

A structure formed by the removing the excess or redundant restraints from an indeterminate structure making it statically determinate is called primary structure. This is required for solving indeterminate structures by flexibility matrix method.

17. Briefly mention the two types of matrix methods of analysis of indeterminate structures.

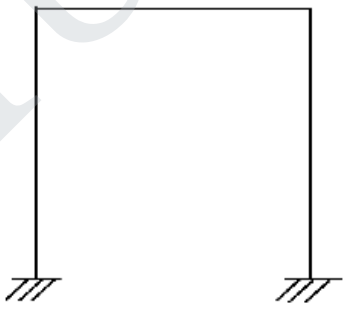
Flexibility matrix method:

This method is also called the force method in which the forces in the structure are treated as unknowns. The no of equations involved is equal to the degree of static indeterminacy of the structure.

Stiffness matrix method:

This is also called the displacement method in which the displacements that occur in the structure are treated as unknowns. The no of displacements involved is equal to the no of degrees of freedom of the structure.

18. Find the indeterminacy for the given rigid plane frame.



$i = (3m + r) – 3j$

Where, $m = 3$; $r = 4$; $j = 4$

$i = (3 \times 3 + 4) – (3 \times 4) = 1$

External indeterminacy, $EI = r – e = 4 – 3 = 1$

Internal indeterminacy, $II = i – EI = 1 - 1 = 0$

19. Define local and global coordinates.

Local coordinates:

Coordinates defined along the individual member axes locally.

Global coordinates:

Common coordinate system dealing with the entire structure. Also known as system coordinates.

20. What is the relation between the flexibility matrix and stiffness matrix?

The relation between the flexibility matrix and stiffness matrix is that, one is the inverse of the other, when they both exist.

PUBLISHED BY STUCOR

DEPARTMENT OF CIVIL ENGINEERING

QUESTION BANK

DEPARTMENT: CIVIL **SEMESTER: V**

SUBJECT CODE / Name: CE8502 / STRUCTURAL ANALYSIS-I

UNIT V - STIFFNESS MATRIX METHOD

PART - A (2 marks)

1. **Define static indeterminacy.** **(AUC Apr/May 2011)**

The excess number of reactions that make a structure indeterminate is called static indeterminacy.

Static indeterminacy = No. of reactions – Equilibrium conditions

2. **Define flexibility of a structure.** **(AUC Apr/May 2011)**

This method is also called the force method in which the forces in the structure are treated as unknowns. The no of equations involved is equal to the degree of static indeterminacy of the structure.

3. **Write down the equation of element stiffness matrix as applied to 2D plane element.** **(AUC Nov/Dec 2011)**

The equation of element stiffness matrix for 2D plane element is

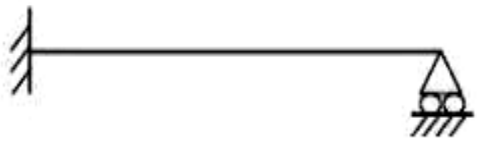
$$K = \frac{EI}{L}\begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$$

4. **Define degree of freedom of the structure with an example.** **(AUC May/June 2012)**
What is degree of kinematic indeterminacy and give an example. **(AUC Nov/Dec 2011)**

Degree of freedom is defined as the least no of independent displacements required to define the deformed shape of a structure.

There are two types of DOF: (a) Nodal type DOF and (b) Joint type DOF.

For example:



i = r – e where, r = no of reactions, e = no of equilibrium conditions r = 4 and e = 3

i = 4 – 3 = **1**

5. **Write a short note on global stiffness matrices.** **(AUC May/June 2012)**

The size of the global stiffness matrix (GSM) = No: of nodes x Degrees of freedom per node.

6. **Write a note on element stiffness matrix.** **(AUC May/June 2013)**

$$K = \begin{bmatrix} K_1 & 0 & 0 \\ 0 & K_2 & 0 \\ 0 & 0 & K_3 \end{bmatrix}$$

The element stiffness is K_1, K_2, K_3 etc.....

7. **List out the properties of rotation matrix.** **(AUC May/June 2013)**

- Matrix multiplication has no effect on the zero vectors (the coordinates of the origin).
- It can be used to describe rotations about the origin of the coordinate system.
- Rotation matrices provide an algebraic description of such rotations.
- They are used extensively for computations.
- Rotation matrices are square matrices with real entries.

8. **What are the basic unknowns in stiffness matrix method?**

In the stiffness matrix method nodal displacements are treated as the basic unknowns for the solution of indeterminate structures.

9. **Define stiffness coefficient 'kij'.**

Stiffness coefficient 'kij' is defined as the force developed at joint 'i' due to unit displacement at joint 'j' while all other joints are fixed.

10. **What is the basic aim of the stiffness method?**

The aim of the stiffness method is to evaluate the values of generalized coordinates 'r' knowing the structure stiffness matrix 'k' and nodal loads 'R' through the structure equilibrium equation.

$$\{R\} = [K] \{r\}$$

11. **What is the displacement transformation matrix?**

The connectivity matrix which relates the internal displacement 'q' and the external displacement 'r' is known as the displacement transformation matrix 'a'.

$$\{q\} = [a] \{r\}$$

12. **How are the basic equations of stiffness matrix obtained?**

The basic equations of stiffness matrix are obtained as:

- Equilibrium forces
- Compatibility of displacements
- Force displacement relationships

13. What is meant by generalized coordinates?

For specifying a configuration of a system, a certain minimum no of independent coordinates are necessary. The least no of independent coordinates that are needed to specify the configuration is known as generalized coordinates.

14. Write about the force displacement relationship.

The relationship of each element must satisfy the stress-strain relationship of the element material.

15. Compare flexibility method and stiffness method.

Flexibility matrix method:

- The redundant forces are treated as basic unknowns.
- The number of equations involved is equal to the degree of static indeterminacy of the structure.
- The method is the generalization of consistent deformation method.
- Different procedures are used for determinate and indeterminate structures

Stiffness matrix method:

- The joint displacements are treated as basic unknowns
- The number of displacements involved is equal to the no of degrees of freedom of the structure
- The method is the generalization of the slope deflection method.
- The same procedure is used for both determinate and indeterminate structures.

16. Is it possible to develop the flexibility matrix for an unstable structure?

In order to develop the flexibility matrix for a structure, it has to be stable and determinate.

17. What is the relation between flexibility and stiffness matrix?

The element stiffness matrix 'k' is the inverse of the element flexibility matrix 'f' and is given by f = 1/k or k = 1/f.

18. List the properties of the stiffness matrix.

- The properties of the stiffness matrix are:
- It is a symmetric matrix
- The sum of elements in any column must be equal to zero.
- It is an unstable element therefore the determinant is equal to zero.

19. Why the stiffness matrix method is also called equilibrium method or displacement method?

Stiffness method is based on the superposition of displacements and hence is also known as the displacement method. And since it leads to the equilibrium equations the method is also known as equilibrium method.

20. If the flexibility matrix is given as $F = \begin{bmatrix} 2 & -1 \\ -1 & 4 \end{bmatrix}$**. Write the corresponding stiffness matrix.**

Stiffness matrix = 1 / (Flexibility matrix)

[K] = [F]-1