Akashi College	Year	2023	Course Title	Advanced Structural System II

Course Information

Course Code	5028	Course Category	Specialized / Elective
Class Format	Lecture	Credits	Academic Credit: 2
Department	Architecture and Civil Engineering	Student Grade	Adv. 2nd
Term	First Semester	Classes per Week	2
Textbook and/or Teaching Materials	Sakimoto T. : Structural mechanics (2nd Ed) (Volume 2), Morikita Publishing Co., Ltd. (as a textbook) Printed synopses of the lecture are distributed as necessary in a class. Aoki R. and Nagashima T. : Fundamental skills of finite element method that design engineers should know, Ohmsha, Ltd. (as a reference)		
Instructor	MIYOSHI Takao		

Course Objectives

This subject aims to help students understand, explain or calculate as follows:
1. Necessity of structural analysis in design, construction and maintenance of structures
2. Outline and characteristics of several numerical methods used in structural analysis
3. Several stiffness equations used in structural analysis based on matrix method
4. Calculation of displacement and nodal force of simple 2D frame structure using structural analysis based on matrix method
5. Practical considerations of element division, boundary condition, load condition etc. in structural analysis based on matrix method

Rubric

	Ideal Level	Standard Level	Unacceptable Level
Achievement 1	A student who can sufficiently understand and explain necessity of structural analysis in design, construction and maintenance of structures	A student who can understand and explain necessity of structural analysis in design, construction and maintenance of structures	A student who cannot understand and explain necessity of structural analysis in design, construction and maintenance of structures
Achievement 2	A student who can sufficiently understand and explain outline and characteristics of several numerical methods used in structural analysis	A student who can understand and explain outline and characteristics of several numerical methods used in structural analysis	A student who cannot understand and explain outline and characteristics of several numerical methods used in structural analysis
Achievement 3	A student who can sufficiently understand and explain stiffness equations used in structural analysis based on matrix method	A student who can understand and explain stiffness equations used in structural analysis based on matrix method	A student who cannot understand and explain stiffness equations used in structural analysis based on matrix method
Achievement 4	Through practical exercise on software for analysis, a student who can calculate displacement and nodal force of simple 2D frame structure using structural analysis based on matrix method without referring calculation examples	Through practical exercise on software for analysis, a student who can calculate displacement and nodal force of simple 2D frame structure using structural analysis based on matrix method with referring calculation examples	Through practical exercise on software for analysis, a student who cannot calculate displacement and nodal force of simple 2D frame structure using structural analysis based on matrix method with referring calculation examples
Achievement 5	A student who can sufficiently understand and explain practical considerations of element division, boundary condition, load condition etc. in structural analysis based on matrix method	A student who can understand and explain practical considerations of element division, boundary condition, load condition etc. in structural analysis based on matrix method	A student who cannot understand and explain practical considerations of element division, boundary condition, load condition etc. in structural analysis based on matrix method

Assigned Department Objectives

Teaching Method

Outline	There is no doubt that structural analysis technologies based on numerical methods such as finite element method have played significant role of technological development to contribute to increasing in size, rationalization, life prolongation etc of structures in civil engineering. Nowadays, the structural analysis technologies are indispensable for design, construction and maintenance of structures in civil engineering. Also, structural analysis technologies are evolving. A lot of commercial software for structural analysis have already been developed. Almost of them are created by considering user friendliness and it is easy for users without any fundamental knowledge of structural mechanics etc to use them. However, a lot of commercial software for structural analysis have a risk that incorrect computation results due to inappropriate input data would be employed in the design and maintenance. Although structural analysis based on matrix method have been deleted from many textbooks of structural mechanics, many civil engineers of design consultants, bridge fabricators, structural design companies etc committing design of infrastructures requires strongly for education on it. In this subject, a professor, who has an experience as an engineer of bridge fabricator and has engaged in design of steel bridges and steel structures, will conduct lecture-style class on structural analysis based on matrix method, which is the most commonly used numerical method in design of infrastructures. Based on his experiences, he will explain fundamental theory, calculation procedure and practical consideration of 2D structural analysis based on matrix method using spring element, truss element and beam element. Consequently, students are expected to be able to learn skills so that they can verify the results of structural analysis as a civil engineer.
Style	This subject will be conducted lecture-style class and the stiffness equation of several elements, assembly of the global stiffness equation etc will be explained by writing its derivation process on the blackboard. Examples of simple framed structures using the matrix method will be specifically explained to show calculation process of the deformation etc and to deepen student’s understanding on significance of stiffness equation, importance of load and boundary conditions. Also, the results of calculation will be compared with the results gained from other structural analysis method. Furthermore, as an assignment, it is necessary for students to calculate the deformation and reaction force of a simple 2D frame structure using some stiffness equations and submit the calculation results as a report so that they can become understanding more practically.

Notice	This subject has a content the summation of learning time guaranteed in class and standard self-learning time including required time for conducting preparation, review, and assignment corresponds 90 hours. This class will be proceeded on the premise that students have fundamental knowledge of structural (or material) mechanics, which has been already learned at each department. It is preferable that students can use Microsoft Excel because a computer program by using Visual Basic will be employed in structural analysis of a simple 2D framed structure. Students who miss 1/3 or more of classes will not be eligible for evaluation.

Characteristics of Class / Division in Learning

☐ Active Learning	☑ Aided by ICT	☑ Applicable to Remote Class	☑ Instructor Professionally Experienced

Course Plan

			Theme	Goals
1st Semester	1st Quarter	1st	Structures and numerical analysis (1) Necessity of numerical analysis such as matrix method, finite element method etc in plan, design, construction and maintenance of structures will be explained.	Students can understand necessity of numerical analysis such as matrix method, finite element method etc in plan, design, construction and maintenance of structures.
		2nd	Structures and numerical analysis (2) Outline and characteristic of several numerical analyses and proper structural analysis method for the problem of structures will be explained.	Students can understand outline and characteristic of several numerical analyses and proper structural analysis method for the problem of structures.
		3rd	Outline of finite element method Characteristics of finite element method and several finite elements will be explained.	Students can understand characteristics of finite element method and several finite elements.
		4th	Matrix method of structural analysis (1) Based on linearity and superposition theorem, stiffness equation of general structures will be derived and its process will be explained as well.	Students can understand the stiffness equation and its derivation process of general structures, based on linearity and superposition theorem.
		5th	Matrix method of structural analysis (2) Based on Hooke's law and equilibrium condition of forces, stiffness equations of 1D spring and truss elements will be derived and the processes will be explained as well.	Students can understand stiffness equations of 1D spring and truss elements and their derivation process, based on Hooke's law and equilibrium condition of forces.
		6th	Matrix method of structural analysis (3) Assembly of global stiffness equation by superimposing local stiffness equations will be explained. Also, characteristics of stiffness matrix will be explained.	Students can understand assembly of global stiffness equation by superimposing local stiffness equations. Also, students can understand characteristics of stiffness matrix.
		7th	Matrix method of structural analysis (4) Simple example of structural analysis using 1D spring element and stiffness equation derivation of 2D spring element by direct method will be explained.	Students can analyze simple 1D spring structure using matrix method of structural analysis. Also, students can understand stiffness equation derivation of 2D spring element by direct method.
		8th	2D truss element (1) Relationship between truss and spring elements and extension of 1D truss element will be explained to derive stiffness equation of 2D truss element. Also, coordinate transformation of displacement and force and coordinate transformation matrix in 2D problem will be explained.	Students can understand relationship between truss and spring elements and extension of 1D truss element to derive stiffness equation of 2D truss element. Also, students can understand coordinate transformation of displacement and force and coordinate transformation matrix in 2D problem.
	2nd Quarter	9th	2D truss element (2) It will be explained that stiffness equation of 2D truss element is derived by applying coordinate transformation to extended 1D truss element.	Students can understand that stiffness equation of 2D truss element is derived by applying coordinate transformation to extended 1D truss element.
		10th	2D truss element (3) A simple structure will be analyzed by using stiffness equation of 2D truss element and the results will be compared with results gained from calculation using force method. It will be shown that both results are identical through the comparison. Also, general calculation procedure in matrix method of structural analysis will be explained.	Students can analyze a simple structure by using stiffness equation of 2D truss element and compare the results with results gained from calculation by using force method. Also, students can understand both results are identical through the comparison. Furthermore, students can understand general calculation procedure in matrix method of structural analysis.
		11th	2D beam element (1) Strain energy and displacement function will be explained to derive stiffness equation of 2D beam element.	Students can understand strain energy and displacement function to derive stiffness equation of 2D beam element.
		12th	2D beam element (2) It will be explained that stiffness equation of 2D beam element is derived from strain energy using Castigliano's 1st theorem. Also, it will be shown that stiffness equation of 2D beam element whose axis has arbitrary direction in 2D space is derived by extending coordinate transformation matrix and applying it to the stiffness equation.	Students can understand stiffness equation of 2D beam element is derived from strain energy using Castigliano's 1st theorem. Also, students can understand stiffness equation of 2D beam element whose axis has arbitrary direction in 2D space is derived by extending coordinate transformation matrix and applying it to the stiffness equation.
		13th	2D beam element (3) A simple structure will be analyzed by using stiffness equation of 2D beam element in order to deepen student's understanding on procedure of structural analysis.	Students can analyze a simple structure using stiffness equation of 2D beam element and they can understand procedure of structural analysis.

		14th	2D beam element (4) Same simple structure analyzed by 2D beam element will be solved by force method and it will be shown that results gained from analysis using 2D beam element are identical to those gained from calculation using force method.	Students can solve same simple structure analyzed by 2D beam element by force method. Also, they can understand results gained from analysis using 2D beam element are identical to those gained from calculation using force method.
		15th	Practical considerations in matrix method of structural analysis Practical considerations such as element division, boundary and load conditions, etc of 2D frame structures in matrix method of structural analysis will be explained.	Students can understand practical considerations such as element division, boundary and load conditions, etc of 2D frame structures in matrix method of structural analysis.
		16th	Final exam	

Evaluation Method and Weight (%)

	Examination	Task	Behavior	Total
Subtotal	50	40	10	100
Specialized Proficiency	50	40	10	100