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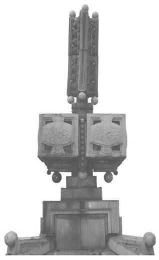
Intercultural Understanding



Vol.12

Koshien Hall, Mukogawa Women's University: Designed as a hotel by Arata Endo in 1930, it functioned as Koshien Hotel until 1944. As a disciple of Frank Lloyd Wright, Endo had worked on the design of the Imperial Hotel completed in 1923. Endo's design of the Koshien Hotel clearly reflects the strong influence of Wright's Imperial Hotel. In 1965 the Koshien Hotel underwent renovations and now houses the Department of Architecture as well as the Institute of Turkish Culture Studies of Mukogawa Women's University.

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Mukogawa Women's University

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Continuous Column Effects of Coupled Shear-Flexural-Beam Models in terms of Static Stability

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Keywords: continuous column effects, story-mechanism, static stability, stiffness matrix, eigenvalue

Abstract: The continuous column (C.C.) effects, in which elastic columns continuous over structural height prevent story failure mechanism and mitigate the drift concentration in particular stories during earthquakes for steel, reinforced concrete and wooden frame structures. The coupled shear-flexural-beam models, which was proposed and investigated by the author, are simplified models consisting with a shear-beam and a flexural-beam that can consider the C.C. effects explicitly. In this paper, the stiffness matrices of the shear-beam, the flexural-beam and that of the coupled shear-flexural-beam model are derived and their characteristics are investigated in terms of the stability. The eigenvalue analyses are conducted for the 2- and 3-story coupled shear-flexural-beam models at the elastic stage and the assumed 1st-story mechanism is investigated quantitatively to evaluate the C.C. effects on static stability of entire structure.

1. Introduction

Elastic columns and multi-story walls that are continuous over the structural height mitigate the drift concentration in the particular stories, prevent the story failure mechanism, and increase the stability during the earthquakes. This is referred to as the continuous column (C.C.) effects. Using the coupled shear-flexural-beam models as shown in Figure 1, it was verified that each story drift angle becomes more uniform as the flexural stiffness of the flexural-beam increases for steel, reinforced concrete frame structures subjected to earthquake motions. In this paper, the stiffness matrices of the shear-beam, flexural-beam and the coupled shear-flexural-beam model are derived and their characteristics are investigated in terms of the stability. Eigenvalue analyses are conducted for 2- and 3-story coupled shear-flexural-beam models to evaluate the C.C. effects on static stability. This C.C. effects may be related to a mystery of Japanese wooden five-story pagodas with a Shinbashira, penetrating a center of the tower, which have not been collapsed until now even subjected to massive earthquakes.

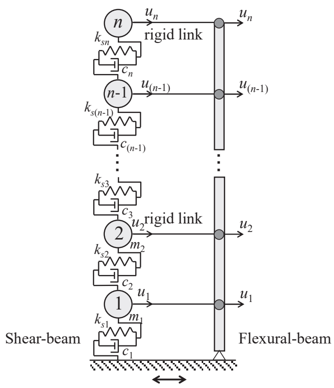
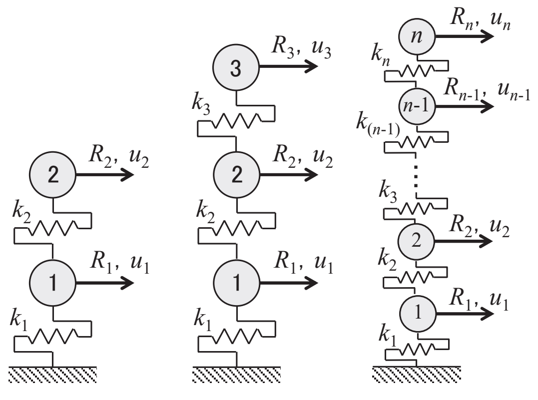


Figure 1. Coupled shear-flexural-beam model

2. Stiffness matrix of coupled shear-flexural-beam models

2.1. SHEAR-BEAM MODEL

Stiffness matrices of 2-, 3- and *n*-story shear-beam models as shown in Figure 2 are derived and these are investigated in terms of static stability.



(a) 2-story (b) 3-story (c) *n*-story

Figure 2. Shear-beam models

We will start with a 2-story shear-beam model as shown in Figure 2(a). Here, k_1 and k_2 is the stiffness of the 1st- and 2nd-story horizontal springs. The masses of the 1st- and 2nd-story are subjected to horizontal forces, R_1 and R_2, resulting in the horizontal displacements, u_1 and u_2, respectively. The relations of the horizontal forces and the displacements are given by (1). Therefore, the stiffness matrix of a 2-story shear-beam model, **K**, is given by (2).

$$\begin{pmatrix} R_1 \\ R_2 \end{pmatrix} = \begin{bmatrix} k_1+k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \qquad \mathbf{R}=\mathbf{Ku} \tag{1}$$

$$\mathbf{K}_{2\times 2} = \begin{bmatrix} k_1+k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} \tag{2}$$

The determinant of the stiffness matrix **K** is calculated as (3).

$$\det \mathbf{K}_{2\times 2} = (k_1+k_2)k_2 - (-k_2)(-k_2) = k_1 k_2 \tag{3}$$

The eigenvalues of **K** can be calculated as the solutions of the characteristic equation $F_K(x)$ defined by (4). **E** is the identity matrix.

$$\begin{aligned} F_K(x) &= \det(x\mathbf{E}-\mathbf{K}) = \det\begin{pmatrix} x-(k_1+k_2) & k_2 \\ k_2 & x-k_2 \end{pmatrix} \\ &= x^2 - (k_1+2k_2) + k_1 k_2 \end{aligned} \tag{4}$$

The eigenvalues, α_1 and α_2, of **K** are the solutions for $F_K(x)=0$ and given by (5).

$$\alpha_1, \alpha_2 = \frac{(k_1+k_2) \pm \sqrt{k_1^2+4k_2^2}}{2} \tag{5}$$

If the values of k_1 and k_2 are positive, the determinant det**K** (=k_1k_2) given by (3) and the two eigenvalues α_1 and α_2 given by (5) become positive, suggesting that structural system is stable.

Similarly, stiffness matrix of a 3-story shear-beam model as shown in Figure 2(b), **K**, is given by (6).

$$\mathbf{K}_{3\times 3} = \begin{bmatrix} k_1+k_2 & -k_2 & 0 \\ -k_2 & k_2+k_3 & -k_3 \\ 0 & -k_3 & k_3 \end{bmatrix} \tag{6}$$

The determinant of $\mathbf{K}_{3\times 3}$ is calculated as (7).

$$\begin{aligned} &\det \mathbf{K}_{3\times 3} \\ &= (k_1+k_2)(k_2+k_3)k_3 - (-k_2)(-k_2)k_3 - (k_1+k_2)(-k_3)(-k_3) \\ &= k_1 k_2 k_3 \end{aligned} \tag{7}$$

Stiffness matrix of the n-story shear-beam model, $\mathbf{K}_{n\times n}$, is given by (8). It is well known that stiffness matrix of a shear-beam model is banded.

$$\mathbf{K}_{n\times n} = \begin{bmatrix} k_1+k_2 & -k_2 & & & & \\ -k_2 & k_2+k_3 & -k_3 & & O & \\ & -k_3 & \ddots & \ddots & & \\ & & \ddots & \ddots & -k_{n-1} & \\ & O & & -k_{n-1} & k_{n-1}+k_n & -k_n \\ & & & & -k_n & k_n \end{bmatrix} \tag{8}$$

The determinant of $\mathbf{K}_{n\times n}$ can be found using the mathematical induction. Assume that $\det \mathbf{K}_{n\times n} = k_1 k_2 \cdots\cdots k_n \left(= \prod_{i=1}^{n} k_i \right)$ (9)

For n=2, 3, (9) is true as given by (3) and (7). Assumed that (9) is true for (n-1), then,

$$\det \mathbf{K}_{n-1\times n-1} = k_1 k_2 \cdots\cdots k_{n-1} \left(= \prod_{i=1}^{n-1} k_i \right) \tag{10}$$

The determinant of $\mathbf{K}_{n\times n}$ is related to $\mathbf{K}_{n-1\times n-1}$ as (11).

$$\begin{aligned} \det \mathbf{K}_{n\times n} &= \begin{vmatrix} k_1+k_2 & -k_2 & & & & \\ -k_2 & k_2+k_3 & -k_3 & & O & \\ & -k_3 & \ddots & \ddots & & \\ & & \ddots & \ddots & -k_{n-1} & \\ & O & & -k_{n-1} & k_{n-1}+k_n & -k_n \\ & & & & -k_n & k_n \end{vmatrix} \\ &= \left|\begin{array}{ccccc|c} k_1+k_2 & -k_2 & & & & 0 \\ -k_2 & k_2+k_3 & -k_3 & & O & \vdots \\ & -k_3 & \ddots & \ddots & & \vdots \\ & & \ddots & \ddots & -k_{n-1} & \vdots \\ & O & & -k_{n-1} & k_{n-1} & 0 \\ \hline & & & & -k_n & k_n \end{array}\right| \\ &= k_n \cdot \begin{vmatrix} k_1+k_2 & -k_2 & & & \\ -k_2 & k_2+k_3 & -k_3 & & \\ & -k_3 & \ddots & & \\ & & & k_{n-2}+k_{n-1} & -k_{n-1} \\ & & & -k_{n-1} & k_{n-1} \end{vmatrix} \\ &= k_n \cdot \det \mathbf{K}_{n-1\times n-1} \end{aligned} \tag{11}$$

As a result, the determinant of stiffness matrix of a n-story shear-beam model is given by (12).

$$\det \mathbf{K} = k_1 k_2 \cdots\cdots k_n \left(= \prod_{i=1}^{n} k_i \right) \tag{12}$$

This equation suggests that if any k_i becomes zero, the determinant of stiffness matrix becomes zero, then structural system becomes unstable.

The relation of the eigenvalues of $\mathbf{K}_{n\times n}$ and stiffness values of horizontal springs is investigated. The characteristic polynomial is given by (13). Here, $\alpha_1, \alpha_2 \cdots\cdots, \alpha_n$ are the eigenvalues of $\mathbf{K}_{n\times n}$. Letting $x=0$, $F_K(0)$ is expressed by both (14) and (15).

$$F_K(x) = \det(x\mathbf{E}_n - \mathbf{K}) = (x-\alpha_1)(x-\alpha_2)\cdots\cdots(x-\alpha_n) \tag{13}$$

$$\begin{cases} F_K(0) = \det(-\mathbf{K}) = (-1)^n \det \mathbf{K} \\ F_K(0) = (-1)^n \alpha_1 \alpha_2 \cdots\cdots \alpha_n \end{cases} \qquad (14), (15)$$

Therefore, (16) is derived.

$$\det \mathbf{K} = \alpha_1 \alpha_2 \cdots\cdots \alpha_n \tag{16}$$

From (12) and (16), (17) is derived.

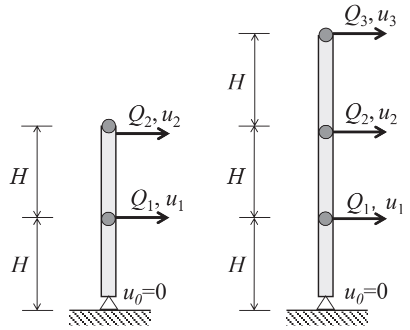
$$\begin{aligned} k_1 k_2 \cdots\cdots k_n &= \alpha_1 \alpha_2 \cdots\cdots \alpha_n \\ \prod_{i=1}^{n} k_i &= \prod_{i=1}^{n} \alpha_i \end{aligned} \tag{17}$$

Although it seems that $k_i = \alpha_i$, this is not true. This is since this is not satisfied for a 2-story shear-beam model as shown in (5).

2.2. FLEXURAL-BEAM MODEL

2.2.1. Flexural-beam supported by a pin

Stiffness matrices of 2-, 3-story flexural-beams supported by a pin at the basement as shown in Figure 3 are derived as follows.



(a) 2-story (b) 3-story

Figure 3. Flexural-beam supported by a pin

For one Bernoulli-Euler beam-element as shown in Figure 4, the relations of the forces, moments ${}^t\{Q_1, M_1, Q_2, M_2\}$ and the displacements, rotations ${}^t\{u_1, \theta_1, u_2, \theta_2\}$ are given by (18). Here, E is the elastic modulus, I is the moment of inertia and L is the length of the element.

$$\begin{Bmatrix} Q_1 \\ M_1 \\ Q_2 \\ M_2 \end{Bmatrix} = \begin{bmatrix} \dfrac{12EI}{L^3} & \dfrac{6EI}{L^2} & -\dfrac{12EI}{L^3} & \dfrac{6EI}{L^2} \\ \dfrac{6EI}{L^2} & \dfrac{4EI}{L} & -\dfrac{6EI}{L^2} & \dfrac{2EI}{L} \\ -\dfrac{12EI}{L^3} & -\dfrac{6EI}{L^2} & \dfrac{12EI}{L^3} & -\dfrac{6EI}{L^2} \\ \dfrac{6EI}{L^2} & \dfrac{2EI}{L} & -\dfrac{6EI}{L^2} & \dfrac{4EI}{L} \end{bmatrix} \begin{Bmatrix} u_1 \\ \theta_1 \\ u_2 \\ \theta_2 \end{Bmatrix} \quad (18)$$

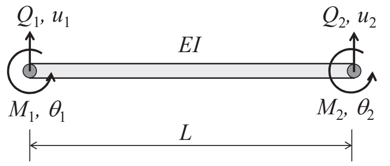


Figure 4. Beam element

2 beam-elements

The relations of the forces, moments and the displacements, rotations of 2 beam-elements connected to each other as shown in Figure 5 are obtained by assembling the stiffness matrices of 2 beam-elements, as given by (19). Here, for clarity, the following symbols are defined as

$\circledcirc = 12EL/L^3$, $\square = 6EI/L^2$, $\triangle = 2EI/L$.

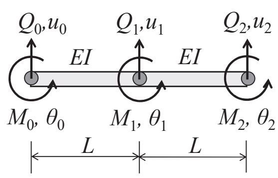


Figure 5. 3 beam-elements connected

$$\begin{Bmatrix} Q_0 \\ M_0 \\ Q_1 \\ M_1 \\ Q_2 \\ M_2 \end{Bmatrix} = \begin{bmatrix} \circledcirc & \square & -\circledcirc & \square & 0 & 0 \\ \square & 2\triangle & -\square & \triangle & 0 & 0 \\ -\circledcirc & -\square & 2\circledcirc & 0 & -\circledcirc & \square \\ \square & \triangle & 0 & 4\triangle & -\square & \triangle \\ 0 & 0 & -\circledcirc & -\square & \circledcirc & -\square \\ 0 & 0 & \square & \triangle & -\square & 2\triangle \end{bmatrix} \begin{Bmatrix} u_0 \\ \theta_0 \\ u_1 \\ \theta_1 \\ u_2 \\ \theta_2 \end{Bmatrix} \quad (19)$$

In order to conduct the static condensation and find the relations of forces and displacement using the condition of $\mathbf{M} = \mathbf{0}$, (19) is arranged to obtain (20), which can be expressed by (21).

$$\begin{Bmatrix} Q_0 \\ Q_1 \\ Q_2 \\ M_0 \\ M_1 \\ M_2 \end{Bmatrix} = \left[\begin{array}{ccc:ccc} \circledcirc & -\circledcirc & 0 & \square & \square & 0 \\ -\circledcirc & 2\circledcirc & -\circledcirc & -\square & 0 & \square \\ 0 & -\circledcirc & \circledcirc & 0 & -\square & -\square \\ \hdashline \square & -\square & 0 & 2\triangle & \triangle & 0 \\ \square & 0 & -\square & \triangle & 4\triangle & \triangle \\ 0 & \square & -\square & 0 & \triangle & 2\triangle \end{array}\right] \begin{Bmatrix} u_0 \\ u_1 \\ u_2 \\ \theta_0 \\ \theta_1 \\ \theta_2 \end{Bmatrix} \quad (20)$$

$$\begin{Bmatrix} \mathbf{Q} \\ \mathbf{M} \end{Bmatrix} = \begin{bmatrix} [\mathbf{K}_{11}] & [\mathbf{K}_{12}] \\ [\mathbf{K}_{21}] & [\mathbf{K}_{22}] \end{bmatrix} \begin{Bmatrix} \mathbf{u} \\ \boldsymbol{\theta} \end{Bmatrix} \quad (21)$$

$$\mathbf{K}_{11} = \frac{12EI}{L^3}\begin{bmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix} \quad \mathbf{K}_{12} = \frac{6EI}{L^2}\begin{bmatrix} 1 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & -1 \end{bmatrix}$$
$$\mathbf{K}_{21} = \frac{6EI}{L^2}\begin{bmatrix} 1 & -1 & 0 \\ 1 & 0 & -1 \\ 0 & 1 & -1 \end{bmatrix} \quad \mathbf{K}_{22} = \frac{2EI}{L}\begin{bmatrix} 2 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 2 \end{bmatrix} \quad (22)$$

Since $\mathbf{M} = \mathbf{0}$, (23) is derived.

$$\begin{aligned} &\mathbf{M} = \mathbf{K}_{21}\mathbf{u} + \mathbf{K}_{22}\boldsymbol{\theta} = \mathbf{0} \\ &\therefore \mathbf{K}_{22}\boldsymbol{\theta} = -\mathbf{K}_{21}\mathbf{u} \\ &\therefore \boldsymbol{\theta} = -\mathbf{K}_{22}^{-1}\mathbf{K}_{21}\mathbf{u} \end{aligned} \quad (23)$$

Substitute (23) into (21) and (24) is derived.

$$\begin{aligned} \mathbf{Q} &= \mathbf{K}_{11}\mathbf{u} + \mathbf{K}_{12}\boldsymbol{\theta} = \mathbf{K}_{11}\mathbf{u} - \mathbf{K}_{12}\mathbf{K}_{22}^{-1}\mathbf{K}_{21}\mathbf{u} \\ &= \left(\mathbf{K}_{11} - \mathbf{K}_{12}\mathbf{K}_{22}^{-1}\mathbf{K}_{21}\right)\mathbf{u} \end{aligned} \quad (24)$$

$$\mathbf{K}_{11} - \mathbf{K}_{12}\mathbf{K}_{22}^{-1}\mathbf{K}_{21} = \frac{EI}{L^3}\begin{bmatrix} 1.5 & -3 & 1.5 \\ -3 & 6 & -3 \\ 1.5 & -3 & 1.5 \end{bmatrix} \quad (25)$$

As a result, the relations of the forces and displacements are derived as (26).

$$\begin{Bmatrix} Q_0 \\ Q_1 \\ Q_2 \end{Bmatrix} = \frac{EI}{L^3}\begin{bmatrix} 1.5 & -3 & 1.5 \\ -3 & 6 & -3 \\ 1.5 & -3 & 1.5 \end{bmatrix}\begin{Bmatrix} u_0 \\ u_1 \\ u_2 \end{Bmatrix} \quad (26)$$

Since $u_0 = 0$ as shown in Figure 3(a), letting $u_0 = 0$ in (26), the relations of the forces ${}^t\{Q_1, Q_2\}$ and displacements ${}^t\{u_1, u_2\}$ are derived as (27). Stiffness matrix $\mathbf{K_f}$ of the model as shown in Figure 3(a) is given by (28).

$$\begin{Bmatrix} Q_1 \\ Q_2 \end{Bmatrix} = \frac{EI}{H^3}\begin{bmatrix} 6 & -3 \\ -3 & 1.5 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} \quad (27)$$

$$\mathbf{K_f} = \frac{EI}{H^3}\begin{bmatrix} 6 & -3 \\ -3 & 1.5 \end{bmatrix} \quad (28)$$

The determinant of $\mathbf{K_f}$ is calculated by (29) and is equal to zero suggesting that a flexural-beam supported by a pin at the basement is unstable itself.

$$\det \mathbf{K_f} = \left(\frac{EI}{H^3}\right)^2 \cdot \begin{vmatrix} 6 & -3 \\ -3 & 1.5 \end{vmatrix} = \left(\frac{EI}{H^3}\right)^2 \cdot \left(6 \cdot 1.5 - (-3)(-3)\right) = 0 \quad (29)$$

3 beam-elements

Similarly, the relations of the forces, moments and the displacements, rotations of 3 beam-elements connected to each other as shown in Figure 6 are obtained by assembling the stiffness matrices of 3 beam-elements, as given by (30).

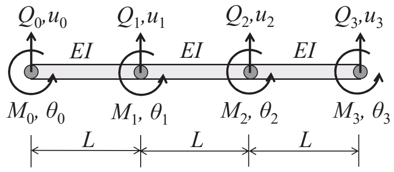


Figure 6. 3 beam-elements connected

$$\begin{Bmatrix} Q_0 \\ M_0 \\ Q_1 \\ M_1 \\ Q_2 \\ M_2 \\ Q_3 \\ M_3 \end{Bmatrix} = \begin{bmatrix} \circledcirc & \square & -\circledcirc & \square & 0 & 0 & 0 & 0 \\ \square & 2\triangle & -\square & \triangle & 0 & 0 & 0 & 0 \\ -\circledcirc & -\square & 2\circledcirc & 0 & -\circledcirc & \square & 0 & 0 \\ \square & \triangle & 0 & 4\triangle & -\square & \triangle & 0 & 0 \\ 0 & 0 & -\circledcirc & -\square & 2\circledcirc & 0 & -\circledcirc & \square \\ 0 & 0 & \square & \triangle & 0 & 4\triangle & -\square & \triangle \\ 0 & 0 & 0 & 0 & -\circledcirc & -\square & \circledcirc & -\square \\ 0 & 0 & 0 & 0 & \square & \triangle & -\square & 2\triangle \end{bmatrix} \begin{Bmatrix} u_0 \\ \theta_0 \\ u_1 \\ \theta_1 \\ u_2 \\ \theta_2 \\ u_3 \\ \theta_3 \end{Bmatrix} \tag{30}$$

Rearranging the terms according to the array of the forces, moments and the displacements and rotations, (31) is derived. This can be expressed by (32).

$$\begin{Bmatrix} Q_0 \\ Q_1 \\ Q_2 \\ Q_3 \\ M_0 \\ M_1 \\ M_2 \\ M_3 \end{Bmatrix} = \left[\begin{array}{cccc:cccc} \circledcirc & -\circledcirc & 0 & 0 & \square & \square & 0 & 0 \\ -\circledcirc & 2\circledcirc & -\circledcirc & 0 & -\square & 0 & \square & 0 \\ 0 & -\circledcirc & 2\circledcirc & -\circledcirc & 0 & -\square & 0 & \square \\ 0 & 0 & -\circledcirc & \circledcirc & 0 & 0 & -\square & -\square \\ \hdashline \square & -\square & 0 & 0 & 2\triangle & \triangle & 0 & 0 \\ \square & 0 & -\square & 0 & \triangle & 4\triangle & \triangle & 0 \\ 0 & \square & 0 & -\square & 0 & \triangle & 4\triangle & \triangle \\ 0 & 0 & \square & -\square & 0 & 0 & \triangle & 2\triangle \end{array}\right] \begin{Bmatrix} u_0 \\ u_1 \\ u_2 \\ u_3 \\ \theta_0 \\ \theta_1 \\ \theta_2 \\ \theta_3 \end{Bmatrix} \tag{31}$$

$$\begin{Bmatrix} \mathbf{Q} \\ \mathbf{M} \end{Bmatrix} = \begin{bmatrix} [\mathbf{K}_{11}] & [\mathbf{K}_{12}] \\ [\mathbf{K}_{21}] & [\mathbf{K}_{22}] \end{bmatrix} \begin{Bmatrix} \mathbf{u} \\ \boldsymbol{\theta} \end{Bmatrix} \tag{32}$$

Here,

$$\mathbf{K}_{11} = \frac{12EI}{L^3}\begin{bmatrix} 1 & -1 & 0 & 0 \\ -1 & 2 & -1 & 0 \\ 0 & -1 & 2 & -1 \\ 0 & 0 & -1 & 1 \end{bmatrix} \quad \mathbf{K}_{12} = \frac{6EI}{L^2}\begin{bmatrix} 1 & 1 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ 0 & 0 & -1 & -1 \end{bmatrix}$$
$$\mathbf{K}_{21} = \frac{6EI}{L^2}\begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \end{bmatrix} \quad \mathbf{K}_{22} = \frac{2EI}{L}\begin{bmatrix} 2 & 1 & 0 & 0 \\ 1 & 4 & 1 & 0 \\ 0 & 1 & 4 & 1 \\ 0 & 0 & 1 & 2 \end{bmatrix} \tag{33}$$

Since $\mathbf{M} = \mathbf{0}$, (34) is derived.

$$\mathbf{K}_{11} - \mathbf{K}_{12}\mathbf{K}_{22}^{-1}\mathbf{K}_{21} = \frac{EI}{L^3}\begin{bmatrix} 1.6 & -3.6 & 2.4 & -0.4 \\ -3.6 & 9.6 & -8.4 & 2.4 \\ 2.4 & -8.4 & 9.6 & -3.6 \\ -0.4 & 2.4 & -3.6 & 1.6 \end{bmatrix} \tag{34}$$

Since $u_0 = 0$ in Figure 3(b), the relations of forces and displacements are given by (35) and then stiffness matrix $\mathbf{K_f}$ of the model as shown in Figure 3(b) is given by (36).

$$\begin{Bmatrix} Q_1 \\ Q_2 \\ Q_3 \end{Bmatrix} = \frac{EI}{H^3}\begin{bmatrix} 9.6 & -8.4 & 2.4 \\ -8.4 & 9.6 & -3.6 \\ 2.4 & -3.6 & 1.6 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} \tag{35}$$

$$\mathbf{K_f} = \frac{EI}{H^3}\begin{bmatrix} 9.6 & -8.4 & 2.4 \\ -8.4 & 9.6 & -3.6 \\ 2.4 & -3.6 & 1.6 \end{bmatrix} \tag{36}$$

The determinant of $\mathbf{K_f}$ is calculated as (37) and is equal to zero suggesting that a flexural-beam supported by a pin at the basement is unstable itself.

$$\begin{aligned} \det \mathbf{K_f} &= \left(\frac{EI}{H^3}\right)^3 \cdot \begin{vmatrix} 9.6 & -8.4 & 2.4 \\ -8.4 & 9.6 & -3.6 \\ 2.4 & -3.6 & 1.6 \end{vmatrix} \\ &= \left(\frac{EI}{H^3}\right)^3 \cdot \begin{pmatrix} 9.6 \cdot 9.6 \cdot 1.6 + (-8.4)\cdot(-3.6)\cdot 2.4 \\ +2.4\cdot(-8.4)\cdot(-3.6) - 2.4\cdot 9.6 \cdot 2.4 \\ -(-8.4)\cdot(-8.4)\cdot 1.6 - 9.6\cdot(-3.6)\cdot(-3.6) \end{pmatrix} \\ &= 0 \end{aligned} \tag{37}$$

2.2.2. Flexural-beam fully fixed at the basement

Stiffness matrices of 2-, 3-story flexural-beams fully fixed at the basement as shown in Figure 7 are derived as follows.

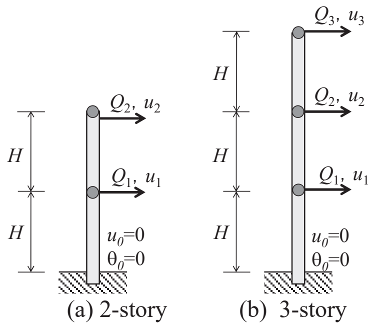


Figure 7. Flexural-beam fully fixed at the basement

2 beam-elements

The relations of the forces, moments and the displacements, rotations of 2 beam-elements connected to each other as shown in Figure 5 are obtained by assembling the stiffness matrices of 2 beam-elements, as given by (19). In a 2-story flexural-beam model as shown in Figure 7(a), since $u_0 = 0,\ \theta_0 = 0$, (38) is derived, which can be expressed by (39).

$$\begin{Bmatrix} Q_1 \\ Q_2 \\ M_1 \\ M_2 \end{Bmatrix} = \left[\begin{array}{cc:cc} 2\circledcirc & -\circledcirc & 0 & \square \\ -\circledcirc & \circledcirc & -\square & -\square \\ \hdashline 0 & -\square & 4\triangle & \triangle \\ \square & -\square & \triangle & 2\triangle \end{array}\right] \begin{Bmatrix} u_1 \\ u_2 \\ \theta_1 \\ \theta_2 \end{Bmatrix} \tag{38}$$

$$\begin{Bmatrix} \mathbf{Q} \\ \mathbf{M} \end{Bmatrix} = \begin{bmatrix} [\mathbf{K}_{11}] & [\mathbf{K}_{12}] \\ [\mathbf{K}_{21}] & [\mathbf{K}_{22}] \end{bmatrix} \begin{Bmatrix} \mathbf{u} \\ \boldsymbol{\theta} \end{Bmatrix} \tag{39}$$

Here,

$$\mathbf{K}_{11} = \frac{12EI}{L^3}\begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix} \quad \mathbf{K}_{12} = \frac{6EI}{L^2}\begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}$$
$$\mathbf{K}_{21} = \frac{6EI}{L^2}\begin{bmatrix} 0 & -1 \\ 1 & -1 \end{bmatrix} \quad \mathbf{K}_{22} = \frac{2EI}{L}\begin{bmatrix} 4 & 1 \\ 1 & 2 \end{bmatrix} \tag{40}$$

Since $\mathbf{M} = \mathbf{0}$, stiffness matrix $\mathbf{K_f}$ of the model as shown in Figure 7(a) is derived as (41).

$$\mathbf{K_f} = [K_{11}] - [K_{12}][K_{22}]^{-1}[K_{21}] = \frac{EI}{H^3}\begin{bmatrix} \frac{96}{7} & -\frac{30}{7} \\ -\frac{30}{7} & \frac{12}{7} \end{bmatrix} \quad (41)$$

The determinant of $\mathbf{K_f}$ is calculated by (42) and this is positive suggesting that a flexural-beam fixed at the basement is stable.

$$\det \mathbf{K_f} = \left(\frac{EI}{H^3}\right)^2 \cdot \begin{vmatrix} \frac{96}{7} & -\frac{30}{7} \\ -\frac{30}{7} & \frac{12}{7} \end{vmatrix}$$
$$= \left(\frac{EI}{H^3}\right)^2 \cdot \left(\frac{1}{7}\right)^2 \left(96 \cdot 12 - (-30)\cdot(-30)\right) \quad (42)$$
$$= \left(\frac{EI}{H^3}\right)^2 \cdot \left(\frac{1}{49}\right) \cdot 252 = \frac{36}{7}\left(\frac{EI}{H^3}\right)^2 \square\ 5.143\left(\frac{EI}{H^3}\right)^2$$

3 beam-elements

Stiffness matrix of 3-story flexural-beam fully-fixed at the basement as shown in Figure 7(b) is derived as follows. Since $u_0 = 0,\ \theta_0 = 0$, the relations are derived as (43).

$$\begin{Bmatrix} Q_1 \\ Q_2 \\ Q_3 \\ M_1 \\ M_2 \\ M_3 \end{Bmatrix} = \left[\begin{array}{ccc:ccc} 2\circledcirc & -\circledcirc & 0 & 0 & \square & 0 \\ -\circledcirc & 2\circledcirc & -\circledcirc & -\square & 0 & \square \\ 0 & -\circledcirc & \circledcirc & 0 & -\square & -\square \\ \hdashline 0 & -\square & 0 & 4\triangle & \triangle & 0 \\ \square & 0 & -\square & \triangle & 4\triangle & \triangle \\ 0 & \square & -\square & 0 & \triangle & 2\triangle \end{array}\right] \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ \theta_1 \\ \theta_2 \\ \theta_3 \end{Bmatrix} \quad (43)$$

$\mathbf{K}_{11}$, $\mathbf{K}_{12}$, $\mathbf{K}_{21}$, $\mathbf{K}_{22}$ in the form of (39) are as follows.

$$\mathbf{K}_{11} = \frac{12EI}{L^3}\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{bmatrix} \quad \mathbf{K}_{12} = \frac{6EI}{L^2}\begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & -1 \end{bmatrix}$$
$$\mathbf{K}_{21} = \frac{6EI}{L^2}\begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & -1 \\ 0 & 1 & -1 \end{bmatrix} \quad \mathbf{K}_{22} = \frac{2EI}{L}\begin{bmatrix} 4 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 2 \end{bmatrix} \quad (44)$$

Stiffness matrix $\mathbf{K_f}$ is derived as (45).

$$\mathbf{K_f} = [K_{11}] - [K_{12}][K_{22}]^{-1}[K_{21}] = \frac{EI}{H^3}\begin{bmatrix} \frac{240}{13} & -\frac{138}{13} & \frac{36}{13} \\ -\frac{138}{13} & \frac{132}{13} & -\frac{48}{13} \\ \frac{36}{13} & -\frac{48}{13} & \frac{21}{13} \end{bmatrix}$$

(45)

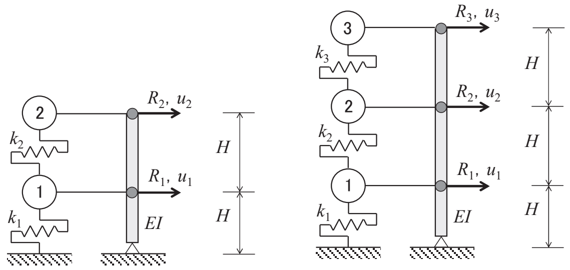
The determinant of $\mathbf{K_f}$ is calculated as (46) and this is positive.

$$\det \mathbf{K_f} = \left(\frac{EI}{H^3}\right)^3 \cdot \begin{vmatrix} \frac{240}{13} & -\frac{138}{13} & \frac{36}{13} \\ -\frac{138}{13} & \frac{132}{13} & -\frac{48}{13} \\ \frac{36}{13} & -\frac{48}{13} & \frac{21}{13} \end{vmatrix}$$
$$= \left(\frac{EI}{H^3}\right)^3 \cdot \left(\frac{1}{13}\right)^3 \begin{pmatrix} 240 \cdot 132 \cdot 21 + (-138)\cdot(-48)\cdot 36 \\ +36 \cdot (-138)\cdot(-48) - 36 \cdot 132 \cdot 36 \\ -(-138)\cdot(-138)\cdot 21 - 240 \cdot (-48)\cdot(-48) \end{pmatrix}$$
$$= \left(\frac{EI}{H^3}\right)^3 \cdot \left(\frac{1}{13}\right)^3 \cdot 18252 = \frac{108}{13}\left(\frac{EI}{H^3}\right)^3 \square\ 8.3077\left(\frac{EI}{H^3}\right)^3$$

(46)

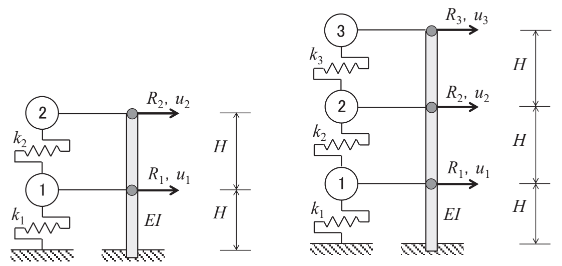
2.3. COUPLED SHEAR-FLEXURAL-BEAM MODEL

Stiffness matrices of the 2- and 3-story coupled shear-flexural-beam models as shown in Figures 8 and 9 are derived as follows. The shear-beam and flexural-beam are connected to each other with rigid link at each floor level.



(a) 2-story (b) 3-story

Figure 8. Coupled shear-flexural-beam models (pin-supported)



(a) 2-story (b) 3-story

Figure 9. Coupled shear-flexural-beam models (fully-fixed)

The displacements at the same floor level of the shear-beam and flexural-beam in the coupled shear-flexural-beam model are identical and then (47) is derived. The forces of the coupled shear-flexural-beam model is a sum of forces of the shear-beam and forces of the flexural-beam and then (48) is derived.

$$u_1 = u_{s1} = u_{f1}, \quad u_2 = u_{s2} = u_{f2}, \quad u_3 = u_{s3} = u_{f3} \quad (47)$$

$$R_1 = R_{s1} + R_{f1}, \quad R_2 = R_{s2} + R_{f2}, \quad R_3 = R_{s3} + R_{f3} \quad (48)$$

The relations of the force and displacements of 2-story coupled shear-flexural-beam model with a pin-supported flexural-beam is derived as (49). Therefore, stiffness matrix is given by (50).

$$\begin{pmatrix} R_1 \\ R_2 \end{pmatrix} = \begin{pmatrix} R_{s1} \\ R_{s2} \end{pmatrix} + \begin{pmatrix} R_{f1} \\ R_{f2} \end{pmatrix}$$
$$= \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix}\begin{Bmatrix} u_{s1} \\ u_{s2} \end{Bmatrix} + \frac{EI}{H^3}\begin{bmatrix} 6 & -3 \\ -3 & 1.5 \end{bmatrix}\begin{Bmatrix} u_{f1} \\ u_{f2} \end{Bmatrix}$$
$$= \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} + \frac{EI}{H^3}\begin{bmatrix} 6 & -3 \\ -3 & 1.5 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} \quad (49)$$
$$= \left(\begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} + \frac{EI}{H^3}\begin{bmatrix} 6 & -3 \\ -3 & 1.5 \end{bmatrix}\right)\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix}$$

$$\mathbf{K} = \mathbf{K_s} + \mathbf{K_f} = \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} + \frac{EI}{H^3}\begin{bmatrix} 6 & -3 \\ -3 & 1.5 \end{bmatrix} \quad (50)$$

Similarly, stiffness matrix of 3-story coupled shear-flexural-beam model with a pin-supported flexural-beam is derived as (51).

$$\mathbf{K}=\begin{bmatrix} k_1+k_2 & -k_2 & 0 \\ -k_2 & k_2+k_3 & -k_3 \\ 0 & -k_3 & k_3 \end{bmatrix}+\frac{EI}{H^3}\begin{bmatrix} 9.6 & -8.4 & 2.4 \\ -8.4 & 9.6 & -3.6 \\ 2.4 & -3.6 & 1.6 \end{bmatrix} \quad (51)$$

When the flexural-beam is fully fixed at the basement, stiffness matrices of 2-, 3-story coupled shear-flexural-beam models are given by (52), (53), respectively.

$$\mathbf{K}=\begin{bmatrix} k_1+k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix}+\frac{EI}{H^3}\begin{bmatrix} \frac{96}{7} & -\frac{30}{7} \\ -\frac{30}{7} & \frac{12}{7} \end{bmatrix} \quad (52)$$

$$\mathbf{K}=\begin{bmatrix} k_1+k_2 & -k_2 & 0 \\ -k_2 & k_2+k_3 & -k_3 \\ 0 & -k_3 & k_3 \end{bmatrix}+\frac{EI}{H^3}\begin{bmatrix} \frac{240}{13} & -\frac{138}{13} & \frac{36}{13} \\ -\frac{138}{13} & \frac{132}{13} & -\frac{48}{13} \\ \frac{36}{13} & -\frac{48}{13} & \frac{21}{13} \end{bmatrix} \quad (53)$$

3. Static stability of coupled shear-flexural-beam models

In order to evaluate static stability of the coupled shear-flexural-beam model, eigenvalue analyses are conducted. Eigenvalue problem is solved using (54). Here, Ω_i is the i^{th}-mode eigenvalue of stiffness matrix $\mathbf{K}$ normalized by mass matrix $\mathbf{M}$, which is equal to a square of the i^{th}-mode natural frequency, ω_i. The i^{th}-mode natural period T_i is calculated as (55).

$$\det\left(\mathbf{K}-\Omega_i\mathbf{M}\right)=0 \quad \text{where, } \Omega_i=\omega_i^2 \quad (54)$$

$$T_i=\frac{2\pi}{\omega_i} \quad (55)$$

The stiffness of each story in the shear-beam model is calculated using (56), which provides uniform distribution of the story drift angles for specified horizontal forces added at i^{th}-floor, f_i. Here, m_i is i-story mass, h_i is i^{th}-floor height. The 1st-natural periods, T, are set to 0.24 sec and 0.36 sec for 2- and 3-story models, respectively.

$$k_i=\frac{4\pi^2}{T^2}\frac{\sum_{i=1}^{n} m_i h_i^2}{\sum_{i=1}^{n} f_i h_i}\frac{\sum_{j=i}^{n} f_j}{\left(h_{i+1}-h_i\right)} \quad (56)$$

Each story stiffness of 2- and 3-story shear-beam model is calculated as (57), (58), respectively, assuming that all masses are equal to m, each story height is equal to H, and horizontal forces added at i^{th}-floor, f_i are an inverted triangle distribution.

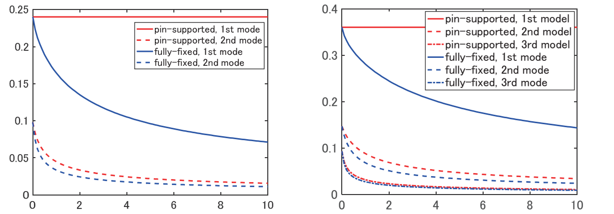
$$k_1=\frac{4\pi^2}{T^2}\frac{m\left(H^2+4H^2\right)}{\left(fH+4fH\right)}\frac{\left(f+2f\right)}{H}=\frac{12m\pi^2}{T^2},\quad k_2=\frac{8m\pi^2}{T^2} \quad (57)$$

$$k_1=\frac{4\pi^2}{T^2}\frac{m\left(H^2+4H^2+9H^2\right)}{\left(fH+4fH+9fH\right)}\frac{\left(f+2f+3f\right)}{H}=\frac{24m\pi^2}{T^2}$$
$$k_2=\frac{20m\pi^2}{T^2},\quad k_3=\frac{12m\pi^2}{T^2} \quad (58)$$

The natural periods of 2- and 3-story models are calculated for various flexural-stiffness ratio, α_{cc}, defined by (59). Here, EI is the flexural stiffness of the flexural-beam, H is a story height and k_1 is the initial stiffness of the 1st-story in the shear-beam.

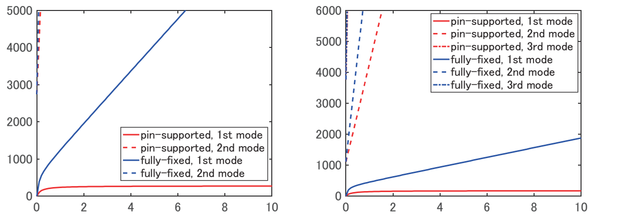
$$\alpha_{cc}=\frac{EI/H^3}{k_1} \quad (59)$$

The natural periods for all modes for 2- and 3-story coupled shear-flexural-beam models with a pin-supported or fully-fixed flexural-beam are plotted in Figure 10. As α_{cc} increases, the 1st-mode natural period of the model with a pin-supported flexural-beam does not decrease since the pin-supported flexural-beam rotates rigidly. However, higher-mode natural periods decrease. For the model with a fully-fixed flexural-beam, the natural periods of all modes decrease. Therefore, a pin-supported flexural-beam increases the stability for all modes except the 1st-mode, and a fully-fixed flexural-beam increases the stability for all modes.



(x-axis:α_{cc}, y-axis: natural period (sec), red: pin-supported, blue: fixed)
(a) 2-story (b) 3-story
Figure 10. Natural periods (at elastic)

The eigenvalue analyses are conducted for 2- and 3-story models with assumed 1st-story mechanism, setting the 1st-story tangent stiffness of the shear-beam to zero. The instantaneous eigenvalues are plotted for various α_{cc} in Figure 11. As α_{cc} increases, the eigenvalues of all modes increase, suggesting that the flexural-beam increases the stability of entire structure under the story-mechanism in a particular story, activating the C.C. effects.



(x-axis:α_{cc}, y-axis: Ω_i (1/sec^2) , red: pin-supported, blue: fixed)
(a) 2-story (b) 3-story
Figure 11. Instantaneous eigenvalues (at 1st-story mechanism)

4. Conclusions

The stiffness matrices of a shear-beam, flexural-beam, and the coupled shear-flexural-beam model derived. Eigenvalue analyses are conducted for 2- and 3-story coupled shear-flexural-beam models at elastic state or assumed 1st-story mechanism to demonstrate the C.C. effects on static stability of entire structure.

The coupled shear-flexural-beam model used in this study can simulate the story-failure, which was observed for piloti-type RC buildings and wooden houses in the 1995 Hyogoken-Nanbu earthquake. The pancake collapse, which was typically observed in the 2023 Turkey-Syria earthquake, is similar to the story-failure, accompanied by progressive collapse from the top to the bottom.

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Tagawa, H., Okada, M., Matsumoto, Y., Sugiura, N. (2018). Kushidango to shinbou wo rireki damper de renketsuseishin shitabaai no shinbou kouka, Proceedings of the Japan Concrete Institute, vol. 40, No. 2

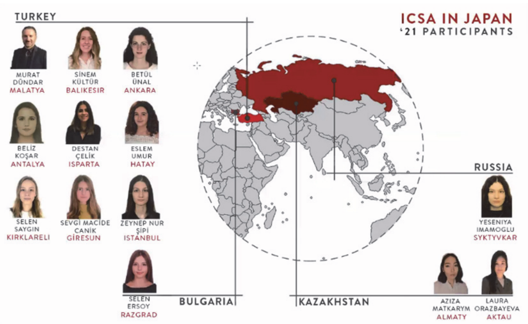
ACTIVITY REPORTS OF THE INSTITUTE OF TURKISH CULTURE STUDIES

Inter Cultural Studies of Architecture (ICSA) in Japan 2021

Based on the general exchange agreement between Mukogawa Women's University (MWU) and Bahçeşehir University (BAU), ICSA in Japan, a short-term study exchange program for BAU students to study together at MWU, has been held annually. However, under the influence of COVID-19, ICSA in Japan 2021 was conducted online, as in the previous year, from June 25 to July 29, 2021.

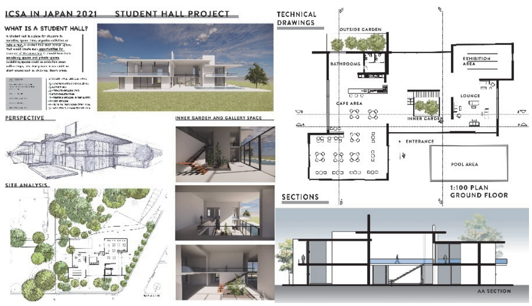
As in the previous programs, BAU students tackled design projects for second-, third- and fourth-year students of MWU's Department of Architecture. By participating in this program, they gained knowledge, learned techniques, and increased their awareness of architectural design. On Saturday, MWU faculty members gave online lectures in place of the fieldwork trips that had been offered in previous years. The welcome ceremony was held at the beginning of the program, and the completion and farewell ceremony were held at the end. These gatherings brought together students and faculty from MWU's Departments of Architecture and Landscape Architecture.

Participants
Professors: Professor Murat Dündar, Assistant Professor Sinem Kültür,
Teaching Assistant Betül Ünal
Students: Aziza Matkarym, Beliz Koşar, Destan Çelik, Eslem Umur,
Laura Orazbayeva, Selen Ersoy, Selen Saygın, Sevgi Macide Canik,
Yeseniya Imamoglu, Zeynep Nur Şipi

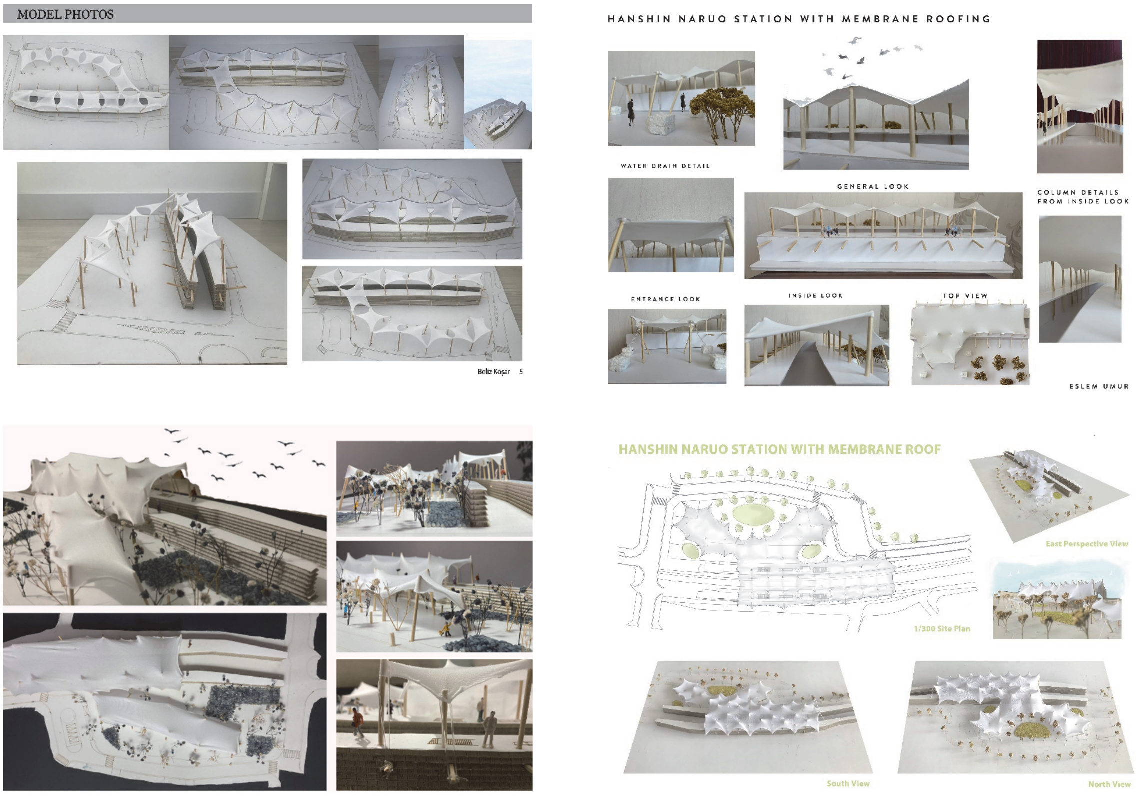


At the welcome ceremony on June 25, each BAU student introduced her own hometown.

At the welcome ceremony, MWU student representatives gave welcome speeches in English or Turkish.

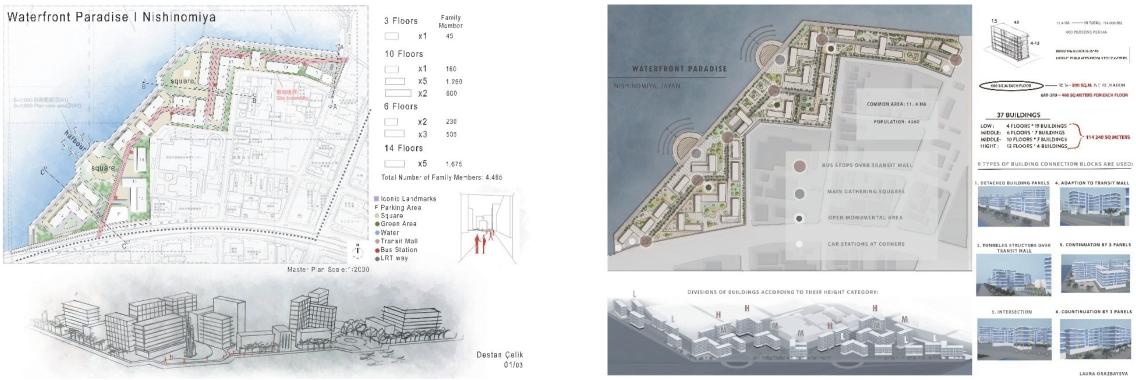


Results of design project for second-year students of MWU's Department of Architecture: Student Hall

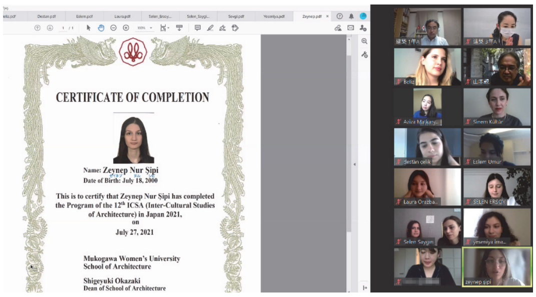


Results of design project for third-year students of MWU's Department of Architecture: Hanshin Naruo Station with Membrane Roof

Results of design project for fourth-year students of MWU's Department of Architecture: Waterfront Paradise



Results of design project for fourth-year students of MWU's Department of Architecture: Waterfront Paradise



Scene from the certificate presentation at the completion ceremony on July 29.

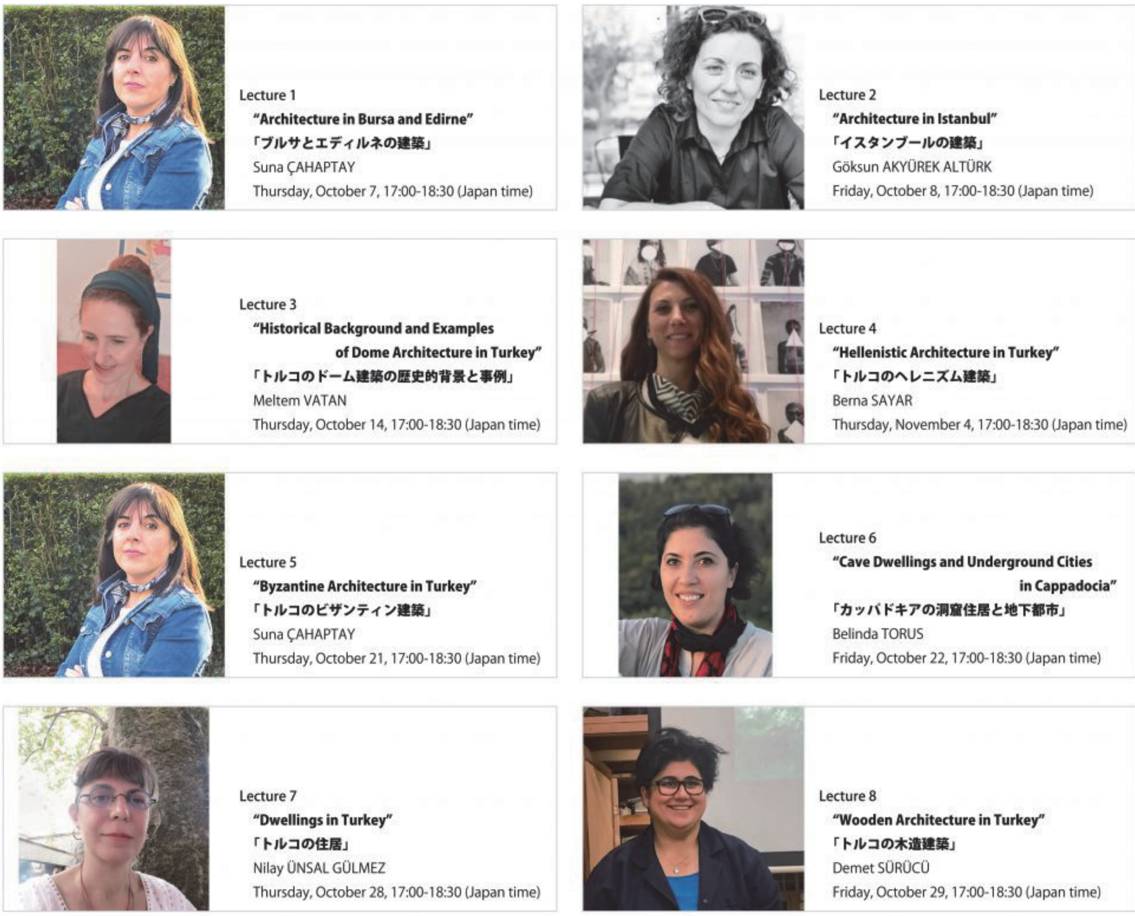

Group photo at the farewell ceremony.

Intercultural Understanding, volume 12, pages 11-12

Lecture Series on Architecture in Turkey : Inter Cultural Studies of Architecture (ICSA) in Istanbul 2021

In 2008, our university and Bahçeşehir University concluded a general exchange agreement. We have thus maintained exchanges such as sending and receiving short-term study abroad students. Due to the COVID-19 pandemic, direct exchanges have been difficult, but from October 7th (Thursday) to November 4th (Thursday), 2021, the “Lecture Series on Architecture in Turkey” by faculty members of Bahçeşehir University was held online, as part of the exchange program “Inter Cultural Studies of Architecture (ICSA) in Istanbul 2021”. Students from the Department of Architecture and the Graduate School of Architecture attended eight lectures on Turkish architecture. Approximately 100 to 130 students attended each lecture.

The subjects of the lectures were “Architecture in Bursa and Edirne,” “Architecture in Istanbul,” “Historical Background and Examples of Dome Architecture in Turkey,” “Hellenistic Architecture in Turkey,” “Byzantine Architecture in Turkey,” “Cave Dwellings and Underground Cities in Cappadocia,” “Dwellings in Turkey,” and “Wooden Architecture in Turkey.”



List of lecturers and lecture titles

A wide range of topics were covered. For example, the various mosques seen in the cities of Bursa, Edirne, and Istanbul; the famous Hagia Sophia; ancient Greek cities like Priene; the mosaics of the Chora Monastery; the strange geological features of Cappadocia; Safranbolu and its landscape of traditional houses; examples of renovated wooden townhouses; and the lives of traditionally nomadic Turkish people. At the end of each lecture, there was a lively question-and-answer session in English, and participating students were able to deepen their knowledge of Turkish architecture.

The students who attended said, “I was able to learn about Turkish architecture and history, which is different from Japan, and it made me want to actually go there.” “It was a valuable experience as I could feel the culture of Turkey from the videos I saw in the lecture.” “It was truly a crossroads of civilizations, with Greek architecture, Christian architecture, and Islamic architecture mixed together.” “I want to put more effort into studying English in order to learn about the culture and architecture of different countries.”

Lecture 3: “Historical Background and Examples of Dome Architecture in Turkey”

Lecture 6: “Cave Dwellings and Underground Cities in Cappadocia”

Lecture 5: “Byzantine Architecture in Turkey” Q and A session

Intercultural Understanding, volume 12, pages 13-14

Archi Design Talks: Space in Japanese Architecture

Date： **May 26 (Wednesday), 2021, 16:00～18:00**
Venue： **Online, using Microsoft Teams**
Lecturer： **Prof. Shigeyuki OKAZAKI (Professor, Mukogawa Women's University)**

The bluish violet Bosphorus divides the city of Istanbul, the capital of Turkey, between the Asian and European continents. Bahçeşehir University is one of Turkey's prestigious private universities with campuses in scenic spots on the European coast. Professor Okazaki gave a special lecture in the lecture series "Archi Design Talks" sponsored by Bahçeşehir University. The lecture was attended by faculty members and students from Bahçeşehir University and architects from outside the university. The lecture was entitled "Space in Japanese Architecture" and explained Japanese gods and views of nature, gardens, roofs, the Ryoanji-Temple, and the borrowed scenery in the gardens, using 3D simulation videos.

Japanese gods and views of nature

First, Prof. Okazaki explained the idea that God is in nature. The Japanese god lives in mountains, trees, rocks, and waterfalls. He gave an example. The Oomiwa-Shrine in Nara does not have a main shrine or enshrine Mt. Miwa as a god. In addition, we offer daily meals and prayers to the rocks on Mt. Miwa. A shimenawa was wrapped around a huge tree to make it a symbol of God. The waterfall drawn on the mandala of Nachi is marked with the god's body. Mt. Fuji and many mountains are painted as objects of worship in the mandala. Ise-Jingu, Izumo-Taisha, Hieizan-Enryakuji-Temple, and Kongobuji-Temple are sacred religious sites that represent Japan, and are located in the deep mountains.

Japanese Garden

Next, he explained the spatial composition of the stones in the Japanese garden. He explained the stone gardening method unique to Japan in the world's oldest garden book "Sakuteiki" written in the Heian period. The book explains that when arranging stones, it is best to first select and erect the main stone, then place the second stone according to the main stone, and then place the third stone according to the main stone and the second stone. He also explained how to compare stones with humans and animals.

As an example, he introduced the garden on the factory grounds and the gardens of the East Studio and West Studio of the Department of Landscape Architecture.

The designing of the garden on the factory premises started by looking for stones in the stone yard in the mountains. He introduced the selection of standing stones and stones that resembled a ship floating in the sea, how they were stood on the site, and how the flowers and stonework bloomed one year after completion.

For the garden on the south side of the Landscape Architecture East Studio, Prof. Okazaki introduced how the sea was represented by crushed stones, bamboo was planted on a small hill on the embankment of the old riverbed to make it look like an island, and stones were assembled to make a dry landscape waterfall. There is a painting called "Niga Byakudou-zu" from the Kamakura period, that recommends entering the Buddhist gate. The white stone bridge depicted here is also quoted in the Katsura Imperial Villa Garden. The garden of the Landscape Architecture East Studio also quotes a bridge over the island.

Japanese Roof

The annual rainfall in Japan is 1700 mm, approximately twice the global average. In Japanese architecture, deep eaves were installed to prevent direct rain on the walls. “Hisashi,” “noki,” and “geya” in Japanese architecture are expressed by one word, “eave,” in English. To enable deeper eaves, a structure called “hanegi” is hidden inside the eaves. This was introduced in the photos of Kiyomizu Temple and Honryuji Temple under construction. Bauhaus combines rectangles with different functions to achieve a structure in which beautiful solids are connected. On the other hand, in Katsura Imperial Villa, “Koshoin,” “Chushoin,” and “Shinshoin” are lined up in a gantry shape, forming the same beautiful plane as Bauhaus. However, designing an eaves roof on top of it requires very complex capabilities.

The Landscape Architecture East Studio inherits the method of constructing eaves and eaves in Japanese architecture. It creates a space that harmonizes with the design of the nearby “Koshien-Kaikan” and the Frank Lloyd Wright design that influenced it.

Ryoanji-Temple and the borrowed scenery in the gardens

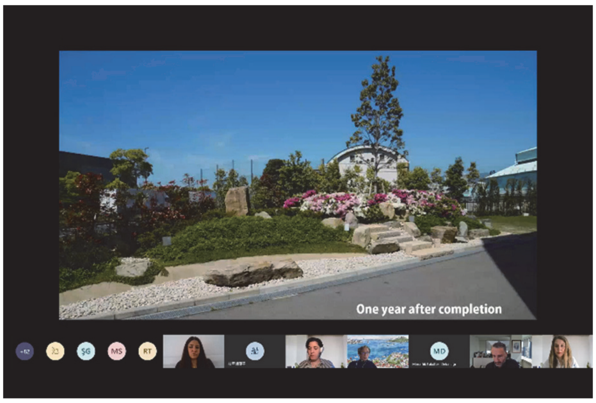
Finally, Prof. Okazaki explained the concept of “Shakkei’ at Ryoanji Rock Garden and Entsuji-Temple. He talked about the arrangement and meaning of the stones, using a simulation video of Ryoanji Rock Garden. The method of designing a garden with a part of the distant landscape as one of the spatial components is called "Shakkei". He introduced Entsuji Temple in Kyoto as an example of a garden with “Shakkei.”

In the current garden of Ryoanji-Temple, the outside of the fence is surrounded by tall trees, so we cannot see the scenery outside at all. However, it has been recorded that Katsumoto Hosokawa, the owner of Ryoanji Temple, worshiped at Iwashimizu-Hachimangu Shrine on Otokoyama, which is located on the other side of the city of Kyoto, from the porch facing the garden every day.

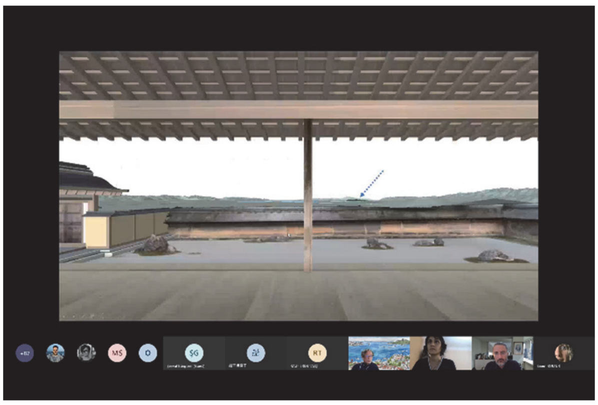
Therefore, 3D data of the buildings and gardens of Ryoanji Temple and the hills surrounding the city of Kyoto were created. Prof. Okazaki discovered by simulation that Iwashimizu-Hachimangu could be seen beyond the wall from the temple and the porch of the temple. The stones in the garden are large near the porch and gradually become smaller as the distance from the porch increases. Beyond the garden, we saw a smaller Otokoyama through the flat city of Kyoto. It was speculated that the entire stonework and Otokoyama were likened to the scenery of an island floating in the ocean.

The west wall that surrounds the garden gradually increases in height as it approaches the veranda in the foreground, making the garden look even wider by emphasizing perspective.

About 100 people participated, including faculty members and students from Bahçeşehir University, students participating in this year's ICSA in Japan, and graduates of the program. After the lecture, there was a discussion on traditional Japanese spaces and contemporary architecture. During the question-and-answer session, many participants asked questions, and the lecture was a great success.



The garden on the factory grounds



The simulation of Ryoanji Garden

ITCS Seminar (2021 Academic Year)

Three Ottoman Capitals: Bursa, Edirne, and Istanbul

Date： **July 31 (Saturday), 2021, 17:00～18:00**
Venue： **Online**
Lecturer： **Dr. Suna Çağaptay (Assistant Professor, Bahçeşehir University)**

The first seminar of the Institute of Turkish Culture Studies of the 2021 academic year was held online on Saturday, July 31, 2021. We invited Dr. Suna Çağaptay, an architectural historian and archaeologist from Bahçeşehir University, to give a lecture titled "Three Ottoman Capitals: Bursa, Edirne, and Istanbul."

She explained the architectural features of the capital cities of the Ottoman Empire—Bursa, Edirne, and Istanbul—based on examples of mosques, tombs, palaces, monasteries, and castle walls, with an eye to the transition from Byzantine architecture. We then discussed the identity of Ottoman architecture based on the traditions of these three capitals. It was a splendid workshop where we could fully enjoy the charm of Turkish architecture.

Traditional Japanese Architecture Interpreted by Bruno Taut

Date： **March 14 (Monday), 2022, 17:00～18:00**
Venue： **Online**
Lecturer： **Dr. Murat Dündar (Dean, Professor, Bahçeşehir University)**

The second seminar of the Institute of Turkish Culture Studies of the 2021 academic year was held online on Monday, March 14, 2022. We invited Professor Murat Dündar, Dean of the Faculty of Architecture and Design of Bahçeşehir University, to give a lecture titled "Traditional Japanese Architecture Interpreted by Bruno Taut."

First, there was an introduction to Bruno Taut. Professor Dündar then discussed the Glass Pavilion, Alpine Architecture, the house Taut designed for himself during his stay in Turkey, and the Faculty of Languages, History and Geography of Ankara University. This was followed by a careful unraveling of Taut's statements to illustrate his way of thinking on traditional Japanese architecture, using the Katsura Imperial Villa, Ise Shrine, Shirakawa Village, and haikus as examples. During the Q&A session after the lecture, a lively discussion took place, and the meeting ended on a high note.

Annual Events Apr. 2021- Mar. 2022

Date	Events
May 26, 2021	**Prof. Shigeyuki OKAZAKI, Director of ITCS, gave a special lecture in the lecture series "Archi Design Talks" sponsored by Bahçeşehir University.**
June 25-July 29, 2021	**Inter Cultural Studies of Architecture (ICSA) in Japan 2021**
July 31, 2021	**ITCS Seminar ＃01 (FY2021)** *"Three Ottoman Capitals: Bursa, Edirne, and Istanbul"* (Dr. Suna ÇAĞAPTAY, Assistant Professor, Bahçeşehir University)
October 7-November 4, 2021	**Lecture Series on Architecture in Turkey : Inter Cultural Studies of Architecture (ICSA) in Istanbul 2021**
March 14, 2022	**ITCS Seminar ＃02 (FY2021)** *"Traditional Japanese Architecture Interpreted by Bruno Taut"* (Dr. Murat DÜNDAR, Professor, Bahçeşehir University)

OUTLINE OF THE INSTITUTE OF TURKISH CULTURE STUDIES

Organization

Position	Affiliation	Title	Name
Director	Department of Architecture	Professor	Shigeyuki Okazaki
Researcher	Department of Architecture	Professor	Shigeki Tosu
		Professor	Chikashi Yamamoto
		Professor	Tetsu Nakae
		Professor	Kazuhiko Yanagisawa
		Professor	Toshitomo Suzuki
		Professor	Hiroyuki Tagawa
	Department of Landscape Architecture	Professor	Junichiro Ishida
		Professor	Azusa Uemachi
		Professor	Noritoshi Sugiura
		Professor	Shigeki Sugita
		Professor	Haruyoshi Sowa
		Professor	Yusei Tazaki
		Professor	Koji Yoneda
	Department of Architecture	Associate Professor	Fumie Ooi
		Associate Professor	Tomoko Uno
		Associate Professor	Akira Tanaka
		Associate Professor	Junko Miyano
		Associate Professor	Hideaki Tembata
		Associate Professor	Keisuke Inomata
	Department of Landscape Architecture	Associate Professor	Junko Morimoto
	Department of Architecture	Lecturer	Aya Yamaguchi
		Lecturer	Yuuka Nakamura
	Department of Landscape Architecture	Lecturer	Yuna Tanaka
	Department of Architecture	Visiting Professor	Kunihiko Honjo
Visiting Researcher	Bahçeşehir University (Turkey) Faculty of Architecture and Design	Professor	Murat Dündar
Assistant	Department of Architecture	Assistant	Moeko Ikezawa

Reviewers of *Intercultural Understanding*

Name	Title and Affiliation
Yasushi Asami	Professor, The University of Tokyo, Japan
Mitsuo Takada	Professor Emeritus at Kyoto University, Japan
Shuichi Hokoi	Professor Emeritus at Kyoto University, Japan
Minako Mizuno Yamanlar	Representative of NPO The Japanese-Turkish Friendship Association, Japan
Kazuya Yamauchi	Professor, Teikyo University, Japan
Murat Dündar	Professor, Bahçeşehir University, Turkey
Murat Şahin	Associate Professor, Özyeğin University, Turkey
Renk Dimli Oraklıbel	Assistant Professor, Bahçeşehir University, Turkey
Kazuhiko Yanagisawa	Professor, Mukogawa Women's University, Japan
Toshitomo Suzuki	Professor, Mukogawa Women's University, Japan

Rules and Regulations of the Institute of Turkish Culture Studies (ITCS) at Mukogawa Women's University

(Establishment)
Article 1 The Institute of Turkish Culture Studies (hereinafter "the Institute") shall be located in Mukogawa Women's University (hereinafter referred to as "the University").
(2) The Institute shall be operated under the administration of the University's School of Architecture for the time being.

(Objective)
Article 2 The objective of the Institute is as follows:
(i) to conduct comparative studies on life, technology, and culture centered on the architecture of Japan and Turkey as the east and west starting points of the Silk Road, and to clarify the cultural base common to both countries beyond their differences in history, climate, and so forth.
(ii) to conduct, by pursuit of the above-mentioned aims, extensive studies on life, technology, and culture centered on the architecture of neighboring Silk Road countries, clarify similarities among them, and contribute to new mutual understandings that promote the peace and prosperity of the Silk Road region.
(iii) to support international exchange of students predominately in the field of the human environment and conduct international educational activities in the fields of architecture and human environment based on the achievements of the studies mentioned in (i) and (ii).
(iv) to discuss internationally the achievements in research and education mentioned in the preceding three items, introduce (*or* transmit) them to the world in various ways at every occasion, and share common values with people around the world.

(Operation)
Article 3 The operations of the Institute to achieve the above-mentioned objectives are as follows:
(i) to conduct studies in cooperation with the Research Center of Japanese Culture Studies, Bahçeşehir University, Istanbul.
(ii) to hold an international workshop, the "Inter Cultural Studies of Architecture in Japan (ICSA in Japan)," where architecture and human environment students of the world, centered around Turkey, are invited every year in principle to support a similar workshop, the "Inter Cultural Studies of Architecture in Istanbul" that is held at the Research Center of Japanese Culture Studies at Bahçeşehir University, and to send teachers and students of the University's School of Architecture for research and educational activities.
(iii) to hold seminars, introduce research achievements, exhibit, and organize lectures concerning life, technology, and culture, centered around architecture, to which researchers, business persons, and residents who belong to the field of studies conducted by the Institute are invited.
(iv) to hold permanent and special exhibitions on the life, technology, and culture of neighboring Silk Road countries, centered around Turkey.
(v) to conduct public relations activities, such as publication of the research and educational achievements of the Institute, symposiums, and so forth.
(vi) other operations required to accomplish the aims specified in the preceding article.

(Organization)
Article 4 The Institute may establish research departments with respect to differences in research fields to perform relevant activities.

(Director)
Article 5 The Institute shall install a director.
(2) The chancellor shall appoint the director from among professors.
(3) The director shall be appointed for a period of two years and may be reappointed.
(4) The director handles the operations of the Institute under the president's direction.

(Vice Director and Head of Research Department)
Article 6 The Institute may install a vice director and heads of research in each department referred to in Article 4.
(2) The chancellor shall appoint the vice director and heads of the research departments from among the faculty. The latter positions may be substituted with adjunct teaching staff.
(3) The vice director assists the director and engages in the administrative operations.
(4) The vice director fills in for the director under the director's direction.
(5) Each head controls his research department and engages in research under the director's direction.

(Senior Researcher)
Article 7 The Institute may install senior researchers with the chancellor's approval.
(2) The director appoints senior researchers from among the researchers.
(3) The senior researchers will assist their heads and engage in research.

(Researcher)
Article 8 The Institute shall install researchers as required.
(2) Teachers at Bahçeşehir University may be appointed as researchers.
(3) The researchers will engage in research under the director's direction.

(Temporary Researcher)
Article 9 The Institute may install temporary researchers as needed.
(2) The president appoints temporary researchers upon the recommendation of the director.
(3) The period of the appointment shall be less than one year and may be renewed when necessary.
(4) The temporary researchers will engage in specific research or joint research.

(Assistant)
Article 10 The Institute may install assistants.
(2) The assistants will assist in research under the director's direction.

(Steering Committee)
Article 11 The University shall establish a steering committee for the Institute (hereinafter "the steering committee") to deliberate basic policy concerning the Institute's operation.
(2) The steering committee shall consist of a director and a few members chosen from among the vice director, the heads of the research departments, the senior researchers, and researchers.
(3) The president will appoint the members of the steering committee.
(4) The director shall be the chairperson of the steering committee.
(5) The chairperson shall convene and lead the steering committee.
(6) Members shall be appointed for a period of two years and may be reappointed. When a vacancy arises, the successor's term of office shall be the predecessor's remaining term.
(7) Details of the steering committee shall be otherwise laid down.

(Secretariat)
Article 12 The Institute shall install a secretariat.
(2) The secretariat shall consist of a few members and the chief clerk of the School of Architecture shall be the chief of the secretariat.
(3) The members of the secretariat will handle clerical duties under the guidance and supervision of the chief clerk under the director's direction.

(Supplementary Rules and Directions)
Article 13 In addition to what is provided in these rules and directions, necessary matters concerning the administrative operations of the Institute shall be prescribed by the director.

(Modification or Elimination of the Rules and Regulations)
Article 14 Modification or elimination of the rules shall be implemented with the chancellor's prior approval.

Supplementary Provisions
(1) The rules and regulations shall be enforced beginning on July 29, 2009.
(2) From the day the rules and regulations are enforced until March 31, 2011, the term of the appointed directors and members of the steering committee shall begin on the day when they are appointed and end on March 31, 2011, notwithstanding the provisions of Article 5, paragraph (3) and Article 11, paragraph (6).

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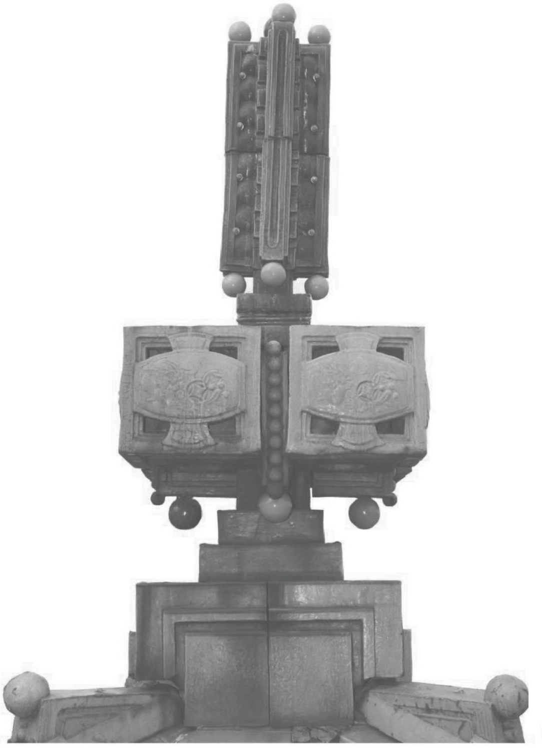

Roof cresting of Koshien Hall: Ceramic cresting with eight legendary mallets sits atop each of the square-shaped roofs. An old Japanese folk legend tells the miracle of a pygmy priest 3cm tall who grew bigger by striking the magic mallet. Daikokuten, one of seven Gods of Wealth, is always portrayed holding the magic mallet in his hand.