



Research Article

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Research of Rod Constructions with 3D-Extended Index Matrix and Aggregation Operations Using Displacement Method

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To Cite This Article: Stela Todorova*. Research of Rod Constructions with 3D-Extended Index Matrix and Aggregation Operations Using Displacement Method. Am J Biomed Sci & Res. 2025 27(6) AJBSR.MS.ID.003625, DOI: 10.34297/AJBSR.2025.27.003625

Received: 📅 July 23, 2025; Published: 📅 July 29, 2025

Abstract

Since ancient times, it has been difficult for humans to move heavy objects from one place to another. Therefore, in order to replace the human strength, the human mind began to invent various types of structures to replace human in the production and work process. In this way, the ancient human became a science researcher who calculated the efforts required to move an object from one point to another. Following their example, with the Theory of Index Matrices a new approach of calculating and analyzing the deformation and stress state of materials during the production and construction process of building structures and equipment will be presented. In advance with the apparatus of the Index Matrices and Predicate Logic an optimization algorithm for reordering the states of the production and working process will be presented.

Keywords: Index Matrices, 3D-Extended Index Matrix, rod constructions, Displacement Method, Aggregation operations, Optimization algorithm

Introduction

Let I be a fixed set of indices,

$$I^n = \{ \langle i_1, i_2, \dots, i_n \rangle \mid (\forall j: 1 \leq j \leq n)(i_j \in I) \} \text{ and}$$

$$I^* = \bigcup_{1 \leq j \leq \omega} I^j$$

and $\mathfrak{R}$ be the set of the real numbers. Let $\mathfrak{X}$ be a fixed set of objects. In the particular cases, they can be either real numbers, or only the numbers 0 or 1, or logical variables, propositions or predicates, IFPs, function etc [1,2].

In [3] V. Traneva, E. Sotirova, V. Bureva and K. Atanassov give a definition of a 3D-Extended Index Matrix and aggregation operations over 3D-Extended Index Matrices. A "3D-Extended Index Matrix" (3D-EIM) with index sets $K, L, H (K, L, H \subset I^*)$ and elements from set $\mathfrak{X}$ is called the object:

$$\left[K, L, H, \left\{ a_{k,l,h_g} \right\} \right] \equiv$$

$$\left\{ \begin{array}{c|cccc} h_g & l_1 & l_2 & \dots & l_n \\ \hline k_1 & a_{k_1,l_1,h_g} & a_{k_1,l_2,h_g} & \dots & a_{k_1,l_n,h_g} \\ k_2 & a_{k_2,l_1,h_g} & a_{k_2,l_2,h_g} & \dots & a_{k_2,l_n,h_g} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ k_m & a_{k_m,l_1,h_g} & a_{k_m,l_2,h_g} & \dots & a_{k_m,l_n,h_g} \end{array} \right\} \mid h_g \in H \right\},$$

where $K = \{k_1, k_2, \dots, k_m\}$, $L = \{l_1, l_2, \dots, l_n\}$, $H = \{h_1, h_2, \dots, h_f\}$ and for $1 \leq i \leq m, 1 \leq j \leq n, 1 \leq g \leq f: a_{k_i,l_j,h_g} \in \mathfrak{X}$

Let $3D - EIM_{\mathfrak{R}}$ be the set of all 3D-EIMs with elements being real numbers; $3D - EIM_{\{0,1\}}$ be the set of all (0,1)-3D-EIMs with elements being 0 or 1; $3D - EIM_{\mathfrak{P}}$ be the set of all 3D-EIMs with elements – predicates.

Let the 3D-EIM $A = \left[K, L, H, \left\{ a_{k,l,h_g} \right\} \right] (K, L, H \subset I^*)$ be given and let $k_0 \notin K, l_0 \notin L, h_0 \notin H$.

Let $\circ: \mathfrak{X} \times \mathfrak{X} \rightarrow \mathfrak{X}$ and $*$: $\mathfrak{X} \times \mathfrak{X} \rightarrow \mathfrak{X}$.

$o \in \{ "max", "min" \}$ if $A \in 3D - EIM_{\{0,1\}}$

The aggregation operations has the form:

($\circ$) - α_k -aggregation

$\alpha_{(k, \circ)}(A, k_0)$

$$= \left\{ \frac{h_g}{k_0} \mid \begin{array}{cccc} l_1 & l_2 & \dots & l_n \\ \circ & \circ & \circ & \circ \\ 1 \leq i \leq m & a_{k_i, l_1, h_g} & a_{k_i, l_2, h_g} & \dots & a_{k_i, l_n, h_g} \end{array} \mid h_g \in H \right\} [3].$$

Discrete System

If the stress state of a model or system is determined by a finite number of elements, then it is a discrete. Plane and space frames, continuous beams, tested for strength under static pressure are discrete systems. Rod (one-dimensional) elements connected by rigid joints or hinge joints construct the discrete systems.

The connection of rods are performed by rigid joints or hinge joints(nodes).

Displacement Matrix Method Applied to Rod Structure

A kinematically determinable basic system replaces the actual rod structure, applying the deformation method, that is also called the displacement method. It is obtained by inserting connections along the direction of the unknown generalized nodal displacements or independent nodal parameters of the system, which we also call nodal linear displacements is obtained the deformation method.

If there are external nodal forces, then, according to the definition, they are equal to the reactive forces in the introduced connections (reactive nodal forces) due to the displacements, that are caused by the applied pressure. The independent nodal displacements are determined by a system of equations are determined by

the occurred independent nodal displacements.

Plane Frame Constructions

Let with the index set $C = \{c_1, c_2, \dots, c_m\}$ define the rigid nodes of a discrete system. Three independent components – horizontal displacement u_{c_i} , vertical displacement v_{c_i} , and rotation φ_{c_i} , determine the displacement of any rigid node c_i , where $1 \leq i \leq m$. Then we can construct a set $Q = \{u_{c_i}, v_{c_i}, \varphi_{c_i}, u_{c_i}, v_{c_i}, \varphi_{c_i}, \dots, u_{c_m}, v_{c_m}, \varphi_{c_m}\}$ for all nodes constitutes the vector $\{Z\} = [u_{c_1}, v_{c_1}, \varphi_{c_1}, u_{c_1}, v_{c_1}, \varphi_{c_1}, \dots, u_{c_m}, v_{c_m}, \varphi_{c_m}]$, where $1 \leq i \leq m$. Let define a coordinate system with horizontal axis x and vertical axis y . Linear displacements are negative if they coincide with the negative directions of the common coordinate system with axes x and y . When rotating the positive y axis until it merges with the positive x axis, the positive direction of rotation is clockwise [4].

If we insert into each rigid node of the frame two linear connections in the horizontal and vertical directions and one angular connection, it can be obtained a kinematically determinable basic system.

Each position of a rigid node is unique of the system and each displacement with a combination with another illustrates the pressure that is applied. The stages of change can be taken into account and recorded with index sets.

Dependences Between Reactive Nodal Forces and Nodal Displacements of an Individual Rod

Let us define a local coordinate system which axis $\bar{x}$ coincides with the axis of the rod, and the axis $\bar{y}$ is perpendicular to it. The numbers of the rigid joints are illustrated in Figure 1.

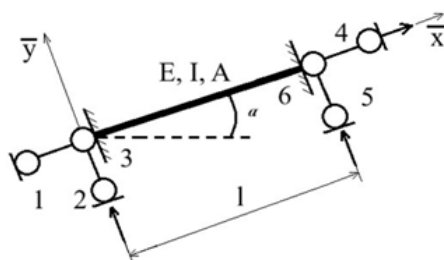


Figure 1: Numbers of the rigid joints of an individual rod.

Let we assume that we assume its bending stiffness $e = EI/l = 0$. According to this condition, can define the 3D-Extended Index Matrix of the states and their corresponding reactions of the unit nodal displacements of a type III rod arbitrarily oriented relative to the general coordinate system. The nodal displacements and rotations do not cause bending moments at the ends of the rod, because of the presence of zero values.

Two linear and one angular connection are inserted into each support node, regardless of its actual support, of a unsupported frame. Let be defined a constant cross-section A and constant bending stiffness EI . Then, a collection of self-acting rectilinear rod elements defines a basic system. Initially, we will assume that the

frame is unsupported. The length of a given rod El or A is considered as an additional rigid node change if along the length is made change stepwise from a given cross-section onwards.

Let the angle of inclination α be measured when rotating from the positive direction of the x axis counterclockwise until it merges with the direction of the rod axis $\bar{x}$. Let the origin of the rod be its lower node [5].

Necessary for calculating the coefficients of a type III rod, the given coordinates x_c and x_c of its left node and y_c and y_c of its right node obtain the lengths of the rods l , $\sin \alpha$ and $\cos \alpha$ using the formulas:

$$I = \sqrt{(x_{c_i} - x_{c_r})^2 + (y_{c_i} - y_{c_r})^2} \quad (1)$$

$$\sin \alpha = (y_{c_i} - y_{c_r}) / I \quad (2)$$

$$\cos \alpha = (x_{c_i} - x_{c_r}) / I \quad (3)$$

where $1 \leq i \leq m$ and $1 \leq r \leq m$.

Let $f = EA/l$, $s = \sin \alpha$ and $c = \cos \alpha$ and let $c \geq s$.

Distribution Function

Let Ω be a space of elementary events.

Let us consider a space (Ω, F, P) .

Let consider a series of Bernoulli experiments. For each experiment i , $i = 1, 2, n$, we assign the functions $\xi_i(\omega)$, which domain is Ω , where $\xi_i(\omega) = 1$ if the corresponding event A occurred as a result of the experiment, and $\xi_i(\omega) = 0$ if the event A did not occur.

The function $\xi = \xi(\omega)$ maps each point ω of Ω to a point $x = \xi(\omega)$ on the number line.

A function $F(x) = P(\xi < x)$, defined for every $x \in \mathbb{R}$, is called the distribution function of the random variable ξ . To each real number x we assign the number $F(x)$, equal to the quantity of probability mass located to the left of x .

Theorem 1. If $F(x)$, $x \in \mathbb{R}$ is a distribution function, then there exists a probability space (Ω, F, P) and a random variable $\xi = \xi(\omega)$, $\omega \in \Omega$ with distribution function $F(x)$ [6].

3D-Extended Index Matrix of States of Single Nodal Displacements of a Rod Type III

Let with the index sets $K = \{k_1, k_2, k_3, k_4, k_5, k_6\}$ and $H = \{h_1, h_2, h_3, h_4, h_5, h_6\}$, where $K, H \subset I^*$ denote the events occurred as a result of the displacement of the rigid joints, illustrated in the Figure 1, where $k_1 = h_1 = 1$, $k_2 = h_2 = 2$, $k_3 = h_3 = 3$, $k_4 = h_4 = 4$, $k_5 = h_5 = 5$, $k_6 = h_6 = 6$ [7].

Then we have a sequence of 6 independent events occurred as a result of the displacement of the rigid joints, each of which results in an event from $\Omega = \{\omega_1, \omega_2\}$. Let with $P(\omega_1) = p$ assigns the probability of the success of the event ω_1 and with $P(\omega_2) = q = 1 - p$ assign the probability of the failure of the event ω_1 with We usually call the event ω_1 a success and the event ω_2 a failure, the probability of ω_1 being $P(\omega_1) = p$, $P(\omega_2) = q = 1 - p$. Let with the index set $B = \{b_1, b_2, \dots, b_6\}$ the sequence of elementary 6 events and let with b_i define the times when in the sequence of elementary 6 events success occurs success and failure 6 - b_i times [8].

Then

$$P = (\{w_{b_1}, w_{b_2}, \dots, w_{b_6}\}) = p^{b_1} q^{6-b_1} \quad (4)$$

where $1 \leq i \leq 6$.

We will denote the number of successes by v_x . The event $\{v_x = x\}$ consists of those elementary outcomes of $\Omega(6)$ that contain x times ω_1 and 6 - x times ω_2 , a total number of C_6^x .

Consequently,

$$P_6(x) = P(v_6 = x) = C_6^x p^x q^{6-x} \quad (5)$$

where $1 \leq x \leq 6$.

The event $\{v_1 = x_1, v_2 = x_2, \dots, v_r = x_r\}$ consists of those elementary events $\omega \in \Omega(n)$ such that ω_1 occurs x_1 times, ω_2 occurs x_2 times, etc., ω_r occurs x_r times, where $1 \leq r \leq 6$.

Since ω_1 can be located at x_1 of all 6 locations $C_6^{x_1}$ ways, in the remaining 6 - x_1 places the element ω_2 can be placed in x_2 of all 6 - x_1 places in $C_{6-x_1}^{x_2}$ ways, and so on, in the remaining n_r places the element ω_r can be placed in

$$C_{6-x_1 \dots - x_{r-1}}^{x_r} = C_{x_r}^{x_r} = 1 \quad (6)$$

way, where $1 \leq r \leq 6$.

Analogically, the index set H we have

$$P_6(y) = P(v_6 = y) = C_6^y p^y q^{6-y}, \quad (7)$$

where the event $\{v_s = y\}$ consists of those elementary outcomes of $\Omega(6)$ that contain y times ω_1 and 6 - y times ω_2 , a total number of C_6^y , where $1 \leq y \leq 6$ and $1 \leq s \leq 6$.

Analogically,

$$C_{6-y_1 \dots - y_{s-1}}^{y_s} = C_{y_s}^{y_s} = 1 \quad (8)$$

way, where $1 \leq s \leq 6$.

Moreover, in order to define the corresponding reactions of a rod of type III, we will assign to any combination of two rigid joints an event.

Let with the index set $L = \{l_1, l_2, l_3, l_4, l_5, l_6, l_7\}$ define the axial stiffnesses, that are determined, according to the possibilities of the rod position in a frame, where $L \subset I^*$ and

$$l_1 = -f \times c^2, \quad (9)$$

$$l_2 = -f \times c \times s, \quad (10)$$

$$l_3 = -f \times s^2, \quad (11)$$

$$l_4 = 0, \quad (12)$$

$$l_5 = f \times s^2, \quad (13)$$

$$l_6 = f \times c \times s, \quad (14)$$

$$l_7 = f \times c^2, \quad (15)$$

where $c \geq s$.

From the Theorem 1, if there is a distribution function $F(l_j)$, $l_j \in \mathbb{R}$, then there exists a probability space (Ω, F, P) and a random variable $\xi = \xi(\omega)$, $\omega \in \Omega$ with distribution function $F(l_j)$ [9,10].

Then we can construct a 3D-Extended Index Matrix of the states of the unit nodal displacements and their corresponding reactions of a type III rod:

$$[K, L, H, \{a_{b_i, l_j, h_k}\}] =$$

$$\left\{ \begin{array}{c|ccccccc} h_1 & l_1 & l_2 & l_3 & l_4 & l_5 & l_6 & l_7 \\ \hline k_1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ k_2 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ k_3 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ k_4 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_5 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ k_6 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{array} \right\},$$

$$\left\{ \begin{array}{c|ccccccc} h_2 & l_1 & l_2 & l_3 & l_4 & l_5 & l_6 & l_7 \\ \hline k_1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ k_2 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ k_3 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ k_4 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_5 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ k_6 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{array} \right\},$$

$$\left\{ \begin{array}{c|ccccccc} h_3 & l_1 & l_2 & l_3 & l_4 & l_5 & l_6 & l_7 \\ \hline k_1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_2 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_3 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_4 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_5 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_6 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{array} \right\},$$

$$\left\{ \begin{array}{c|ccccccc} h_4 & l_1 & l_2 & l_3 & l_4 & l_5 & l_6 & l_7 \\ \hline k_1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ k_2 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ k_3 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_4 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ k_5 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ k_6 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{array} \right\},$$

$$\left\{ \begin{array}{c|ccccccc} h_5 & l_1 & l_2 & l_3 & l_4 & l_5 & l_6 & l_7 \\ \hline k_1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ k_2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ k_3 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_4 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ k_5 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ k_6 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{array} \right\},$$

$$\left\{ \begin{array}{c|ccccccc} h_6 & l_1 & l_2 & l_3 & l_4 & l_5 & l_6 & l_7 \\ \hline k_1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_2 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_3 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_4 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_5 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ k_6 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{array} \right\},$$

where $K = \{k_1, k_2, \dots, k_6\}$, $L = \{l_1, l_2, \dots, l_7\}$,

$H = \{h_1, h_2, \dots, h_6\}$, $K, L, H \subset I^*$ and for, $1 \leq j \leq 7$, $1 \leq g \leq 6$: $a_{k_i, l_j, h_g} = 1$, if $\omega \in k_i$ and $\omega \in h_g$ and $a_{k_i, l_j, h_g} = 0$, if $\omega \notin k_i$ and $\omega \notin h_g$.

Then with operation $(\circ)$ - αK -aggregation

$\alpha(K, \circ) (A, k_0)$

$$= \left\{ \begin{array}{c|ccccccc} h_g & l_1 & l_2 & \dots & l_6 \\ \hline k_0 & \overset{\circ}{a_{k_1, l_1, h_g}} & \overset{\circ}{a_{k_1, l_2, h_g}} & \dots & \overset{\circ}{a_{k_1, l_7, h_g}} \end{array} \middle| h_g \in H \right\},$$

the positions of the rigid rods can be reordered in ascending order. In order to reduce the use of an energy an optimization algorithm can be applied as the elements of the index set $K = \{k_1, k_2, k_3, k_4, k_5, k_6\}$ are rearranged. As an illustration, let h_1 is the left

rigid node, then the rigid node k_1 can be replaced with k_5 , k_2 can be replaced with k_6 . If h_3 or h_6 are the left rigid nodes, then for the displacement of all rigid nodes, the consumed energy will be equal [11].

Let $P_1(k_i) = "k_i > k_{i+1}"$ be a predicate that receives a condition whether a given element is greater than its next in a given index set, where $1 \leq i \leq m$ and $m \geq 2$. Similarly, we can define a second predicate $P_2(i) = "i < m \geq 2"$ that receives a condition whether the index of the element is less than the number of elements $m \geq 2$ in the index set [12,13].

Then can be defined an algorithm of reordering elements, which are real numbers of an index set in ascending order:

Step 1: $i = 1$ (i - A number of step);

Step 2: $P_1(k_i)$,

if $P_1(k_i)$ is true, go to step 3)

if $P_1(k_i)$ is false, go to step 4);

Step 3: $k_i = k_{i+1}$ and $k_{i+1} = k_i$;

Step 4: $i = i + 1$, $P_2(i)$,

if $P_2(i)$ is true, go to step 2)

if $P_2(i)$ is false, go to step 5);

Step 5: End.

Let with the index set

$$P \{p_1 = \langle k_1, h_1 \rangle, p_2 = \langle k_1, h_2 \rangle, p_3 = \langle k_1, h_3 \rangle, p_4 = \langle k_1, h_4 \rangle, p_5 = \langle k_1, h_5 \rangle, p_6 = \langle k_1, h_6 \rangle, p_7 = \langle k_2, h_1 \rangle, p_8 = \langle k_2, h_2 \rangle, p_9 = \langle k_2, h_3 \rangle, p_{10} = \langle k_2, h_4 \rangle, p_{11} = \langle k_2, h_5 \rangle, p_{12} = \langle k_3, h_1 \rangle, p_{13} = \langle k_3, h_2 \rangle, p_{14} = \langle k_3, h_3 \rangle, p_{15} = \langle k_3, h_4 \rangle, p_{16} = \langle k_4, h_1 \rangle, p_{17} = \langle k_4, h_2 \rangle, p_{18} = \langle k_4, h_3 \rangle, p_{19} = \langle k_5, h_1 \rangle, p_{20} = \langle k_5, h_2 \rangle, p_{21} = \langle k_6, h_1 \rangle\},$$

define the events occurred as a result of the unit nodal displacements, where their corresponding reactions of a type III rod are

$$\langle k_1, h_1 \rangle = l_1 = f \times c^2, \langle k_1, h_2 \rangle = l_2 = f \times c \times s, \langle k_1, h_3 \rangle = l_3 = 0, \langle k_1, h_4 \rangle = l_4 = f \times c^2, \langle k_1, h_5 \rangle = l_5 = f \times c \times s, \langle k_1, h_6 \rangle = l_6 = 0, \langle k_2, h_1 \rangle = l_7 = f \times s^2, \langle k_2, h_2 \rangle = l_8 = 0, \langle k_2, h_3 \rangle = l_9 = f \times c \times s, \langle k_2, h_4 \rangle = l_{10} = f \times c^2, \langle k_2, h_5 \rangle = l_{11} = 0, \langle k_2, h_6 \rangle = l_{12} = 0, \langle k_3, h_1 \rangle = l_{13} = 0, \langle k_3, h_2 \rangle = l_{14} = 0, \langle k_3, h_3 \rangle = l_{15} = 0, \langle k_3, h_4 \rangle = l_{16} = f \times c \times s, \langle k_3, h_5 \rangle = l_{17} = f \times c^2, \langle k_3, h_6 \rangle = l_{18} = 0, \langle k_4, h_1 \rangle = l_{19} = f \times c^2, \langle k_4, h_2 \rangle = l_{20} = f \times s^2, \langle k_4, h_3 \rangle = l_{21} = 0, \langle k_5, h_1 \rangle = l_{22} = f \times s^2, \langle k_5, h_2 \rangle = l_{23} = 0, \langle k_5, h_3 \rangle = l_{24} = 0, \langle k_5, h_4 \rangle = l_{25} = 0, \langle k_6, h_1 \rangle = l_{26} = 0,$$

where $P = \{p_1, p_2, \dots, p_{21}\}$, $L = \{l_1, l_2, \dots, l_{26}\}$, $P, L \subset I^*$

for $1 \leq j \leq 7$: $b_{p_r, l_j} = 1$ if $\omega \in p_r$ and $b_{p_r, l_j} = 0$, if $\omega \notin p_r$.

Then, an Extended Index matrix can be constructed

$$\left[P, L, \{b_{p_r, l_j}\} \right] \equiv$$

	l_1	l_2	l_3	l_4	l_5	l_6	l_7
p_1	0	0	0	0	0	0	1
p_2	0	0	0	0	0	1	0
p_3	0	0	0	1	0	0	0
p_4	1	0	0	0	0	0	0
p_5	0	1	0	0	0	0	0
p_6	0	0	0	1	0	0	0
p_7	0	0	0	0	1	0	0
p_8	0	0	0	1	0	0	0
p_9	0	1	0	1	0	0	0
p_{10}	1	0	0	0	0	0	0
p_{11}	0	0	0	1	0	0	0
p_{12}	0	0	0	1	0	0	0
p_{13}	0	0	0	1	0	0	0
p_{14}	0	0	0	1	0	0	0
p_{15}	0	0	0	1	0	0	0
p_{16}	0	0	0	0	0	0	1
p_{17}	0	0	0	0	1	0	0
p_{18}	0	0	0	1	0	0	0
p_{19}	0	0	0	0	1	0	0
p_{20}	0	0	0	1	0	0	0
p_{21}	0	0	0	1	0	0	0

Conclusion

The condition for defining with a 3D-Extended Index Matrix and an Extended Index Matrix of the states of the unit nodal displacements and their corresponding reactions of a type III rod is taking into account two-unit nodal positions relative one to another. Also, analysis is made of the transitions of the states of a rigid structure with index sets. An algorithm of reordering elements, which are real numbers of an index set in ascending order was defined. The Representation of constructions that are part of industrial and engineering process with the Theory of Index matrices and probability space, makes it possible accurate defining the power that is needed to move two elements (unit nodes) relative one to another of a construction from one place to another, which will help in software development for automation of industrial and medical structures.

Conflict of Interest

None.

Acknowledgements

None.

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