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# **A Study on Problems of Construction Workers in West Bengal Based on Neutrosophic Cognitive Maps**

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**Abstract:** In this paper, we studied the problems faced by construction workers in West Bengal in order to find its solutions using neutrosophic cognitive maps, which is the generalization of fuzzy cognitive maps. Florentin Smarandache and Vasantha Kandasamy studied neutrosophic cognitive map which is an extension of fuzzy cognitive map by incorporating indeterminacy.

Construction sector plays a major role in which construction workers face many problems in their day-to-day life. Some of the problems are discussed in the present study. The major problems are working for more number of hours, staying away from home, bad habits, absence of social security, misunderstanding, arguments with partners, stress, skin problems, sexual behavior & sexual health problem, and physical health problems. Based on the expert's opinion and the notion of indeterminacy, we formulate neutrosophic cognitive map. Then we studied the effect of two instantaneous state vectors separately on connection matrix  $E$  & neutrosophic adjacency matrix  $N(E)$ .

**Keywords:** Cognitive map, connection matrix, construction workers, fuzzy cognitive map, neutrosophic cognitive map, state vector

## **I. INTRODUCTION**

Construction sector falls under unorganized sector of an economy. Unorganized laborers refer to those workers who have not been able to organize themselves in pursuit of their common interest owing to certain constraints like casual and uncertain nature of employment, ignorance and illiteracy, small and scattered size of establishment etc. Various studies found that most of the construction workers are illiterate or literate and ignorant about market conditions and labor market variations. Skilled and unskilled construction workers work with low wages. They are working under unsecured environment or work culture. They are migrating from different regions and states leaving their native villages in search of daily job. They have maximum mobility because of the nature of their work. These laborers are engaged in huge industrial constructions, residential flat constructions, city beautification works.

Political scientist Robert Axelrod introduced cognitive maps (CMs) in 1976 and applied in political science [2]. Axelrod developed CMs, i.e. signed digraphs designed to capture the causal assertions of an individual with respect to a certain domain and then applied them in order to analyze the effects of alternative, e.g. policies, business decisions, etc. upon certain goals. A cognitive map comprises of only two basic types of elements namely, nodes and edges. Nodes represent variable concepts and edges represent causal connections. In the field of cognitive maps, the concept of fuzzy set theory introduced by Zadeh [17] was introduced by B. Kosko [6] in 1986. Fuzzy cognitive maps are widely used in ([3]-[5], [8]-[9], [11], [13]-[15]).

F. Smarandache and Vasantha Kandasamy ([10], [12]) studied neutrosophic cognitive map (NCM) which is the extension of fuzzy cognitive map by incorporating indeterminacy. The concept of neutrosophic logic [7] plays a vital role in several real life problems like law, information technology, stocks and share etc. Construction laborers' problem in India is one of the major problems in India. Nowadays, construction sector plays a major role in which construction workers face so many problems in their day-to-day life. Some of the problems are discussed in the present study. A study was done among 100 construction workers in West Bengal. Major problems of construction workers are working for more number of hours, staying away from home, bad habits, absence of social security, misunderstanding, argument with partners, stress, skin problems, sexual behavior and sexual health problems, physical health problems.

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Rest of the paper is presented in the following way. Section II describes the preliminaries of NCM. Section III presents the method of finding hidden pattern. Section IV is devoted to modeling the problems of the construction workers using NCM. Section V presents conclusions.

## II. PRELIMINARIES

### Definition: 2.1

Neutrosophic graph: A neutrosophic graph refers to a graph in which at least one edge is an indeterminacy denoted by dotted lines.

### Definition: 2.2

Neutrosophic directed graph: A neutrosophic directed graph is a directed graph which has at least one edge to be an indeterminacy.

### Definition: 2.3

Neutrosophic oriented graph: A neutrosophic oriented graph is a neutrosophic directed graph having no symmetric pair of directed indeterminacy lines.

### Definition: 2.4

Neutrosophic Cognitive Map (NCM): An NCM refers to a neutrosophic directed graph with concepts like policies, events etc. as nodes and causalities or indeterminate as edges. It reflects the causal relationship between concepts.

Let us suppose that  $C_1, C_2, \dots, C_k$  represent  $k$  nodes. Also let each node be a neutrosophic vector from neutrosophic vector space  $V$ . So a node  $C_j$  ( $j = 1, 2, \dots, k$ ) can be represented by  $(x_1, x_2, \dots, x_k)$  where  $x_i$ 's are zero or one or I (I represents the indeterminacy) and  $x_i = 1$  means that the node  $C_i$  is on state and  $x_i = 0$  implies that the node is in the off state and  $x_i = I$  means the nodes state is an indeterminate at that time or in that situation.

Let  $C_m$  and  $C_n$  denote the two nodes of the NCM. The directed edge from  $C_m$  to  $C_n$  represents the causality of  $C_m$  on  $C_n$  called connections. Every edge in the NCM is weighted with a number in the set  $\{-1, 0, 1, I\}$ . Let  $\alpha_{mn}$  denote the weight of the directed edge  $C_m C_n$ ,  $\alpha_{mn} \in \{-1, 0, 1, I\}$ .  $\alpha_{mn} = 0$  if  $C_m$  does not have any effect on  $C_n$ ,  $\alpha_{mn} = 1$  if increase (or decrease) in  $C_m$  causes increase (or decreases) in  $C_n$ ,  $\alpha_{mn} = -1$  if increase (or decrease) in  $C_m$  causes decrease (or increase) in  $C_n$ .  $\alpha_{mn} = I$  if the relation or effect of  $C_m$  on  $C_n$  is an indeterminate.

### Definition: 2.5

NCMs with edge weight from the set  $\{-1, 0, 1, I\}$  are called simple NCMs.

### Definition: 2.6

Let  $C_1, C_2, \dots, C_k$  be the nodes of a NCM. Let the neutrosophic matrix  $N(E)$  be defined as  $N(E) = (\alpha_{mn})$  where  $\alpha_{mn}$  is the weight of the directed edge  $C_m C_n$ , where  $\alpha_{mn} \in \{-1, 0, 1, I\}$ .  $N(E)$  is called the neutrosophic adjacency matrix of the NCM.

### Definition: 2.7

Let  $C_1, C_2, \dots, C_k$  denote the nodes of the NCM. Let  $A = (\alpha_1, \alpha_2, \dots, \alpha_k)$  where  $\alpha_m \in \{0, 1, I\}$ .  $A$  is called the instantaneous state neutrosophic vector and it denotes the on – off – indeterminate state position of the node at an instant

$\alpha_m = 0$  if  $\alpha_m$  is off (no effect)

$\alpha_m = 1$  if  $\alpha_m$  is on (has effect)

$\alpha_m = I$  if  $\alpha_m$  is indeterminate (effect cannot be determined)

for  $m = 1, 2, \dots, k$ .

### Definition: 2.8

Let  $C_1, C_2, \dots, C_k$  be the nodes of the NCM. Let  $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_m C_n}$  be the edges of the NCM. Then the edges constitute a directed cycle.

An NCM is said to be cyclic if it possesses a directed cyclic.

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An NCM is said to be acyclic if it does not possess any directed cycle.

## Definition: 2.9

An NCM having cycles is said to have a feedback. When there exists a feedback in the NCM i.e. when the causal relations flow through a cycle in a revolutionary manner the NCM is termed a dynamical system.

## Definition 2.10

Let  $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4} \dots, \overrightarrow{C_{k-1} C_k}$  be a cycle, when  $C_m$  is switched on and if the causality flows through the edges of a cycle and if it again causes  $C_m$ , then the dynamical system goes round and round. This is true for any node  $C_m$ , for  $m = 1, 2, \dots, k$ . The equilibrium state for this dynamical system is termed the hidden pattern.

## Definition 2.11

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point. Consider the NCM with  $C_1, C_2, \dots, C_k$  as nodes.

For example, let us start the dynamical system by switching on  $C_1$ . Let us assume that the NCM settles down with  $C_1$  and  $C_k$  on, i.e. the state vector remain as  $(1, 0, \dots, 1)$ . This neutrosophic state vector  $(1, 0, \dots, 0, 1)$  is termed the fixed point.

## Definition 2.12

If the NCM settles with a neutrosophic state vector repeating in the form:  
 $A_1 \rightarrow A_2 \rightarrow \dots \rightarrow A_m \rightarrow A_1$ , then this equilibrium is called a limit cycle of the NCM.

### III. METHODS OF DETERMINING THE HIDDEN PATTERN

Let  $C_1, C_2, \dots, C_k$  be the nodes of an NCM with feedback. Let us assume that  $E$  be the associated adjacency matrix. We find the hidden pattern when  $C_1$  is switched on when an input is provided as the vector  $A_1 = (1, 0, 0, \dots, 0)$ , the data should pass through the neutrosophic matrix  $N(E)$ , this is performed by multiplying  $A_1$  by the matrix  $N(E)$ . Let  $A_1 N(E) = (\alpha_1, \alpha_2, \dots, \alpha_k)$  with the threshold operation that is by replacing  $\alpha_m$  by 1 if  $\alpha_m > p$  and  $\alpha_m$  by 0 if  $\alpha_m < p$  ( $p$  – a suitable positive integer) and  $\alpha_m$  by 1 if  $\alpha_m$  is not an integer.

The resulting concept is updated; the concept  $C_1$  is included in the updated vector by transforming the first coordinate as 1 in the resulting vector.

Suppose  $A_1 N(E) \rightarrow A_2$ , then consider  $A_2 N(E)$  and repeat the same procedure. The procedure is repeated till we get a limit cycle or a fixed point.

### IV. MODELING OF THE PROBLEMS OF THE CONSTRUCTION WORKERS IN WEST BENGAL USING NCM

To assess the impact of problems faced by construction laborers in the age group 20-45 years, data was collected from 100 construction works in West Bengal. Based on linguistic questionnaire and the expert's opinion, we have considered the following concepts as  $\{C_1, C_2, \dots, C_9, C_{10}\}$ . The following nodes are considered as the main nodes for the problem.

$C_1$  -Work for more number of hours: It means working more than eight hours. The construction workers have to work more than eight hours to earn money for their livelihood.

$C_2$  - Staying away from home: The construction workers are generally migrant laborers and they have to live in tents near the construction site temporarily. So they have to stay away from home.

$C_3$  -Bad habits: It includes smoking (bidi, cigarette, ganja, etc.), consumption of gutka, alcohol, and addiction of drugs.

$C_4$  -Absence of social security: The construction workers do have no social security and benefits in terms of labor welfare measures and provisions. They are deprived of having provisions like pension and insurance schemes, maternity leave, accident and death claims, concession of loans and financial aid for children's education and medical needs. They don't have recreation facilities, availability of drinking water, toilets, bathrooms, canteens etc.

$C_5$  -Misunderstanding: It is a situation where something is not understood properly.

$C_6$  - Arguments with partners: A quarrel or disagreement between spouses or coworkers.

$C_7$  -Stress: Stress occurs when a person's brain feels a threat from bursts of hormones. Certain triggers, such as heavy work load, a job loss or death can cause these threats. Symptoms such as back pain, chest pain, anxiety and muscle tension are just a few physical signs of stress. Since construction workers have to work more than eight hours, they easily feel heavy work load. In general, they do not get overtime rates for excess work. In case of accidents, there

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exists, in general, no provision for financial and medical aid. Sometimes they observe deaths of their coworkers due to accidents during the working hours which produce tension but nobody owns the responsibility. Every construction worker feels stress at one time or another.

$C_8$  - Skin problems: Construction laborers handle cement which has constituents to create irritant, contact dermatitis (redness, itching, pain at the site of the contact with the cement or the subjects complaining of itching due to rubber gloves were involved), corrosive effect and sanitization, leading to allergic contact dermatitis from ingredients such as chromium.

$C_9$  - Sexual behavior & sexual health problems: Little study [1] is reported in the literature about the sexual behavior or health of the migrant workers in India. A human being's sexual behavior is the product of not only by the biological, psychological or cultural factors but also by his/her immediate affiliation to the various groups he/she belongs to. Sex refers to a personal affair of an individual. Sexuality exists in reality and is very intimately linked with broad societal factors as well as the characteristics of an individual's community, work/school, family and societal networks [16]. It is a difficult task to objectively study the sexual behavior of a human being or a community. Individual's ignorance about the potential health threats during sexual behavior is one of the principal reasons for fast spread of Sexually Transmitted Diseases (STDs), Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome (HIV/AIDS) and other sexual health problems. Construction workers are victims of multiple complications due to unstable nature of their employment, vulnerable living conditions, dearth of health care facilities and lack of health awareness. Akram's study [1] on migrant construction workers revealed that they are marginalized people in urban spaces and more susceptible to sexual health problems.

$C_{10}$  - Physical health problems: It includes respiratory diseases from inhaling dust, muscular skeletal disorder, injuries from heavy load, noise induced hearing loss.

However more number of conceptual nodes can be added by the expert or investigator. Now we give the directed graph as well as neutrosophic directed graph in the following figures Fig.1 and Fig.2. Fig. 1 gives the directed graph with  $C_1$ ,  $C_2$ , ...,  $C_9$ ,  $C_{10}$  as nodes and Fig.2 gives the neutrosophic directed graph with the same nodes.

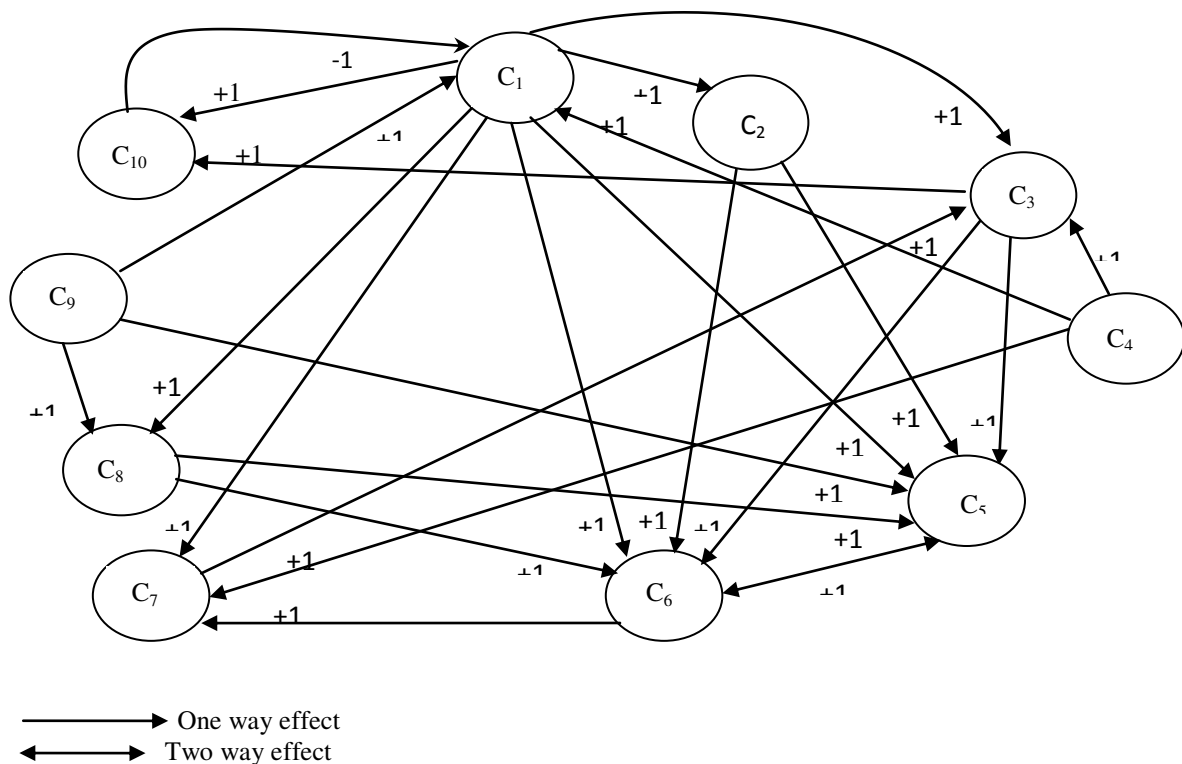


Fig.1: Fuzzy cognitive map

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The connection matrix E related to the graph (see Fig.1) is given by the following matrix:

$$E = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Now based on the expert's opinion and the notion of indeterminacy, we get the following neutrosophic directed graph:

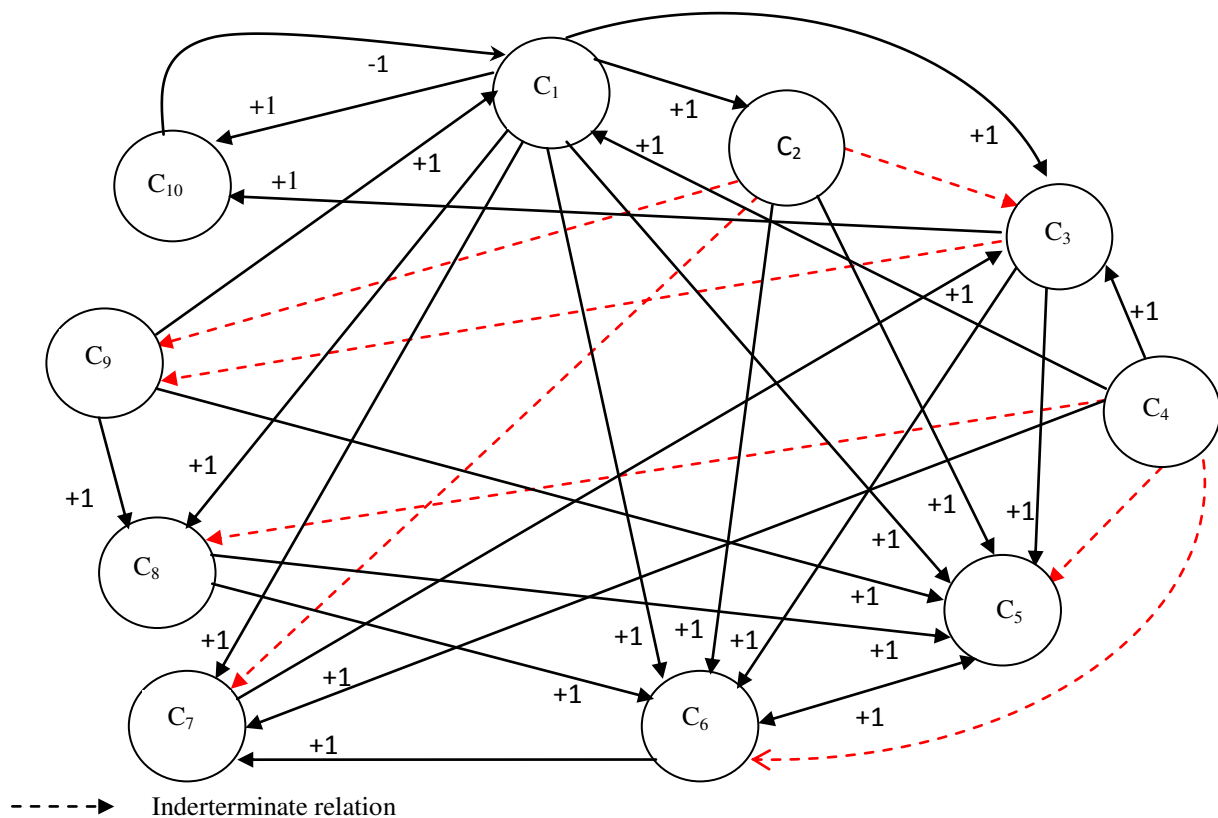


Fig. 2-Neutrosophic cognitive map

The corresponding neutrosophic adjacency matrix N(E) related to the neutrosophic directed graph (see Fig.2) is given by the following matrix:

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$$N(E) = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

## IVA. Effect of two instantaneous state vectors separately on connection matrix E & neutrosophic adjacency matrix N(E)

### Case-I:

Suppose we take the instantaneous state vector  $A_1 = (1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)$ , the node “work for more number of hours” is on state and all other nodes are off state.

At first, we study the effect of  $A_1$  on E.

$$A_1 E = (0 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) \rightarrow (1 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) = A_2$$

$$A_2 E = (-1 \ 1 \ 2 \ 0 \ 5 \ 5 \ 2 \ 1 \ 0 \ 2) \rightarrow (1 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) = A_3 = A_2$$

According to the expert’s opinion, the nodes absence of social security and sexual behavior & sexual health have no effect on the construction laborers in working for more number of hours and vice versa and all other nodes are on state.

Now we study the effect of  $A_1$  on N(E).

$$A_1 N(E) = (0 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) \rightarrow (1 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) = A_2$$

$$A_2 N(E) = (-1 \ 1 \ 2 + I \ 0 \ 5 + I \ 5 \ 2 + I \ 1 \ 2I \ 2) \rightarrow (1 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = A_3$$

$$A_3 N(E) = (I - 1 \ 1 \ 2 + I \ 0 \ 5 + 2I \ 5 \ 2 + I \ 1 + I \ 2I \ 2) \rightarrow (1 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = A_4 = A_3$$

Thus according to the expert’s opinion if  $C_1$  is on state then the nodes  $C_2, C_3, C_5, C_6, C_7, C_8, C_{10}$  are on state, whereas the node  $C_9$  is an indeterminate state.

Note. Since indeterminacy is allowed in questionnaire, flexibility in terms of indeterminacy appears in the equilibrium state.

### Case-II:

Again we take the state vector  $B_1 = (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)$ , absence of social security (node) is on state and all other nodes are in off state. We will see the effect of  $B_1$  on E and on N(E).

Now we find the effect of  $B_1 = (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)$  on E.

$$B_1 E = (1 \ 0 \ 1 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0) \rightarrow (1 \ 0 \ 1 \ 1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0) = B_2$$

$$B_2 E = (1 \ 1 \ 3 \ 0 \ 2 \ 2 \ 2 \ 1 \ 0 \ 2) \rightarrow (1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) = B_3$$

$$B_3 E = (0 \ 1 \ 3 \ 0 \ 5 \ 5 \ 3 \ 1 \ 0 \ 2) \rightarrow (0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 0 \ 1) = B_4$$

$$B_4 E = (0 \ 0 \ 2 \ 0 \ 4 \ 4 \ 2 \ 0 \ 0 \ 1) \rightarrow (0 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 1) = B_5$$

$$B_5 E = (0 \ 0 \ 2 \ 0 \ 2 \ 2 \ 2 \ 0 \ 0 \ 1) \rightarrow (0 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 1) = B_6 = B_7$$

Thus when the node “absence of social security” is on state node we see, work for more number of hours, staying away from home, skin problems have no effect on the construction laborers and all other nodes are on state.

Now we find the effect of  $B_1 = (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0)$  on N(E)

$$B_1 N(E) = (1 \ 0 \ 1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 0 \ 0) \rightarrow (1 \ 0 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 0 \ 0) = B_2$$



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$$B_2N(E) = (1 \ 1 \ 3 \ 0 \ 2 + 3I \ 2 + 3I \ 2 + I \ 1 + I \ 1 \ 2) \rightarrow (1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = B_3$$

$$B_3N(E) = (I \ 1 \ 3 + I \ 0 \ 5 + 3I \ 5 + I \ 3 + I \ 1 + 2I \ 2I \ 2) \rightarrow (I \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = B_4$$

$$B_4N(E) = (I \ 1 \ 2 + 2I \ 0 \ 4 + 4I \ 4 + 2I \ 2 + 2I \ 3I \ 2I \ 1 + I) \rightarrow (II \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = B_5$$

$$B_5N(E) = (I \ 1 \ 2 + 2I \ 0 \ 2 + 6I \ 4 + 2I \ 2 + 2I \ 3I \ 2I \ 1 + I) \rightarrow (I \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1) = B_6 = B_5$$

Therefore, when the node  $C_4$  is on state then the nodes  $C_3, C_5, C_6, C_7, C_{10}$  are on state, whereas the nodes  $C_1, C_2, C_8, C_9$  are on indeterminate state.

## V. CONCLUSION

The problems of construction workers were studied based on NCM. Based on NCM, it is noticed that if the construction laborers work for more number of hours then they have to stay away from home for more number of days and other factors like bad habits, misunderstanding, argument with partners, stress, skin problems, physical health problems will increase, whereas sexual behavior & sexual health problems is in indeterminate state. Again, when absence of social security increases or is on state, the following nodes namely, work for more number of hours, staying away from home, skin problems, sexual behavior & sexual health are in indeterminate states, whereas misunderstanding, addiction of drugs, argument with partners, stress and health problems will increase or are on states. If new situation arises in the construction sector, new concepts need to be incorporated for modeling the construction workers problems and that can be easily done by introducing new nodes.

However, government should implement "Regulation of Employment & Conditions of Service Act, 1996 [18] to protect the rights of construction workers and government should provide them education regarding their profession in order to avoid professional hazards.

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