Analysis Study of Failure Structural and Preventions before Constructions

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Article Info

Page Number: 8012 - 8029

Publication Issue:

Vol 71 No. 4 (2022)

Article History

***Article Received**: 25 March 2022*

***Revised**: 30 April 2022*

***Accepted**: 15 June 2022*

***Publication**: 19 August 2022*

Abstract

The construction industry is intrinsically related to the problem of structural breakdowns that have been occurring recently. The accidental and violent destruction of a building component or a component of it, as well as the structural components of scaffolding, forming elements, sheet piling, and excavation linings, constitute a structural failure. This type of failure can be defined as an example of a structural failure. Failures in structural integrity invariably result in monetary and environmental losses, both of which pose significant challenges for businesses. The analysis of the structural failures not only makes it possible to identify the factors that contributed to the failures, but it also makes it possible to provide solutions that will help prevent or reduce the likelihood that similar failures will occur in the future. It is a very significant component of an organization's overall business process management not just because of the potential threats to human life, the environment, and corporate responsibility, but also because of the potential costs to the firm financially. In a great number of research paper, artificial neural networks (ANNs) have been used to investigate various elements of RC buildings. They have mostly concentrated on the aftershock effect that earthquakes have on RC constructions. During the process of optimization, a trained artificial neural network (ANN) uses the information that is generated from a number of characteristics specified as design vectors to carry out both deterministic and probabilistic constraint tests. The trained NN is then employed to forecast the structure response in terms of probabilistic and deterministic constraint test owing to varied design factors. This is done by applying the learned NN. These values are the result of a number of different phenomena, including basic periods, base bending

moments, base shear force, and top-floor displacement of buildings in two different directions. Therefore, it is necessary to make predictions regarding these factors.

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1. INTRODUCTION

Failure of a building comes before its collapse. The failure can be characterized as a $defect$, $flaw$, $imperfection$, $deficiency$, $weakness$, $shortcoming$, $mistake$, $error$, $kink$, bug, or $fault$ in the building parts and components that make up a building structure. These words all refer to the same thing. Failure of a structure can be attributed to the presence of forces that are acting on it. These might be static forces (forces that are stationary), such as the weight of the structure itself or the load that it is carrying, OR they can be dynamic forces (forces that are moving), such as those created by the $wind, the\ sea, automobiles$, $people$, etc.

The design of structures should satisfy three fundamental requirements:

1. $Stability$: $The\ structure\ should\ be\ stable\ under\ the\ action\ of\ loads$.
2. $Strength$: $The\ structure\ should\ resist\ safely\ stresses\ induced\ by\ the\ loads$.
3. $Serviceability$: $The\ structure\ should\ perform\ satisfactorily\ under\ service\ loads$.

The only way to ensure the stability, strength, and serviceability of a design is to adhere to the fundamental design principles [1].

The civil engineers and designers, who were ultimately persuaded by their experiences, came across a variety of hazy and unstructured challenges. [2][3][7] One of these issues is the structural failure that was determined to have occurred in the reinforced concrete (RC) building [5]. When developing structures that are optimal in terms of one or more parameters, employing the classic Limit state method is typically complex and time consuming due to the nature of the process. Recent studies have shown that Artificial Neural Networks [4] may be useful in finding solutions to a variety of issues that arise in everyday life. Therefore, the current work utilised the Three Layer Perceptron Feed-Forward Network (TLP-FFN) classifier in order to address the issue of predicting the structural failure of multistoried reinforced concrete buildings [10]. This was accomplished by determining the likelihood that the structure of a multistoried RC building will fail in the near future.

Objectives of the study

- Designing a structure that can sustain all applied loads for its anticipated lifetime is the aim of structural analysis and design. The purpose of a structure is to support weights and prevent collapse.
- Preventive maintenance is a collection of checks and tasks that help prevent equipment failure. Equipment uptime boosts industrial capacity and output. Unwanted downtime causes extra costs and lost production.
- Needs to reduce building and other construction failures competent design, clear engineering drawing transmission to the contractor, careful and competent construction, and efficient construction supervision utilizing ANN technique to bring all analyses under one roof.

2. ANN AND NEURAL NETWORK WITH STRUCTURE AND MATERIALS

This Predicting when a structure will fail has been and will continue to be one of the most difficult aspects of structural design. The problem becomes a significantly greater challenge in the event that RC buildings have multiple storeys. The necessity for failure prediction has arisen as a consequence of recent developments in structural design, and it must now be addressed. Statistical methods have traditionally been utilised for failure prediction; however, due to the ever-increasing complexity of designs and related characteristics, forecasting failure with a high level of accuracy has become highly laborious and challenging. Because of this, researchers started looking at other options for high accuracy prediction. A s it turned out, utilising Artificial Intelligence for such a data mining, analysis, and prediction mechanism came forth as a potential strategy for the same.

3. RESEARCH METHODOLOGY

Materials and methods

The structural failures that were caused by man (human faults) were examined because these are the types of reasons that people have some level of control over. It was suggested that certain actions be taken in order to lessen the likelihood of future failures. [9] The primary risk factors (threats) that could result in structural failures have been determined. Each threat's likelihood of occurrence (P), severity (S), and detection range (D) were evaluated.

$$RPN = P.S.D$$

P	On a scale from 1 to 10, where 1 indicates that it never happens and 10 indicates that it happens in every production cycle, the probability coefficient is a measure that indicates the frequency with which the structural failure associated with a certain risk occurs.
S	On a scale from 1 to 10, where 1 indicates that the risk of structural failure is not very important and 10 indicates that the risk is very high, the severity coefficient indicates how serious the particular risk of structural failure is.
D	On a scale from one to ten, with one being an easy possibility to stop and ten representing a very difficult one, the detection coefficient indicates how difficult it would be to prevent a certain kind of structural collapse from occurring (early detection of the cause).

The RPN could be anything between 1 and 1000. The RPN number indicates the level of risk connected with the danger; the higher the value, the higher the level of risk. It is important to note that the primary reasons for the failure of the structures correspond to each stage of the investment process, beginning with investment planning (the design of the building) and continuing through its implementation (the construction of the building) and ending with operation (use). The FMEA (Failure Modes and Effective Analysis) approach was used throughout the design, construction, and operation phases of the life cycle of structures (Figure 1). A new risk priority number is assigned in addition to the three updated ratings (severity, incidence, and detectability) that are generated for each item that is fixed. After that, the overall RPN of the structure is computed for the whole thing. This value is frequently many tens of percent lower than the RPN that was initially calculated, in part because some of the factors that contributed to failures have been removed. The evaluation of the FMEA's usefulness is demonstrated by the comparison of the two RPN. In situations when there are multiple viable ways of making improvements, using a variety of RPNs, it can also be helpful in selecting what actions should be made.

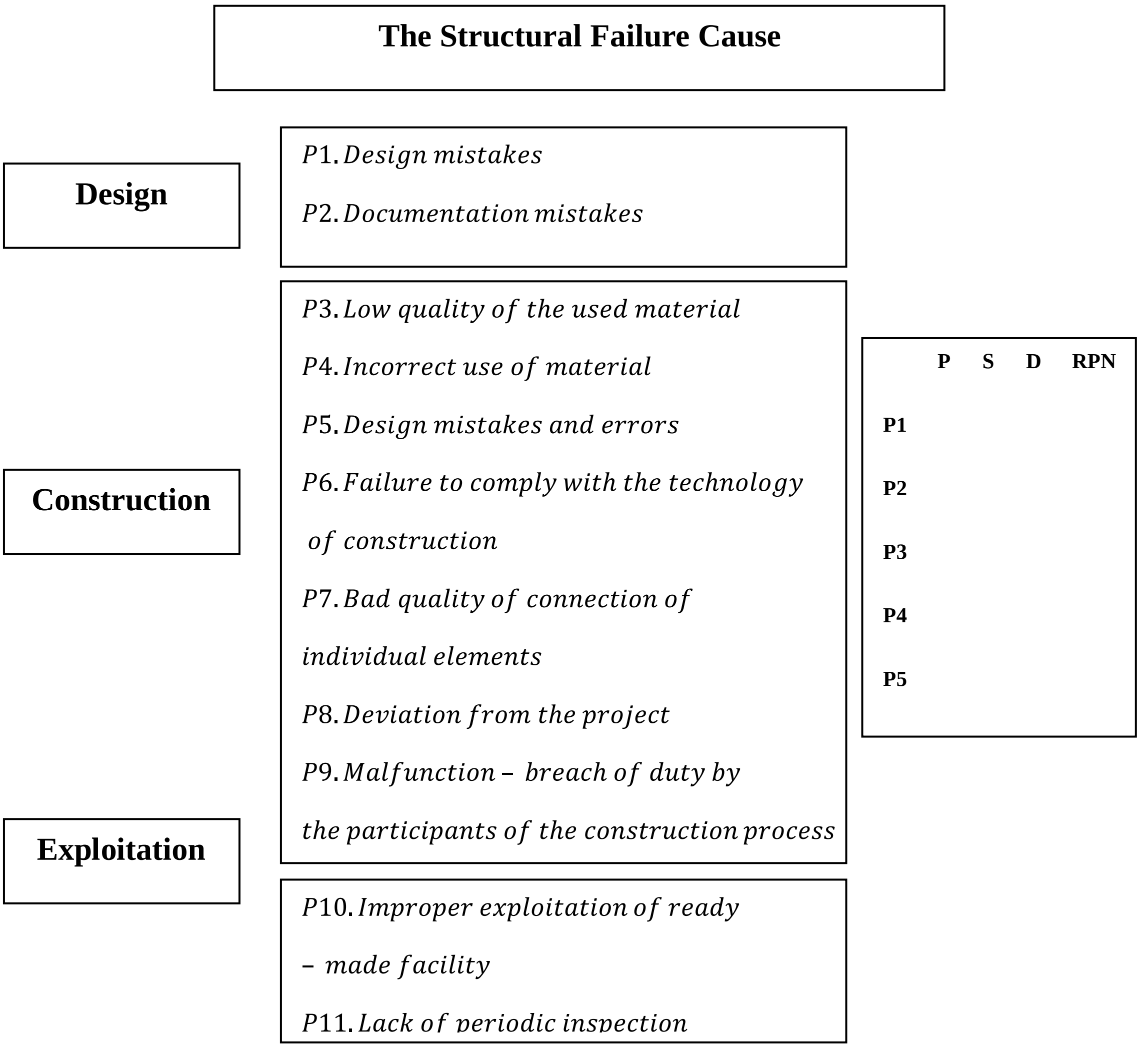

Figure 1. FMEA in Structural Failures Analysis

Finding the Attributes and Methodology

It is possible to conduct an assessment of the danger posed by structural breakdowns by making use of the various stages of risk management. The following applications of these steps can be found throughout this paper:

Step 1	*Risk Identification*	Based on an analysis of India's large-scale projects and bridges, the threats were found.

$Step$ 2	$Hazard$ $Classification$	Based on the reasons for the structural failures, classification was developed. Disasters created by man and those produced by random causes (mostly owing to the force of nature) were divided into two primary categories (human errors). The design, construction, and exploitation subgroups of the second set of failures—human errors—are all strongly tied to the life cycle of a building.
$Step$ 3	$Risk$ $Assessment\ and$ $Measurement$	Using the FMEA method, namely the evaluation of a threat's probability (P), the severity of its effect (S), and the difficulty in detecting it (D). These information allowed for the calculation of the Risk Priority Number (RPN). According to the structural failures, this number indicates which of the dangers (causes) listed in stages 1 and 2 is the most serious.
$Step$ 4	$Risk$ $Monitoring\ and$ $Response$ $Methods$	In the groupings of causes that have been analysed, preventative measures or risk reduction measures are adopted. As was previously noted, the FMEA method was utilised to examine how the risk of structural breakdowns was managed. The United States military forces first used the FMEA approach in the late 1940s. It served as a reliable design process in the aircraft sector in the 1960s.

4. CAUSES OF STRUCTURAL FAILURES

The causes of structural failures can be split into two categories: those induced by man and those caused by random factors (random causes), such as $wind$, $snow$, and $storms$ (resulting from human error). Both negligent behaviour and improper behaviour fall under the second category. Design, construction, and exploitation of a building item all involve structural flaws that are directly attributable to human activity. When it is too late to modify, hidden design flaws can become apparent. The use of too-low-quality materials causes significant issues during both the construction and use stages. Its consequences can be extremely damaging. It's crucial to keep an eye out and do routine checks and repairs as needed during the exploitation.

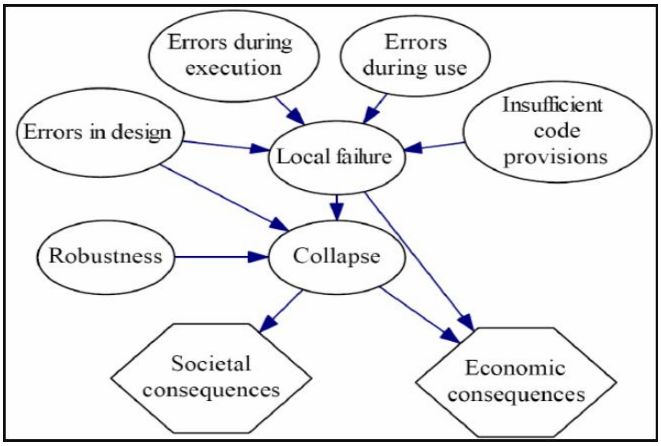

Figure 2. Causes and consequences of structural failures

5. BACKGROUND STUDY AND SAMPLE DATA FOR INPUT

The collapse of numerous bridges has been analyzed by engineers in order to glean information about the reasons for the structure's demise, with the objectives of gaining knowledge and preventing expensive errors in the future. When a bridge fails, a cause of failure is usually reported as to why the bridge failed. As a result of these factors, a bridge may suffer from either a partial or a whole collapse, which h are both considered to be forms of bridge failure. A primary reason can be subdivided into two distinct types of causes of failure, which are referred to as enabling causes and trigger causes respectively. Both of these fall under the umbrella concept of being unsuccessful.

Table 1. The listed bridge failures occur after year 2000

Bridge	*Type*	*Year, Cause*	*Casualties*	*Sources*
Bhagalpur Pedestrian bridge (Bihar)	*Arch bridge*	*collapsed onto a railway train as it was passing underneath Due to unstable arch*	*At least 30 killed*	*The Hindu News*
Kota Chambal Bridge (Rajasthan)	*Cable stayed Bridge*	*During Construction, the construction sequence was not followed*	*Claimed 48 lives*	*Reported by Road transport and highways ministry*

Kadalundi River rail bridge (Kerala)	Girder Bridge	Scouring, Pier Unstable (Repair needed)	At least 57 killed	Reported by government investigators, Outlook India, Mapofindia.
Majerhat Bridge collapse (West Bengal)	RCC Girder Bridge	Mid − span failure of RCC Girder, (Repair required)	AT least 3 Killed	Reported by RVNL chief project manager
Vivekananda Flyover Bridge (West Bengal)	Steel girder, flyover bridge	Buckling Failure, Design error on Cantilever Beam	AT least 27 Killed	Collapse Of Kolkata FlyoverPractitioner's Perspective by N. Prabhakar & Dr. N. Subramanian
Sanvordem River Bridge (Goa)	footbridge made of steel	The bridge was closed for use but Overload a portion of Girder Collapsed	2 Killed	India today News
Flyover bridge (Andhra Pradesh)	RCC Girder Bridge	Erosion of the soil, saturation and settlement But Poor Construction, Design Failure	15– 30 killed	Committee by Government, comment on anything
Rafiganj rail bridge (Bihar)	Steel Girder Bridge	Terrorists sabotaged rail bridge, high − speed causing crash	130 + killed	Times of India News
Veligonda Railway Bridge (Andhra Pradesh)	Railway Bridge	Scouring Failure, flood washed rail bridge away	114 killed	Times of India News
Savitri River Bridge (Maharashtra)	Stone Arched Bridge	Dilapidated Condition. (Repair required), About 100 years old.	28 Killed	IIT Report

Bridge Collapse at Siliguri (West Bengal)	*Girder Bridge*	*The bridge was in a dilapidated condition, (Repair required)*	1 *hurt*	*Times of India News*
Charus Bridge	*Deck type Truss Bridge*	*Buckling Failure*	*Unknown*	*Failure of chauras bridge, Harshad*
Andheri Bridge	*RCC Girder Bridge*	*Corrosion Failure*	5 *Injured*	*Economictimes. indiatimes*
Jahu Bridge	*RCC Girder Bridge*	*Scouring Failure*	4 *Killed*	*Jahu Bridge Pankaj*
Langi Durg Road Bridge	*RCC Girder Bridge*	*Scouring Failure*	*Unknown*	*Foundation failure of bridges, Narayan,* 2018
CAHDOORA BRIDGE	*RCC Girder Bridge*	*Scouring Failure*	*Unknown*	*Bridge failures in extreme flood events, Azmat*
Mumbai −Goa bridge	*RCC Girder Bridge*	*Scouring Failure*	2 *Killed,* 20 *Missing*	*India today*

The next study takes the data from the previous collection of failed structures, merges and simulates the reasons and occurrences of those failures, and then analyses the combined data.

Table 2. Results of FMEA for the structural failures caused by human error (own study)

Stage	*Cause of the Structural Failure*	*No*	*P*	*S*	*D*	*RPN*	*Preventive Actions*
Design	*Design mistakes*	**P1**	**1**	**10**	**9**	**90**	-
	Documentation mistakes	**P2**	**1**	**10**	**9**	**90**	-

Construction	*Low quality of the used material*	**P3**	**5**	**10**	**9**	**450**	a set of regulations that must be complied with, including a set of minimum criteria for the material
	Incorrect use of material	**P4**	**3**	**9**	**9**	**243**	The implementation of controls during the building phase of a new facility
	Design mistakes and errors	**P5**	**2**	**10**	**8**	**160**	**-**
	Failure to comply with the technology of construction	**P6**	**6**	**8**	**7**	**336**	Legal regulations that prohibit any and all participants in the investing process from behaving in an unprofessional manner. The implementation of controls during the building phase of a new facility
	Bad quality of connection of individual elements	**P7**	**1**	**4**	**8**	**32**	**-**
	Deviation from the project	**P8**	**2**	**8**	**7**	**112**	**-**

	Malfunction – breach of duty by the participants of the construction process	**P9**	**6**	**8**	**8**	**364**	Legal regulations that prohibit any and all participants in the investing process from behaving in an unprofessional manner. The implementation of controls during the building phase of a new facility
Exploitation	*Improper exploitation of ready – made facility*	**P10**	**8**	**to**	**9**	**720**	Observance of the prescribed time limits for the inspections. Performing routine checks on the facility's technical condition and performing routine upkeep and maintenance on the building.
	Lack of periodic inspection of the facility	**P11**	**8**	**to**	**8**	**640**	rules that are well established and followed during routine inspections. sanctions in the event that technical inspections and modifications were not completed as required.

P8. Deviations from the project (RPN = 112) and P5. Design mistakes and errors (not detected during the design process) (RPN = 160), both of which have a value that is greater than 100, but at the same time, they have a probability of occurrence that is very low (P = 2). Because of this, the reasons for which RPN is more than 240 were further investigated because there is a direct connection between the issue that was analysed and the data that was obtained. The authors reached their conclusion based on the analyses that were carried out, and they came to the conclusion that, from the perspective of the problem that was analysed, it is essential to select for further analysis those causes whose value is greater than 240. The analysis focuses on those causes that occur more frequently throughout the course of the study. The RPN values for each individual factor contributing to the structural failures are listed, and the limit level is indicated by the red line (240).

Table 2 outlines potential preventative measures to take in the event that the RPN for the cause in question is greater than 240. As can be seen, seven of the eleven causes were involved here.

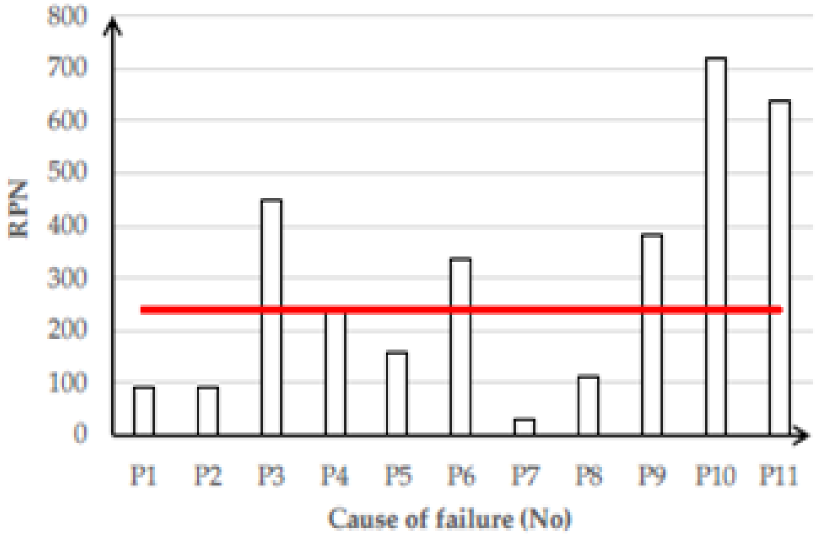

Figure 3. RPN of the structural failure caused by human error (own study based on online and news feeds study)

P10, improper use of a ready-made facility (RPN = 720), and P11, failure to conduct routine facility inspections (RPN = 640) are examples of these violations. For the causes with RPNs more than 240, preventive measures were suggested based on the risk analysis:

- *Controls at the construction stage of a new facility*
- *Regulations including the minimum parameters with which the material must comply*
- *Legal provisions preventing unprofessional actions of all participants of the investment process*
- *Compliance with the inspection deadlines*
- *Conducting regular inspections of the technical condition*
- *and regular renovation of the facility*
- *Clearly defined rules for periodic inspection*
- *Sanctions for failure to carry out technical inspections and renovations*

Causes and Prevention of Structural Failures

The layout plan cannot be utilised to train an ANN since the ANN method only understands numeric data. Below are the raw data that were utilised to calculate important parameters or attributes [11][12].

1. *Number of Columns*	8. *Width of Beam*
2. *Number of Beams*	9. *Breadth of Column*
3. *Area*	10. *Width of Column*
4. *Height of Parapet*	11. *Grade of Steel*
5. *Thickness of Side Wall*	12. *Grade of Concrete*
6. *Thickness of Interior Wall*	13. *Bearing Capacity of Soil*
7. *Depth of Beam*	14. *Reinforcement Area*

The strength of the structures and each node of the structures must be evaluated using tools from the engineers' side. Three further inputs (findings, causes of building collapse, and major recommendations) are chosen to assess the classification outcome after this initial set of inputs.

6. RESULT DISCUSSION

ANN and Study of Layers

Artificial neurons (or nodes) are technically defined as structures made up of densely interconnected adaptable basic processing units that can do parallel computing at a huge scale of data processing and knowledge representation. [13] High parallelism, robustness, fault tolerance, learning, the ability to handle ambiguous and fuzzy input, and generalizability are all features that ANNs have successfully incorporated (Jain et al. 1996).

Many learning algorithms can be used to train a NN [14]. One of the core learning algorithms, the perceptron learning rule, has been created to find the best weight vector over an infinite number of repetitions, regardless of the original weight vector. It has been found that this rule only applies to classes that can be linearly separated. The performance of NN has been improved by a number of network architectures.

A variety of factors, including multiple layers of artificial neurons, connections between layer neurons, and the activation function of each neuron, constitute an ANN structure. Input, hidden, and output layers are the three progressively integrated levels that make up a standard ANN. In each of these layers, a neuron has its own summarised inputs that determine its own amount of activation. The layered neurons may have complete or incomplete connectivity. A typical ANN structure with three layers is seen in Figure 2. Because the target values serve as the supervisor in the supervised training approach, which is used to train the ANN, errors between the target values and output values are corrected. Unsupervised ANN training is a different variety. Since there are no target values, the un-supervised system performs its training by ordering its own weights. Back-propagation network (BPN) technique is a supervised ANN training approach utilised in Figure 9.

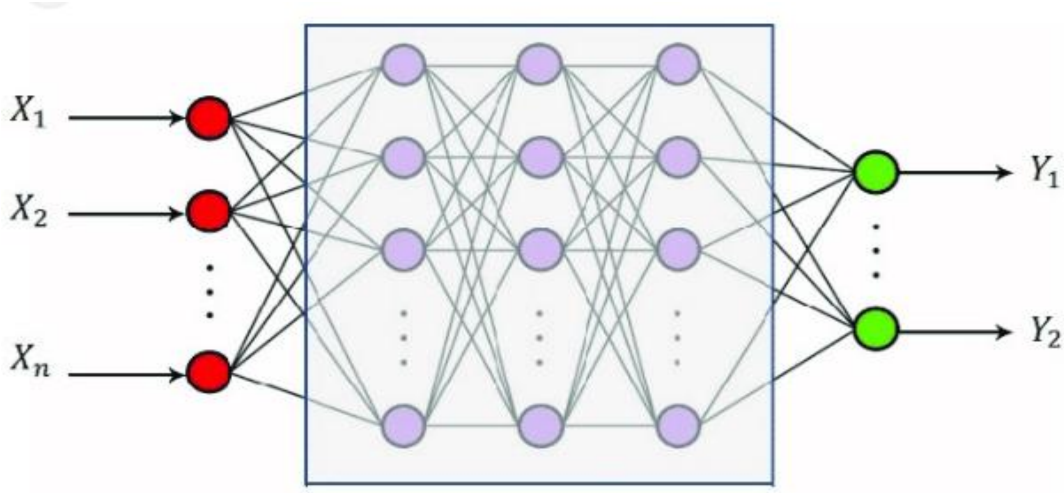

Figure 4. A typical 3-layer perception feed forward network

ANN for FMEA: To correlate the causality and severity among system aspects, there are numerous traditional and classical FMEA systems accessible (parameters). They all have their own benefits and drawbacks, but one common flaw among them all is that none of them can deal with an unanticipated failure occurrence; as a result, they can only recognise data that has already been saved in their database. Due to this serious flaw, a traditional FMEA system,

1. *Easily integrate with other reliability design systems*
2. *Promptly associate failure modes, effects, causes with corrections*
3. *Appropriately interpret a defect process*
4. *Necessarily memorize the newly occurred failures*
5. *Competently predict future failures*

The purpose of a study will dictate both the path that the research will take and the findings that will be obtained. It is essential to have a solid understanding of the points of agreement and disagreement amongst the parties involved. The most important outcomes obtained from research activities are referred to as the primary findings. They are examined to see whether or not the objectives of the research have been accomplished. The most important conclusions from the study that was based on both self-analysis and surveys [8], which provides, to some extent, evidences on the causes of building collapse in main and common terms. The five columns that follow indicate three inputs, one suggestion, and one output respectively. This data is being fed into ANN at this time (3-layer perception feed-forward network).

A confusion Calculating a matrix in order to provide a visual representation of how well a classification system works is the task at hand. The rows of the matrix list the examples that belong to each actual class, whereas the columns of the matrix list the examples that correspond to each predicted class. This helps to discover any form of misclassification that may have occurred as a result of the classifier. It gives analysis that is more extensive than just the accuracy of classification. Because it is possible for classification accuracy to generate deceptive results when the quantity of samples in various classes change substantially, it is not a reliable indicator to use when evaluating the effectiveness of a classifier. The following is a list of possible definitions for the entries in the confusion matrix:

$$True\ positive\ (TP)\ is\ the\ number\ of\ „positive“\ instances\ categorized\ as\ „positive“.$$

$$False\ positive\ (FP)\ is\ the\ number\ of\ „negative“\ instances\ categorized\ as\ „positive“.$$

$$False\ negative\ (FN)\ is\ the\ number\ of\ „positive“\ instances\ categorized\ as\ „negative“.$$

$$True\ negative\ (TN)\ is\ the\ number\ of\ „negative“\ instances\ categorized\ as\ „negative“.$$

$Accuracy = \frac{tp + tn}{tp + fp + fn + tn}$	$Precision = \frac{tp}{tp + fp}$	$FP\ rate = \frac{fp}{fp + tn}$
$Recall = \frac{tp}{tp + fn}$	$F - measure = 2 * \frac{Precision * Recall}{Precision + Recall}$	

Table 3. Performance measures of the proposed model for different phases

	$Training$	$Validation$	$Testing$	$Overall$
$Accuracy$	100	100	80	99
$Precision$	100	100	100	100
$Recall$	100	100	50	98.04
$Fp-rate$	0	0	0	0
$F-Measure$	100	100	66.67	99.01

According to Table 3, it was determined that the "Testing" phase was successful in achieving 100% precision, while the total recall for the proposed model attained a value of 98.04%. Consequently, the proposed system is both promising and effective in terms of determining the current status of the RC building structure that has several storeys.

6. CONCLUSION

In situations when there is a large concentration of the government ought to provide assistance to the population. Buildings are required to have geotechnical reports available before, during, and after construction has been completed. The price of building supplies have to be subsidised by the government in order to limit the number of instances in which people buy substandard building materials. The government is responsible for ensuring that the building regulations are followed to the letter, and it must also revise the laws that are currently in place so that they are in accordance with the most recent developments in construction technology and practise. The general public ought to be educated by the government on the significance of purchasing property insurance. The public and commercial sectors ought to collaborate in order to make investments in emerging building technologies. These technologies have the potential to assist in lowering the cost of building construction while simultaneously maintaining its quality [15]. It is imperative that the government establish a task force for the purpose of ensuring the stringent execution of building codes and the imposition of penalties on those who fail to do so. This task force must include specialists working in the built environment [6]. It is the responsibility of the government to ensure that random, continuous testing of building materials is performed on all building materials, including those that are manufactured domestically and those that are imported, in order to determine when expected standard specifications have been deviated. It is imperative that competent supervision be carried out at each stage of the building construction process, and the practice of using artisans with poor levels of expertise should be abolished. We are only allowed to utilize construction methods that have been approved. Those homes that did not pass the stress test are required to be flagged for demolition. Penalties need to be imposed for the conversion, addition, and alteration of sanctioned buildings that are done illegally.

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