International Journal of Advanced Research in Engineering Technology & Science
ISSN: 2349-2819
Impact Factor: 7.10
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Email: editor@ijarets.org Volume-11, Issue-3 March – 2024 www.ijarets.org

An Approach of Investigation of Structural Failures Causes Consequences and Remedial Strategies

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Abstract

In addition to causing total collapses, structural failures can also cause partial damages. These failures pose substantial concerns to public safety, financial stability, and public faith in infrastructure. The purpose of this paper is to investigate the myriad of reasons that might lead to structural collapses. These issues are broken down into four categories: design flaws, material faults, building mistakes, and unanticipated loads and environmental circumstances. Individual causes are investigated by means of case studies, which illustrate the dynamic relationship between human mistake and the constraints imposed by material resources. Loss of life and economic costs, as well as legal implications and long-term psychological effects on communities, are only some of the consequences that can result from systemic failures. Failures that have received widespread media attention, such as the collapse of bridges, buildings, and industrial structures, highlight the critical need for detailed investigation and preventative actions. Remedial options are described, with the primary emphasis being placed on improving the structural integrity and resilience aspects. The application of sophisticated design approaches, the utilization of high-quality materials, demanding building standards, and protocols for continually monitoring and maintaining the structure are all essential tactics. Furthermore, several technical breakthroughs, such as real-time structural health monitoring systems and new repair materials, are investigated in order to determine their relevance.

keywords:*Investigation, Failures, Consequences*

INTRODUCTION

Structures are engineered during production to withstand certain loads without experiencing undue distortion. Examples of living loads include the masses of people and commodities, the impacts of weather conditions like rain and snow, and the gravitational pull of the wind. The dead load of the building is considered in addition to the loads. Live loads are loads that are thought of as being external. Buildings with several stories often combine strength with the right amount of stiffness, and their primary function is to provide shelter from the rain over vast expanses of open space. The primary concern with multi-story skyscrapers is whether or not their roofs can bear the combined weight of all the levels. To a roof, it's all relative. Large buildings are just as likely as lengthy bridges to fall, and the collapse of either might have catastrophic consequences.

For the sake of keeping things simple, we may classify the causes of a building's collapse into overarching themes. Many factors come together to cause these collapses. Some of these factors include: improper design, inadequate construction, foundation breakdown, unusual load, unexpected failure mode, and a mix of these. When we speak about bad design, we're not just talking about computational mistakes; we're also talking about things like not considering the loads that the structure will have to bear, having wrong theories, depending on wrong data, not knowing how repeated or impulsive stresses will affect the structure, and using the wrong materials or not understanding their properties. As far as design goes, all of these items are terrible. The engineer must own up to these mistakes that are made on the design board.

As the investigation's results show, the most important factor leading to structures breaking down is poor construction. The present situation may be somewhat the engineer's fault if the examination was insufficiently thorough. Common practices among construction workers include using salty sand as a concrete ingredient, using subpar steel instead of the specified, riveting or even improperly tightening nuts, relying too much on the drift pin to align holes, creating weak welds, and many more examples.

Without a sufficiently sturdy base, even the most meticulously planned and built edifice would collapse. Buildings can withstand loads provided the foundation can, but that may not always be the case. Although there are several instances of structures with inadequate foundations, the Leaning Tower of Pisa is among the most famous. Despite plunging at least twenty feet into soft soil, the historic armory in St. Paul, Minnesota, remained standing. Damaged foundations can cause displacements, which can change the distribution of stresses in a significant way. Since this was a major problem with American railroad bridges, statically determinate trusses were much sought after because they could avoid this problem. Storm gusts or seismic activity are two such instances. A building with enough strength to last for a long period should be able to overcome these challenges. Buildings composed of solid stone would be leveled by an earthquake, while those that are more pliable and delicate may survive. Foundation difficulties might arise in the case that filled, damp land liquefies after an earthquake. We have recently got a great example of how the unexpected failure modes are the most intricate reasons for the collapse. Unexpected failure may occur if the characteristics of a new structural type are not thoroughly understood. It seemed like suspension bridges were the way to go for crossing massive chasms. A reliable and well-understood member kept everything together with a strong cable that was under stress. Unfortunately, it was shown by the incident that the bridge deck could pivot and gallop freely without being restrained by the cables. The bridge at Wheeling, which fell in the 1840s and belonged to Ellet, and the bridge at Tacoma Narrows, which fell in the 1940s, were both caused by this issue.

LITERATURE REVIEW

Abhijeet Gurule et al. (2022) In the context of pavement, failure is described as a decrease in serviceability that is brought about by the formation of cracks and ruts among the pavement. A thorough investigation into the factors that lead to the collapse of bituminous pavements is required before we can move on to the maintenance solutions. Failures of bituminous pavements can be attributed to a wide variety of factors or a particular combination of factors. The implementation of correction in the surface that is already there will extend the lifespan of maintenance operations as well as the lifespan of the layer that is strengthening. there are a variety of strategies for pavement preservation that will assist in extending the life of the pavement and postponing the time at which it will fail. This study was conducted with the intention of determining the potential factors that lead to pavement distresses and making suggestions for solutions that would reduce the amount of pavement distress it experiences. In this paper, the lessons that were learned from the failures and problems that occurred with the pavement throughout the course of the past few years on a number of different projects in India are described. In addition, a variety of pavement preservation strategies and measures that will be beneficial in expanding the serviceable life of pavement are described. These techniques and measures are based on the experiences that have been gained in the past. A thorough literature review was conducted on the subject of the elements that contribute to road deterioration, as well as the common road faults and the factors that cause them. An examination of the current pavement problems was carried out through the inquiry, which included both field surveys and laboratory testing on those projects. Cracks, potholes, and rutting in the wheel path were some of the significant failures that were found with the roads that were inspected, according to the findings of the investigation. Those failures were found to be mostly caused by inadequate drainage, traffic overloading, expansive subgrade soils, and the utilization of low-quality materials in the construction process. Highway engineers were provided with recommendations that were based on the findings in order to assist them in identifying the most effective repair solutions for particular types of distresses.

Ajay Thombre et al. (2023) It is necessary to execute road widening projects in order to meet the increased volume of traffic and to improve the infrastructure of transportation. In certain instances, however, structural breakdowns may take place in the wider road portions, which may result in increased expenses for maintenance as well as increased risks to public safety. The purpose of this study is to analyze the factors that lead to structural failure in road sections that have been widened and to suggest corrective actions that can be taken to address the problems. The research technique consisted of conducting field inspections, collecting data, and conducting an analysis of road portions that had failed. There were a number of problems that were found as contributing to structural failures. These factors included inadequate design considerations, incorrect building procedures, and insufficient soil stabilization measures. Additionally, the study investigated the impact that rising traffic loads and environmental conditions have on the performance of individual roads. According to the findings of the research, a number of corrective actions were suggested in order to solve the structural weaknesses. Among these steps are the retrofitting of the road portions with additional reinforcements, the improvement of drainage systems to minimize water collection, and the use of appropriate procedures for soil stabilization. In addition, suggestions were made for improving quality control during the construction process. These suggestions included ensuring that design criteria were adhered to in a stringent manner and conducting regular monitoring. As an additional point of interest, the research highlighted the significance of taking into account the long-term maintenance requirements during the process of road widening. It is possible to greatly extend the service life of the enlarged road sections by putting in place a thorough maintenance plan that includes regular inspections, prompt repairs, and preventative maintenance methods.

P. V. Divya et al. (2022) This research primarily aims to illuminate particular instances of subpar performance or failure of geosynthetic-reinforced MSE walls in the Indian state of Kerala. In India, you may find these walls. On top of that, the research provides recommendations for both proactive and reactive activities. Near or after the monsoon season, most of these geosynthetic-reinforced MSE wall collapses in Kerala happened. Remember this since it is a crucial piece of information. The use of locally available marginal lateritic soils for the backfill, poor management of the drainage systems (both external and internal), poorly designed filters and drains, foundation soil that was not adequately compacted, and the absence of necessary ground improvement measures before the construction of the MSE walls were the main causes of these failures. Among the procedures that have been suggested for fixing the structure are repairs, reconstruction, the insertion of stone columns, and soil nailing and compaction grouting. It is advised to take precautions before, during, and after construction to lessen the quantity of rainfall that can seep through low-permeability backfill material. Precipitation infiltration is known to cause unsightly bulging and deformations in MSE walls. Covering the backfill at the end of each workday during construction allows for its eventual application of a geomembrane layer to preserve its integrity once construction is finished. The fact that rain-induced soaking reduces suction causes the interface shear strength to diminish, which must be considered when utilizing marginal lateritic soil as MSE wall backfill. Furthermore, the study demonstrated that compressible clay foundations under MSE walls can have their bearing capacity and drainage greatly enhanced by the use of stone columns. The necessity of doing a thorough site assessment and executing suitable ground improvement measures where necessary is brought to light during the restoration of a fallen MSE wall.

Sumanta Dutta et al. (2022) People used to live in huts that were constructed using materials that were readily available in the natural environment. It was possible for them to build their huts in secure areas that were not affected by any natural disasters occurring at the time. Should something go wrong, they would be able to fix it using the most inexpensive materials that could be discovered in nature. Having said that, it is becoming increasingly important to have a solid understanding of the structural weaknesses that exist in buildings and the corrective actions that need to be taken as the population continues to increase and new building materials are produced. Failures in engineering are brought on by the gradual deterioration of a range of building materials over time, which can be attributed to a number of different factors. In order to comprehend the issue at hand and devise a solution, it is essential to have a knowledge of the numerous factors that contribute to the deterioration of the situation. Specifically, this article focuses on the structural problems and the corrective actions that have been taken.

Letso Audrey Jacob et al. (2023) Aim or purpose the purpose of this study is to analyze the factors that led to the failure of ISO 9001 Quality Management Systems in Botswana to maintain their sustainability. Arrangement, methodology, and strategy the research utilized both qualitative and quantitative approaches, such as conducting a literature review and secondary data analysis to gain an understanding of trends pertaining to Botswana. Additionally, a survey was conducted to identify gaps that led to certification sustainability failures. The survey focused on the following topics: the reasons for certification, the factors that led to decertification, and the problems that arise during the processes of certification. The results The governmental sector in Botswana has a low acceptance rate of 12 percent, whereas the private sector has an acceptance rate of 87 percent. This indicates that the adoption of ISO 9001 is gradual. Over the course of twenty years, termination rates have been high, reaching 55%. Certification is dominated by manufacturing, which accounts for 45% of the total certification. The ability to maintain certification is difficult for micro and small businesses, and they frequently fail to do so within two years. On the other hand, medium-sized businesses display stronger sustainability, lasting for more than six years. It is the quality of the product or service and the improvement of the process that drives certification, whereas managerial issues, financial restrictions, and process management are the reasons that affect decertification. In order to facilitate the successful incorporation of ISO 9001, the study suggests a paradigm. The value of originality When it comes to achieving lasting organizational success, integrated systems are absolutely necessary for ensuring constant process performance and continuous improvement across all industries. In spite of the fact that the ISO 9001 Quality Management System has demonstrated good effects on a worldwide scale, the impact of its implementation in Botswana is still debatable due to the significant failure rates that have occurred after it was implemented. The quality management system (QMS) appears to have a considerable absence in terms of its development, implementation, and maintenance.

Mykola Kuzin et al. (2023)A method for determining why components break has been suggested. The foundation of this method is the application of finite-element analysis to the mathematical modeling of mechanical loads and strength parameters. An assessment of the structure's endurance is subsequently carried out using damaged media mechanics methods that account for the buildup of structural flaws in product material. Critical loads that caused a passenger vehicle engine's crankshaft to fail were determined using the previously established method. Furthermore, the method was used to ascertain the causes of these loads' emergence and to facilitate the development of technological remedies to eradicate such emergency situations.

RESEARCH METHODOLOGY

In this paper, the requirements that must be satisfied in order to include failures into the database are outlined. The implementation of a labeling system that is capable of categorizing each failure is carried out throughout this process. The reasons of failure, the kind of structure, the building material, and other aspects are taken into consideration by this labeling approach, and after that, it is compared to the causes of failure that were taken into consideration in studies that were carried out by other researchers. In addition to that, this chapter includes a variety of tables and figures that highlight the information that is contained inside the failure database. It is in this chapter that you will find these tables and figures provided. The entirety of the database system is included in the appendix of this article for your convenience.

DATA ANALYSIS

This section describes the methodology that may be used to calculate the likelihood of failure based on the structural failures that have been documented. Furthermore, in the following sections, the labeling system is employed in order to split the failure database into datasets for distinct sets of labels that are taken into account. This is done in order to ensure that the failure database is appropriately organized. An example of this would be the collapse of steel bridges that were brought about by deficiencies in the design. On the other hand, such labels will be ignored in this introductory section since they do not have any influence whatsoever on the general strategy that is used in order to compute the risk of failure.

An abbreviation that represents the number of failures that have been reported for a certain set of labels is denoted by the letter n. There is a certain period of time that has passed since failures of that sort have been reported, T. In order to be able to evaluate the likelihood, it is necessary to create an estimate of the number, N, of structures of the sort that is being assessed that may have failed throughout the course of the time period T. It is reasonable to believe that we have obtained a reasonable estimate of N; hence, the probability of failure is

$$p_f = \frac{n}{N} \qquad (1)$$

When it comes to countries like Canada and Germany, where n is relatively low, the values of n and N are up for debate. Canada is a prime example of this.

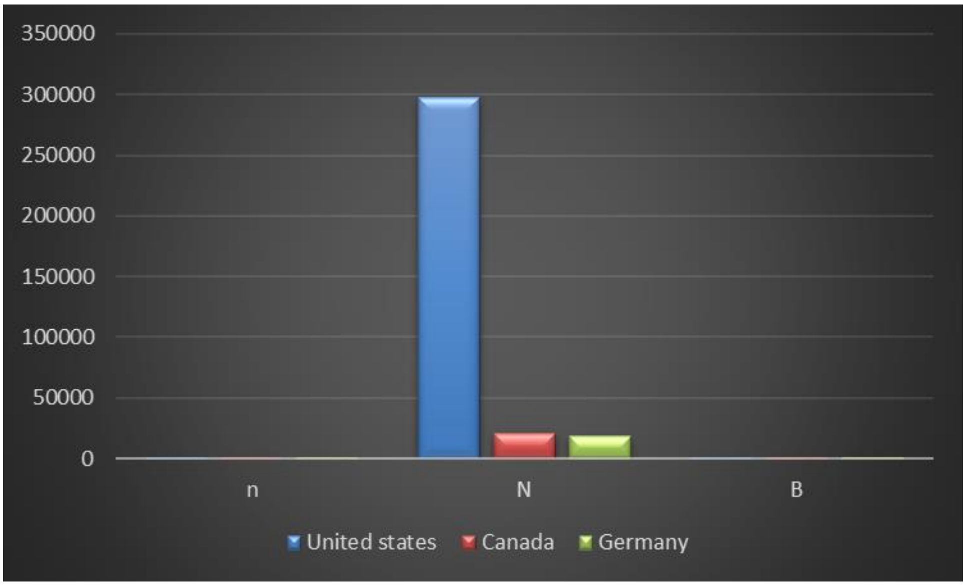
Table 1: The dependability of the construction phase for road bridges in three different nations

Country	n	N	β
United States	16	297,910	4.87
Canada	4	21,040	4.44
Germany	6	18,200	4.41

An extension of Table 1 would be to take into account the failures that occurred during the building phase in the United States according to the material that was used in the construction. The dataset contains a total of three failures in the steel category, six failures in the composite category, and seven failures in the concrete category. Failures of composite building materials that were included in the failure database are listed in the following. These failures are classified as steel failures. Considering that the National Bureau of Investigation does not provide any information on composite bridges, it is plausible to assume that this is the case. Additionally, the composite category in the failure database refers to the composite action that is brought about by steel girders that are supported by a concrete deck.

Table 2: Indexes of reliability for the various kinds of bridge superstructures in the United States

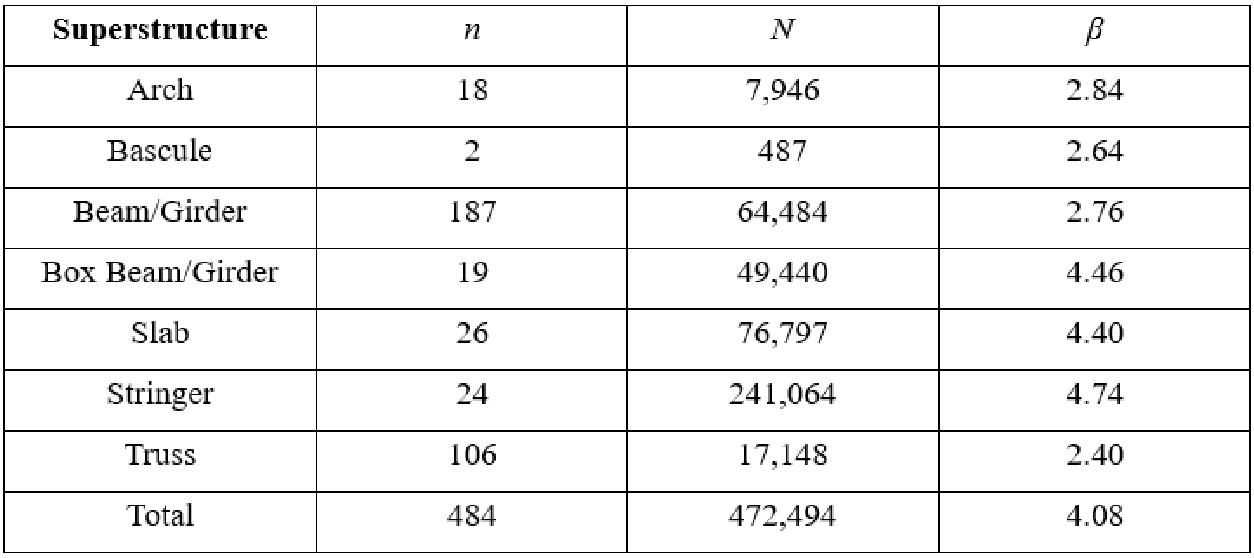
Superstructure	n	N	β
Arch	2	6,964	4.44
Beam	40	446,786	4.82
Truss	9	9,210	4.10



The reliability indices for the beam bridge superstructure type range from 4.82 to 4.10, whereas those for the truss bridge superstructure type are displayed in Table 2. The table displays these indices. Based on the data collected from bridge failures, beam bridges are the cause of 61% of all U.S. bridge collapses. The most inaccurate of the N-type superstructure estimates is probably the one for beam bridges. The results support the theory. The National Building Inspectorate (NBI) finds this to be true because beam bridges constitute

96% of all bridges they analyze. There may be less room for interpretation if the failure database for beam bridges were more thoroughly classified according to the various types of superstructures considered by the NBI. Based on the data collected from bridge failures, beam bridges are the cause of 61% of all U.S. bridge collapses.

Table 3: Types of bridge superstructure reliability indicators proposed by Wardhana and Hadipriono (2004b)



Superstructure	n	N	β
Arch	18	7,946	2.84
Bascule	2	487	2.64
Beam/Girder	187	64,484	2.76
Box Beam/Girder	19	49,440	4.46
Slab	26	76,797	4.40
Stringer	24	241,064	4.74
Truss	106	17,148	2.40
Total	484	472,494	4.08

In accordance with the findings of the National Bureau of Investigation (2021) for the year 2000, the estimates for N that are shown in Table 3 were derived. The shortcomings that were reported in that study span the years 1989 through 2000. This time range includes the years 1989 through 2000. It should be noted that the "total" category in Table 3 takes into account all of the various kinds of superstructures that were evaluated, with the exception of culverts and pedestrian bridges. In light of the fact that the definition of failure and the time period that were used in both sets of study are distinct from one another, a comparison between Table 2 and Table 3 is subject to some restrictions. As a consequence of this, it is fair to expect that the dependability indices that are found in Table 2 are greater than those that are found in Table 3. The fact that truss bridges were discovered to have the lowest dependability in both of the trials that were conducted when they were studied is an intriguing fact to take into consideration.

CONCLUSION

It has been demonstrated via the work that has been done on this project that the breakdown of the foundation can mostly be traced to mistakes that occurred during the building phase, which led to settlement that exceeded the allowed limit. The ability to forecast settlement through the use of techniques such as Hough and Schmertmann can assist a builder in making well-informed judgments on foundation design, despite the fact that certain natural occurrences, such as earthquakes, may not be completely foreseeable. Therefore, it is possible to draw the conclusion that failure of the foundation in buildings may be avoided by adhering to rules in the appropriate manner during the construction process. In addition, the routine monitoring and inspection of buildings can provide early warning of failures that are related with unavoidable causes. These failures may be handled by employing remediation activities that are appropriate for the situation.

REFERENCES

1. Muhammed, S., Asad, U.Q., Asif, H. and Mohammed, H.B. Multi-layer Parallel Crack Extension Model for Deformational Responseof Post-installed Anchor. KSCE Journal of Civil Engineering (2013) 17(5): 908-920. DOI: DOI 10.1007/s12205-013-0014-9
2. Kurt, H., Santiago, P. and Julio, R. Axial Failure of Reinforced Concrete Columns Damaged by Shear Reversals. Journal of Structural Engineering, 139(7), 2013.
3. Dario, C., Kamyab, Z.H., Karin, L. Severely corroded RC with cover cracking. Journal of Structural Engineering, 139(2), 2013.
4. Sabahattin, A., Ilker, K. Strengthening and Repair of Reinforced Concrete Beams Using External Steel Plates. Journal of Structural Engineering, 139(6), 2013.
5. Li, H., Dong, S., El-Tawil, S., Kamat, V. Relative displacement sensing Techniques for post event structural damage assessment: review. Journal of Structural Engineering, 139(9), 2013. 1421-1434
6. Dimitrios, G.L., Tsuyoshi, H., Masayoshi, N. Collapse Assessment of Steel Moment Frames Based on E-Defense Full-Scale Shake Table Collapse Tests. Journal of Structural Engineering, 139(1), 2013.
7. Stefano, M., Lusia, M., Giulia, S., Franscesco, U. Simple Beam Model to Estimate Leakage in Longitudinally Cracked Pressurized Pipes. Journal of Structural Engineering, 138(8), 2013.
8. Lokesh, A.D., Shivakumara, S.B., Vijaya, S. The Study on strength and stiffness of RC beam retrofitted with GFRP Wrapping. IJRET, 3(9), 2014.
9. Shinde, D.N., Pudale, Y.M., Nair, V.V. Flexural Behavior of Reinforced Cement Concrete Beam Wrapped with GFRP Sheet. IJRET, 3(30), 2014.
10. Sundarraja, M.C., Rajamohan, S. Strengthening of RC beams in shear using GFRP inclined strips – An experimental study. Construction and Building Materials, 23(20), 2009. DOI: 10.1016/j. conbuildmat.2008.04.008
11. Tran, H.Q., Khai Lam, T.Q., Do, T.M.D. Model of prefabricated concrete frame in the condition of southern Vietnam. E3S Web of Conferences, 135 03043, 2019. DOI: 10.1051/e3sconf/201913503043
12. Khai Lam, T.Q., Thi My, D.D., Ngo, V.T., Chuc Nguyen, T., Phuoc Huynh, T. Numerical simulation and experiment on steel fiber concrete beams. Journal Physics: Conference Series, 1425 012007, 2020. DOI: 10.1088/1742-6596/1425/1/012007
13. Do, T.M.D., Nguyen, T.C., Lam, T.Q.K. Investigating the effectiveness of insulation for walls of buildings in Vietnamese climatic condition. IOP Conf. Series: Materials Science and Engineering, 869 032008, 2020. DOI: 10.1088/1757-899X/869/3/032008
14. Ngo, V.T., Khai Lam, T.Q., Dung Do, T.M., Nguyen, T.C. Nano concrete aggregation with steel fibers: A problem to enhance the tensile strength of concrete. E3S Web of Conferences, 135 03001, 2019. DOI: 10.1051/e3sconf/201913503001
15. Ngo, V.T., Lam, T.Q.K., Do, T.M.D., Nguyen, T.C. Increased plasticity of nano concrete with steel fibers. Magazine of Civil Engineering, 93(1), 2020. Pp. 27–34. DOI: 10.18720/MCE.93.3
16. Ngo, V.T., Bui, T.T., Lam, T.Q.K., Nguyen, T.T.N., Nguyen, V.H. Experimental Evaluation of Nano Silica Effects to High Performance Concrete Strength in Early Age. IOP Conf. Series: Materials Science and Engineering, 869 032011, 2020. DOI: 10.1088/1757- 899X/869/3/032011
17. Ngo, V.T., Bui, T.T., Lam, T.Q.K., Do, T.M.D. Study the effects of nano-silica on crack toughness of high performance concrete base on double-K model. IJMPERD, 10(3), 2020. Pp. 8041-8050. DOI: 10.24247/ijmperdjun2020764
18. Do, T.M.D., Lam, T.Q.K., Ngo, V.T. Analysis of textile and steel fibers based reinforced concrete beam. IJMPERD, 10(3), 2020. Pp. 8033-8040. DOI: 10.24247/ijmperdjun2020763

19. Do, T.M.D., Lam, T.Q.K., Ngo, V.T., Nguyen, T.T.N. Analysis of high performance concrete with steel fiber reinforcement. IJMPERD, 10(3), 2020. Pp. 8139-8147. DOI: 10.24247/ijmperdjun2020772
20. Do, T.M.D., Lam, T.Q.K. Quality of Construction Works at the Design Phase. Lecture Notes in Civil Engineering, 70, 2020. Pp 15-24. DOI: 10.1007/978-3-030-42351-3_2