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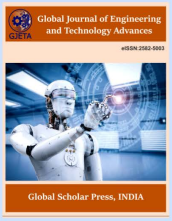

(RESEARCH ARTICLE)

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Modification and implementation of bridge maintenance process in south Gujarat

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Abstract

Bridge maintenance is a critical aspect in bridge transportation. It is a necessary social infrastructure for daily life. Surat has 118 bridges that have been built or are being built. There are no effective bridge maintenance systems or inspection regulations in place, resulting in bridge degradation. The maintenance process is repeated every five years; however, the time lapse causes further damage and repair work. The objective of this study was to identify the factors affecting bridge maintenance. This study is divided into two parts: questionaire survey and analyses the factors affecting bridge maintenance policy. The RII (Relative Importance Index) approach is used to analyses. Top 5 factors were determined by RII method that are traffic volume, surrounding environment, unfavorable government policy, live load and other load for which the bridge to be design and weather effect. Improvement factors are given for bridge maintenance.

Keywords: Bridge; Maintenance; RII; Inspection.

1. Introduction

India is a developing country and construction sectors are rapidly growing and transportation is increasing as the population is increasing so the construction of bridges is rapidly growing but their maintenance is lacking. The construction industry is very complex because it contains a large number of people as project managers, architects, engineers, clients, and many more. The bridge contains different components like a pier, foundation, sub-structure, superstructure, and girder. Maintenance of bridges in India suffers from many problems and complex issue

Bridges are aging and degrading faster than they are being maintained and replaced, and this is introducing a major problem for bridge authorities across the world, and bridge maintenance is been the major issue(Macdonald & Arjomandi, 2018). Surat has the highest number of bridges and is called “The City of Bridge” with a total of 118 bridges constructed till now.

A bridge is a structure that is built over some physical obstacle such as a body of water, valley, or road, and its purpose is to provide a crossing over that obstacle. It is built to be strong enough to safely support its weight as well as the weight of anything that should pass over it. As the number of bridges is increasing day by day due to the increase in the population and development of the city.(Wu et al., 2021)Due to coupling effects, bridge structure will ultimately deteriorate; as a result, bridge maintenance has been a focus of research. Environmental erosion, traffic loads, aging, and other variables have an impact on bridge structures.To assist bridge asset engineers, identify the most cost-effective maintenance, rehabilitation, and replacement (MR&R) options for bridge networks, bridge management systems (BMSs) have been developed.(Santamaria et al.,2021).

This research is to identify the maintenance process of bridges and the main objective of this study is to identify the factors affecting the maintenance procedure of the bridges and to provide suggestion for the maintenance policy of the bridge.

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The most essential factor in a country's economy is its transportation infrastructure. The development of transport infrastructure is a major investment for all nations. Because transport systems allow for the mobility and accessibility of people and products, they have a significant impact on the economic vibrancy of an area or nation. Railways, bridges, roadways, and other forms of infrastructure make up the transportation system. The transportation network and the process of economic production both heavily rely on bridges.(Jeong et al., 2018)Devastating collapses of deteriorated bridges, like the Silver Bridge in Ohio, United States, in 1967 and the Seongsu Bridge in Korea, in 1994, have the potential to result in significant losses of life and traffic congestion. The need for optimal maintenance and inspection programmes that can reduce maintenance and repair costs while keeping bridges at a sufficient degree of safety(Shepard, 2005)

Bridges may need routine or irregular maintenance. The most sustainable approach is routine bridge repair. Every 1 to 5 and 10 years, minor maintenance tasks are completed, and every 25 to 30 years, substantial maintenance tasks are completed. Despite this, the data suggests that bridge repair procedures vary widely around the globe. larger environmental effects and larger socioeconomic consequences result from this. As a result, sustainability problems are neglected.One of the main problems in the construction sector is believed to be project delays. Project delays negatively affect the project's performance, timeline, and budget. Understanding the many sorts of delays that frequently affect projects is crucial. Delays may happen concurrently with or after other events and may or may not be compensated. Additionally, the impact on the project's performance may be immediate or delayed. Their existence results in increased expenses, disputes amongst project participants, and, in the worst situation, potential lawsuit with associated expenditures.(Tayade et al., 2008)Environmental erosion, traffic loads, ageing, and other variables have an impact on bridge structures, which will result in various degrees of performance degradation. In order to better respond to the dynamic change in bridge performance throughout the course of service life, the maintenance decision-making framework of multi-agent reinforcement learning may alter the maintenance policy in response to the updated Markov matrix over time. By using simulation data of a cable-stayed bridge and a bridge with a simply supported beam, the framework's efficacy was confirmed. In order to better respond to the dynamic change in bridge performance throughout the course of service life, this system may alter the maintenance strategy in response to the updated Markov matrix over time.(Q. N. Zhou et al., 2022). An innovative method for assessing bridge condition by visual inspection, intended for broad maintenance planning within a BMS framework. It is used for the Veneto area road network in northeastern Italy, which includes 200 bridges and viaducts. The process is applied to the Veneto area road network in northeastern Italy's stock, which consists of 200 bridges and viaducts, and then analysed. Bridges' resistance and safety can be seriously compromised by structural issues brought on by corrosion, ageing, durability, harsh environments, material flaws, lack of flexibility, and unanticipated behaviors under seismic stresses.(Pellegrino et al., 2011a). The quality assurance practices and method for bridge inspections during a structure's lifetime are outlined. A review of the Bridge Management Systems implemented in Poland is presented, including the system “SGM” (national roads) and the system “SZOK” (local and municipal roads). All elements of the quality control system are described, including the bridge structure inspections, the classification of testing techniques used during each type of inspection, the taxonomy and coding system for defects found in the bridge during inspections, the general methodology for assessing the technical condition of the bridge, the operability assessment and rating, and the anticipated development paths for the bridge quality control system.(Pellegrino et al., 2011b).Using BIM leads in cost savings, quality assurance, and efficiency improvements throughout the life cycle. The bridge is currently being designed and built using BIM technology. However, the administration and upkeep of bridges seldom employs BIM technology.(Ichwan et al., 2021)Using a combination of BIM technologies, a visible and accurate model is created to increase the efficiency of bridge management and maintenance. In this model, BIM technology is used to analyses and regulate bridge deterioration.(Z. Zhou, 2022) Bridges when exposed to adverse environmental conditions and changes in traffic loads, bridges might suffer serious damage variety of live loads are used to convey heavy automobile traffic over the bridge. Due to the extreme climatic conditions and loads, the components of the bridge that affect safety and serviceability may lose their strength and stiffness.(Dey et al., 2019)In addition, risk analysis, risk assessment, and risk management should be employed to reduce failures brought on by hidden defects in already-built bridges.

Recent advancements in information technology (IT) encourage modifications to bridge management, improved inventory and inspection databases, and more control over management models for degradation and forecasting.(Darbani & Hammad, 2007)Maintenance expenses account for an important part of the construction budget, and downtime for inspection and maintenance activities results in additional expenses in terms of traffic delays. Additionally, because to rising traffic loads and the impacts of climate change, the pace of deterioration of these infrastructures has accelerated during the past 30 years.(Turksezer et al., 2021)

Fiber Reinforced polymers bridges have been frequently utilized for overpasses over streets, railroads, and highways. However, long-term static and dynamic stresses will inevitably cause damage to FRP bridges. The condition of these bridges is crucial.(Tang, 2021)Delays in building construction projects in Egypt were chosen and categorized under 9

groups, including financing, manpower, changes, contractual relationships, environment, equipment, rules and regulations, materials, scheduling, and control. They came to the conclusion that the most significant contributing factors were: financing provided by the contractor during construction; delays in the owner paying the contractor; changes to the design made by the owner or his agent during construction; partial payments made during construction; and a lack of use of professional/contractual management.(Abd El-Razek et al., n.d.)The need for sustainable bridge construction and restoration has increased, and the environmental effects of maintenance need to get enough consideration.(Xie et al., 2018)

1.1. Data collection and analysis

The data was collected from civil engineers, contractors, owners, supervisors, and Site engineer. Total 105 questionnaires were distributed out of which 71 questionnaries received which helped to calculate the relative importance index which is shown in table 2 of different stakeholders. Table 1 shows the list of factors affecting the bridge maintenance.

Table 1 Factors affecting bridge maintenance

Sr.No.	Affecting Factor
1	Traffic volume
2	Surrounding environment
3	Tests results
4	Testing equipment availability
5	Improper planning of project maintenance
6	Required ratio rate
7	Man Made disaster
8	Weather effect
9	Unfavourable government policy
10	Condition of bridge
11	Method of checking process
12	Method of maintenance process
13	Increasing traffic issue
14	Life span of bridge
15	Post construction work
16	Construction method
17	Poor communication with other parties
18	Available project resource
19	Live load and other load for which the bridge to be design
20	Structural design
21	Accidents during maintenance
22	Bridge element replacement requirement
23	Wear and tear of bridge
24	Poor workmanship
25	Inspection schedule
26	Site survey (Project size)
27	Effect of Earthquake on bridge

Table 2 Percentage of questionnaire distributed and responses received

Sr.No.	Respondent	Questionnaire Distributed	Questionnaire Received	Percentage
1	Engineer	40	35	87.5
2	Supervisor	20	11	55
3	Site Engg.	15	10	66.7
4	Contractor	10	4	40
5	Project Manager	20	11	55
	Total	105	71	67.62

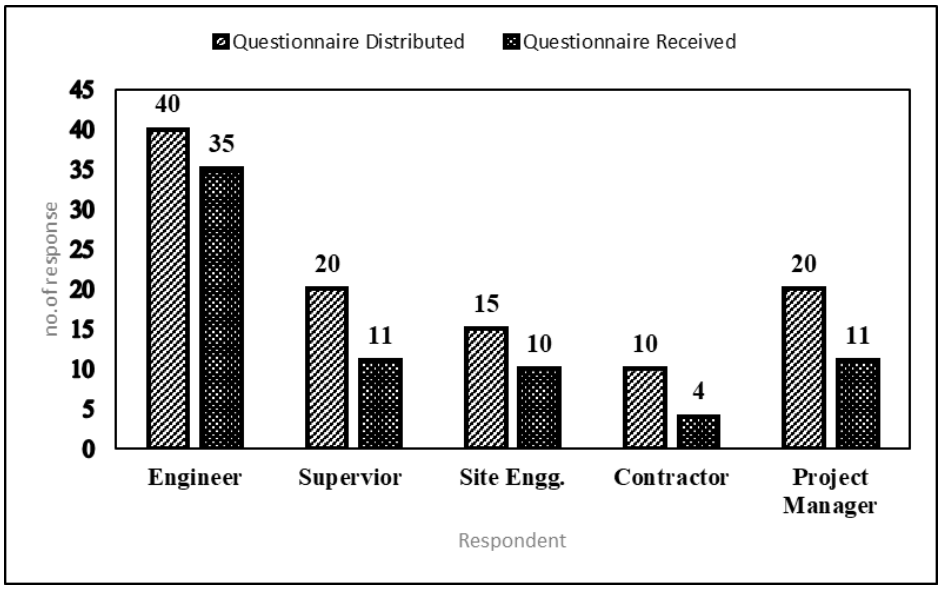

Figure 1 Percentage of questionnaires

Figure 1 shows the questionnaire distributed that is 105 out of which 71 questionnaires were received so the total percentage is 67.62.

2. Methodology

The use of quantitative questionnaires allowed for the collection of a significant number of responds from the construction industry.

The purpose of the widely distributed questionnaire was to identify the present project factors affecting bridge maintenance in the construction industry. The main aim was to offer an accurate assessment of experience with and awareness of these elements. Figure 2 shows the research methodology of the study.

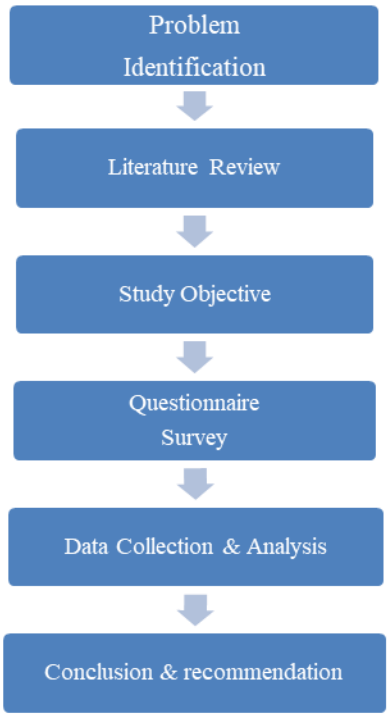

Figure 2 Research Methodology

It is used determine the relative importance of the various causes and effects of delays. The same method is going to adopted in this study within various groups (i.e., contractors, project engineers, owner and site supervisor). The four-point scale ranged from 1 (Not Important) to 5 (Extremely Important) is adopted and transformed to relative importance indices (RII) for each factor as follows:

$$RII = \Sigma W / (A*N)$$

Where, W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e.,5 in this case), and N is the total number of respondents. Higher the value of RII, more important was the cause of delays.(Tayade et al., 2008)

3. Result and discussion

Results of responds collected from various stakeholders are present here. The findings of the questionnaire data were presented. Total surveys from different stakeholders were conducted forstudy.Various methods of bridge maintenance policy are studied and factors affecting the bridge maintenance policy is identified. Table 3 represent the top 5 factors that are identified from questionnaire and table 4 shows the ratings of different stakeholders of top 5 factors.

Table 3 Top 5 Factors affecting bridge

Sr.no	Affecting Factor	RII Index	Rank	Sr.no
1.	Traffic volume	0.816	1	
2.	Surrounding environment	0.766	2	
3.	Unfavourable government policy	0.738	3	
4.	Live load and other load for which the bridge to be design	0.712	4	
5.	Weather effect	0.695	5	

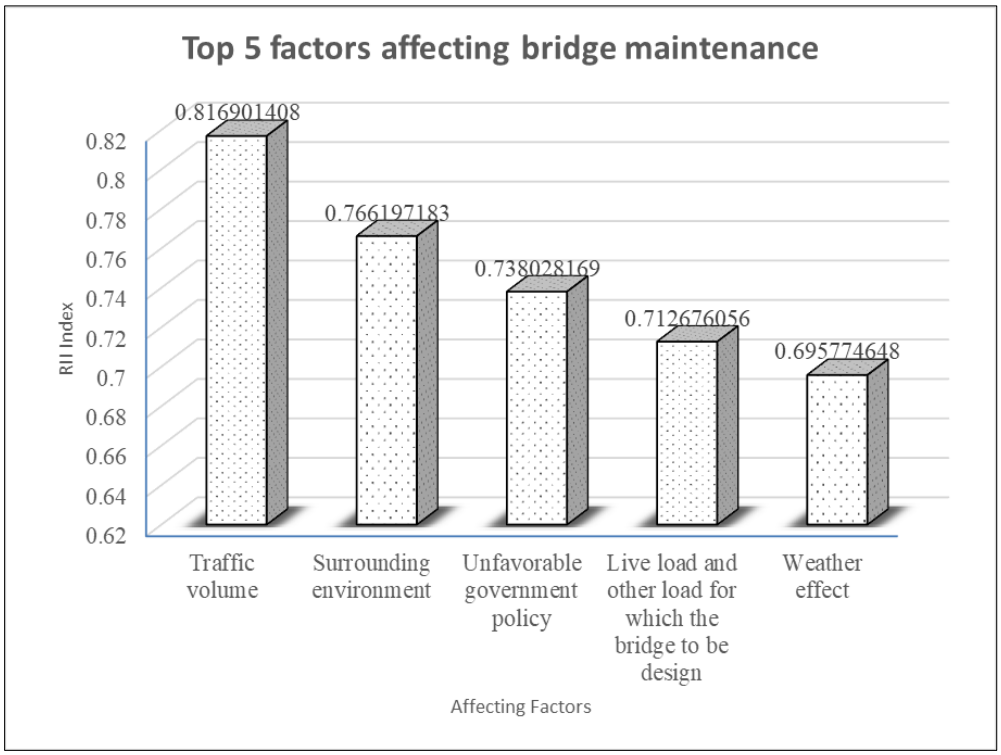

Figure 3 Top 5 factors affecting bridge maintenance

Figure 3 represents the top 5 factors that are affecting bridge maintenance. The factor is traffic volume, surrounding environment, unfavorable government policies, live load and dead load for which the bridge is to be designed, and weather effect. Value of RII index is 0.861, 0.766, 0.738, 0.712 and 0.695 respectively for the top 5 factors.

Table 4 Ratings of different Stakeholders

Sr. No	Stakeholder	Traffic volume	Surrounding environment	Unfavourable government policy	Live load and other load for which the bridge to be design	Weather effect
1	Engineer	4.2	3.5	4.5	3	2.5
2	Supervisor	4.5	4.6	3.8	4.8	4.2
3	Site Engg.	3.8	4	4.1	4.5	4
4	Contractor	4	3.5	3.1	4	4
5	Project Manager	4	3.8	3.6	3.8	4.3
	Total	20.5	19.4	19.1	20.1	19

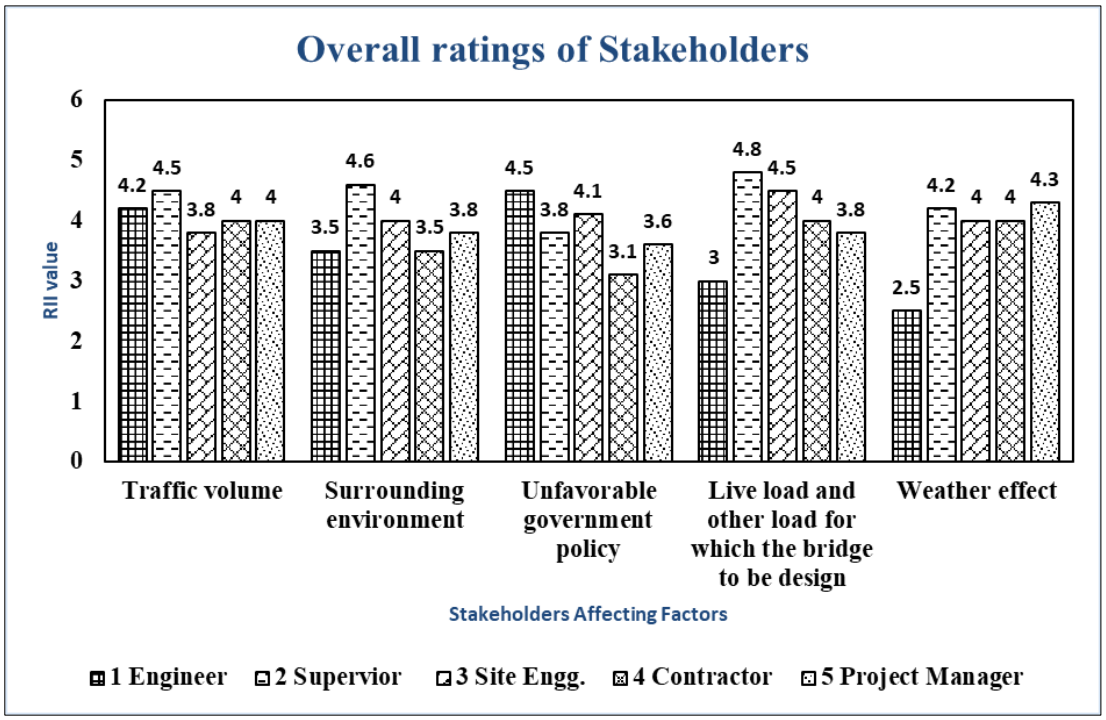

Figure 4 Overall Ratings Of stakeholders

Figure 4 represents the overall rating of different stakeholders with respect to the factors affecting bridge maintenance. The overall rating of the top 5 factors that are identified.

The process of calculating the amount of traffic or the number of cars using a certain piece of road at a specific moment is known as traffic volume. This time frame may be expressed in "minutes," "hours," "days," etc. Figure 5 represent the traffic that is preset on the Tapi river bridge which is the overload of the traffic that can cause damage to bridge maintenance process.

Figure 5 Traffic on the Tapi river bridge

Traffic volume is ranked first with an RII value of 0.816 which affects the bridge maintenance very high and needs to solve first and designed the bridge accordingly to improve the life span of bridge. The traffic volume growth has a higher influence on the maximum deformation of the bridge and thus leads to a higher probability of failure in the bridge's lifetime.For areas with high traffic, vehicle overloading management is crucial since it is an extremely effective means of assuring the durability of the bridge. According to the perspective of practical application, the numerical findings can offer a theoretical foundation for truck overloading management. With the increase in traffic volume, the vehicles excessed the limitation, resulting in bridge failure,

The term "environment" refers to the entirety of our immediate surroundings, encompassing all living and non-living things as well as all-natural chemical, physical, and other elements. The natural environment is composed of soil, water, air, plants, and animals. Figure 6 shows the environmental effect on the bridge.

The pollution caused by humans and industries affects the bridge parts and decreases the life span of bridge. The polluted water also makes the sub-structure of the bridge damaged and makes the structure week.

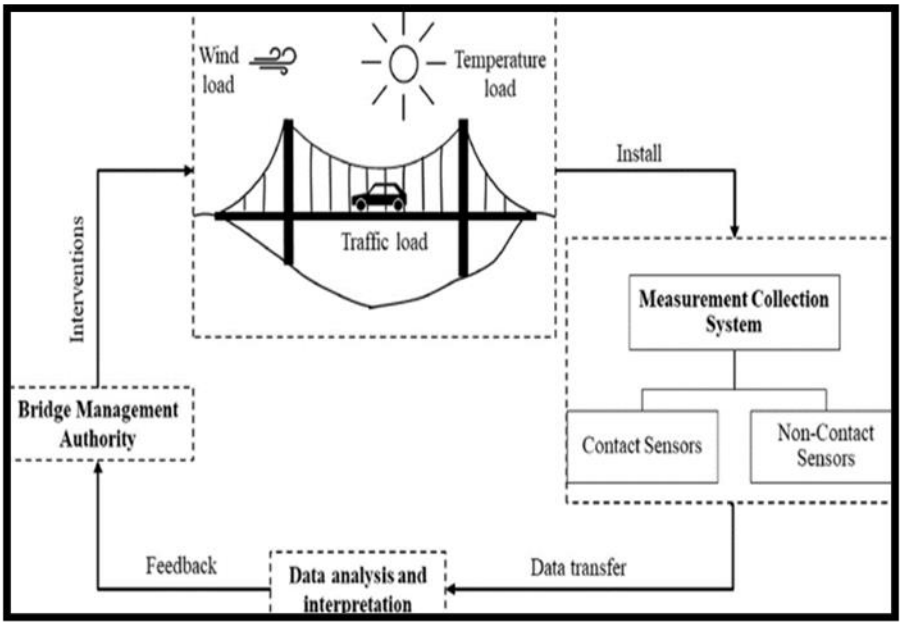

Figure 6 Environment effect

Government regulations known as policies have a significant impact on bridge maintenance and lifespan. To keep the bridge in excellent condition and reduce accidents, there should be certain laws governing bridge maintenance. The laws should focus more on monthly maintenance than yearly maintenance and address issues like the state of the roads, bridge painting and lighting, and other upkeep. The government needs to establish guidelines and regulations for the upkeep of bridges and the variables that have an impact on them and result in damage to them.

Any bridge is subject to three different types of forces:The dead weight the term "dead load" describes the bridge's weight. A bridge, like any other structure, is prone to collapse due to gravitational forces acting on the materials used to construct it.The term "live load" refers to both the flow of traffic across the bridge as well as typical climatic variables like temperature, precipitation, and wind fluctuations. The dynamic load, too. Dynamic load refers to environmental phenomena, such as unexpected wind gusts and earthquakes that go beyond typical weather conditions. Building a bridge requires consideration of all three elements.The bridge engineer must consider a wide range of loads that differ dependent on: 1- Duration (whether permanent or transient) Secondly, the direction (vertical, longitudinal, etc.). 3- Deformation (heat expansion, concrete creep, etc.) Four Effects (shear, bending, torsion, etc.)

Bridges have suffered substantial damage as a result of the strong rain, heat, flames, and winds. Figure 7 shows the weather effect that causes crack on the road surface of the bridge. Unexpected reactions and performances are occurring in buildings that were built decades ago under more typical weather circumstances. Roads are giving way. The metal is bending. Piers are being lost to flooding. There are two different impacts of temperature loading to take into account: changes in the effective bridge temperature that cause the deck to expand and shrink. The top surface of the deck as well as other points throughout its depth will vary in temperature, which will cause the deck to warp.

Figure 7 Weather effect on the bridge

4. Conclusion

The construction industry is growing rapidly and with the increase in population, bridge construction is also increasing in the city.However, none of these bridges' maintenance is carried out correctly or follows a suitable procedure. To enhance the state of the bridge and make it safe for traffic, it is necessary to maintain it on time. This study aims to determine the elements that impact bridge maintenance.

From the pilot study, total of 27 factors affecting bridge maintenance have been identified. After that questionnaire survey was carried out and 71 responses were received from engineers of different expertise, surveyor, project manager, etc. out of 105 questionnaires distributed.

The top five elements that have an impact on bridge maintenance were identified after the data was assessed using the Relative Important Index (RII) approach. The factors are traffic volume, surrounding environment, unfavorable government policy, live load and dead load on the bridge, and weather effect with RII values of 0.8169,0.7662, 0.738, 0.713, and 0.696 respectively.

Further, all these factors are to be considered while maintaining the bridge. The government of India is surely giving the policy on bridge maintenance so they can use this information to give proper guidelines for the maintenance to agencies.

The traffic volume on the bridge should be managed as per the design of the bridge. At the time of the design period of the maintenance bridge, the load carrying capacity is more than at the time of the maintenance period should we refurbishment. Due to increase the in-traffic Volume, it increases pollution, and that pollution effect directly to the life of the bridge. Pollution damages the components of the bridge and may collapse the bridge if maintenance is not done properly. So proper maintenance should be done every six months.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to disclosed.

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