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A STUDY OF THE RCC BRIDGE FOR MONITORING ITS STRUCTURAL HEALTH USING ANSYS

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Abstract

This study presents a comparative analysis of an RCC bridge with and without bearing support using advanced numerical simulations and analysis techniques. The investigation encompasses structural analysis, modal analysis, and random vibrational analysis to assess the performance and effectiveness of the bridge models under various loading conditions. The results reveal distinct differences between the two models in key parameters, including total deformation, stress distribution, strain characteristics, strain energy, and vibrational behavior. Notably, the model with bearings consistently demonstrates superior performance, exhibiting lower total deformation, reduced stresses, and enhanced vibrational characteristics. These findings underscore the significance of bearing support in optimizing the structural integrity and overall effectiveness of RCC bridges, providing valuable insights for engineering design, maintenance practices, and ensuring long-term structural health. The study contributes to the understanding of the dynamic behavior of bridges and informs decisions aimed at enhancing their resilience and performance.

Keywords: *RCC Bridge, Structural Analysis, Modal Analysis, Random Vibrational Analysis, Effectiveness, Structural Health and Ansys.*

1. INTRODUCTION

For engineers, investigators, and members of the civil engineering society as a whole the concerns concerning the upkeep and surveillance of structures have grown significantly[1]. Bridge and other civil engineering-based facilities that are aged —continuing to be utilised long beyond their original plans load capacity and beyond their expected lifespan There couldn't have been a better time for creating powerful and trustworthy damage sensing algorithms[2]. Due to the significant expenses connected with constructing a new bridge, the primary strain on bridging authorities is to prolong the usefulness of current ones to the greatest extent as is practical[3]. The costs linked to the true deconstruction of the previous structure as well as the subsequent expenses of turning down the operation are also listed. It could be wise to establish new structures more often instead of repairing those that are outdated in numerous scenarios if cost was not a consideration[4]. The decision to maintain the current bridges, however, is supported by a number of other considerations besides cost, such as the environmental impact, the safeguarding of cultural and traditional values, and traffic disruptions that result in a variety of implications on passengers as well as freight transit[5]. It makes sense to keep the current structures in place for as long as practicable while preserving structural integrity and safety for people at the lowest feasible cost, given these challenges and the reality that decisions are almost always based on costs[6]. Programmes for replacement as well as rehabilitation must be prioritised by executives and decision-makers simultaneously to accomplish this. The issue is that when major structural damage is identified, it has often already advanced significantly, necessitating extensive and expensive repairs[7]. The occurrence of fatigue fractures, corrosion, impact-induced delamination in composite structures, malfunctioning expansion joints, and deterioration of structural connectors are a few examples of the observed damage. One method to address this problem is by developing astute maintenance plans that take use of structural monitoring at the right time, allowing for the early discovery of problems plus precise remaining life projections[8].

By getting accurate data regarding a bridge's present condition, monitor changes over time, as well as documenting the deterioration, Structural Health Monitoring (SHM) intends to complement current approaches[9]. By permanently integrating a wide variety of sensors that constantly track metrics linked to the health of the structure as well as additional architectural outside variables, it is possible to generate an immediate visualisation of the structure's present state[10]. But the usefulness of the gathered data depends on its not being false or misleading, which may be prevented by putting in place a trustworthy SHM system, a data analysis procedure, and statistical tools[11]. Ensuring the quality of the gathered data is a positive step towards the successful completion of well-informed decision-making[12]. By combining contemporary monitoring with FEA software, this research project aims to improve data management and interpretation procedures rather than create any novel sensing techniques. to assess RCC bridges' behaviour and structural integrity under various loading scenarios[13]. It is necessary to comprehend how the bridge structure responds to different loads, stresses, and environmental factors. applying SHM principles to the RCC bridge using ANSYS software. In order to gather real-time data on structural state metrics like vibrations, strain, and other pertinent features, sensors and monitoring systems are used[14]. creating and refining methods for ongoing bridge assessment and monitoring. ANSYS simulation and monitoring data are used to build procedures for routine maintenance and inspections. A component of the study involves verifying the results of the simulation using input data obtained from the bridge or other structures[15]. This process enhances the modelling skills and accuracy of the simulation model[16].

RCC Bridge

Because they provide vital connections for the flow of people and goods, bridges are essential parts of the transportation infrastructure[17]. An RCC bridge is a poured-in-place monolithic construction. After setting up the forms, the concrete mixture is poured into them together with the reinforcing steel[18]. Because of its affordability and adaptability, reinforced concrete (RCC) girder bridges are often used in bridge construction. In order to link to the subsequent part that has to be poured, the rebar extends beyond the form[19]. A girder and slab (T-beam) bridge is the typical form of reinforced concrete bridge. For spans between 10 and 30 metres, the T-beam girder bridge is one of the most often utilised types of bridges[20]. The design and analysis of RCC girder bridges involve careful consideration of a number of factors, such as structural stability, load capacity, and serviceability requirements[21]. Energy is necessary to produce the components, therefore influences emissions of greenhouse gases and discharges CO2 into the environment. As a result, it affects the economy, society, and environment in some direct and indirect ways. Scientists are trying to find a way to lessen this impact[22].

Many infrastructures and buildings, such as RCC bridges, are dilapidated and not operating to their full potential[23]. This deterioration can be caused by fatigue from long-term use, environmental changes like sharp temperature swings and natural disasters, design defects or subpar building techniques, rust in the reinforcing, inadequate upkeep, modifications to the original or planned application of the structures (such as converting office spaces into residences), and, in the case constructed roads, a surge overall passenger[24].

Figure No.1 Damages In Bridge

[Source: [25]]

Structural Health Monitoring of RCC Bridge

The goal of structural monitoring is to provide precise and timely information on the state and performance of structures[26]. It is comprised of the long- or short-term, continuous, periodic, or permanent recording of representative characteristics. One tool The Structural Health Monitoring (SHM) programme is used for reviewing and maintaining check of a building's structural fitness[27]. Because of its versatility in adapting to unfavourable structural changes and enhancing structural dependability and life cycle management, it has been extensively used in many engineering domains[28]. The four tiers of structural health monitoring are as follows: (1) identifying if a damage escapes a structure; (2) locating the damage; (3) assessing the extent of the damage; and (4) calculating the structure's remaining lifetime. For a considerable amount of time, many engineers and academics have been interested in structural health monitoring, or SHM, of bridges[29]. To enhance SHM systems, several research have been carried out in the past. The positioning of cameras at certain measurement locations was taken into consideration while designing the SHM system. The primary objectives of this system were to identify structural damages, monitor the suspension system's loading conditions, notice the functional behaviours of the bridge's box girders along with suspension system, and evaluate rheological phenomena[30]. The SHM equipment may be used in this way to measure the structural reaction and deformation, perform synchronous kinetic evaluations (dynamic deformation and accelerations), & monitor the effects of temperature, humidity, & wind on the integrity of the structure itself[31].

Figure No.2 Structural Health Monitoring of RCC Bridge

(Source:[32])

Real-time structural response monitoring and measurement (SHM) is a technique used to identify abnormalities in the early phases of structural degradation[33]. The creation of health monitoring protocols, which may preserve the bridge's operability and extend its lifespan, is one of the most recent developments in the bridge business[34]. The installation and validation process must be done correctly before functional usage may begin. For the freshly installed SHM systems to begin their operational lives, authentication is crucial. In addition, field load testing of the bridge may guarantee that the SHM system has been calibrated[35]. Therefore, trustworthy data about the SHM system's performance and serviceability parameters is produced. The effectiveness and durability of certain sensors have a significant impact on the SHM system's performance. Liquid levelling sensors (LLS), accelerometers, strain gauges, and LVDTs are the most often used sensors in SHM systems[36]. Each of these sensors is matched to the measurement of many variables and factors that aid in evaluating the performance of the bridge and identifying any irregularities. Strain is one of the fundamental parameters, and it may be measured using reliable tools like vibrating wire strain gauges[37]. Furthermore, the assessment of bridge health also heavily relies on the measurement of vertical displacement. LLS is the most promising and appropriate device for this kind of measurement as it can solve the issue of not having enough reference points that deliver more accurate results[38]. Additional factors include directional shifts measured using inclinometers that and Using linear variable differential transformers (LVDT)38, linear bending is monitored. MEMS acceleration sensors supply the most accurate statistical information for vibration detection as well as dynamic component assessment in a bridge's SHM system[39]. Another essential part of the SHM system are weather-monitoring stations. Temperature, humidity, anemometer, and barometer sensors are often mounted at the centre span of the bridge beside these stations[40].

In recent decades, countries all over the globe have come to view the bridge transit system as the cornerstone of economic progress[41]. As bridge engineering has advanced, large-span bridges like the Golden Ears Bridges from the United States, the Messina Strait Bridge from Italy, the Tsing Ma Bridge from Hong Kong, & the Hangzhou Bay Sea Crossing Bridge have been utilised one after the next[42]. However, as the service life of the bridges increases, their surrounding environment—which includes temperature, humidity, geology, wind loads, and humidity—will cause the strength and security of the bridge frames to gradually deteriorate[43]. In order to promptly determine the current condition of the bridges' health, many large-span bridge are thus equipped with health monitoring devices in order to assess and minimise any health risks associated with the bridge as well as to extend the service life of bridges[44]. Compared to human eye investigation with carried instruments, modern bridge wellness tracking (BHM) systems dramatically reduce personnel and material expenses associated with inspections[45]. The monitoring system makes the whole process of structural testing bridges interactive and easy to use by integrating features like data gathering, health diagnosis, and damage warning. Scholars from many different countries have given BHM considerable attention because to its intricacy and significance, and they are always coming up with new ideas for advancement and improvement[46].

In the early stages of BHM's development, there were significant safety risks to bridges because of the often mismatched projections and actual findings caused by inexperienced analytical procedures and a lack of reliable monitoring equipment[47]. Unfavourable state changes often happen to bridges throughout their service life as a result of internal structural features and exterior environmental influences, which present safety risks. If these negative changes are not identified in a timely way, there might be disastrous outcomes and a large loss of life and property[48]. BHM systems monitor and offer real-time input on a bridge's structural reaction, structural faults, and external environment using a large number of sensors that are strategically placed using acceptable techniques. Image-based techniques are utilised for the identification of fractures, peeling, deformation, corrosion, and other structural problems[49].

2. RELATED WORK

Zhihang Deng, et.al. [2023] studies on the state of structural health monitoring (SHM) for bridges, with an emphasis upon the last five years of progress. Considering data mining techniques and anomalous data early warning systems, it classifies advancements in sensor and computer imaging technologies. The review delves into vibration-based and non-destructive testing-based damage identification methods, concluding with an assessment of existing research and future directions, offering a valuable framework for upcoming studies[50]. **Wei Xiang, et.al. [2023]** Paper focus on A comprehensive study on Structural Health Monitoring Design and Performance was conducted, focusing on a middle-span bridge in Shenzhen. The research introduces an efficient monitoring and warning system employing sensors and measuring points to gather extensive data. This system enables close scrutiny of operational indicators, facilitating early detection of threshold exceedances. The study includes a four-month monitoring period, analyzing data on main beam strain, pier strain and settlement, and bridge body crack width. Real-time operational status is assessed through a combination of collected data and a structural finite element model[51]. **Muhammad Fawad, et.al. [2023]** conducted research on automation of a bridge's Development of a BIM-based finite element model and a BIM updating technique for the Structural Health Monitoring (SHM) platform. Finite Element Analysis (FEA) is used for computational computations, validating the finite element (FE) design and SHM system via actual load tests. In order to create a smart SHM system that offers offline access and visualization of health data, sensors are integrated with an Internet of Things (IoT) platform using the BIM model[52]. **Saif Saudagar, et.al. [2023]** The study explores the analysis and design optimization of RCC girder bridges using the STAAD PRO program. Software-based analytical techniques prove more accurate than manual calculations, enhancing structural performance. Design optimization procedures are introduced, emphasizing the importance of precise analysis and software-based approaches for safer, efficient, and sustainable bridge designs. Further research is needed for continuous improvement[53]. **M. S. Alam, et.al. [2022]** conducted study on sustainable solutions for strengthening and renovating deteriorated RCC structures. It explores the use of FRP strips/sheets or bars bonded outside the member, employing materials like steel, GFRP, CFRP, and AFRP. The study observes improved strength in strengthened members, suggesting these techniques as sustainable solutions, though further research is needed for accurate predictive models[25].

Adam Marchewka, et.al. [2020] This study explores a comprehensive framework for Structural Health Monitoring (SHM) of steel bridges using computer vision. The approach includes literature review, drone route planning, image acquisition, identification of visual markers indicating structural issues, and defines the applicability scope, especially focusing on riveted steel truss bridges[54]. **Aminu Muhammed, et.al. [2020]** studied on The Finite Element Analysis of a reinforced concrete bridge deck subjected to vehicular vibrations reveals a maximum span deflection of 2.8974mm, significantly below the allowable limit of 22.5mm (676% difference). Modal analysis indicates failure modes related to dynamic vehicle movement, ground shifts, and severe wind forces, with observed maximum deflections of 26.354mm and 21.624mm for different scenarios. The study concludes that the 18000mm span bridge, featuring a 220mm thick deck reinforced with T16/200 steel, effectively withstands design loads and vehicular vibrations with minimal deformation throughout its design life methodology for efficient non-destructive evaluation. This study focuses on the vital end plate steel beam-column connection, crucial in steel structures. Using ANSYS, the simulated electro-mechanical impedance technique successfully identified defects and assessed the strengthening effects of retrofitting[55]. **James Brownjohn et.al. [2020]** Paper focus on The Tamar Bridge has been under study since 2005, with a focus on performance observations through a structural health monitoring system. The system, part of the IRIS project, records dynamic and static responses, revealing insights into the bridge's behavior influenced by temperature, traffic, and wind. Anomalies have been detected over six years of observation[56]. **A. Sofi et.al. [2022]** Structural Health Monitoring (SHM) is on the rise due to technological advancements, emphasizing repair and rehabilitation needs. The shift from wired to wireless technologies is increasing, especially in monitoring large structures like bridges and buildings. This paper reviews recent developments in SHM, highlighting wireless data acquisition and the integration of AI tools such as Artificial Neural Networks, Machine Learning, and Cloud Computing. Despite academic progress, there's a lag in real-world SHM implementation, urging the establishment of standards to bridge the gap[57].

Varinder Singh Kanwar et.al. [2008] This study focuses on monitoring the structural health of RCC bridges, crucial for seismic safety. The four-level scheme involves developing a finite element model, identifying changes in dynamic properties through controlled damage, locating damaged components, and evaluating damage extent using frequency response function (FRF). Findings reveal a decrease in FRF magnitude with increased damage, and the damage index correlates with the level of damage. Limitations include a three-storey RCC model without infill walls, and induced damage via a static horizontal load at the roof level[58]. **Venu Gopal Madhav Annamdas et.al. [2015**] This paper explores Structural Health Monitoring (SHM) in Asian countries, emphasizing its significance in densely populated cities like Singapore and Mumbai. While SHM is less prioritized in poor nations, it is crucial for developed ones to prevent catastrophic infrastructure failures. The study reviews SHM approaches in various Asian countries and highlights research conducted at Nanyang Technological University in Singapore. Additionally, it discusses energy harvesting using piezoelectric patches as a wired SHM alternative[59]. **Sandeep Gaikwad et.al. [2021]** The study focuses on the growing significance of Structural Health Monitoring (SHM) for civil structures globally and in India. SHM aids in construction management and maintenance, reducing inspection costs, and enhancing understanding of structural behavior and damage evolution. Nondestructive testing (NDT) is a key aspect, aiming to assess material properties without causing harm. The paper aims to review SHM practices worldwide and advocate their adoption in India for effective infrastructure management[60]. **Shridhar K. Panigrahi et.al. [2015]** The study of an RCC bridge reveals a 26% reduction in deflection and 53% reduction in flexural strain after rehabilitation, indicating the effectiveness of the strengthening system. Shear strain shows a 56.8% average reduction, highlighting enhanced shear stiffness. Structural health monitoring is vital for infrastructure management, offering cost reduction, improved understanding of structural behavior, and support for post-earthquake scenarios. The paper emphasizes the global importance of such monitoring techniques and advocates their adoption in India for better infrastructure management[61].

3. PROBLEM STATEMENT OF THE STUDY

The study's goal is to use ANSYS software to evaluate the structural health of an RCC bridge. The main goal is to evaluate and analyze the structural integrity of two bridge models, one with bearings and one without bearings, utilizing structural, modal, and random vibration analysis. The project aims to identify a model that has better structural integrity, less vibrations, and increased stability. It aims to provide knowledge about the significance of adding bearings in such structures and their impact on overall structural health and performance by comparing the performance of RCC bridge models with and without bearings. Fast Fourier Transform (FFT) analysis in ANSYS is a technique used for frequency domain analysis of structures. The specific commands and procedures for FFT analysis in ANSYS may vary based on the version of ANSYS.

4. MODEL DIMENSIONS

The model dimensions of the structure are as follows: the length of the model spans 29 meters, providing the longitudinal extent of the structure. The height of the model stands at 10 meters, representing the vertical dimension from the base to the highest point. The thickness of the structure measures 2.5 meters, signifying the depth or thickness of the structural elements. Additionally, the width of the model extends to 12.1 meters, denoting the horizontal span or breadth of the structure. These dimensions collectively define the geometric characteristics of the model, forming the basis for further structural analysis and evaluation.

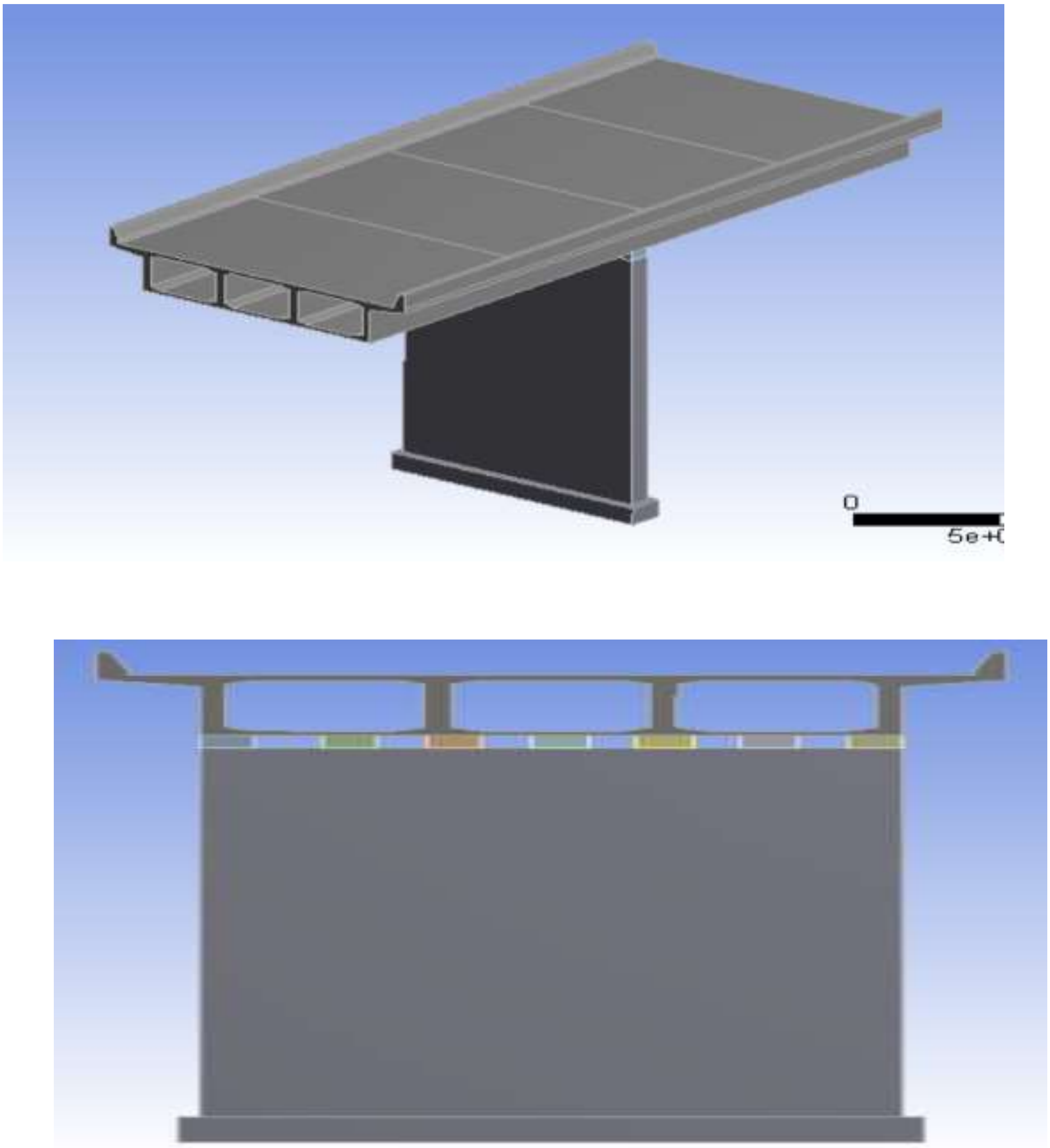


Figure No.3 Bridge Model with Bearing

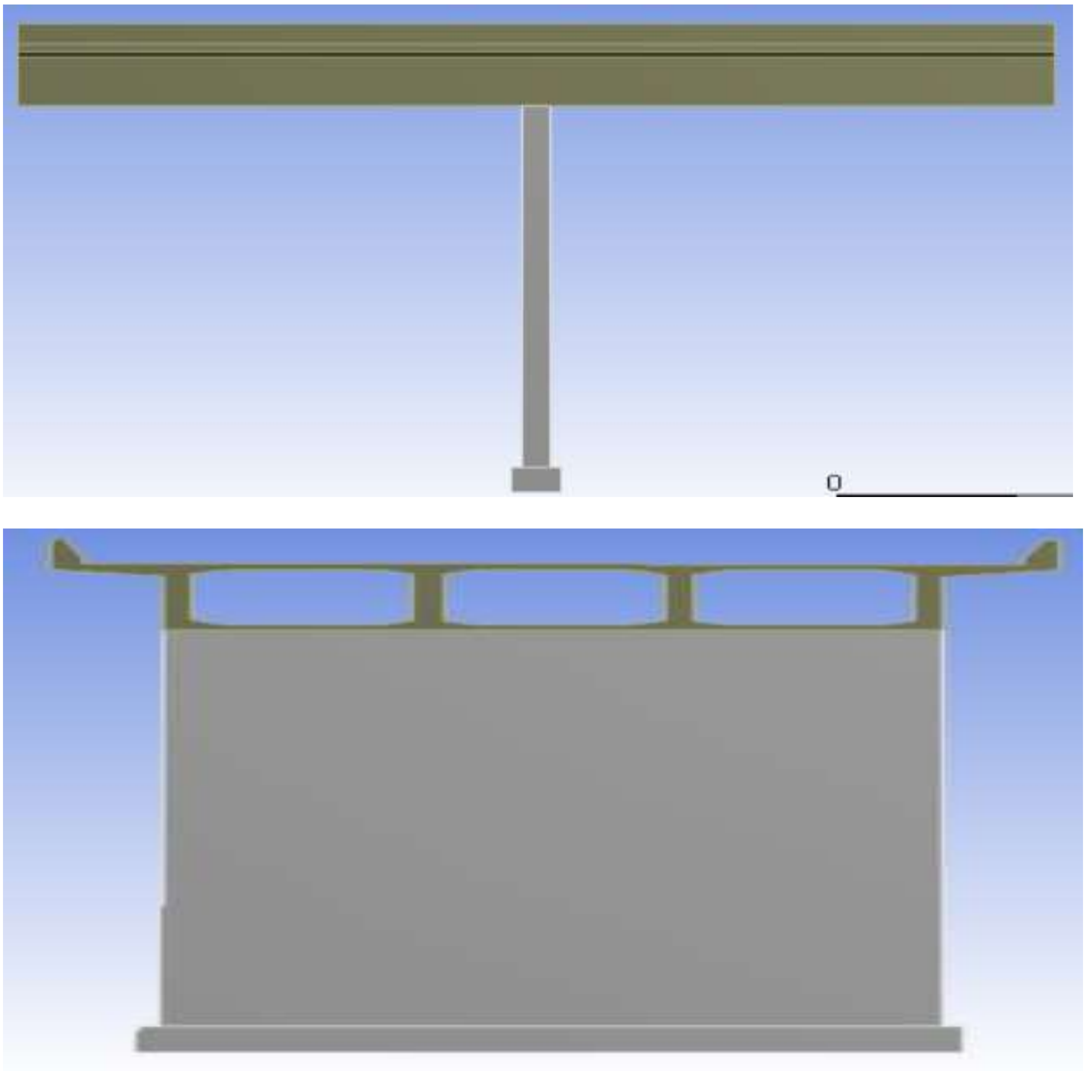


Figure No.4 Bridge Model without Bearing

A. Material Used

The materials used in the construction of a structure, particularly when considering concrete and rubber, play a crucial role in determining its performance, durability, and functionality.

Table No.1 Material Properties

Property	Concrete	Rubber
Density (kg/m³)	2400 - 2500	900 - 1600
Compressive Strength (MPa)	20 - 40	2 - 30
Tensile Strength (MPa)	2 - 5	15 - 40
Elastic Modulus (GPa)	20 - 40	0.01 - 0.1

Thermal Conductivity (W/m·K)	1 - 2	0.1 - 0.2
Coefficient of Thermal Expansion (1/°C)	10 - 15 x 10^-6	100 - 200 x 10^-6
Poisson's ratio	0.15 to 0.25	0.45 to 0.49

5. ANALYSIS AND SIMULATION

A. Steps of Analysis using FEA

In ANSYS, created finite element models of both bridge designs, taking into consideration the stated dimensions and material qualities. To simulate actual incidents, use proper loading conditions that take into consideration traffic loads, environmental considerations, and possible dynamic pressures. Conduct structural analysis on each model to evaluate stress, strain, and deformation characteristics. Modal analysis is used to find the natural frequencies and mode shapes. Use random vibration analysis to better understand how the bridge models respond to random stimulation. Compare and contrast the results from both models to decide which design is more successful and reliable

B. Vibration Analysis (FFT)

In this project, we use the Fast Fourier Transform (FFT) to determine the present state of a bridge. We also use the FFT to determine the vibration of the bridge over a moving load. The vibration testing values for greater moving load and lower moving load for the bridge's midsection are as follows.

Table No.1 FFT Test Readings of RCC Bridge

Sr. No.	**SIDE**	**Amplitude**	**Frequency**
1	Left-1	900.8	13.12
2		827.67	4.71
3		575.84	14.13
4		207.16	11.78
5		90.43	55.85
6		83.09	19.18
7		72.62	10.77
8		60.75	23.89
9		28.86	20.86
10		26.43	22.21
Sr. No.	**SIDE**	**Amplitude**	**Frequency**
1	Middle-1	4159.7	14.8
2		463.95	12.45
3		216.11	4.37
4		191.94	16.82
5		92.35	18.17

6		76.67	7.07
7		60.86	11.1
8		53.2	21.2
9		53.05	5.38
10		35.66	22.21
Sr. No.	**SIDE**	**Amplitude**	**Frequency**
1	Right-1	1013.3	11.44
2		875.8	5.05
3		627.34	13.12
4		506.1	13.79
5		330.35	8.41
6		283.68	9.42
7		273.44	25.91
8		196.01	17.5
9		184.68	20.19
10		169.63	46.43

6. ANALYSIS OF BRIDGE IN ANSYS

A. Boundary Conditions

- **Meshing**

The meshing capabilities of Ansys help in reducing the amount of time and effort required to get precise results. Because meshing often contributes to a large percentage of the time required to get simulation results.

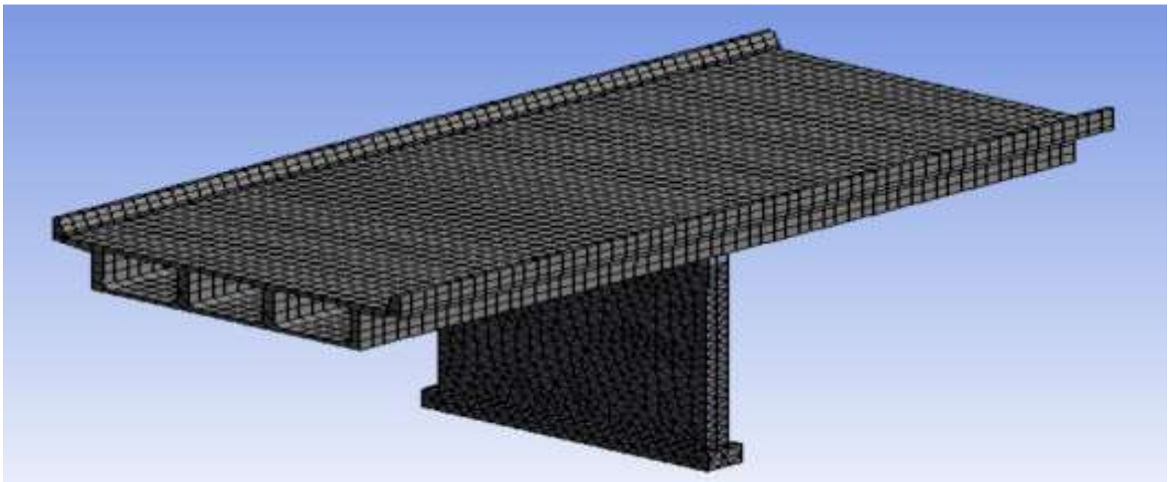


Figure No.5 Meshing

There are 37771 nodes in the situation where different calculations on the structural behaviour of the bridge will be performed. The model has been divided into 10297 distinct elements to correctly show the shape and behaviour of the bridge.

- **Fixed Support**

All translation degrees of freedom across the given entities are reduced to zero by the Fixed support constraint boundary condition. It is used to represent an area of geometry that is attached to a rigid body.

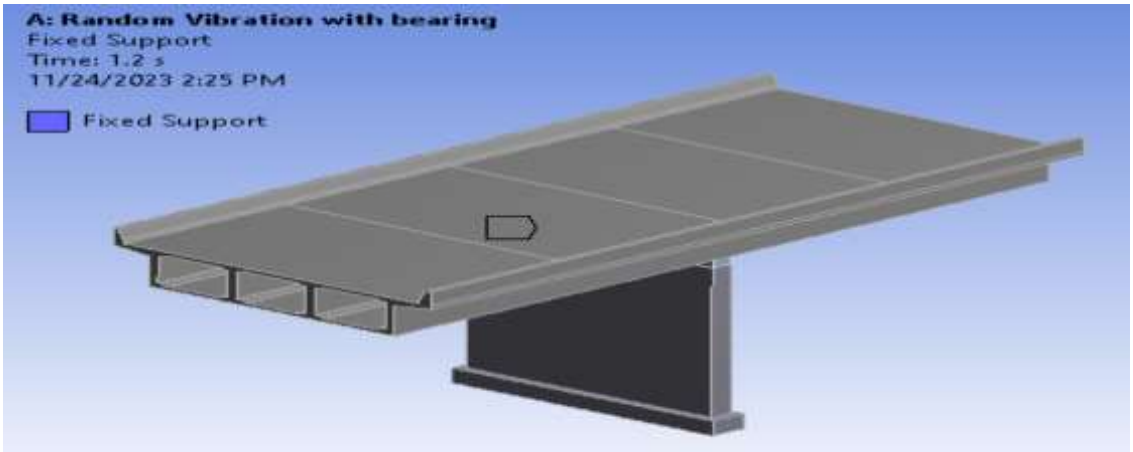


Figure No.6 Fixed Support

Applying a fixed support to the bridge model's bottom surface would normally mean that this surface is totally attached against movement in all six degrees of freedom.

- **Load Applied**

The loads must be applied in such a manner that they correctly replicate the real-world conditions, ensuring that the simulation closely mimics the actual behaviour of the structure under various situations. Depending on the study's aims, the loads might be dynamic or static, varying in intensity and direction.

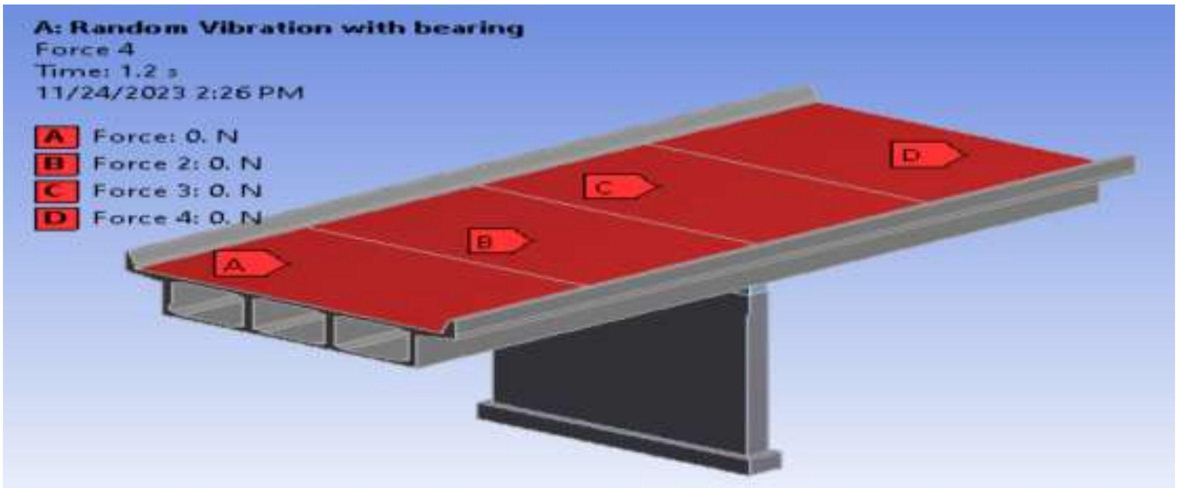


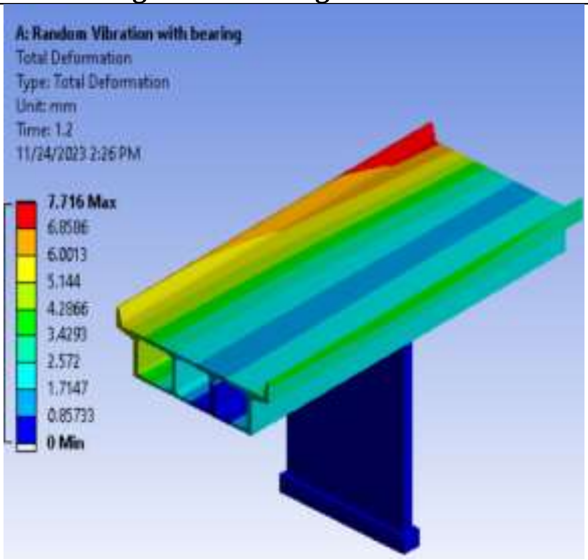
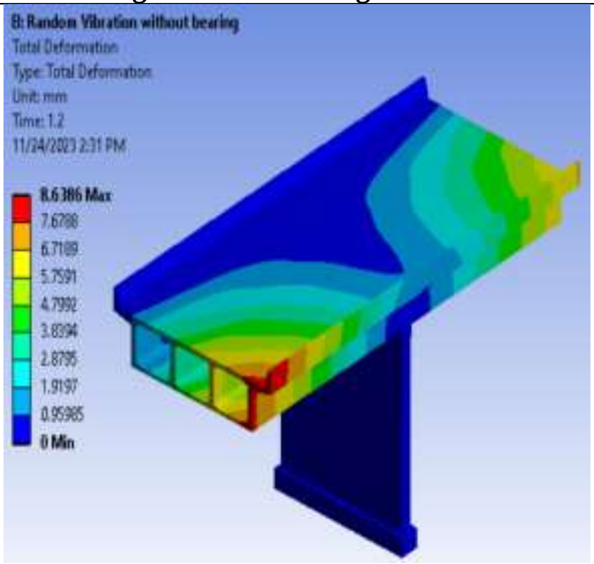
Figure No.7 Load Applied

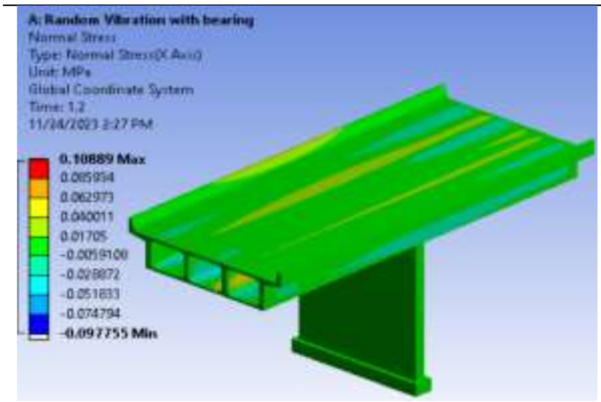
A particular load of 3.9227e+005 N was applied to the top surface of the structure in the ANSYS Workbench simulation of the RCC bridge model.

C. Structural Analysis

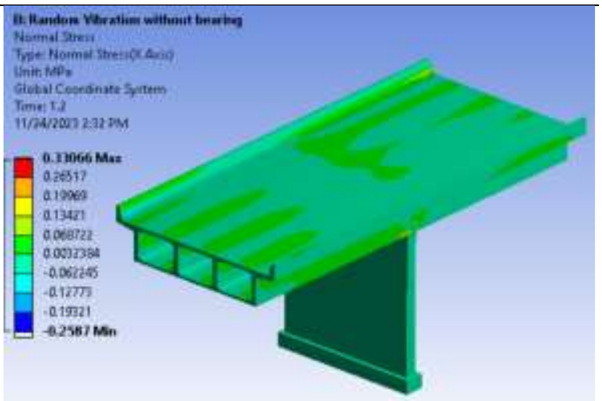
Structural analysis is an important part of engineering design because it protects the safety, stability, and performance of structures under varying loads and situations. Engineers often depend on advanced software tools such as ANSYS to perform accurate and fast structural analysis.

Table No.3 Results of Structural Analysis

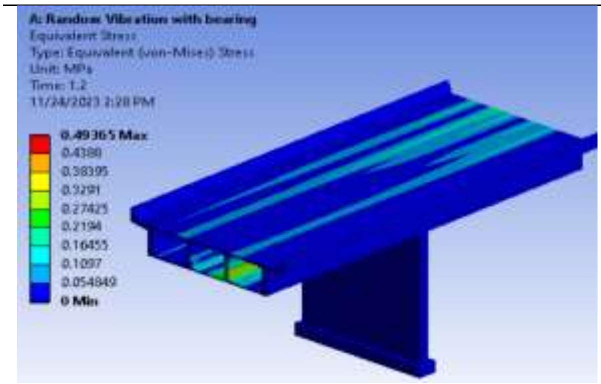
RCC Bridge with Bearing	RCC Bridge without Bearing
	
Total Deformation	Total Deformation



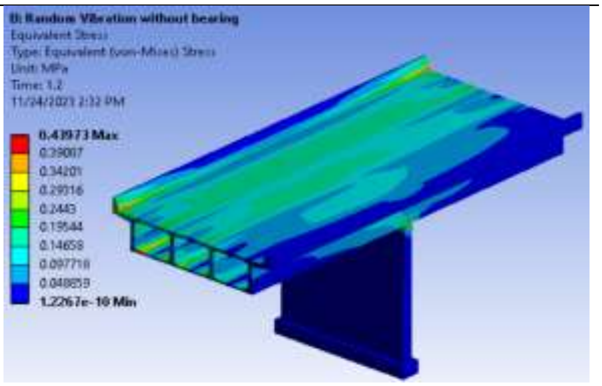
Normal Stress



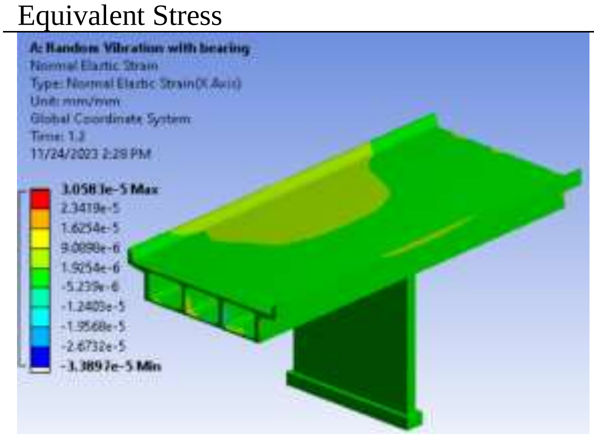
Normal Stress



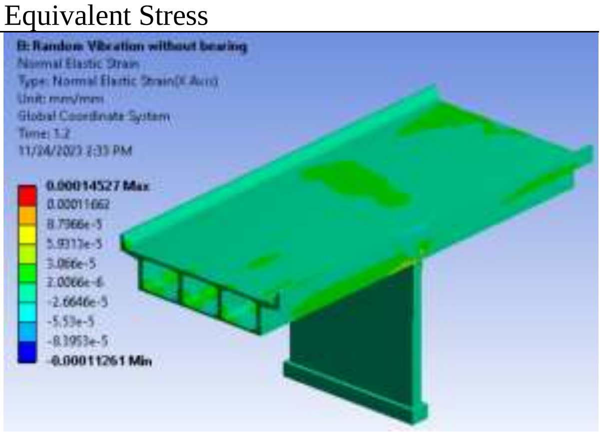
Equivalent Stress



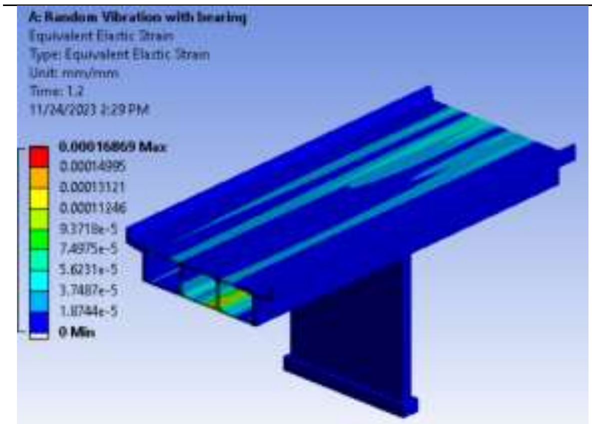
Equivalent Stress



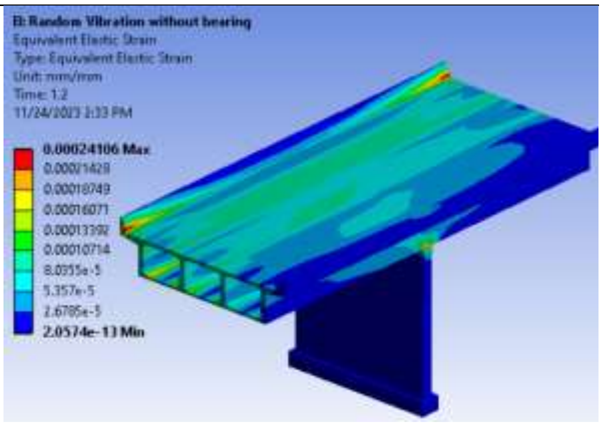
Normal Elastic Strain



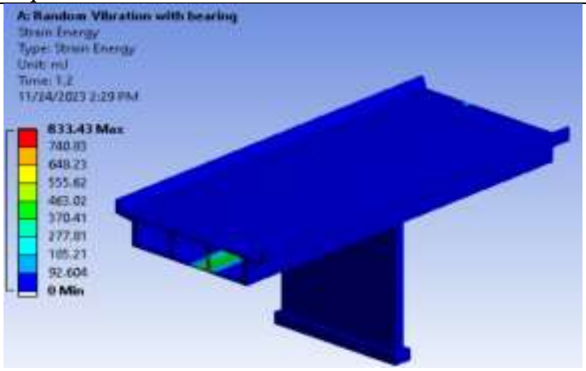
Normal Elastic Strain



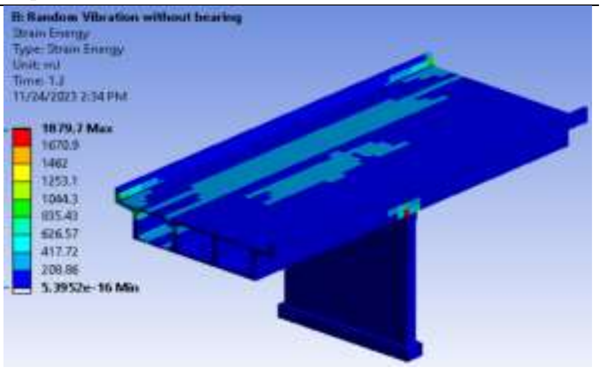
Equivalent Elastic Strain



Equivalent Elastic Strain



Strain Energy



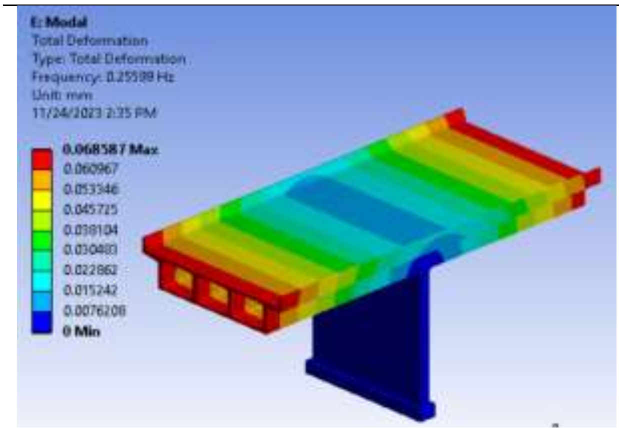
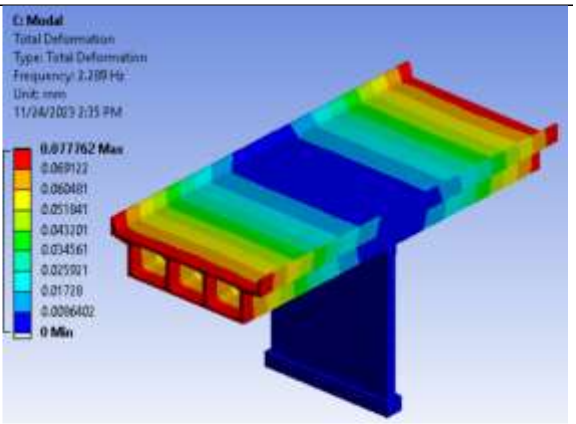
Strain Energy

D. Modal Analysis

Modal Analysis is used in Finite Element Analysis (FEA) to evaluate the dynamic nature of a system or component and to estimate its natural frequencies. The system's dynamic nature impacts the system's response to generated vibration and dynamic forces.

Table No.4 Results of Modal Analysis

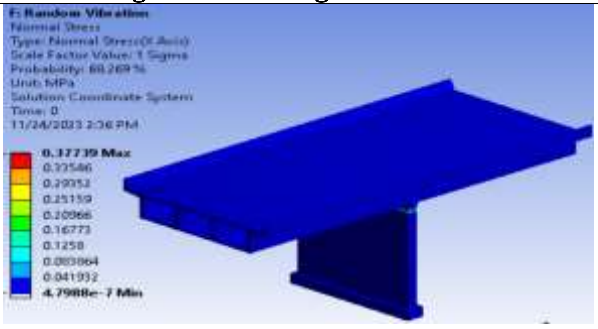
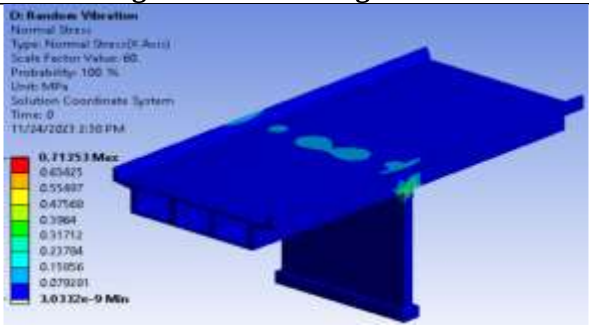
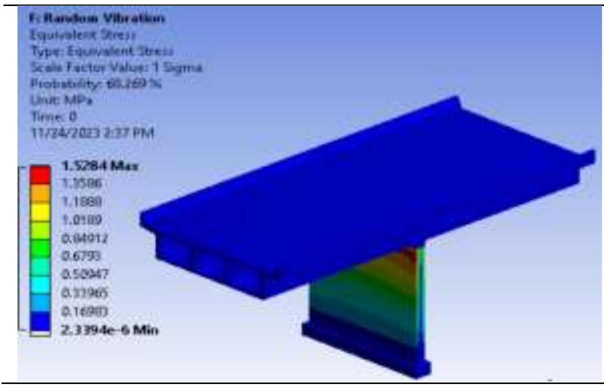
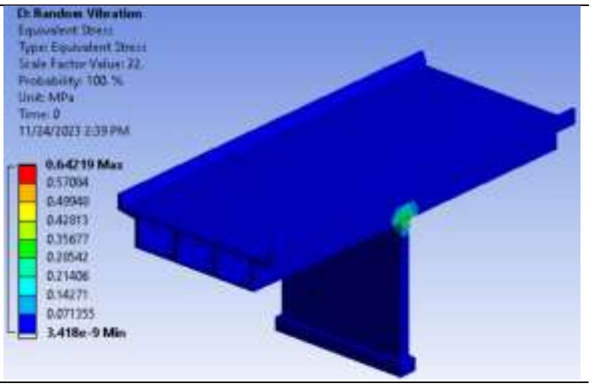
RCC Bridge with Bearing	**RCC Bridge without Bearing**

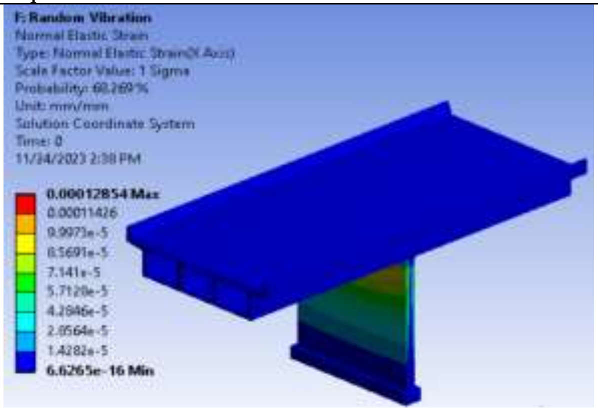
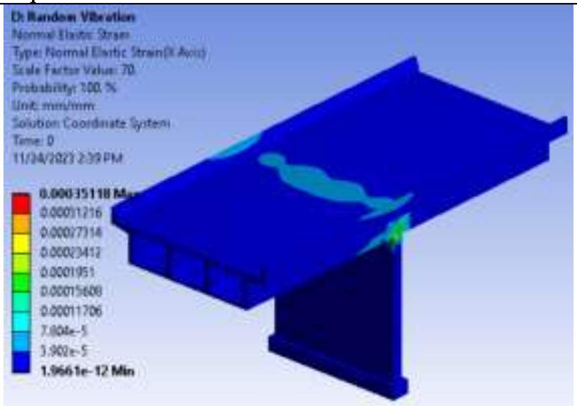
 Total Deformation	 Total Deformation

E. Random Vibration Analysis

While the input excitations in a random vibration study are statistical in nature, the output reactions like as displacement and stress are as well. The spectral density response is often referred to as a response power spectral density (RPSD) at Ansys.

Table No.5 Results of Random Vibration Analysis

RCC Bridge with Bearing	**RCC Bridge without Bearing**
 Normal Stress	 Normal Stress
	

Equivalent Stress	Equivalent Stress
	
Normal Elastic Strain	Normal Elastic Strain

7. RESULTS

Based on the results of the structural, modal, and random vibration evaluations, the RCC bridge with bearings was determined to be the most effective model.

A. Structural Analysis

- **Total Deformation**

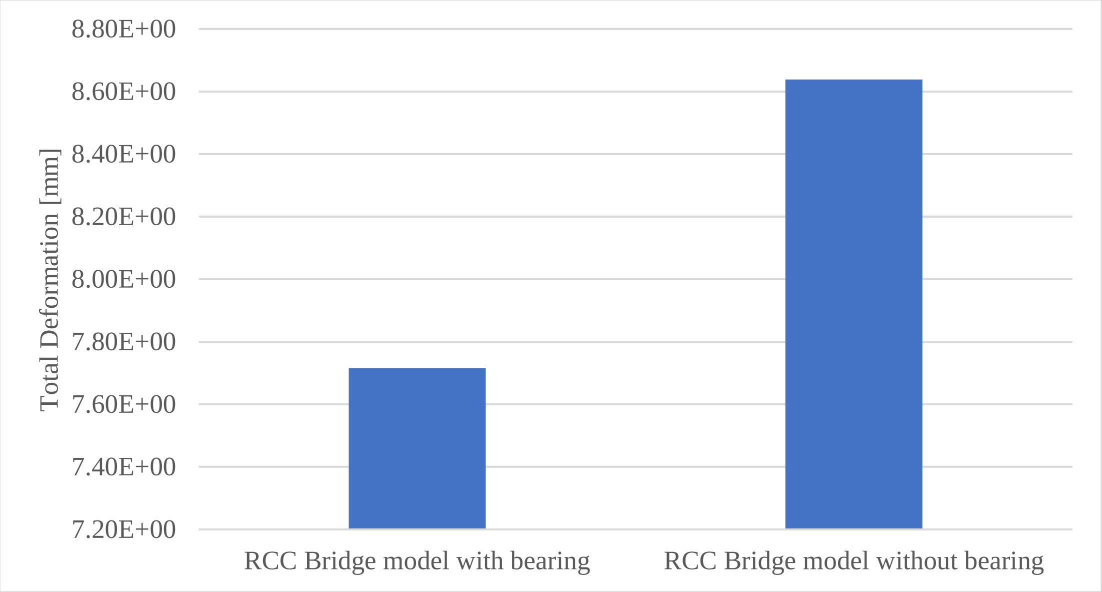


Figure No.8 Total Deformation

Comparing the two values, it appears that the RCC bridge model without bearings has a slightly higher total deformation (8.64) compared to the RCC bridge model with bearings (7.72).

- **Normal Stress [Mpa]**

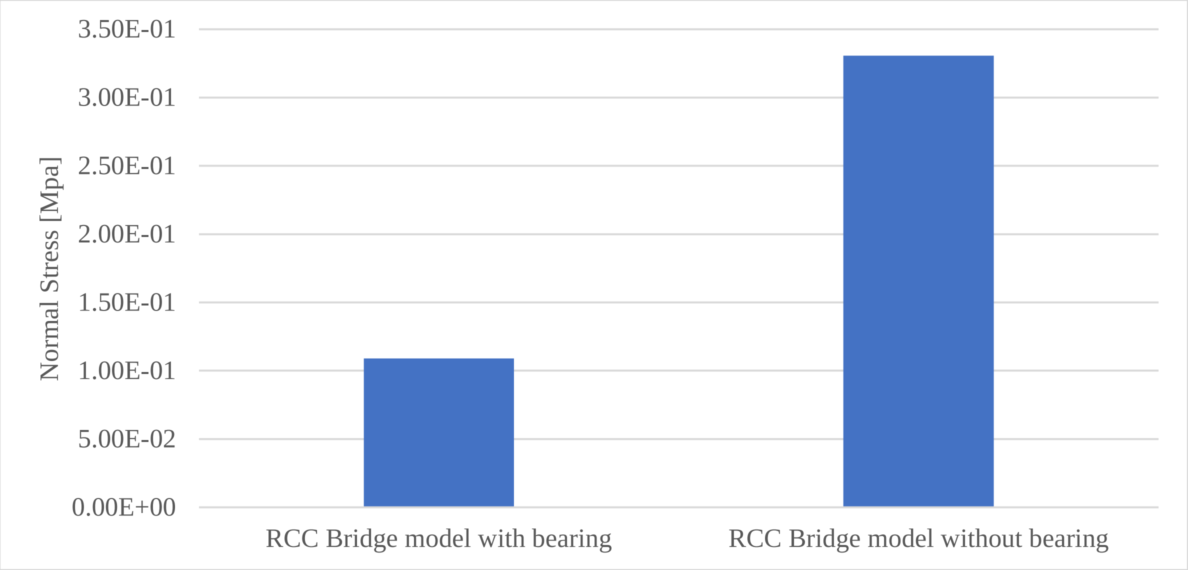


Figure No.9 Normal Stress

Comparing the two values, it is evident that the RCC bridge model without bearings has a significantly higher normal stress (0.331) compared to the RCC bridge model with bearings (0.109).

- **Equivalent Stress [Mpa]**

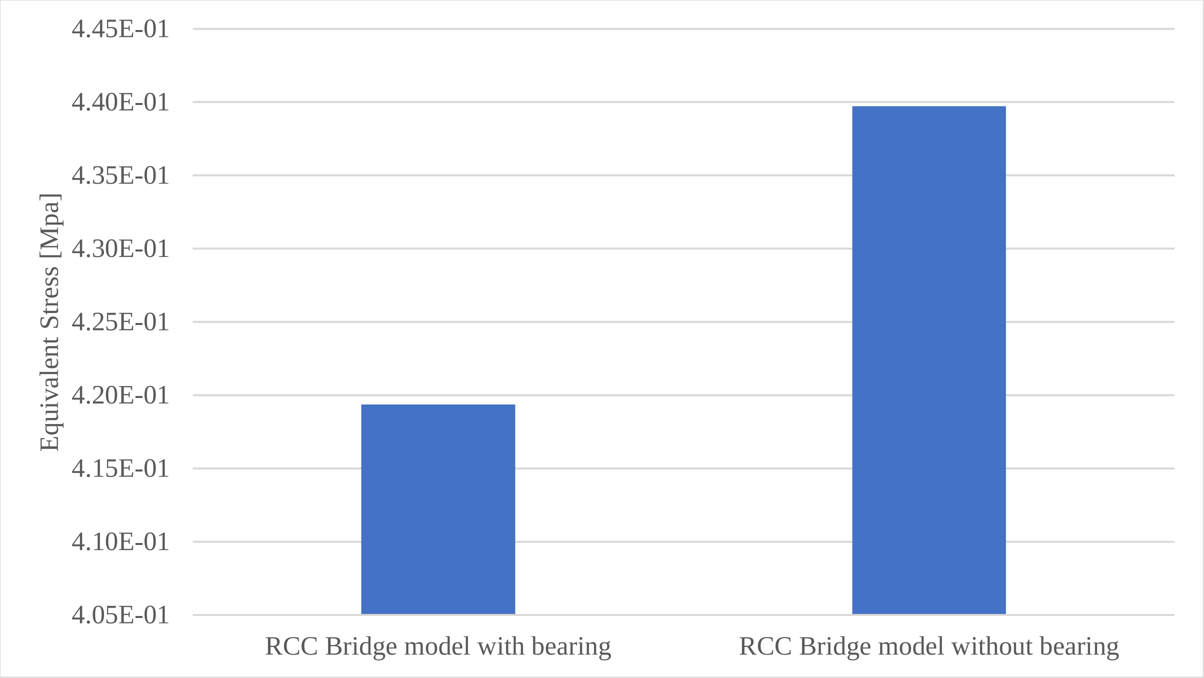


Figure No.10 Equivalent Stress

Comparing the two values, it appears that the RCC bridge model without bearings has a slightly higher equivalent stress (0.440) compared to the RCC bridge model with bearings (0.419).

- **Normal Elastic Strain [mm]**

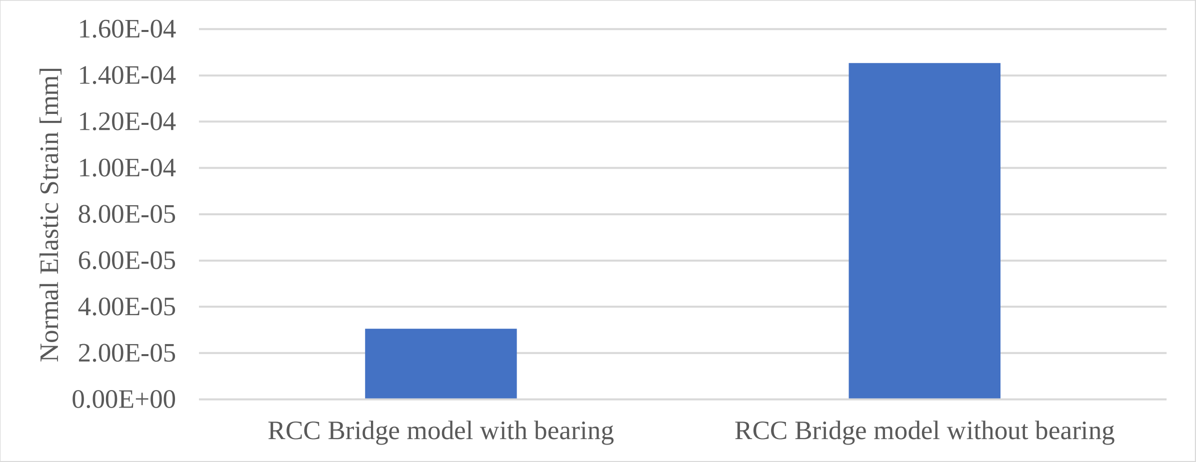


Figure No.11 Normal Elastic Strain

Comparing the two values, it is evident that the RCC bridge model without bearings has a significantly higher normal elastic strain (0.000145) compared to the RCC bridge model with bearings (0.0000306).

- **Equivalent Elastic Strain [mm]**

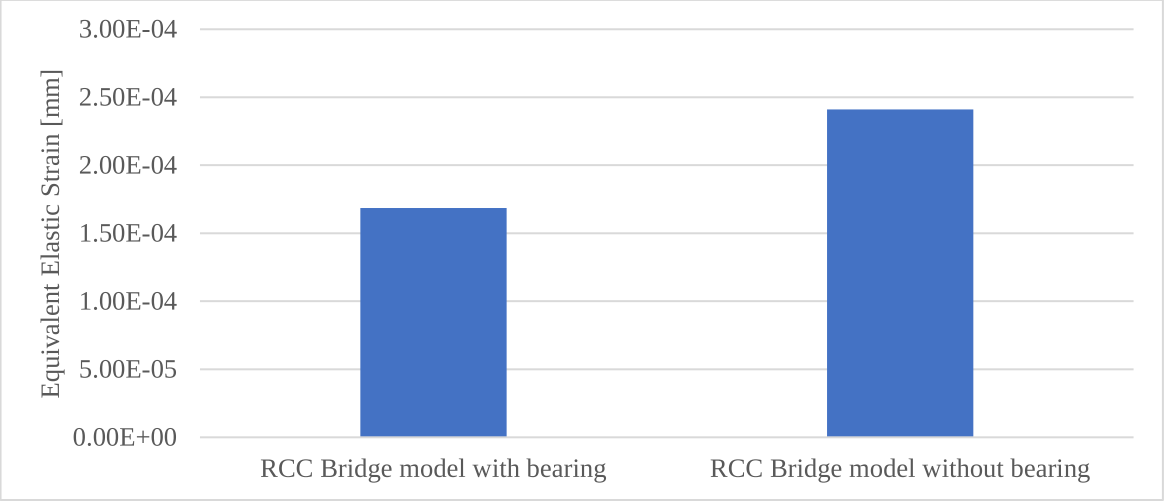


Figure No.12 Shear Elastic Strain

Comparing the two values, it appears that the RCC bridge model without bearings has a slightly higher equivalent elastic strain (0.000241) compared to the RCC bridge model with bearings (0.000169).

- **Strain Energy [mJ]**

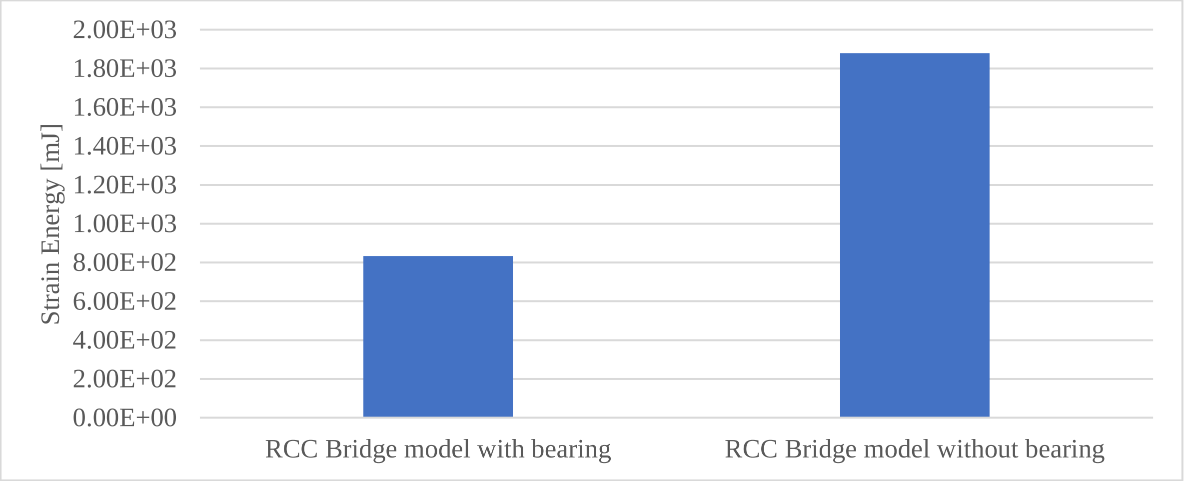


Figure No.13 Strain Energy

Comparing the two values, it is evident that the RCC bridge model without bearings has a significantly higher strain energy (1880) compared to the RCC bridge model with bearings (833).

B. Modal Analysis

- **Frequency [Hz]**

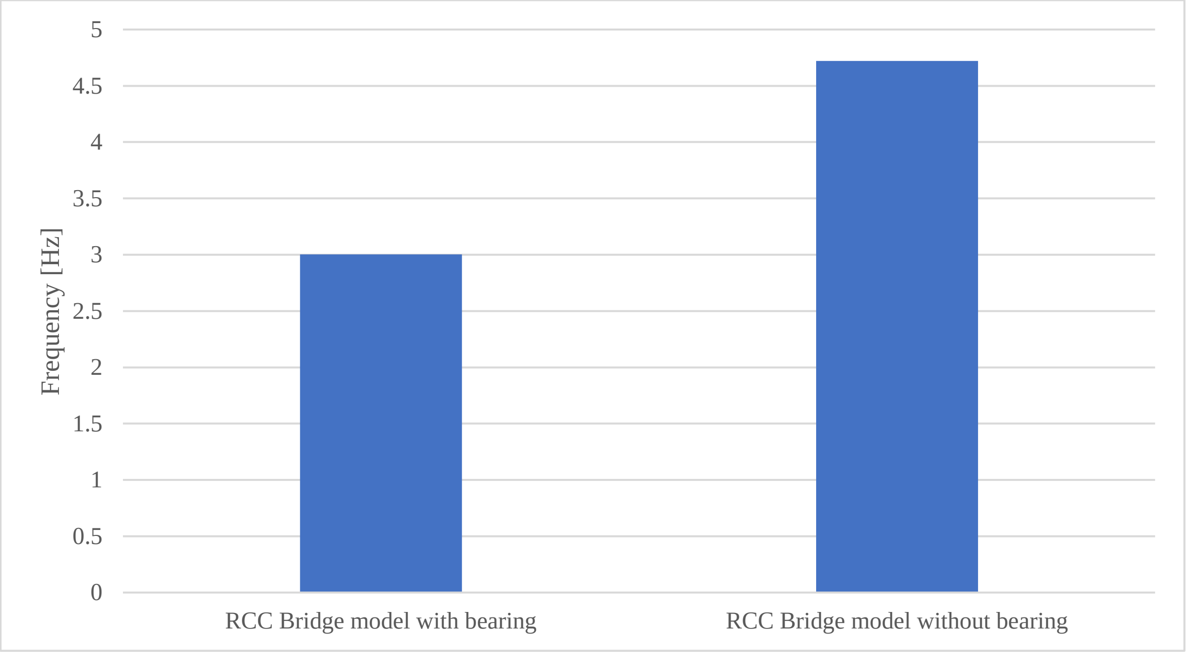


Figure No.14 Frequency [Hz]

Comparing the two values, it is evident that the RCC bridge model without bearings has a higher frequency of vibration (4.7222) compared to the RCC bridge model with bearings (3.0033).

C. Random Vibration Analysis

- **Normal Stress [Mpa]**

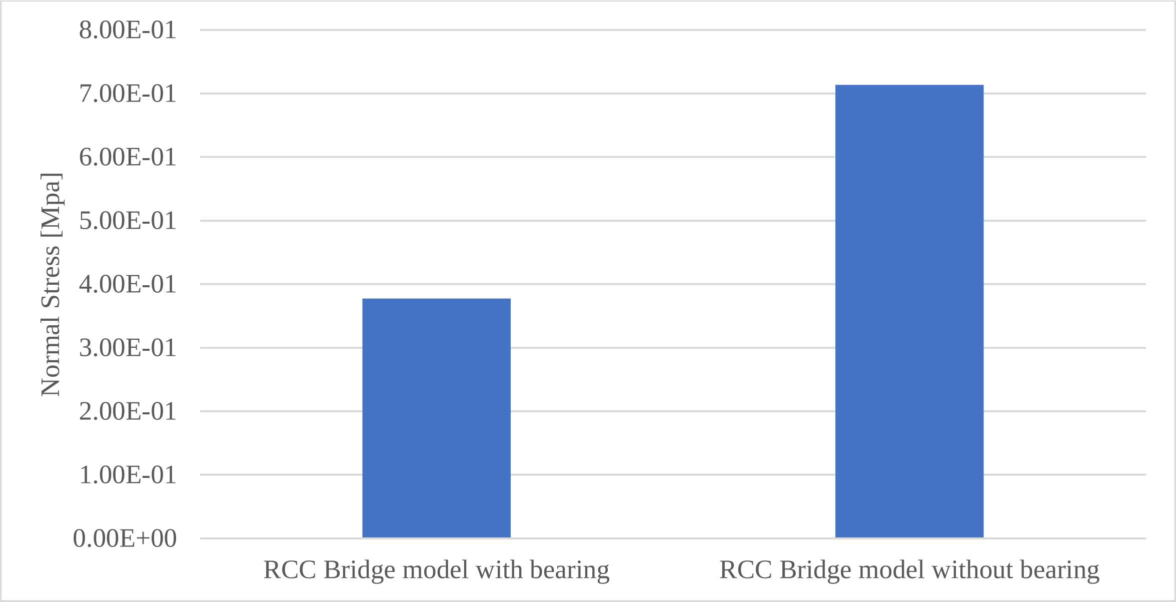


Figure No.15 Normal Stress

Comparing the two values, it is evident that the RCC bridge model without bearings has a significantly higher normal stress (0.714) compared to the RCC bridge model with bearings (0.377).

- **Equivalent Stress**

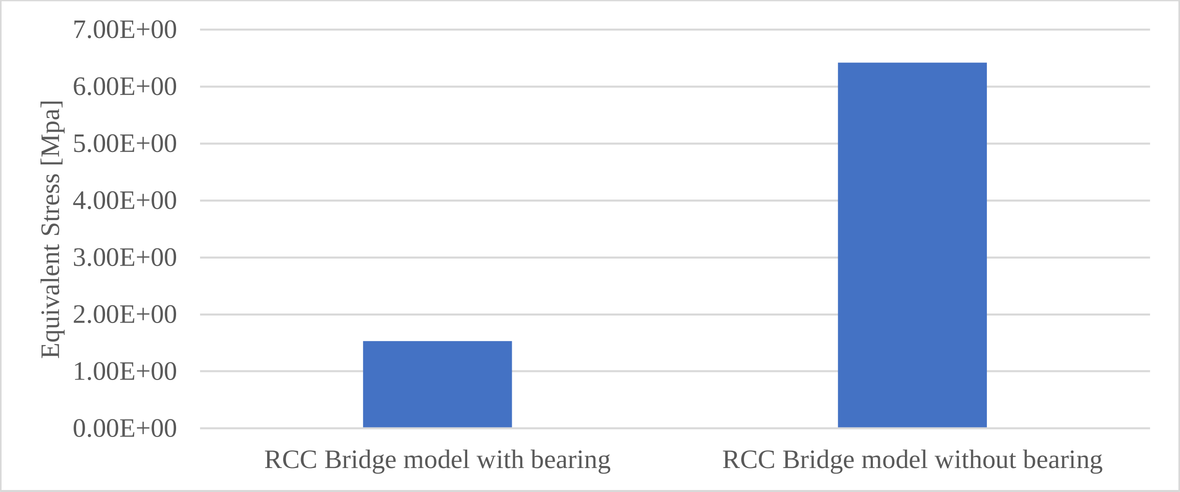


Figure No.16 Equivalent Stress

Comparing the two values, it is evident that the RCC bridge model without bearings has a significantly higher equivalent stress (6.42) compared to the RCC bridge model with bearings (1.53).

- **Normal Elastic Strain**

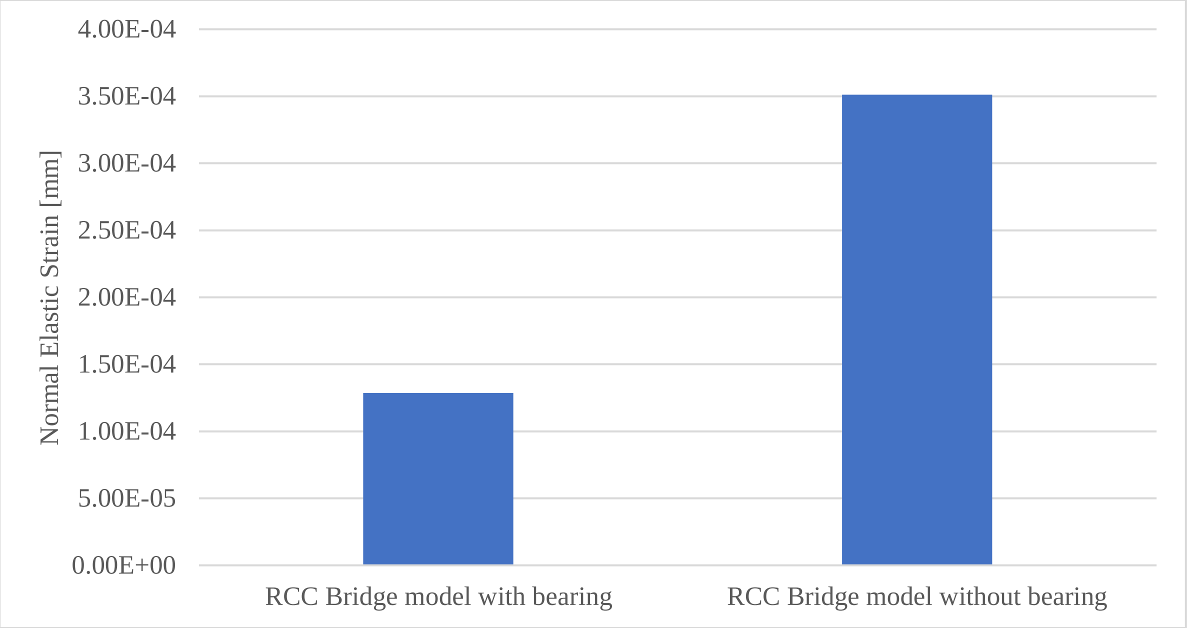


Figure No.17 Normal Elastic Strain

Comparing the two values, it is evident that the RCC bridge model without bearings has a significantly higher normal elastic strain (0.000351) compared to the RCC bridge model with bearings (0.000129).

- **Shear Elastic Strain**

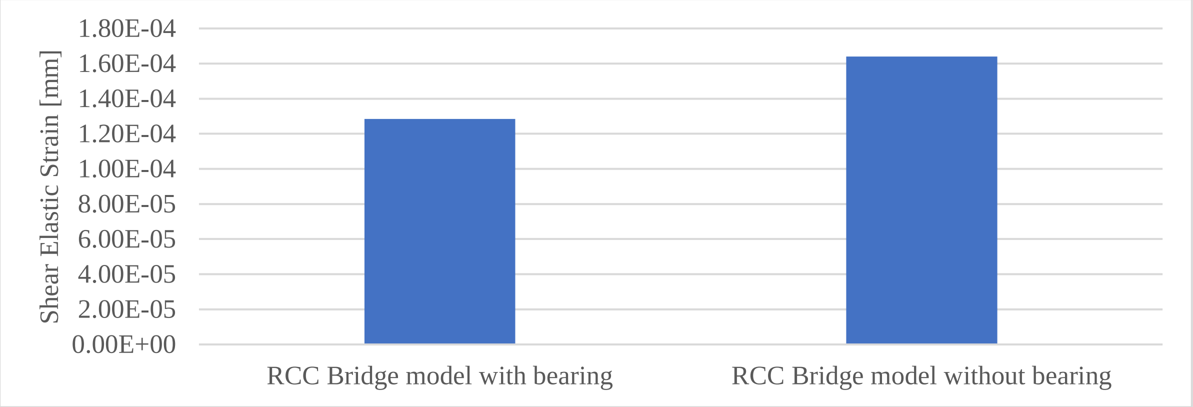


Figure No.18 Shear Elastic Strain

Comparing the two values, it is evident that the RCC bridge model without bearings has a slightly higher shear elastic strain (0.000164) compared to the RCC bridge model with bearings (0.000129).

8. CONCLUSION

The study conducted on the RCC bridge for monitoring its structural health using Ansys provides valuable insights into the structural behaviour, stresses, strains, and overall health of the bridge. The utilization of Ansys, a powerful finite element analysis (FEA) software, has allowed for an assessment of the bridge's performance under various loading conditions. Analysis of the bridge with and without bearings highlighted the impact of bearing support on stress, strain, and overall structural performance. The presence of bearings was found to contribute to a reduction in certain stress components, suggesting that bearings play a role in enhancing the bridge's ability to withstand external forces. The frequency analysis conducted using Ansys provided insights into the dynamic behaviour of the bridge. The differences in vibration frequencies between the models with and without bearings can be crucial for assessing the structural stability and resonance characteristics of the bridge. Examination of strain energy and equivalent stress levels contributes to the overall assessment of the bridge's structural integrity. The study indicated variations in strain energy and equivalent stress between the models, highlighting the importance of factors such as bearing support in influencing the overall stress distribution.

The RCC bridge model without bearings exhibited a 11.92% higher total deformation (8.64) compared to the model with bearings (7.72). A significant difference was noted in normal stress, with the model without bearings having 203.67% higher stress (0.331) than the model with bearings (0.109). The equivalent stress in the model without bearings was slightly higher (0.440) compared to the model with bearings (0.419), with a percentage difference of 5.01%. The normal elastic strain in the model without bearings was significantly higher (373.54%) at 0.000145, in contrast to the model with bearings (0.0000306). The model without bearings exhibited a 42.60% higher equivalent elastic strain (0.000241) than the model with bearings (0.000169). The strain energy in the model without bearings was significantly higher at 1880 compared to 833 in the model with bearings, with a percentage difference of 125.95%. The RCC bridge model without bearings showed a 57.23% higher frequency of vibration (4.7222) compared to the model with bearings (3.0033). These results collectively suggest that the inclusion of bearings has a positive impact on the structural performance of the bridge, leading to reduced deformations, stresses, and strains, as well as improved vibrational characteristics. Therefore, the bridge model with bearings is considered more effective in terms of structural integrity and overall performance.

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