# "Study the Hydraulic and Hydrological Impact On Bridge by using Model Study"

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**Abstract –**

The importance of monitoring the hydraulic and hydrological impacts on bridge structures and the need for efficient prediction of potential damage. Automating bridge monitoring is indeed crucial for ensuring transportation safety and infrastructure resilience. Using new technologies, such as sensors and modeling techniques, can significantly aid in this process. By installing sensors on bridges to collect data on factors like water levels, flow rates, and structural stresses, engineers can monitor the bridge's health in real-time. This data can then be analyzed using predictive models to identify potential issues before they become critical Implementing automated monitoring systems reduces the need for manual inspections and can provide more accurate and timely information about the bridge's condition. Additionally, it allows for proactive maintenance and helps prevent catastrophic failures. While industrial-grade instruments may be expensive, advancements in sensor technology are making cost-effective solutions more accessible. By integrating these technologies into bridge infrastructure, we can improve safety, reduce maintenance costs, and ensure the longevity of these vital transportation assets.

**Key words-** cable bridge, Pamban bridge, deflection, movable bridge, make automative, nano technology, prediction of structural bridge damage, make easy for operation, instrument ,new technology

## 1. Introduction-

The model on based of the movable bridge mostly accuracy provided but the also use for the another any one bridge the most important purpose for the make this report is safe to the human life while the use that type of structure We consider the bridges for the study is Pamban, Annai Indira Gandhi road bridge, Airoli, Bandra Worli Sea Link Bridge, Gadgil bridge Pune, Kakasaheb Gadgil Pune that bridges are locater from the various point and the hydraulic and hydrological performance also change the bridges construction technique the bridge are different type. The Pamban Bridge is a railway bridge that connects the town of Mandapam in mainland India with Rameswaram on Pamban Island. It was opened on 24 February 1914 and was India's first sea bridge . The bridge spans a 2.06 km wide strait between the Indian mainland and Rameswaram Island, with the mainland end of the bridge located at Shrilanka. The pamban bridge had history is A deadly cyclone, overturning the pamban bridge in 1964 I the dark night train was travel and in the middle of the bridge the cyclone in up lift to the 22 ft and the train was slide from the track and whole train into the sea the approximately 200 people was. That reason we take the precaution. Bridges serve as vital infrastructure elements, facilitating transportation and connecting communities. Their structural integrity is paramount for ensuring public safety and maintaining uninterrupted flow of goods and services. Movable bridges have been an essential part of any country's transportation system, their development being in coherence with that of the

development of the highway and railroad systems. Movable bridges have proved to be an economical solution to the problem of how to carry highway and rail lines across an active waterway. The number of movable bridges being constructed are increasing at a fast pace. One of the most important types of movable bridge is the bascule bridge.

The importance of make bridge more safety adopted is the good to know everyone the how was the quality of the bridge and the record frequently so that was easy to understand condition of bridge. That was consider various type of technique and the instrument use. Sensors based study is good and accurate with good record.

## 2. Methodology

### 2.1 Flow Diagram Of Project Work


#### 2.1.1 General

A report on the hydraulic and hydrological impacts on a bridge typically involves a comprehensive study of how water flow and water-related factors affect the integrity, safety, and functionality of the bridge structure. Below is a suggested methodology for conducting such a report.

#### 2.1.2 Define Objectives and Scope

Clearly define the objectives of the study, such as assessing the vulnerability of the bridge to flooding, evaluating scour potential around bridge foundations, or analyzing the hydraulic performance of the bridge during extreme events.

Determine the scope of the study, including the geographic area, the type of bridge(s) under consideration, and the specific hydraulic and hydrological factors to be evaluated.

The study of the bridge and that innovation condition of the bridge before any major defect.

That was make easy to understanding of the real time condition of the bridge.

That was easy to observe the bridge and the make the proof in x-erox .

That was very easy to use and its accuracy is very good.

The are main purpose for the make more automation in the bridge is in Pamban Rameshwaram that location construct new lift bridge that's work in process so we think the study of the topic is use-full for the bridge and also much another bridge.

### 2.1.3 Gathering the study material

Gather relevant data on the bridge(s) under study, including design plans, construction details, and maintenance records. Collect hydrological data such as rainfall records, river discharge measurements, and floodplain mapping. Obtain hydraulic data, including water flow rates, water levels, and velocity profiles. the data collect from various website and such data collect from the private web. The another data gate from the visit to bridge and collect the data. The data collect from the various sources.

### 2.1.4 Identifying study area

we are considering various area and various change in the hydraulic and hydrological impact on bridge

first preference to the Pamban Rameswaram bridge cause the suffering from the big accident in India the 200 people should be die so we collect all the details of the bridge and identify the my methodology was use-full for the bridge the impact of most is hydraulic and also hydrological more. and the bridge was importance is more for the transportation.

Next we consider the we same bridge in Rameshwaram but the bridge was constructed for cars transportation that height is so high the flood condition the impact only hydrolic pressure and hydraulic impact was so minimum the bridge name is Annai Indira Gandhi road bridge.

Then we consider next bridge is critical for construction and that was very importance matter for transportation and the bridge cote is so high the bridge name is Airoli Bridge and the bridge is located in the new-Mumbai. The bridge was constructed curve alignment

The next bridge was consider in Mumbai the Bandra Worli Sea Link the bridge is suffering from the more impact of hydraulic and hydrological impact and the bridge is more importance matters so for prevention of the impact on bridge the use cable suspension bridge and the make span between pier .

That are various locations consider for the more better accuracy gate.

Next we visit to the 2,3 bridge in Pune and the bridge was near to the Narayan Peth the name of the bridge is Kakasaheb Gadgil bridge and also another bridge was place front and back to near the bridge.

### 2.1.5 Analyzing importance

The importance of make more automative of the bridge is the for safety of human life that so importance matters. The was instrument use for the safe more and identify the life of the bridge also. The useful for the easy to provide data for regarding the structure of the bridge and also identify the structural behaviour of the bridge.

### 2.1.6 Hydrological Analysis

Use hydrological models to analyze the rainfall-runoff relationship in the watershed upstream of the bridge. Estimate design floods and determine the flood frequency analysis to assess the probability of different flood events occurring.

### 2.1.7 Hydraulic Analysis

Utilize hydraulic models to simulate water flow conditions around the bridge. Evaluate the bridge's hydraulic capacity under various flow scenarios, including normal flow conditions, peak flow events, and flood conditions. Assess the potential for scour around bridge foundations using appropriate methodologies and models.

### 2.1.8 Use instruments

The various instrument use for the identify structural behaviour of the bridge.

Instrument name is accelerometer, tilting, ultrasonic sensor, optical fiber, water level sensor, etc.

Instrument make easy to work with accuracy.

Accelerometer sensor work to identify the x coordinate y coordinate and z coordinate while any small deflection in the bridge the show on screen

Tilting sensor are take reading of the any tilt deflection in the bridge the show on screen with good accuracy.

Ultrasonic sensor are measure the clearance between the bottom of the bridge slab and the water level that was directly show on the screen

Optical fiber sensor measure the traffic volume sensor movement on the bridge and that show any gap on the bridge and gap width or length

Water level sensor are show the water level in the lamp while the increase the level of the safety the blow the red lamp.

Much more sensors use are show below

### 2.1.9 Data inspection

All the instrument work in model base bridge and take readings and slotted easy way. The reading was use to find out structural behaviour and the show readding in very easy all the details about instrument the show below.

### 2.1.10 Discussion about the outcome

The are outcome in the graph and also in the readings. various instrument outcome should be produced in various format the are detail specify below in result . the results are provide in easy way and that was good to identify the deflection in the bridge.

### 2.1.11 Risk Assessment:

Conduct a risk assessment to identify potential hazards and vulnerabilities associated with hydraulic and hydrological factors. Evaluate the consequences of bridge failure or damage due to flooding, scour, or other hydraulic events. Quantify the risk using techniques such as probabilistic risk analysis or risk matrices.

### 2.1.12 Mitigation Strategies:

Propose mitigation measures to address identified risks and vulnerabilities. Consider structural modifications, such as retrofitting bridge foundations or strengthening superstructures to withstand hydraulic forces. Recommend non-structural measures, such as improved maintenance practices, early warning systems, or land use planning to reduce flood risk.

### 2.1.13 Verify Impact on various point on bridge

The water are affected in the various part on the bridge in various type damage such as corrosion hydraulic impact ice pressure etc are effect on the bridge and also tilting of bridge deflection of the bridge that's everything was measure and identify the problem in the bridge and we easy to find the solution on it.

### 2.1.14 Report Writing

Summarize the findings of the study, including key data, analysis methods, and results. Provide recommendations for bridge management, maintenance, and future design considerations based on the study findings. Include relevant figures, tables, and maps to illustrate the hydraulic and hydrological impacts on the bridge.

### 2.2 Details of Model Design

Model was constructed by the foam sheet and base with MDF sheet the bridge was opening and closing by the use of servo motor and servo driver the should be open and close properly. Then the sensors attached to the bridge is given below. For the sensor work use the Arduino IDE

1) **Accelerometer:** The accelerometer was use to the measure small deflection or seismic forces acting on the bridge. The bridge was resist ice pressure, wind pressure, seismic wave and self-weight the forces acting on the bridge then bridge deflect in the small measure that small change is not catch by the eye observation or survey structural monitoring but the small deflection show on screen as you need that should be show on the screen as we need time they provide data.

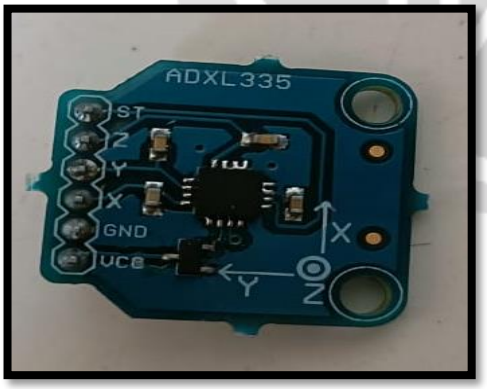



Fig. Accelerometer sensor

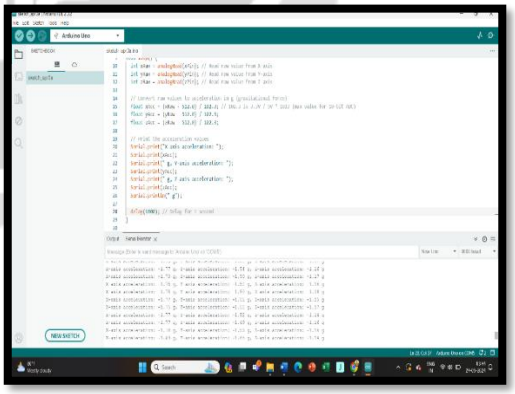


Fig. Reading's record on screen

2) **Ultrasonic sensor:**

The sensor are use for the measure distance of the object such as level of water distance of ship and the sensor use ton the clearance in between the slab of the bridge and water level that instrument was attach to the pamban bridge so the accident of the 200 people was should be alive. But we use the instrument another that type of accident try to prevent.

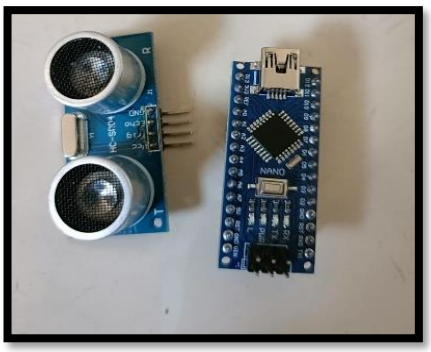


Fig. ultrasonic sensor b

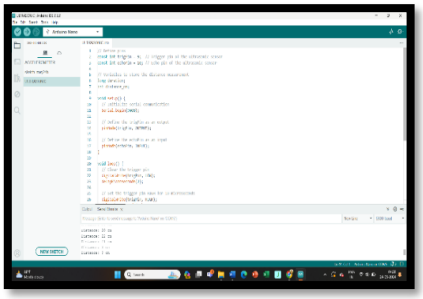


Fig. This show the depth of slab

**3) Tilt sensor:**

The sensor was use for the measure tilting of the bridge the was show direct while the tilt of the structure and the measure tortional movement of bridge

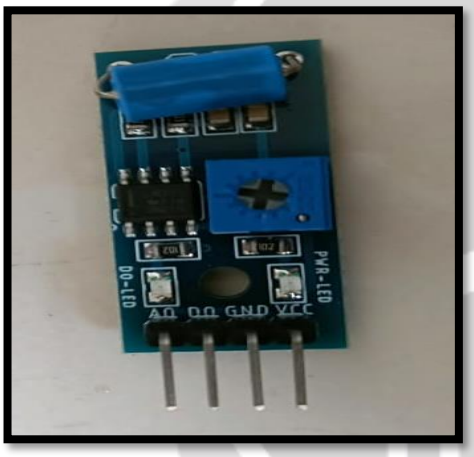



Fig. tilt sensor

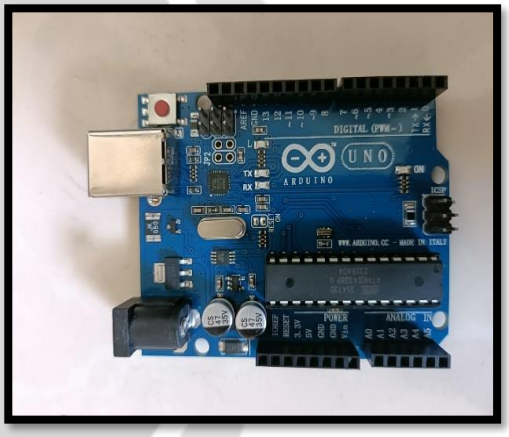



Fig. Arduino

**4) Water level sensor**

The sensor is more important and easy to install that was use with the electric magnate and as per the height should be increase the lamp blow and the 3 stag are marked on the lamp 1st is safe WL 2nd is high WL 3rd is in danger but the not show the accurate depth only the was show the level

As like that so many sensors are available in market but we think not all but the 3,4 are compulsory to attach bridge for safety of human life

5) **Optical fiber sensor:**

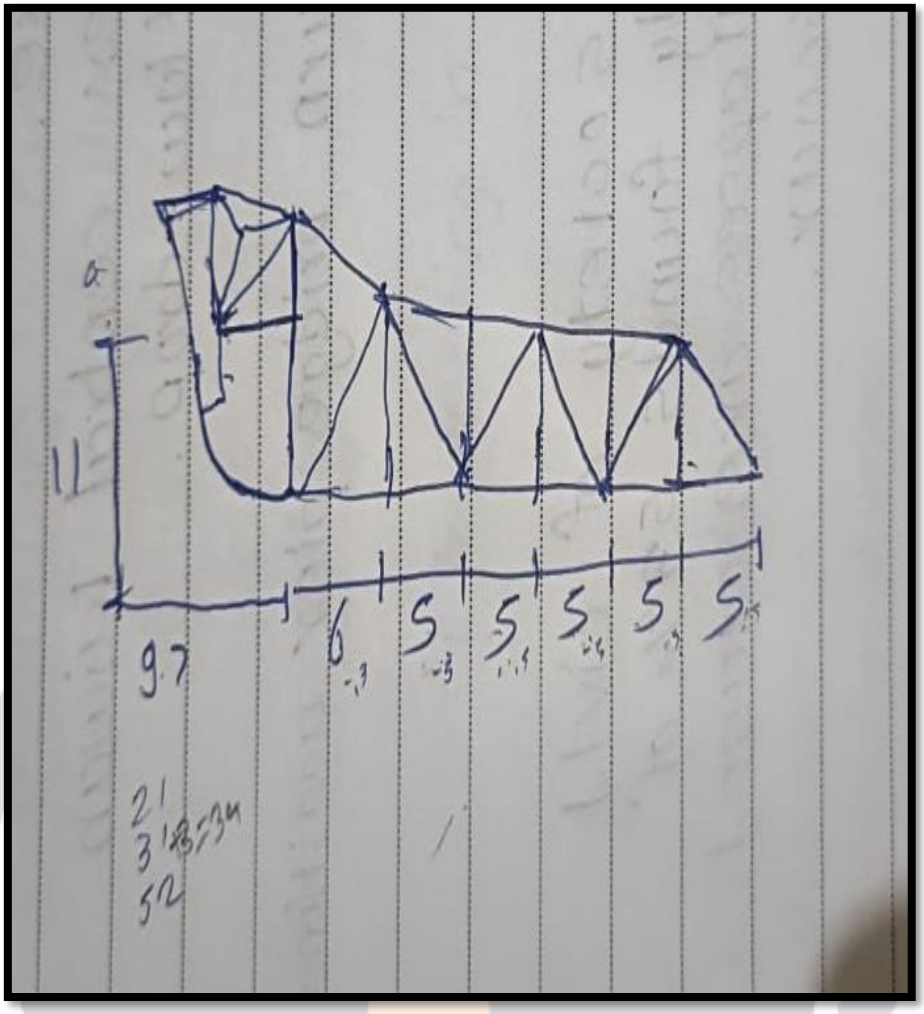
The optical fiber was use to the traffic volume and to measure the crack in between the bridge the sensor are so expensive and the accuracy is very good and also that was many work obtain and data collected at a time


Fig. Optical fiber

**2.3 Details of Model Design**

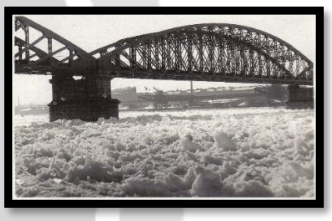
We make the model of pamban bridge the bridge was opening and close the bridge was conduct sensors of HFL level measure instrument, clearance of bridge and water surface by ultrasonic sensor, tilt sensor for tilt and small changes in bridge , accelerometer for in small changes in bridge by heavy load vehicle moving on bridge the contraction and expansion in joint measure , optical fiber was use in very small deflection or minimum moment on bridge is capture .Much more instruments are in the industry but we cant affordable that’s

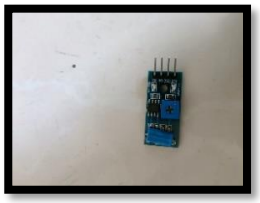
The bridge operating use the server moter and server driver for operating opening and closing of the bridge the bridge attach the all sesors and the readings are given in the Arduino IDE very accurate . For the bridge use the PVC foam sheet , and for the base use the MDF ply sheet .

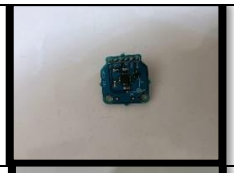
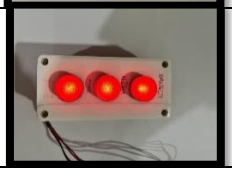


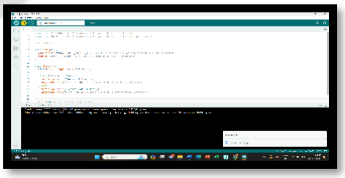
**2.3Observation Table**

| SR. NO | BRIDGE NAME | HISTORY | HFL | YEAR |
|---|---|---|---|---|
| 1. | Pamban rameshwaram | A deadly cyclon ,overturning the pamban bridge | 22M | 1964 |
| 2. | Annai Indira Gandhi road bridge | Make the smooth passage of ship under it | 22M | 1988 |
| 3. | Airoli Bridge | Connected suburban area of navi mumbai | not detailed in commonly public | 1999 |
| 4. | Bandra Worli Sea Link | First cable stayed bridge | NDP | 2000 |
| 5. | Gadgil bridge | Frequently in rainy season that HFL in high | NDP | 1768 |
| 6. | Kakasaheb gadgil | Its unique shape | NDP | 1768 |

| SR.NO | HYDREAULIC AND HYDROLOGICAL PROBLEM | DETAILS OF PROBLEM | PHOTO |
|---|---|---|---|
| **1.** | Scour | Scour to below of pile ,pier,abutement |  |
| **2.** | Hydraulic Loading | Impact on pillars |  |
| **3.** | Flood Considerations | Over flow of water and stop transportation |  |
| **4.** | Ice Accumulation | Impact to pressure on upstream side |  |
| **5.** | corrosion | Steel Piles are very quick corrosion |  |

| SR.NO | DEFINE PROBLEM | INSTRUMENT USE | PHOTO |
|---|---|---|---|
| 1. | scour | Ultrasonic sensor |  |
| 2. | Alignment or deflection of bridge | Tilt sensor |  |

| | | | |
|---|---|---|---|
| 3. | Movement or seismic forces | Accelerometer sensor |  |
| 4. | Water level | Magnetic level check sensor |  |
| 5. | Expansion contraction | Temperature sensor |  |
| 6. | Heavy traffic volume study | Optical fiber sensor |  |
| 7. | Strain gage | Strain gage sensor |  |

| SR.NO | INSTRUMENT NAME | INSTRUMENT OPERATION | FIND OUT READING | PHOTO OF OPERATING |
|---|---|---|---|---|
| **1.** | Ultrasonic sensor | The sensor are detect the depth of water | As per the depth |  |
| **2.** | Tilt sensor | Measure the tilting of the bridge | Nothin reading show while do not disturb |  |
| **3.** | Accelerometer sensor | Movement of the bridge | Show small and small changes as per time and as per the length |  |
| **4.** | Magnetic level check sensor | Check flood water level | The sensor are check the water level in 3 part 1 safe 2 high 3 is danger |  |

### 2.4 Scour Analysis and Prediction

There are Various type of technique present for measuring the scour depth. There are two technique are selected because that provide good accuracy and in use of this technique is very easy so we adopted that technique

1) Scour depth measure by ECHO SOUNDER (sonar): this is the use in the ship instrument and the can measure the perfect depth under the water. This instrument is usable for meters under the water ground should be measure. But in some case they can't measure depth as required time, so much another instrument is use. Sonar, or Sound Navigation and Ranging, is a technique that uses sound waves to navigate, measure distances, and detect objects underwater. It's useful for exploring and mapping the ocean because sound waves travel farther in water than radar and light waves


2) Hand lead line: this is easy method to measure depth of the water. The lead is the weight of the metal that's so heavy and rope under the 20-30 m is reliable and accuracy is good and also we attach the camera for the exact condition identify under the water to the pile also identify the pile condition that was need to colour on need to apply anti corrosive colour apply or epoxy material. this i0s so easy method for operate.

### 2.5 Scour prevention technique

Riprap and gravel: Place a layer of large, durable rocks or concrete blocks around the base of a structure, provide at the pier foundation and also at the abatement for erosion

Geotextiles: Install permeable fabrics in multiple layers to stabilize the soil around a structure

Armor placement: Place riprap or other materials around bridge piers or abutments to protect against erosion

Grout injection: Inject grout into the soil around bridge piers or abutments to stabilize the soil and prevent erosion

Monitoring and maintenance: Regularly monitor and maintain bridge structures to identify potential scour problems before they become serious issues

Change the current flow: Change the flow of the current or the shape of the foundation at the sea bed

Change the material: Change the material of the seabed the river bed was change with murrum soil. While in the shape of rivel is v and depth is sufficient or more catchment area than water level then concrete cube or stone cubes.

## 3.Conclusion

The conclusion drawn from utilizing models to monitor the hydraulic and hydrological impacts on bridges suggests a significant improvement in detecting changes and deflections in bridge structures. This methodology streamlines the process of observing variations, particularly in terms of scour prevention, which is vital for ensuring the longevity of bridge infrastructure.

By employing these methods, we can effectively enhance the lifespan of bridges, mitigating the risks associated with structural damage due to hydraulic and hydrological factors. Furthermore, the ease of adopting these techniques makes them accessible for widespread implementation across various bridge projects.

Riprap and gravel
Place a layer of large, durable rocks or concrete blocks around the base of a structure
Geotextiles
Install permeable fabrics in multiple layers to stabilize the soil around a structure
Armor placement
Place riprap or other materials around bridge piers or abutments to protect against erosion
Grout injection
Inject grout into the soil around bridge piers or abutments to stabilize the soil and prevent erosion
Monitoring and maintenance: Regularly monitor and maintain bridge structures to identify potential scour problems before they become serious issues
Change the current flow: Change the flow of the current or the shape of the foundation at the sea bed
Change the material: Change the material of the seabed the use of the material such as stone concrete block and murrum

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5) Check publication from google art and culture Pamban Bridge - The one-off span to Rameshwaram An engineering marvel of yesteryear, the Pamban Bridge is 103 years old and still counting. By Rail Enthusiasts' Society Ravi Sunderarajan
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