



सत्यमेव जयते  
Ministry of Science & Technology  
Government of India

## **Project Proposal On**

*"Seismic Risk Mitigation and Damage Assessment Strategies for  
Temple Structures A Comprehensive Approach"*

**Submitted to**

**Division :SHRI**

**Programme or Scheme : Science and Heritage Research Initiative  
SHRI**

**Submitted by**

**Project Investigator:**

Dr. vijayalakshmi

**K S SCHOOL OF ENGINEERING AND MANAGEMENT-Bangalore**

## Part 1 : General Information

## General Information:

1. Name of the Institute/University/Organisation submitting the Project Proposal :

K S SCHOOL OF ENGINEERING  
AND MANAGEMENT

2. State

Karnataka

3. Principal Investigator Name:

Dr. vijayalakshmi

4. Category:

General

5. Type of the Institute :

Academic Institutions (Private)

6. Project Title :

Seismic Risk Mitigation and Damage Assessment Strategies  
Structures A Comprehensive Approach

7. Division :

SHRI

8. Programme Or Scheme :

Science and Heritage Research Initiative SHRI

9. Academic Area :

Civil Engineering,

10. Application Area :

11. Government National Initiative : Smart Cities, Aatmanirbhar Bharat,

12. Type of Proposal :

Proposal Against Call

13. Project Duration :

2 Years

14. Proposal Submit Date :

24/03/2023

15. Project Keywords :

Temples, Seismic behavior, Fragility curves, Risk assessment

16. Project Summary :

The seismic response of temples in India is a topic of great interest as the country is located in a region. Studies have shown that the seismic behaviour of temples depend on various factors such as used in construction, the geometry of the structure, the quality of workmanship and the foundation. The structure response of a temple to an earthquake can be evaluated by analysing its dynamic characteristics, natural Frequencies and mode shapes and by assessing the potential damage that could occur. There is a need to investigate the structural vulnerability of temples and to develop appropriate techniques, such as addition of seismic resistant elements and strengthening the existing structures. Some measures that have been proposed to improve the seismic behaviour of temples include development of new construction techniques that are designed to withstand the earthquake forces.

1. To identify the different styles of temple architecture for study

2. To procure the necessary permissions from Archeological department and Geological survey department

3. To document the building selected

4. Preparing the models of beam columns to suitable scale

5. To do shake table analysis, to obtain natural frequency, time period and other parameters

6. To design the capacity of shear key

7. To numerically model the building and validate the results

8. To draw fragility curves based on experimental and simulation studies

## Part 2: Particulars of Investigators

### Principal Investigator:

Name: Dr. vijayalakshmi  
Gender: Female  
Date of Birth: 01/07/1965  
Designation : professor  
Department: civil  
Institute/University: K S SCHOOL OF ENGINEERING AND MANAGEMENT  
State: Karnataka  
District: Bengaluru Urban  
City/Place: bangalore  
Address: 15, mallasandra, off kanakapura road, bangalore  
Pin: 560109  
Communication Email: hod.civil@kssem.edu.in  
Alternate Email: vijaya.akella@gmail.com  
Mobile: 9845399068  
Phone: 08028425012  
Category: General

### Investigator:

Name: Dr. K Rama Narasimha  
Gender: Male  
Date of Birth: 23/07/1971

**Designation :** Principal  
**Department:** Mechanical  
**Institute/University:** K S SCHOOL OF ENGINEERING AND I  
**State:** Karnataka  
**District:** Bengaluru Urban  
**City/Place:** Bangalore  
**Address:** 15, mallasandra, off kanakapura road, B  
**Pin:** 560109  
**Communication Email:** principal@kssem.edu.in  
**Alternate Email:**  
**Mobile:** 9900633688  
**Phone:** 08028425012  
**Fax:**  
**Category:** General

### Part 3: Suggested Refrees

**Suggested Refrees: NA**

### Part 4: Financial Details

**Financial Details:**

#### A. Non - Recurring

Equipment

S.	Equipments	Qty.	Justification	1 Ye
1.	accelerometers	1	to connect to various points to measure	3
2.	DAC	1	Instrumentation to take reading, analyzing with software and storing data	3
3.	servo shake table	1	Shake table to study the seismic response of various types of beam column joints	18
4.	vibration analyser software,	1	to analyse the data	3
<b>Total</b>				<b>27</b>

Other NonRecurring

Description	Justification	1 Year	2 Year	Total
consumables	model making with the stone used in the temple	700000	0	700000
contingencies	unforeseen expenditure	200000	200000	400000
manpower	experimental setup, preparing model, testing	320000	320000	640000
overhead charges	office accounts keeping and procuring	100000	100000	200000
shear key	to understand the strength of the joint	0	100000	100000
travel	to and fro for other documentation work	0	100000	100000
travel	to and fro to the selected temple site	300000	0	300000
<b>Total</b>		<b>1620000</b>	<b>820000</b>	<b>2440000</b>

## B. Recurring

### Budget Head Summary in (INR)

Budget Head	Year-1	Year-2	Total
<b>Non-Recurring</b>			
Equipment	2700000	0	2700000
Other NonRecurring	1620000	820000	2440000
Subtotal (Capital)	4320000	820000	5140000
<b>Recurring</b>			
Subtotal (General)	0	0	0
<b>Total Project Cost (Capital + General)</b>	<b>4320000</b>	<b>820000</b>	<b>5140000</b>

### Part 5: PFMS Details

#### PFMS Unique Code Available: No

Type of Registration : Academic Institutions (Private)  
 PAN Number : AAATK2287R  
 Agency Name : K S School of Engineering & Management  
 Registration No. : S844/52-53  
 Registering Authority : Sub-Registrar  
 PIN Number : NA  
 PAN Number : BLRK01512A  
 GST Number : 29AAATK2287R1ZT  
 Block No /Building /Village /Name of Premises : 15/1, KSSEM  
 Street/Post Office : Off. Kanakapura Road  
 Locality : Mallasandra

<b>City :</b>	Bengaluru
<b>Pin Code :</b>	560109
<b>State :</b>	Karnataka
<b>District :</b>	Bengaluru Urban
<b>Contact Person :</b>	Rama Narasimha K
<b>Designation :</b>	Principal
<b>Phone Number :</b>	08028425012
<b>Mobile Number :</b>	8050773173
<b>Email ID :</b>	principal@kssem.edu.in
<b>Bank Name :</b>	AXIS BANK
<b>Branch Address of the Bank :</b>	Axis Bank, J.P Nagar, 6th Phase, Bengaluru
<b>Bank Branch Name :</b>	J.P Nagar, 6th Phase
<b>Bank Account Number of the Beneficiary :</b>	911010055761116
<b>IFSC Code of the bank :</b>	UTIB0001513
<b>MICR Code of the bank :</b>	560211034

## Part 6: Current Ongoing Project

**Current Ongoing Project: NA**

## List of Uploaded Documents:-

Complete Project proposal

Biodata

Certificate from PI

Conflict of interest

Endorsement from head of Institute

Quotation for Equipments

## Science and Heritage Research Initiative (SHRI)

1. Title of the Proposal:

**“Seismic Risk Mitigation and Damage Assessment Strategies for Temple Structures: A Comprehensive Approach”**

Key Words:

Temples, Seismic behavior, Fragility curves, Risk assessment

2. State: Karnataka

3. Thematic Areas: - (Please tick mark (√))

- i. Conservation Engineering
- ii. 3D Digitization of Heritage Sites/Practices
- iii. Geospatial Mapping
- iv. **Risk Assessment** √
- v. Documentation of Folklore and Culture
- vi. Development of Heritage Clusters
- vii. Centre of Excellence
- viii. Protection of Indigenous Languages
- ix. Science and Technology for Yoga and Meditation (SATYAM)
- x. Any other area related to Science & Heritage

4. Proposed Duration of the Project: **24 months**

5. **Total Cost:** Rs./- **51,40,000**

Recurring Cost: Rs./- 24,40,000

Non-recurring Cost: Rs./- 27,00,000

Contribution by Host Institute (if any) -nil

6. **Principal Investigator:**

6.1.Name: Dr Vijayalakshmi Akella

6.2.Department: Civil Engineering

6.3.Designation: Professor

6.4.Organization/ Institution Name: K S School of Engineering and Management

6.5.Address (Including Telephone (Off & Res, E-mail, Fax))

Off: 9606055906

Res:9845399068

Email: hod.civil@kssem.edu.in

Pin: 560109



6.6.Date of Birth: 01/07/1965

6.7.Sex (M/F): F

6.8.E-mail ID: vijaya.akella@gmail.com

**7. Co-Investigator :**

- 7.1 Name: Dr Rama Narasimha  
7.2 Designation: Principal and Director  
7.3 Department: Mechanical engineering  
7.4 Organization/Inst. Name: K S School of Engineering and Management  
7.5 Address: (Including Telephone (Off &Res), E-mail, Fax),  
Off: 9606055906  
Res: 9900633688  
Email: principal@kssem.edu.in  
Pin: 560109  
7.7 Date of Birth: 23/7/1971  
7.7 Sex (M/F): Male  
7.8 E-mail ID: [principal@kssem.edu.in](mailto:principal@kssem.edu.in)

**8. Capability of the Organization (s):**

(a) Expertise available:

1. The department of civil engineering has 3 professors, and 9 faculty ably mentored by Dr BK Raghuprasad, formerly prof from IISC,Bengaluru. The department also runs a Master's program in Structural Engineering and has a recognized Research center with 10 scholars.
2. The department of civil engineering is well equipped with loading frame, horizontal and vertical shake tables of 400x400mm size, Compressive testing machine, Non-destructive testing equipment. The department is actively involved in consultancy works like material testing, third party verification, mix design solutions, Design of multistoried structures, retrofitting of columns using micro concrete and Carbon fiber reinforced plastic sheets.
3. The Kammavari Sangham, a nonprofit Organization has five institutions namely, KSIT, KSSEM, KSSA, KSPUC, KSP and the campuses are located in south Bengaluru, and the Sangham (trust) is into educational field since 30 years.

4. The P I was awarded a fund of 20 lacs from Vision group of science and technology to perform Dynamic analysis of heritage structure, Amruthapura temple, located in Karnataka. The P I has experimentally found the Natural frequency of the structure, analyzed the building in finite element software and validated the data. An attempt is also been made to study the joints in the masonry structures.
5. The Institute is also well equipped with workstations and licensed software like ANSYS, ETABS, AUTOCAD etc. to do the numerical analysis of the temples.

(b) List of on-going and completed projects giving the following details:

Project Title	Start Date	Completion Date	Project Cost	Sponsoring Organization
Dynamic Analysis and Retrofitting of Heritage Buildings in South India	20/6/2016	Completed 15/11/2022 (Second instalment was released only in 2019)	Rs. 20,00,000/-	Vision Group of Science and Technology
Analysis of Groundwater Potential Zones using Electrical Resistivity, Remote Sensing and GIS Techniques in Bidadi Industrial Area, Ramanagaram Taluk, Karnataka	15-06-2019	17-12-2019	Rs. 1,50,000/-	Visvesvaraya Technological University
Probabilistic Prediction of Earthquakes and Sustainability of Heritage Structures under High Seismic Activity (National seminar)	24-02-2020	25-02-2020	Rs. 50,000/-	DST-SERB
Performance of Climatic Responsive Buildings- A Qualitative and Quantitative Approach (National seminar)	10-06-2022	11-06-2022	Rs. 1,50,000/-	DST-SERB

## B. TECHNICAL DETAILS

### 1. Background

#### 1.1 Description of problem:

As per National Disaster Management Authority, the current seismic zone map of the country (IS 1893: 2002) shows over 59 per cent of India's land area is under threat of moderate to severe seismic hazard, that means it is prone to shaking of MSK Intensity VII and above (BMTPC, 2006). In fact, the entire Himalayan belt is considered prone to great earthquakes of magnitude exceeding 8.0, and in a relatively short span of about 50 years, four such earthquakes have occurred: 1897 Shillong (M8.7); 1905 Kangra (M8.0); 1934 Bihar-Nepal (M8.3); and 1950 Assam-Tibet (M8.6)

Temples are built using stone masonry in India since ancient times. Temples are an integral part of India's cultural, social and religious fabric. Some of the famous architectural styles include Dravidian, Nagara and Hoysala. Joint details in stone masonry are an important aspect of temple architecture, as they play a critical role in determining the structural integrity and aesthetic appearance of the building. The type of joints used can be dry masonry joint, mortar joints or Metal Dowels and cramps.

The seismic response of temples in India is a topic of great interest as the country is located in seismically active region. Studies have shown that the seismic behaviour of temples depend on various factors such as the materials used in construction, the geometry of the structure, the quality of workmanship and the foundation system. The structure response of a temple to an earthquake can be evaluated by analysing its dynamic characteristics, such as natural frequencies and mode shapes and by assessing the potential damage that could occur.

There is a need to investigate the structural vulnerability of temples and to develop appropriate mitigation measures. Some measures that have been proposed to improve the seismic behaviour of temples include retrofitting techniques, such as addition of seismic resistant elements and strengthening the existing structure and the development of new construction techniques that are designed to withstand the earthquake forces.

#### 1.2 Review of work already done:

Modelling and seismic analysis of a typical 9-tier gopuram and, 4- and 16-pillared mandapam of the 16th c. AD Ekambareswar Temple in Kancheepuram, South India, was carried out by Arun Menon et.al. Finite element and limit analysis approaches were adopted for the assessment

of the mandapam. The seismic input is based on a probabilistic seismic hazard analysis of an archaeological site. Two modelling strategies, namely lumped plasticity and distributed plasticity modelling, and three analysis approaches, namely linear dynamic, non-linear, static and dynamic analyses were adopted for the seismic assessment of the gopuram.

L.Tong ,W.Wu modelled the Xianren temple in Taihao mausoleum and determined the structure's dynamic characteristics and the dynamic performance by the numerical simulation analysis method. The results show that the basic natural vibration period of the structure is 0.826 s, longitudinal stiffness is weaker than lateral stiffness. Under the action of frequent earthquakes, the structure remains intact, can meet the specification of "no damage in small earthquakes" seismic fortification goal. When the medium earthquake occurs, the structure is prone to local damage phenomenon. When the severe earthquake occurs, timber frame tilts, damage to part of the side wall or even collapse may occur. The timber frame produces vertical torsion deformation.

Shaochun Ma et.al studied the Seismic behaviour of the Pagoda in Songyue Temple. The dynamic properties of Pagoda in Songyue Temple were studied by numerical simulation method. The equivalent model reflecting the force transfer mechanism was established. The dynamic characteristics of the computational model, the vibration modes, natural vibration frequency and natural period of vibration are measured. The correctness of the model was verified by comparing the theoretical calculation results with the simulation results. The seismic behavior of the Pagoda in Songyue Temple was evaluated according to the elastic spectrum analysis and time-history analysis results and related data. The results show that the stiffness is uniformly distributed and the seismic performance is good enough.

Eleonora Spoldi et.al, studied the micro tremor analysis and numerical analysis of the collapse's mechanisms of the Nepalese wood-masonry monuments Radha Krishna and the Bhimsen Temples damaged by the 2015 seismic event that struck Kathmandu and the valley. A global dynamic ambient test (micro tremor) was carried out for qualitative characterisation of the structural system, residual stiffness and strengths. The capacity curve of Radha Krishna temple shows behavior close to collapse at 0.26 g, while the Bhimsen temple presents important damage at 0.3 in Z direction and 0.23 in X direction.

### **1.3 Rationale for taking up the project:**

The seismic behaviour of temples is a complex and multi-faceted topic and further research is needed to understand better, the behaviour of these structures during earthquakes and to develop the mitigation strategies that can preserve these cultural and religious landmarks for future generations. There is a need to investigate the traditional construction aspects used in these temples and their capacity to withstand strong earth quake forces. The beam column joint behaviour has not been investigated. Shake table test will give a better understanding on how these joints behave. The capacity of shear key also needs to be investigated.

### **1.4 Relevance to Heritage Science.**

The dynamic analysis of temples is highly relevant to heritage science because it provides valuable information about the structural behaviour of these cultural heritage sites under different loads and environmental conditions. Dynamic analysis involves the measurement and analysis of vibrations and other dynamic responses of a structure, which can reveal information about the structural integrity, stability, and overall health of the building.

In the case of temples, dynamic analysis can help to identify potential structural issues or weaknesses that may threaten the longevity and stability of the building. This can help to inform conservation and restoration efforts, as well as aid in the development of effective maintenance plans to prevent further deterioration and damage to the building.

Dynamic analysis can also provide valuable insights into the historic construction techniques and materials used in the temple's construction. By analyzing the frequency response of the building to external stimuli such as earthquakes or wind loads, researchers can gain a better understanding of the temple's original construction and the materials used in it. This information can help to inform restoration and conservation efforts by identifying appropriate materials and techniques that are consistent with the original construction.

Overall, the dynamic analysis of temples is an important tool in heritage science for understanding and preserving these important cultural heritage sites for future generations.

### **1.5 Financial resources committed at Host Institute/Industry (if any)**

Nil

## 2 Challenge & Constraints:

Analyzing a temple structure for seismic response can be a challenging task due to various factors, including the complexity of the structure, the lack of design drawings, the use of traditional construction techniques and the materials used as locally sourced materials were used. Some of the **challenges** faced are

1. Lack of Design drawings: Many temple structures in India were built centuries ago and do not have detailed design drawings or documentation. This makes it difficult to determine the structural properties of the building and to accurately model the structure for seismic response.
2. Traditional construction techniques: temple structures may not conform to modern construction standards or codes. This can make it difficult to assess the seismic response of the structure using standard analysis methods.
3. Complex geometry: The temple structures have complex geometry, including arches, domes and intricate ornamentation. This can make it difficult to accurately model the structure for seismic analysis, as the behavior of the structure can vary depending on the properties of the stones used.
4. Site specific ground motion: the behavior of a temple structure during an earthquake is heavily dependent on the characteristics of the ground motion of the site. However, ground motion can vary widely depending on the location of the structure, making it difficult to accurately predict the seismic response of the structure.

### **Constraints:**

The constraints can limit the accuracy and reliability of the analysis. The common constraints are

1. Limited access: this can make it difficult to conduct on-site inspections and collect detailed information on the structural properties.
2. The accuracy of the seismic analysis can be influenced by the uncertainty in seismic hazard at the site. This uncertainty can be due to a lack of reliable seismic data, insufficient knowledge of the local geology etc.

The PI has taken permission from archaeological department to study the temple located at Amruthapura of Hoyasala style. To study the joint details lot of effort was required to look for ruins of other temples and lift the stone pieces to understand the column and beam column details.

Co PI has immense experience in numerical modelling using ANSYS software.

With this experience the PI and Co-PI are confident to overcome the difficulties and execute the project.

### **3 Description of Proposal**

#### **3.1 Objectives of the project.**

1. To identify the different styles of temple architecture for study
2. To procure the necessary permissions from Archeological department and Geological survey of India
3. To document the building selected
4. Preparing the models of beam columns to suitable scale
5. To do shake table analysis, to obtain natural frequency, time period and other parameters
6. To design the capacity of shear key
7. To numerically model the building and validate the results
8. To draw fragility curves based on experimental and simulation studies

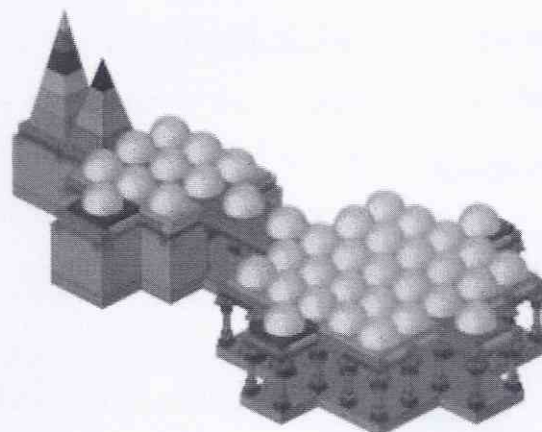
#### **3.2 Preliminary Investigations or Initial work done by PI and team.**



Amruthapura temple, Hoyasala style, Karnataka

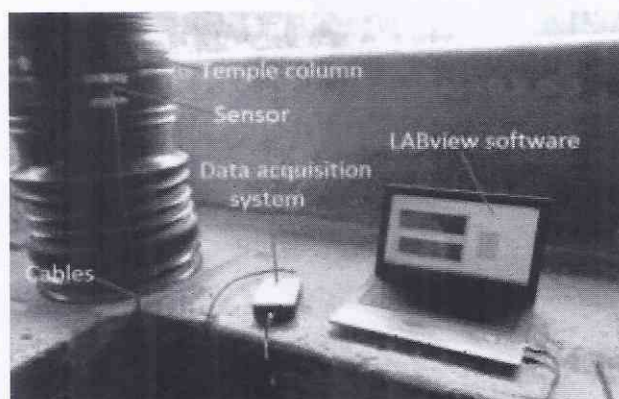
- Case Study of the temple, documentation of the building, measurement of the natural frequency of the building using the accelerometer and DAC was carried out. Soil samples were taken from the temple site and were investigated for bearing capacity.
- It was also simulated in Finite element software and tested numerically to check

and validate the model. The frequencies were almost same.



FEM model

- A part of the building was scaled ( 1:5 ) and tested again in shake table at CPRI to obtain the natural frequency.



Actual measurements at site



Testing at CPRI on shake table

### 3.3 S&T component in the project:

The analysis of temples involves the use of various scientific and technological components, which are essential for studying and understanding these cultural heritage sites. Some of the key science and technology components of temple analysis include:

- The analytical tools and techniques, including finite element analysis (FEA) are used to simulate and evaluate the structural behavior of the temple under different loading conditions



- The soil investigations and geological conditions surrounding the temple are required to determine its stability and potential risk of foundation failure.
- Investigating Material properties and behavior, their response to environment and durability is a major science and technology component.
- NDT techniques such as ultrasonic testing, ground-penetrating radar, and thermography may be used to assess the condition of the temple's structural elements and identify any potential weaknesses or defects.
- CAD models can also be used to simulate the temple's behavior under different loading conditions and test the effectiveness of proposed conservation and restoration strategies

### **3.4 Novelty/uniqueness of the proposal.**

Studying the beam-column joints of masonry structures in temples is a relatively new area of research that has gained interest among scholars and researchers in recent years. This research is particularly significant in the context of heritage conservation and seismic retrofitting of historic structures.

Some of the novel aspects of studying beam-column joints of masonry structures in temples include:

1. **Masonry structures are unique:** Masonry structures are unique and pose specific challenges compared to other building materials such as steel or concrete. The study of masonry structures requires a multidisciplinary approach that involves the study of the material properties, design, and construction techniques.
2. **Limited research:** There is limited research on the seismic behavior of beam-column joints of masonry structures in temples. This research is particularly relevant in areas prone to seismic activity, where the safety of these historic structures is of utmost importance.
3. **Importance of beam-column joints:** Beam-column joints are critical components of any structure and are particularly significant in the case of masonry structures. The seismic behaviour of beam-column joints can significantly impact the overall structural performance and safety of the building.
4. **Preservation of cultural heritage:** Temples are an essential part of cultural heritage and require special attention for their preservation. The study of beam-column joints of masonry

structures in temples can help in identifying the structural vulnerabilities and provide recommendations for seismic retrofitting and conservation.

5. Fragility curves are also useful to predict the intensity of earthquake for which the collapse of the structure occurs.

In summary, studying the beam-column joints of masonry structures in temples is a novel and important area of research that can provide valuable insights into the seismic behaviour and structural performance of these historic structures. This research is critical for the preservation and conservation of cultural heritage sites and ensuring the safety of people visiting and working in these structures.

### **3.5 Linkage with S&T Instts./NGO,s/ resource persons/ R&D organization/ Industry for technical backup.**

- CPRI Central power research institute, Bengaluru
- SERC, CHENNAI
- Dr Raghukanth, prof, IIT Chennai
- Dr Shivaji, IIT Hyderabad

### **3.6 Other organizations working in this area**

IIT, Chennai

### **3.7 Methodology detailing stepwise activities and sub-activities.**

1. Necessary permissions are to be obtained to study the selected temple structure.  
Temple for study will be selected from earthquake zone 4 or zone 5
2. Procurement of servo shake table with necessary instrumentation
3. Prepare the models of beam column connections and shear keys
4. Experimental set up on shake table and testing for different frequencies
5. Simulating the models in FEM
6. Validate the data
7. Test shear key for its capacity
8. Prepare fragility curves and suggest retrofitting measures

#### 4 Work Plan

(Phase-wise plan of action up to post-project activities detailing time schedule, and milestones may clearly be indicated. PERT/GANTT chart may be attached.)

Time chart for the Project													
FIRST YEAR													
sl.no	DESCRIPTION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Identification of temple for study and procuring necessary permissions	█	█	█									
2	Document the building				█	█							
3	Preparation of beam columns, preparing the model					█	█	█	█	█	█	█	█
4	numerical modelling					█	█	█	█	█	█	█	█
5	procuring servo shake table				█	█	█	█	█	█			
SECOND YEAR													
1	To study the beam column joints and their behavior	█	█	█	█	█	█						
2	shear key capacity				█	█	█						
3	Developing fragility curves							█	█	█	█	█	█
4	report making and submission											█	█

#### 5 Expected outcome of the Project

Fragility curves are used to assess the vulnerability of a structure or system to damage or failure under different levels of stress or hazard. They are commonly used in engineering, risk analysis, and disaster management to evaluate the performance of buildings, bridges, dams, and other critical infrastructure components.

Fragility curves are developed by analyzing the probability of failure or damage of a structure at different levels of stress or hazard intensity. This analysis can be based on past data, laboratory experiments, or computer simulations. The resulting curve provides a graphical representation of the relationship between the level of stress or hazard intensity and the probability of damage or failure.

Fragility curves will be developed for stone masonry temple structures of selected styles of architecture.

#### 6 Deliverables of the project (precise and in bullet form).

- Fragility curves
- Capacity of the Shear key to withstand lateral loads
- Seismic response of beam column joints

- Suggest retrofit measures

## **7 Likely impact**

Dynamic analysis involves in assessing the structural integrity and behavior of temple buildings. The impact is significant as it can help to identify potential weakness and vulnerabilities and suggest appropriate measures.

- Improved safety: Dynamic analysis can help identify potential risks to the structural integrity of the temple building, such as inadequate foundations or weak structural elements. This information can be used to take appropriate measures to reinforce the structure, thereby improving its safety.
- Enhanced structural resilience: Through dynamic analysis, one can identify potential damage scenarios and determine how the temple structure would respond to them. Based on this information, they can develop strategies to improve the structural resilience of the building, making it able to withstand natural disasters such as earthquakes and strong winds.
- Preservation of cultural heritage: Temples are important cultural and historical landmarks that are often at risk due to natural disasters or structural decay. Dynamic analysis can help ensure that these buildings are preserved for future generations by identifying areas of concern and implementing appropriate preservation measures.
- Cost savings: By identifying potential structural weaknesses and recommending appropriate interventions, dynamic analysis can help prevent costly repairs or even catastrophic failures.

## **8 Parameters for monitoring effectiveness of project:**

- The quality of the project deliverables can be monitored to ensure they meet the standard procedures of testing.
- The project schedule can be monitored to ensure that tasks are completed on time and that the project is progressing according to plan. This can involve tracking milestones, deadlines, and critical path activities.
- As most of the testing is going to take place in the structures laboratory, in the institution premises itself using the shake table procured, timely completion of the project can be assured.
- The project budget can be monitored to ensure that costs are being managed effectively and that the project is staying within budget.

## 9 Suggested post-project activities

- Studies on feasibility of Carbon fibre reinforced plastic sheets as a retrofitting measure
- Work on different retrofitting measures so that the structure can withstand powerful earthquakes without changing its aesthetics and form.

### C. BUDGET ESTIMATES: SUMMARY

<b>BUDGET</b>					
<b>Fifty one lacs forty thousand</b>					
<i>(amount in rupees)</i>					
S.No	Item	1 <sup>st</sup> Year	2 <sup>nd</sup> Year	3 <sup>rd</sup> Year	Total
<b>A. Recurring</b>					
1.	Manpower	320000	320000		640000
2.	Consumables	700000	100000		800000
3.	Contingency	200000	200000		400000
4.	Travel	300000	100000		400000
<b>B. Non-Recurring</b>					
5.	Permanent Equipment	2500000	200000		2700000
6.	OverheadCharges	100000	100000		200000
<b>Grand Total (A+B)</b>		4000000	900000		51,40,000

- Financial Year: April to March.
- Count six months from submission of the proposal to arrive at expected time point for commencement of the project.
- Please provide brief justification for each head (100 words for each).

### BUDGET FOR SALARIES/WAGES

S.No.	Designation	Monthly emoluments	Number	1st Year	2nd Year	Total (Rs.)	Justification or Role of the Manpower
<b>Full Time</b>							
1	SRF	40000	1	320000 (8)	320000 (8)	640000	To oversee the preparation of the model, setting up instrumentation, testing maintenance etc
<b>Part Time</b>							
<b>Total (Rs.)</b>					640000		

- man months to be given within brackets before the budget amount

## BUDGET FOR CONSUMABLES

Eight lacs (In Rupees)

S.No	Items	Qty.	Justification	1 Year	2 Year	Total
	Beams	6	<ul style="list-style-type: none"> <li>In the first year the amount is used to build the model to suitable scale using the actual material used in the selected temple.</li> <li>In the second year the amount is used to make joints in column and beams to test the capacity of shear keys</li> </ul>	700000	100000	800000
	Columns	6				
	Base	6				
	Slab	1				
	Shear keys	3				
Total				700000	100000	800000

## BUDGET FOR TRAVEL

4 lacs (In Rupees)

S.No	Description	Justification	1 Year	2 Year	Total
1.	Local	100000	50000	50000	100000
2.	Outstation	200000	250000	50000	300000
Total			300000	100000	400000

## BUDGET FOR OTHER COSTS

Items	6 lacs (In Rupees)				BUDGET
	1st yr.	2nd yr.	3rd yr.	Total	
a. Contingencies	200000	200000		400000	
b. Others					
Total	200000	200000		400000	400000

## BUDGET FOR PERMANENT EQUIPMENT

BUDGET FOR PERMANENT EQUIPMENT				
(In Rupees)				
Sl. No.	Name of equipment *	Qty	Estimated cost	Justification
1.	shake table with Servo shake table with base motions such as sine, square, random etc	1	1800000	Shake table to study the seismic response of various types of beam column joints
2.	DAC, vibration analyser software, Laptop, accelerometers	1	900000	Instrumentation to take reading, analyzing with software and storing data
Total			27,00,000	

- Please give justification for each equipment.

### D.PROFORMA FOR BIODATA OF INVESTIGATORS

A. Name: Dr Vijayalakshmi Akella

B. Date of Birth: 01/07/1965

C. Institution: K S School of Engineering and Management

D. General/SC/ST: General

E. Academic Career:

- PhD in Civil Engineering, JNT University, Hyderabad, August 2007
- M.E in Structural Engineering, Andhra University, Vizag, 1988
- B.Tech in Civil Engineering, JNT University, Hyderabad, June 1986.

F. Professional Career:

- Professor and Head, Dept of Civil Engineering, K S School of Engineering and management, June 2011 till present
- Professor and Head, Dept of Civil Engineering, The Oxford College of Engineering, November 2008 to June 2011
- Assistant Professor, BMS college of Engineering, 2007  
Sr Lecturer, Department of Architecture, BMS college of Engineering, 1997
- Lecturer, Department of Architecture, BMS college of Engineering, 1990



- Academic Assistant, JNT University, Hyderabad, 1989

G. Award/prize/ certificate etc., won by the investigator:

- Dr A P J ABDUL KALAM life achievement award from International Institute of Social and Economic reforms- 2019
- Rs 20.80 lakhs sanctioned by VGST to carry out Dynamic Analysis of Heritage Buildings in South India.
- Rs 9.03 lacs sanctioned to carry out parametric study on heat island effect in 2010 by VTU
- Rs 22,500 Sanctioned by AICTE and towards travel grant to present a paper in Malaysia
- Rs 50000 sanctioned by BMS college of engg to present paper in Ontario University, Canada

H. Publication (Numbers only):

Books -1

Research Paper - 17

Report General articles-nil

Patents others (please specify): Applied for Patent for "Process for manufacturing Geopolymer aggregates"

I. List of completed and ongoing projects

Sl. No.	Title of Project	Duration	Total Cost	Funding Agency	From-To
1	Dynamic Analysis and Retrofitting of Heritage Buildings in South India	2	20,00,000	VGST Vision group	2017- 2022
2	Study of the heat island effect in Bengaluru	2	9,05,000	VTU	2010-2012

J. Projects Submitted by PI

Sl. No.	Title of Project	Name of the Funding Agency	Status
1	Structural Health Monitoring using Non-Destructive Techniques and Prediction of Damage Detection using Machine Learning	DST-SERB	Not Approved
2	Quantitative and Qualitative Analysis of Living Spaces in Warm and hot dry climates of Vernacular Buildings of Karnataka and Kerala	DST	Approved
3	Faculty Development Programme-Recent Advances in Earthquake Engineering	VGST	Not Approved
4	A Predictive Earthquake Risk Assessment Model of Gol Gumbaz, a Heritage Monument located in Zone III	VGST	Not Approved
5	Seismic Performance of RCC Column-Steel Beam Connection in Hybrid Structures	VTU-TEQIP	Not Approved
6	Experimental Investigations on Push Over Analysis of Reinforced Geo-polymer Concrete Frames	VTU-TEQIP	Not Approved
7	Performance of Climatic Responsive Buildings- A Qualitative and Quantitative Approach	DST-SERB	Approved
8	Capacity Building of Skilled Women in Core Areas for Construction Industry	DST-SEED	Not Approved
9	Dynamic Analysis and Retrofitting of Heritage Buildings in South India	VGST	Approved

10	Probabilistic Prediction of Earthquakes and Sustainability of Heritage Structures under High Seismic Activity	DST-SERB	Approved
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VIJAYALAKSHMI AKELLA  
(Name & Signature)

Date: 21/3/2023


Place: Bengaluru



# K. S. SCHOOL OF ENGINEERING & MANAGEMENT

**KSSEM**

# 15, Mallasandra, Off.Kanakapura Road,Bengaluru-560109, Karnataka, INDIA.

<b>Faculty Name</b>	Dr Vijayalakshmi Akella	
<b>Designation</b>	Professor and Head	
<b>Educational Qualification</b>	P.hD	
<b>Experience in Years</b>	Teaching: 32 Research 25 Industry : 1	
<b>Areas of Interest</b>	Building Performance, Earthquake Engineering	
<b>E-mail</b>	hod.civil@kssem.edu.in	

<b>Experience in Years</b>	Experience in KSSEM : 11 years and 6months Experience in Teaching : 32 Experience in Industry : 1 Total Experience :33
<b>Subject Handled</b>	Strength of materials, Structural analysis, RCC, structural dynamics, indeterminate structures, earthquake engineering, research methodology, Air Pollution
<b>Subject Handling</b>	Strength of materials, structural dynamics,
<b>Areas of Interest</b>	Building Performance, Earthquake Engineering

<b>Educational Details</b>		
<b>Examination/ Degree</b>	<b>College / University</b>	<b>Year of Passing</b>
UG	JNTU	1986
PG	Andhra University	1988
PhD	JNTU, Hyderabad	2007

## Publications

### Journal Publications:

1. Vijayalakshmi Akella, "Effect of Glazing on Building Envelope - A case study", The journal of the Indian Institute of Architects. Oct 2004.
2. Vijayalakshmi Akella, "Buildings for moderate climates- Bangalore", The journal of The Indian Institute of Architects. May 2007.
3. Vijayalakshmi Akella, "Relative Magnitude Analysis (RMA) and its Comparison over other Computational Approaches", International Journal of mathematical sciences and Engineering Applications, ISSN 0973-9424, Vol 6, No 1, Jan 2012, pp-381-390
4. Vijayalakshmi Akella, "Influence of Bangalore's canyon geometry on the intra-urban Ambient Air Temperature", International Journal of Construction and Architecture Scientific Herald Issue No; 3(23), ISSN 2075-0811, 2014, 40-50.
5. Vijayalakshmi Akella, "Structural condition assessment and feasibility study", The International reviewer, Vol 2, Issue 2, 2015, ISSN-2395-1575, December 2015, 35-37.
6. Vijayalakshmi Akella, "Township Guidelines to curb Urban Heat Island effect", National Journal on the Indian Institute of Architects, Issue No; 12, Volume; 80, December 2015.
7. Vijayalakshmi Akella, "Experimental Studies on Bearing Capacity of Inclined Skirted Footings on Sand", Journal of Geotechnical Studies ( MAT Journals), July 2016.
8. Vijayalakshmi Akella, " Experimental Studies on Bearing Capacity of Skirted Footings on C- $\phi$  Soils", International Journal of Research in Engineering and Technology, September 2016.
9. Vijayalakshmi Akella, "Impact of Building Orientation on energy Consumption in the design of Green Building" International Journal of Emerging Research in Management & Technology, Vol 6, Issue 2, ISSN 2278-9350, February 2017, 8-11.
10. Vijayalakshmi Akella, "Design and Testing of Geopolymer Blocks for Infills in Masonry Structures" International Journal of Emerging Research in Management & Technology, , Volume 6, Issue 5, ISSN-2278-9359, May 2017, 82-86.
11. Vijayalakshmi Akella, "Ajanta Caves: Past Present and Future", International Research Journal of Engineering and Technology (IRJET), 2019.
12. Vijayalakshmi Akella, "Estimation of Ductility for High Rise Buildings for a Different Plant Aspect Ratio", International Research Journal of Engineering and Technology (IRJET), 2019.
13. Vijayalakshmi Akella, "Experimental Studies and Numerical Validation on Bearing Capacity of Skirted Footings on c- $\Phi$  Soils", "Advances in Structures, Systems and Materials. Springer,

Singapore, ISBN 978-981-15-3254-2, pp 85-98. 2020

14. Vijayalakshmi Akella, "Numerical Validation of Experimental Results for Bearing Capacity of Internal Inclined Skirted Footings on c-φ Soil" Journal of Construction Management, Vol. XXXVI, No II, ISSN 0970-3675, pp 5-12. 2021.
15. Vijayalakshmi Akella, " Internet of Things for High Performance Net Zero Energy Buildings", Innovations in the Industrial Internet of Things (IIOT) and Smart Factory, 2021

**Conference Papers:**

1. Vijayalakshmi Akella "Thermal performance of vernacular building in Kerala, South India", World conference on sustainability", Tokyo, Japan, September 2005. This work is translated to Spanish by Institute of tropical architecture, Costa Rica, 2005.
2. Vijayalakshmi Akella "parametric study of heat loads in air conditioned buildings" Paper Presented and Published in the proceedings of "International Conference on Green Energy (IGEC-2)" in Ontario, Canada, June 2006
3. Vijayalakshmi Akella, "Guidelines for Energy Efficient Buildings in moderate climate" presented and Published in the proceedings of "International Conference on sustainable building East Asia SB07", Kuala Lumpur, Malaysia, Nov 2007.
4. Vijayalakshmi Akella, "Combating Global Warming and Wetlands: A Conjoint Analysis for Bangalore City" International Conference on "ICCFRE", University of Kerala & NEA. December 9-11, 2011,
5. Vijayalakshmi Akella, "Influence of land use pattern on temporal climatic variations mapping Bangalore City" , Proceedings of the 5th International congress of Environmental Research , University of Malaysia, Terengganu, Kualalumpur, Malaysia, 22-24 nov, 2012
6. Vijayalakshmi Akella, "Urbanization of Bangalore and Its Impact on water bodies", International Conference, 2012, 115.
7. Vijayalakshmi Akella, "Municipal Solid Waste Management in Bangalore-Existing Scenario and Recommendation –A Review", International Conference on "Sustainable Waste Management, Infosysis Campus, July30-Aug01, 2012, 53-57.
8. Vijayalakshmi Akella, "Influence of land-use pattern on temporal Climatic variations mapping Bangalore city, India", International Conference on "5th International Congress of Environmental Research ICER-12". Malaysia 2012, 623.

9. Vijayalakshmi Akella, "Morphometric Analysis of Tippagondanahalli Watershed (T.G Halli) Karnataka using Geographic Information System (GIS)", International conference Sustainable water, Wastewater and Energy management (SWWEM), IISC, 17th to 19th August 2016.
10. Vijayalakshmi Akella, "Design and Testing of Geopolymer Blocks for Infills in Masonry Structures", International Conference on Emerging trends in science & Engineering (ICETSE) 11th and -12<sup>th</sup> May 2017, Coorg Institute of Technology, Ponnampet, Kodagu, Karnataka.
11. Vijayalakshmi Akella, "Seismic Analysis of Hoysala Architectural Building", 16th Symposium on Earthquake Engineering, 20<sup>th</sup> to 22<sup>nd</sup>, December 2018, IIT, Roorkee.
12. Vijayalakshmi Akella, "Experimental Studies on Bearing Capacity of Inclined Skirted Footings on C- $\phi$  Soils", 2<sup>nd</sup> International Conference on Emerging Research in Civil, Aeronautical & Mechanical engineering- ERCM 2019, 25<sup>th</sup> 26<sup>th</sup> July 2019, NMIT, Bangalore.
13. Vijayalakshmi Akella, "Experimental Investigation on SCC with Indigenously Developed Geopolymer Aggregates", 2<sup>nd</sup> International Conference on Emerging Research in Civil, Aeronautical & Mechanical engineering- ERCM 2019, 25<sup>th</sup> 26<sup>th</sup> July 2019, NMIT, Bangalore.

### **Awards**

1. **Received a grant of Rs 20 lacs from VGST to conduct Dynamic analysis of Heritage structures**
2. **Received a grant of Rs 9.03 lacs from VTU, to conduct impact of Urban heat Island in Bangalore**
3. **Received Rs 50,000 from to conduct national seminar on heritage structures, 2020**
4. **Received Rs 1,50,000 to conduct performance of vernacular architecture, 2022**

### **Other Accomplishments**

1. **Co-Authored a Text Book on Surveying , published by PHI, Prentice Hall of India, ISBN No: 978-81-203-4991-9**
2. **NAAC overall coordinator for 2016-2021**
3. **Chairman, grievance committee**
4. **Conducted national conference in 2015, 2016**
5. **Presently organizing National conference on Emerging Trends in Sustainable Built Environment on Feb 3rd 2023**
6. **Conducted Faculty development programs, organized workshops on mix design, Etabs software etc.**
7. **Organized industrial visits in water treatment plants, block manufacturing industries, RMC plant , dam visits etc**

## Research Guidance

Department	Name of the researcher	registered for	Research Supervisor	year of registration	course work completed
Civil Engineering	Vasantha Lakshmi G	KSSEM, VTU	Dr Vijayalakshmi Akella	2015	Yes
Civil Engineering	Sushma C K	KSSEM, VTU	Dr Vijayalakshmi Akella	2016	Yes
Civil Engineering	Sushma M	KSSEM, VTU	Dr Vijayalakshmi Akella	2019	Yes
Civil Engineering	Abhilash Reddy B L	KSSEM, VTU	Dr Vijayalakshmi Akella	2019	No

## Professional Membership

1. Life member - Indian Society for Technical education
2. Life member- Indian Society for Earthquake technology ISET

## Contact Details

**Name:** 9845399068

**Official Address:** dept. of civil engineering, K S School of Engineering and Management

**Alternate Email:** vijaya.akella@gmail.com



Annexure-I

**UNDERTAKING FROM THE PRINCIPAL INVESTIGATOR**

**Project Title: "Seismic Risk Mitigation and Damage Assessment Strategies for Temple Structures: A Comprehensive Approach"**

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1. I have carefully read the terms and conditions of the Science and Heritage Research Initiative (SHRI) Programme and I agree to abide by them.
2. I have not submitted this or a similar Project Proposal elsewhere for financial support.
3. I have no any ongoing project under the Science and Heritage Research Initiative (SHRI) Programme.
4. I shall ensure that no item/equipment available in my Institute/ Organisation, shall be purchased under this Project.
5. I shall ensure that no parking of Government money will be done on the project. I shall take the responsibility of effective utilization of the fund.
6. I undertake that idle capacity of the permanent equipment procured under the Project will be made available to other users.
7. I have enclosed the following:
  - a. Endorsement from the Head of the Organization *(on letter head)*



Principal Investigator:

Name Dr Vijayalakshmi Akella

Signature

Date: 21/3/2023

Place: Bengaluru

**FOR REVIEWER & COMMITTEE MEMBER or APPLICANT or DST OFFICER  
ASSOCIATED/ DEALING WITH THE SCHEME/ PROGRAM OF DST**

Issues of Conflicts of Interest and ethics in scientific research and research management have assumed greater prominence, given the larger share of Government funding in the country's R & D scenario. The following policy pertaining to general aspects of Conflicts of Interest and code of ethics, are objective measures that is intended to protect the integrity of the decision making processes and minimize biasness. The policy aims to sustain transparency, increase accountability in funding mechanisms and provide assurance to the general public that processes followed in award of grants are fair and non-discriminatory. The Policy aims to avoid all forms of bias by following a system that is fair, transparent and free from all influence/ unprejudiced dealings, prior to, during and subsequent to the currency of the programme to be entered into with a view to enable public to abstain from bribing or any corrupt practice in order to secure the award by providing assurance to them that their competitors will also refrain from bribing and other corrupt practice and the decision makers will commit to prevent corruption, in any form, by their officials by following transparent procedures. This will also ensure a global acceptance of the decision making process adopted by DST.

**Definition of Conflict of Interest:**

Conflict of Interest means "any interest which could significantly prejudice an individual's objectivity in the decision making process, thereby creating an unfair competitive advantage for the individual or to the organization which he/she represents". The Conflict of Interest also encompasses situations where an individual, in contravention to the accepted norms and ethics, could exploit his/her obligatory duties for personal benefits.

**1. Coverage of the Policy:**

- a) The provisions of the policy shall be followed by persons applying for and receiving funding from DST, Reviewers of the proposal and Members of Expert Committees and Programme Advisory Committees. The provisions of the policy will also be applicable on all individuals including Officers of DST connected directly or indirectly or through intermediaries and Committees involved in evaluation of proposals and subsequent decision making process.
- b) This policy aims to minimize aspects that may constitute actual Conflict of Interests, apparent Conflict of Interests and potential Conflict of Interests in the funding mechanisms that are presently being operated by DST. The policy also aims to cover, although not limited to, Conflict of interests that are Financial (gains from the outcomes of the proposal or award), Personal (association of relative / Family members) and Institutional (Colleagues, Collaborators, Employer, persons associated in a professional career of an individual such as Ph.D. supervisor etc.)

**2. Specifications as to what constitutes Conflict of Interest.**

Any of the following specifications (non-exhaustive list) imply Conflict of Interest if,

- (i) Due to any reason by which the Reviewer/Committee Member cannot deliver fair and objective assessment of the proposal.

- (ii) The applicant is a directly relative# or family member (including but not limited to spouse, child, sibling, parent) or personal friend of the individual involved in the decision making process or alternatively, if any relative of an Officer directly involved in any decision making process / has influenced interest/ stake in the applicant's form etc..
- (iii) The applicant for the grant/award is an employee or employer of an individual involved in the process as a Reviewer or Committee Member; or if the applicant to the grant/award has had an employer-employee relationship in the past three years with that individual.
- (iv) The applicant to the grant/award belongs to the same Department as that of the Reviewer/Committee Member.
- (v) The Reviewer/Committee Member is a Head of an Organization from where the applicant is employed.
- (vi) The Reviewer /Committee Member is or was, associated in the professional career of the applicant (such as Ph.D. supervisor, Mentor, present Collaborator etc.)
- (vii) The Reviewer/Committee Member is involved in the preparation of the research proposal submitted by the applicant.
- (viii) The applicant has joint research publications with the Reviewer/Committee Member in the last three years.
- (ix) The applicant/Reviewer/Committee Member, in contravention to the accepted norms and ethics followed in scientific research has a direct/indirect financial interest in the outcomes of the proposal.
- (x) The Reviewer/Committee Member stands to gain personally should the submitted proposal be accepted or rejected.

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# The Term "Relative" for this purpose would be referred in section 6 of Companies Act , 1956.

### 3. Regulation:

The DST shall strive to avoid conflict of interest in its funding mechanisms to the maximum extent possible. Self-regulatory mode is however recommended for stake holders involved in scientific research and research management, on issues pertaining to Conflict of Interest and scientific ethics. Any disclosure pertaining to the same must be made voluntarily by the applicant/Reviewer/Committee Member.

### 4. Confidentiality:

The Reviewers and the Members of the Committee shall safeguard the confidentiality of all discussions and decisions taken during the process and shall refrain from discussing the same with any applicant or a third party, unless the Committee recommends otherwise and records for doing so.

### 5. Code of Conduct

#### 5.1 To be followed by Reviewers/Committee Members:

- (a) All reviewers shall submit a conflict of interest statement, declaring the presence or absence of any form of conflict of interest.

- (b) The reviewers shall refrain from evaluating the proposals if the conflict of interest is established or if it is apparent.
- (c) All discussions and decisions pertaining to conflict of interest shall be recorded in the minutes of the meeting.
- (d) The Chairman of the Committee shall decide on all aspects pertaining to conflict of interests.
- (e) The Chairman of the Committee shall request that all members disclose if they have any conflict of interest in the items of the agenda scheduled for discussion.
- (f) The Committee Members shall refrain from participating in the decision making process and leave the room with respect to the specific item where the conflict of interest is established or is apparent.
- (g) If the Chairman himself/herself has conflict of interest, the Committee may choose a Chairman from among the remaining members, and the decision shall be made in consultation with Member Secretary of the Committee.
- (h) It is expected that a Committee member including the Chair-person will not seek funding from a Committee in which he/she is a member. If any member applies for grant, such proposals will be evaluated separately outside the Committee in which he/she is a member.

**5.2 To be followed by the Applicant to the Grant/Award:**

- (a) The applicant must refrain from suggesting referees with potential Conflict of Interest that may arise due to the factors mentioned in the specifications described above in Point No. 2.
- (b) The applicant may mention the names of individuals to whom the submitted proposal should not be sent for refereeing, clearly indicating the reasons for the same.

**5.3 To be followed by the Officers dealing with Programs in DST:**

While it is mandatory for the program officers to maintain confidentiality as detailed in point no. 6 above, they should declare, in advance, if they are dealing with grant applications of a relative or family member (including but not limited to spouse, child, sibling, parent) or thesis/ post-doctoral mentor or stands to benefit financially if the applicant proposal is funded. In such cases, DST will allot the grant applications to the other program officer.

**6. Sanction for violation**

**3.1 For a) Reviewers / Committee Members and b) Applicant**

Any breach of the code of conduct will invite action as decided by the Committee.

**3.2 For Officers dealing with Program in DST**

Any breach of the code of conduct will invite action under present provision of CCS (conduct Rules), 1964.

**7. Final Appellate authority:**

Secretary, DST shall be the appellate authority in issues pertaining to conflict of interest and issues concerning the decision making process. The decision of Secretary, DST in these issues shall be final and binding.

**8. Declaration**

I have read the above "Policy on Conflict of Interest" of the DST applicable to the Reviewer/ Committee Member/ Applicant/ DST Scheme or Program Officer # and agree to abide by provisions thereof.

I hereby declare that I have no conflict of interest of any form pertaining to the proposed grant \*

I hereby declare that I have conflict of interest of any form pertaining to the proposed grant \*

\* & # (Tick whichever is applicable)

Name of the Reviewer/ Committee Member or Applicant or DST Officer  
(Strike out whichever is not applicable)

*m. Kelle*  
23/3/23  
(Signature with date)

Professor & Head  
Dept. of Civil Engineering  
K.S. Group of Institutions  
K.S. School of Engineering & Management  
Bangalore-560 062



KAMMAVARI SANGHAM (R), 1952  
**K.S. School of Engineering and Management**

Approved by AICTE-1-5279601, Affiliated to VTU, Belagavi

ACCREDITED BY NAAC

# 15, Near Vajarahalli, Mallasandra, off Kanakapura Road,  
Bengaluru - 560 109, www.kssem.edu.in

Fax : +91 80 28425164, Mob : 8884444408 / 9606055906

**Project Title: "Seismic Risk Mitigation and Damage Assessment Strategies for Temple Structures: A Comprehensive Approach"**

Cost: Rs 51,40,000

Duration: 2 years

1. Affirmed that the Organisation welcomes the participation of Dr Vijayalakshmi Akella as the PI and Dr. Rama Narasimha as the Co-PI for the Project and that in the unforeseen and legitimate event of discontinuation by the PI, the Co-PI will assume full responsibility for completion of the Project. Information to this effect, endorsed by me, will be promptly sent to DST
2. Affirmed that the equipment and basic as well as other administrative facilities as per the terms and conditions of the award of the Project, will be made available to the Investigator(s) throughout the duration of the Project. All the equipment purchased under the projects will remain the administrative custody of the DST unless any order regarding the same issue by the DST.
3. The Organisation shall ensure that as per the rule of GFR 2017, purchase of the equipments may done through the Government e-Marketplace (GEM), to the extent available there as the project involves government funding.
4. The organization shall ensure that under any circumstances, parking of Government Fund will not be done. The Fund will be utilized only for the purpose it was granted.
5. The organization/ institute shall ensure to use Expenditure Advance & Transfer (EAT) module of PFMS.
6. The Organisation shall provide timely the Audited Statement of Expenditure and the Utilization Certificate of the Funds under the Grant as required by DST in the prescribed format and all interests and other earnings against released Grant shall be remitted to Consolidated Fund of India (through Non-Tax Receipt Portal (NTRP), i.e. www.bharatkosh.gov.in), immediately after finalization of accounts, as it shall not be adjusted towards future release of Grant.

Date: 22/3/2023  
Place: Bengaluru

*K. Rama*  
(Head of Organisation)

Dr. K. RAMA NARASIMHA  
Principal/Director

K S School of Engineering and Manag  
Bengaluru - 560 109

# MILENIUM TECHNOLOGIES (I) PVT. LTD.

(An ISO 9001:2015 Certified Company)

Sy No 116/7, Mookambika Temple Road Behind Parishrama Granites  
Machohalli Forest Gate Machohalli Industrial Area Magadi Road  
Bengaluru – 560091 Email : mileniumindia@gmail.com



URS is a member of Registrar of Standards Holdings Ltd.

To  
HOD – CIVIL  
K. S. SCHOOL OF ENGINEERING AND MANAGEMENT  
No.15, Mallasandra, Off. Kanakapura Road,  
Bengaluru-560109,  
Email : hod.civil@kssem.edu.in

MTI/22-23/Q-ST/KA/05  
23/03/2023

**Kind Attention: Dr Vijaylaxmi**

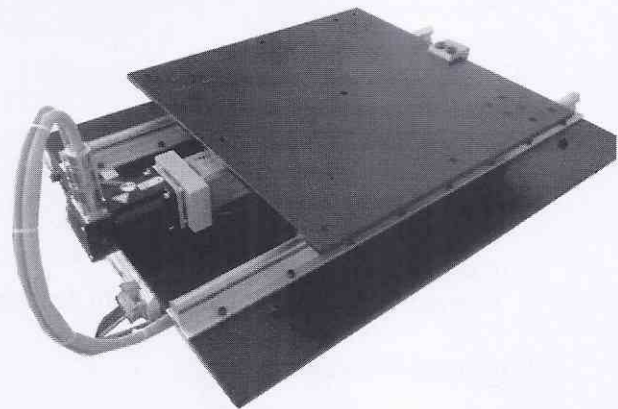
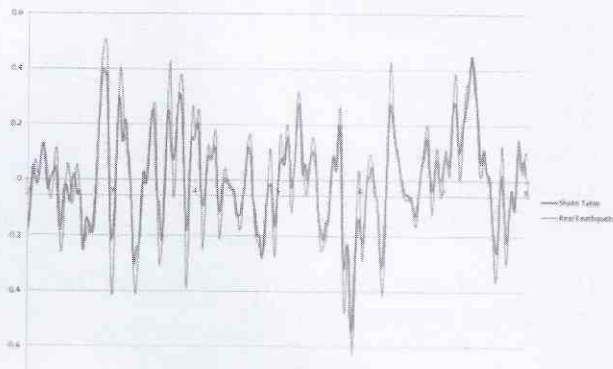
Dear Sir,

Subject: Quotation for Supply of Servo Shake Table.

Reference: Your telephonic enquiry on 23.11..2022

Thank you for the enquiry; Following are the technical specifications along with the prices for the shake tables and Instrumentation. I have also attached the partial list of the institutes where our shake tables are working.

## 1) Servo Shake Table (For Random Vibrations And Earthquake Simulation)



The shake table will be consisting of a Servo Actuator, connecting link, a Top table, linear guide ways . The Servo Actuator is controlled through computer. Various Base motions such as sine, square, random etc will be given to the actuator and accordingly the top table will vibrate. Linear guide ways will ensure that the motion of the table is linear. A circular mounting plate will be placed on the vibrating plate through a T-slot, so that, the test structure can be mounted at any desired angle relative to the angle of incidence of the base motion.

# MILENIUM TECHNOLOGIES (I) PVT. LTD.

(An ISO 9001:2015 Certified Company)

Sy No 116/7, Mookambika Temple Road Behind Parishrama Granites  
Machohalli Forest Gate Machohalli Industrial Area Magadi Road  
Bengaluru – 560091 Email : mileniumindia@gmail.com



## Specifications

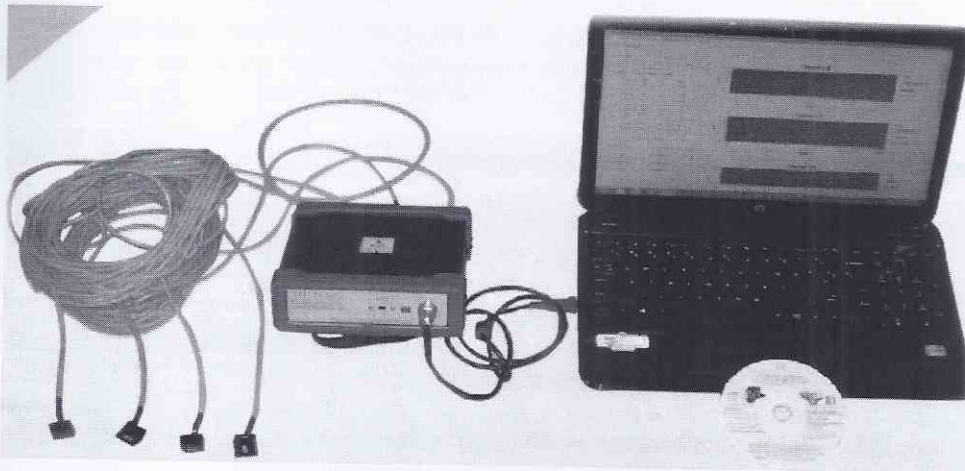
- |                                    |   |  |
|------------------------------------|---|--|
| 1) Base Motion                     | : | Horizontal   |
| 2) No of Axis                      | : | Single   |
| 3) G Value                         | : | 1 g  |
| 4) <b>Maximum payload</b>          | : | <b>As per Price Schedule (Mentioned in next page)</b>  |
| 5) <b>Sliding table dimension</b>  | : | <b>As per Price Schedule (Mentioned in next page)</b>  |
| 6) Table Actuation by              | : | Servo Actuator with  |
| 7) Actuation Mechanism             | : | Precision Multi Start Roller Screws with Accuracy of 0.01mm  |
| 8) Motor                           | : | Servo Motor with the Control Accuracy of 0.05 Deg or better  |
| 9) Drive                           | : | Servo Motor Drive  |
| 10) Control panel                  | : | Will Have All Basic Functions And Safety Features  |
| 11) Over Travel Protection         | : | Non Contact Type Electronic Switches with accuracy of 0.01mm   |
| 12) Emergency Stopping             | : | By Electronic Trigger  |
| 13) Motion Controller              | : | Electronic Single Axis Expandable type to Multi Axis   |
| 14) Frequency                      | : | 0 -15 Hertz  |
| 15) Velocity                       | : | 0 to 300mm/sec Variable  |
| 16) Natural Frequency of Equipment | : | Will be Beyond 150 Hertz   |
| 17) Resolution For Frequency       | : | 0.05 Hertz (Variable)  |
| 18) Frequency Control              | : | 1%   |
| 19) Amplitude                      | : | 0 to 200 mm ( +/- 100mm)   |
| 20) Amplitude Resolution           | : | 0.01 mm  |
| 21) Base Table Bearings            | : | Linear Bearings Having Tolerance of 0.01mm   |
| 22) Base Table Bearing Shafts      | : | Linear Shaft Hard Chrome plated and ground   |
| 23) Types of Base Motions<br>etc   | : | Sine, Sine Sweep, Random (Earthquake), Triangular/Square   |
| 24) Data Feeding                   | : | User Will be able to feed any Earthquake Data Available on Internet and Will be able to create and feed user defined time histories also |
| 25) Control Software               | : | Will be able operate the Shake Table in  |
- i. Manual Mode For Impact with selection of amplitude and Velocity.
  - ii. Cyclic Mode for Sine, Square, Triangular and Ramp with selection of Amplitude and No of Cycles.
  - iii. Earthquake Mode, where in user can feed earthquake time histories
  - iv. Sine Sweep Mode , both in increasing and decreasing mode with target frequency
  - v. There Will be FFT Option available in the control software itself.



## 2) Shake Table instrumentation for measurement of Shake Table Vibrations ( Data Acquisition System)

The following instrumentation for measuring shake table vibrations is developed indigenously by us.

- |                                     |             |
|-------------------------------------|-------------|
| 1) Accelerometers                   | : 4 No's    |
| 2) Data Acquisition System (MILDAQ) | : 1 No      |
| 3) Vibration Analyzers Software     | : 1 NO (CD) |
| 4) Suitable Laptop –                | : 1 No      |



### Detailed Specifications

#### a) Accelerometers:

- |                             |                     |
|-----------------------------|---------------------|
| ➤ g value                   | : ± 10g.            |
| ➤ Sensitivity               | : 80mV/g.           |
| ➤ Frequency                 | : 1000 Hz.          |
| ➤ Type                      | : MEMS              |
| ➤ Size                      | : 16 x 16 X 12 mm   |
| ➤ Body                      | : Aluminum Enclosed |
| ➤ Sensor weight             | : 30 Grams          |
| ➤ Cable shielding/isolation | : 40dB min          |

#### b) Data Acquisition System with Software should have the followings

- Total Number of Channels should be 4 Channels
- Analog Bandwidth of 1000 Hz
- 24 Bit ADC Dynamic Range
- Sampling frequency of 20 KHz
- Acceleration sensitivity better than 0.1 g
- Effective number of bits > 17 in high speed sampling mode.
- Frequency estimation within 0.05 Hz
- Simultaneous sampling ADC for real time analysis
- Signal conditioned analog front end
- Digital filter with Pass band and Taps setting

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- Supports windowing for Hanning, Hamming, Blackman and Flat Top response.
- Should Have Modal Analysis
- Time and Frequency Domain Plots
- Real time plotting of Acceleration Velocity and Displacement
- Plot and Data Selection Option of Acceleration Velocity and Displacement Individually and All together.
- Data logging in CSV format
- Continuous and Timed operation
- USB Communication to Host
- Archived Data Visualization
- Offline Data storage for Analysis
- Easy push pull circular connectors for interfacing sensors.
- Software Compatibility – Windows 7 OR Any Latest Windows Version
- Rugged construction and industrial standard rack mount enclosure panel as Per IP 67 Standards

## c) The System Should Have the Following Features

- High Performance 32-bit DSP Architecture
- Accelerometer Signal Conditioning and hardware filtering for noise reduction
- Ready-to-measure application software
- Real time data visualization
- Sensors specifically designed to suit low frequency applications at least upto 0.1 Hz.
- User friendly GUI based application for easy operation
- Time stamped Auto Data Archival
- Industrial MIC type connectors with threaded lock
- Compact and Rugged design
- Offline data Analysis
- Supply voltage protection against the sudden Surges and Voltage variations

## d) Specs for Laptop

- HP or Dell Make/ Core i5
- 4 GB RAM
- 1 TB Hard Disc
- 15 Inch Screen
- Windows 10 / Latest

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## Price Schedule

Sl. NO	DESCRIPTION	Servo Electric Shake Table Payload – 500 kg Table Size – 1000 x 1000 mm With 4 Channel Data Acquisition System With Accelerometers and Software and Laptop
1	Basic Price	Rs.25,00,000/-
2	GST @18%	Rs.4,50,000/-
3	<b>Grand Total</b>	<b>Rs.29,50,000/-</b>

Rs 29,50,000/- ( Rs Twenty Nine Lakhs Fifty Thosand Only)

Special Discounted Price Rs 27,00,000/- ( Rs Twenty Seven Lakhs Only)

## Commercial Terms and conditions:

- 1) Payment : 50% Advance Along With P.O, 50% Against Delivery & Installation & Demonstration.
- 2) Validity : 90 Days.
- 3) Training : Free of cost during installation/ inspection.
- 4) Installation : Free Of Cost
- 5) Manuals : Instruction manuals will be provided with the each shake table
- 6) Warrantee : Warranted for the period of 1year from the date of supply when used as Instructed.
- 7) Civil Work : All the civil work will be in your scope and have to be as per our layout.
- 8) Delivery :10-12 Weeks
- 9) Mode of Payment : Payment By DD / Multicity Cheque.

I request you to feel free to ask in case of any techno-commercial clarifications. Expecting your Positive Response at the earliest.

Thanking you

Regards

For Milenium Technologies (I) Pvt Ltd

Shrikant Shinde  
Mobile: - 9343097797

PARTIAL LIST OF THE INSTITUTES WHERE OUR SHAKE TABLES AREWORKING

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Sl.No	Name of the Institute	Place
<b>Karnataka</b>		
1	IISC	Bangalore
2	NIT Surathkal	Surathkal
3	Bangalore Institute of Technology	Bangalore
4	SJC Institute of Technology - Chikkaballapur	Bangalore
5	Dayanadsagar College of Engineering	Bangalore
6	Reva Institute of Technology and Management	Bangalore
7	Vijaya Vittal College of Engineering	Bangalore
8	Nitte Meenakshi Institute of Technology	Bangalore
9	Alpha College of Engineering	Bangalore
10	Nagarjuna College of Engineering	Bangalore
11	Oxford College of Engineering	Bangalore
12	ACS College of Engineering	Bangalore
13	Global Academy of Technology	Bangalore
14	BMS College of Engineering	Bangalore
15	SJB Institute of Technology	Bangalore
16	Malnad College of Engineering	Hassan
17	Vijayanagar Engineering College	Bellary
18	Jain College of Engineering	Belgaum
19	KLE'S College Of Engg & Technology	Belgaum
20	K.L.S – Gogte Institute of Technology	Belgaum
21	S.G Balekundri Institute of Technology	Belgaum
22	BGS Institute of Technology	Nagamangala
23	Basaveshwar Engg Collage	Bagalkot
24	Siddhaganga Institute of Technology	Tumkur
25	Adichunchanagiri Institute of Technology	Chikkamagaluru
26	Shree Jayachamarajendra College of Engineering	Mysore
27	National Institute of Engineering	Mysore
<b>Gujarat</b>		
28	CEPT University	Ahmedabad
29	Charotar University of Science and Technology	Changa
30	Birla Vishwakarma Mahavidyalaya	Anand
31	Sardar Vallabhai Institute of Technology	Anand
32	Chandubhai S Patel Institute of Technology	Anand
33	M.S University	Baroda
34	Nirma University	Ahmedabad
35	SVNIT Surat	Surat
<b>Andhra Pradesh</b>		
36	IIIT(Earthque Engg Reaserch Centre)	Hyderabad
37	RVR and JC Guntur	Guntur
38	Chaitanya Bharati Institute of Technology	Hyderabad
39	Nuclear Fuel Complex (BERC)	Hyderabad
40	Gudlavalleru Engineering College	Guntur
41	Vasireddy Venkatadri Institute of Technology	Guntur
42	Bapatla Engineering College	Bapatla

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44	Ramdeo Baba Engg College	Nagpur
45	VNIT	Nagpur
46	Ballarpur Institute of Technology	Nagpur
47	Tulasiramji Gayakwad Patil Institutions	Nagpur
48	KDK College of Engineering	Nagpur
49	Sinhagad Institute of Technology	Pune
50	AISSMS	Pune
51	DY Patil Institute of Engineering and Technology	Pune
52	Vishwakarma Institute of Information Technology	Pune
53	Shahu College of Engg	Pune
54	College Of Engg Pune	Pune
55	Padmshri Dr Vikhe Patil Engg College	Ahmed Nagar
56	Amrutvahini Engg College	Sangamner
57	SND College of Engineering	Yeola
58	Walchand College of Engineering	Sangli
59	Tatyasaheb Kore Institute of Technology	Warananagar
60	Govt. college of Engineering	Aurangabad
61	Jawaharlal Nehru Engineering College	Aurangabad
62	Sanjay Ghodawat University	Atigre
62	Sanjeevani College of Engineering Kopargaon	Kopargaon
<b>Kerala</b>		
63	NIT Calicut	Calicut
64	Govt College of Engineering	Kannur
65	TKM Institute of Technology	Kollam
66	Younus College of Engineering & Technology	Kollam
67	TKM College of Engineering	Kollam
68	College of Engineering Vatakara	Vadakara
69	College of Engineering Kasargod	Kasargod
70	TOC H Institute of Science & Technology	Cochin
71	CUSAT - School Of Engineering	Cochin
72	Sharabhai Institute of Technology	Thiruvananthapuram
73	Mar Baselios College of Engg & Tech	Thiruvananthapuram
74	Sri Vellapalli Natesan College of Engineering	Kayankulam
75	College of Engineering	Pathanapuram
76	Sree Buddha College of Engg & Tech	Alappuzha
<b>Orissa</b>		
77	N.I.T Rourkela	Rourkela
78	College of Engg & Technology	Bhuvaneshwar
<b>Tamil Nadu</b>		
79	IIT Madras	Chennai
80	Kumar Guru College of Engineering	Coimbatore
81	Annamalai University	Chidambaram
82	Karunya University	Coimbatore
83	B.S. Abdur Rehman University	Chennai

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85	Kumar Guru College of Engineering	Coimbatore
86	Govt College of Engineering	Tirunelveli
87	NIT Trichy	Thiruchirapalli
<b>Assam</b>		
88	NIT Silchar	Silchar
89	Johrat Engineering College	Jorhat
<b>Delhi</b>		
90	IIT Delhi	Delhi
91	Aligarh Muslim University	Aligarh
92	Jamia Millia Islamia	Jamia Nagar
<b>Others</b>		
93	Khowpa Engg Collage	Kathmandu
94	Banaras Hindu University	Varanasi
95	Malaviya National Institute of Technology	Jaipur

And many other.....