CAPSULE PROPOSAL FORM

Date Submitted: February 28, 2023	Semester: 2nd Semester 2022-2023	Duration of the Project: April-December 2023
Team Leader: Engr. Merricris U. Pangilinan		
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College/Campus: COE/Main	Department: Civil Engineering	Program: Civil Engineering
Project Title: Structural Resiliency of the Roxas Hall using Non-Destructive Test and Response Spectrum Analysis		
Funding Source: BulSU	Total Project Amount: ₱165,600.00	

Members:

	College/Department/Agency:
Dr. Cecilia A. Geronimo	COE - Civil Engineering
Engr. Radger Teddy Manuel	COE - Civil Engineering:

Research Agenda: KAGYAT-Disaster Risk Reduction and Management

☐ Climate Change and Adaptation	☐ Diagnosis and Prevention of Human Diseases and Health Status of Vulnerable Groups	☐ Restructuring Society and understanding of Culture towards Inclusive Nation Building
☐ Biodiversity and the Management of the Natural Environment	☐ Industry assistance Towards Efficient production and Achieving Global Standards	☒ Emerging Technology and Applications to Inclusive nation Building
☐ Food Safety and Security	☐ Cultural Heritage and Conservation	☐ Education and the Pedagogy for the Filipino Learners

United Nations Sustainable Development Goals

☐1 No Poverty	☐2 Zero Hunger	☐3 Good Health and Well-Being	☐4 Quality Education
☐5 Gender Equality	☐6 Clean water and sanitation	☐7 Affordable and Clean Energy	☐8 Decent work and Economic Growth
☐9 Industry, Innovation, and Infrastructure	☐10 Reduced Inequalities	☒11 Sustainable Cities and Communities	☐12 Responsible Consumption and Production
☐13 Climate Action	☐14 Life Below Water	☐15 Life on Land	☐16 Peace, Justice, and Strong Institutions
☐17 Partnerships for the Goals			

Program Component:

☐ ANIB DAMPI	☐ YAMAN	☒ KAGYAT
☐ BALAT	☐ UGNAY	

Subprogram/s (Pls. Specify) **Disaster Risk Reduction and Management**

Projected Output

☒ Publication	☒ Partnership and Places	☐ Policies
☐ Patent/IPs	☐ Profit	☐ People Services: Specify___________
☐ Product/Process		

Rationale: The Philippines being in the Pacific Ring of Fire is prone to earthquake hazards. In the country, fault line system is located. The PHILVOCS stated that the Fault system moves every 400 years to 600 years. The West Valley Fault is over 100 kilometers long, running through the provinces and cities of Bulacan, Laguna, Rizal, Cavite, Quezon City, Makati,

Marikina, Taguig, and Muntinlupa. The Fault system is capable of generating a 7.2-magnitude earthquake.
With the threat of a powerful earthquake hanging over our heads like a sword, people are motivated to research greater ways of designing and improving structures against earthquakes.

With the constant demand for change, along with the passage of time, the provisions for earthquakes also change. Along with the changes, the demand for already built buildings to be analyzed and checked for their resiliency in withstanding earthquake loads.

The design of every structure may vary due to the different locations where it will be built. Also, in structural design, the dead loads, live loads, wind loads, and earthquake loads are always considered. Structures are commonly the country's most costly national investment and asset like Roxas Hall are being used by students, faculty members, and non-academic personnel.

For a building, the foundation, floors, walls, beams, columns, footings, roof, stairs, etc., are its fundamental parts. These components help to support, enclose, and safeguard the building. High compressive strength is required for these components to withstand the weight of the building and other forces acting on the structural members.

Roxas Hall is one of the many buildings that is being utilized in the Bulacan State University-Main Campus, mainly used by Education students. The hall has been there for decades, and there may be cracks or corrosion – which may affect its structural components and react to loads such as earthquake (seismic) load.

The lifespan of any concrete building is between 75 to 100 years. Maintenance or periodical inspection of a building allows the researchers to keep track of a building's structural resiliency over the years as it is being utilized. Structural analysis can also serve as an audit for a building assessing its possessed structural damages and mitigating them.

Response Spectrum Analysis is a dynamic linear method of analysis that measures and analyzes the response of an elastic structure to all modes of vibrations for any seismic response with no given exact time history. Response Spectrum Analysis is needed in the design process of a structure as well as to check the vulnerability and resiliency of a structure to seismic waves. The researchers are interested in investigating the building that housed the entire College of Education and see if the building is failing or not. (https://www.midasbridge.com/en/blog/project_tutorial/response-spectrum-analysis)

According to the National Structure Code of the Philippines (2015) Section 103, Table 103-1, *"Buildings used for college or adult education with a capacity of 500 or more occupants"* would categorize the building as Category III – Special Occupancy Structure.
Roxas Hall is located around 35.7 km away from the nearest fault line, the West Valley Fault.

Using software programs in assessing the current resiliency of the structure will not just help the future researchers of the study, but it will also help in developing mitigation plans to avoid any destruction that is bound to happen if left unanalyzed. This study is a long-term investment for the university, it will help more than just the mitigation of plans, but it will also serve as an eyeopener that structures, especially old structures that are constantly used, must be analyzed in intervals to ensure a safe place for any occupants.

Objectives:
General Objective
- To investigate the structural resiliency of the Roxas Hall using non-destructive test and

response spectrum analysis

Specific Objectives

1. To describe the status of Roxas Hall in terms of:
   1.1 age of the building;
   1.2 building occupancy;
   1.3 number of floors;
   1.4 vertical clearances;
   1.5 earthquake history; and
   1.6 total height of the building
2. To use MIDAS software and determine the possible outcomes of the analysis in terms of:
   2.1 floor plans and elevations;
   2.2 soil classification;
   2.3 concrete and reverse strength;
   2.4 utilization of each room;
   2.5 dead load, live load, wind load, and earthquake load;
   2.6 sizes of structural members; and
   2.7 load combinations.
3. To determine the response of the Roxas Hall using Response Spectrum Analysis considering the following factors:
   3.1 building displacement;
   3.2 structural members' internal stresses;
   3.3 column PPM interaction ratio;
   3.4 beam longitudinal shear and torsion rebars; and
   3.5 column and beam rebar percentage.

Earlier results within the research area by applicants; related works already in progress
Monitoring of Structural Health and Safety of the Flores Hall and Valencia Hall: Inputs for Repair, Renovation, and Retrofitting using Rapid Visual Screening and Non-Destructive Testing – Rebound Hammer Test

Related Literature and Studies

Non-Destructive Tests

Nondestructive testing (NDT) is the practice of looking for flaws or variations in a material, component, or assembly without damaging the part's or system's capacity to function normally. In other words, the part can still be utilized once the inspection or test is over. Some tests, as opposed to NDT, are destructive in character and are carried out on a small number of samples ("lot sampling") rather than on the materials, components, or assemblies that will be used. These destructive tests are frequently used to assess the material's physical characteristics, such as impact resistance, ductility, yield and ultimate tensile strength, fracture toughness, and fatigue strength, but NDT is more efficient at identifying discontinuities and variations in the material's properties. Modern nondestructive tests are being utilized in manufacturing, fabrication, and in-service inspections to guarantee product dependability and integrity, to regulate production procedures, to cut costs, and to maintain a constant level of quality. In-service NDT inspections are used to make sure that the products being used continue to have the integrity required to ensure their usefulness and the safety of the general public. NDT is used during construction to ensure the quality of materials and joining processes during the fabrication and erection phases. Although the medical industry employs many of the same techniques, it should be emphasized that the phrase "nondestructive testing" is often not used to describe medical applications. (https://asnt.org/en/MajorSiteSections/About/Introduction_to_Nondestructive_Testing.aspx#:~:text=Nondestructive%20testing%20(NDT)%20is%20the,part%20can%20still%20be%20used).

Response Spectrum Analysis

In order to estimate the most likely maximum seismic response of a basically elastic structure, response-spectrum analysis (RSA), a linear-dynamic statistical analytic approach, evaluates the contribution from each natural mode of vibration. By measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a certain time history and damping level, response-spectrum analysis sheds light on dynamic behavior. The peak response for each realization of the structural period can be represented as a smooth curve by enclosing the response spectrum. Response-spectrum analysis links the choice of structural type to dynamic performance, which is helpful for design decision-making. Longer structures undergo higher displacement, and shorter structures have greater acceleration. Prior to final design and response-spectrum analysis, structural performance objectives should be taken into consideration. (https://wiki.csiamerica.com/display/kb/Response-spectrum+analysis).

Related Studies

In her work "Structural Soundness of Carpio Hall and Federizo Hall: Inputs for Design and Reconstruction of Buildings at Bulacan State University," Rivera (2021) employed non-destructive testing, namely the use of a rebound hammer, to ascertain the compressive strength of each structural element. The hammer rebound test is effective in giving quick test results and is advised for usage because it won't cause further damage to the members. The building's age, the materials used, the state of the structure, and the compressive strengths of the beams, columns, and slabs of the two structures were utilized as parameters. A structural plan was put forward based on the findings and may help and serve as a foundation for assigning a budget for repair, retrofitting, and remodeling. Based on the results, some members of the buildings already display indications of degradation owing to its age and insufficient care**.**

In research published in 2016, Lopes et al. used the non-destructive test to estimate the compressive strength of concrete. The non-destructive test employed was an ultrasound examination. The study's goal was to establish connections between the findings of surface hardness and ultrasonic nondestructive testing (NDTs) and the compressive strength of the structural concrete in the stadium's bleachers in Cianorte, Parana, Brazil. The 26-year-old concrete building exhibits flaws like corrosion, concrete segregation, and fractures. Recent worries about concrete spalling in one slab have been highlighted. After a standard-compliant mapping of the reinforcement, a standard-compliant ultrasonic test was conducted for the identical sites used in the surface hardness test. The concrete specimens were removed according to guidelines of the standard to evaluate compressive strength, perform the NDT and generate the correlation curves for the results. The correlation curves between the compressive strength of the concrete specimens and the values of the surface hardness index and the ultrasonic wave propagation velocity were found to provide extremely trustworthy equations, it was determined. (Concrete Compressive Strength Estimation by Means of Non-Destructive Testing: A Case Study, Yuri Danilo Lopes, Leandro Vanali, Vladimir Jose Ferrari, Open Journal of Engineering, Volume 6 No.4, September 2016).

“Response” means “to react” in a dynamic way. For designing pile-supported structures for earthquakes, it is mostly utilized as a preliminary design approach. In the analysis algorithm, the frame with a virtual fixed point or the frame supported by a soil spring are used to simulate piles. The natural period of a dynamic study, such as a response spectrum analysis, cannot be effectively and accurately simulated by the virtual fixed-point approach. A modeling technique for response spectrum analysis that can accurately replicate the dynamic response of pile-supported structures was developed as a result of this work. Initially, p-y loops were created by testing a dynamic centrifuge model, which were then contrasted with currently used soil spring techniques. The dynamic responses of pile-supported structures were therefore accurately modelled by the response spectrum analysis utilizing the Terzaghi elastic spring. (Evaluation of soil spring methods for response spectrum analysis of pile-supported structures via dynamic centrifuge tests, JW Yun, JT Han, Soil Dynamics and Earthquake Engineering, Volume 141, February 2021, 106537 – Elsevier).

Peak floor acceleration (PFA) reactions and the design of acceleration-sensitive nonstructural components are closely connected. We provide a better technique for calculating PFAs in structures during earthquakes. This offers a supplementary mode that correctly considers ground accelerations. It offers precise forecasts of PFA at the base and is just as useful as traditional response spectral analysis. We first use linear dynamic studies to establish the typical PFA distribution for the complementary mode, and we then adapt the approach to nonlinear instances. The suggested technique is promising for both linear elastic and somewhat inelastic instances, according to an error analysis. (Response Spectrum Analysis of Peak Floor Accelerations of Buildings under Earthquakes, Y Cao, Y Huang, Z Qu - Journal of Earthquake Engineering, Volume 26, 2022, Issue 14- Taylor & Francis).

Methodology:

Research Design

This experimental research will use non-destructive testing-RHT and MIDAS software. The results of the NDT will be inputted into the software. The researchers will request plans and designs of the Roxas Hall from the Project Management Office. Other information needed by the MIDAS software, such as the type of soil the structure is built-on and the zone where the structure is built will be gathered. After the important variables were collected it will be followed by the modeling of the structure into the MIDAS software. As expected, the results will be generated based on the different modal analyses of the Roxas Hall. Also, the National Structure Code of the Philippines 2015 will be used instead of the International Building Code of 2021, since it is not being used in the country.

Research Site and the Participants/Respondents /Subjects (If applicable)

The area of the study is the Roxas Hall located in the BulSU Main Campus

Data Collection and Analysis

The results from the NDT-RHT will be inputted into MIDAS Gen Software. Its graphical user interface perceives structural models, approaches for input and output, processing data, and performing calculations. The development of seismic analysis through Response Spectrum Analysis (RSA) will also consider the MIDAS Gen outputs. To determine concrete’s elasticity and shrinkage, the building stage analysis will focus on its properties. The researchers can develop load combinations using the post-processor feature to evaluate the forces, stresses, and displacements of the Roxas Hall. The interface between MIDAS Gen and Microsoft Excel makes it effective since it enables the changing and adaptability of the sequence of steps. With the aid of Autodesk, AutoCAD, and structural plans that may require to be performed or modified are attainable.
The following steps of the research include:

1. accumulating structural plans or, if necessary, laying out an as-built plan using Autodesk, AutoCAD; 2. rebound hammer testing; 3. input the data in MIDAS Gen and Microsoft; and 4. contingent on the report from MIDAS Gen for findings and recommendations on whether the building will undergo repair, renovation, or retrofitting.
Ethical Considerations: (*Provide a brief discussion*) N/A – the area of study is the structural components of Roxas Hall
Specific Expected Output of Research Project: Response of the Roxas Hall using Response Spectrum Analysis considering the following factors: 1.1 building displacement; 1.2 structural members' internal stresses; 1.3 column PPM interaction ratio; 1.4 beam longitudinal shear and torsion rebars; and 1.5 column and beam rebar percentage
Summary of Budgetary Requirements
Personal Services Details: Project leader: ₱8,800 x 9 = ₱ 79,200.00 Partners: ₱4,800 x2 X 9 = ₱ 86,400.00 **Estimated Cost:** ₱165,600.00
Maintenance and Other Operating Expenses Details: **Estimated Cost:**
Grand Total: Php [165,600.00]

References:

Note: Please use the Sample Budgetary Requirements in Excel

Work Plan / Gantt Chart														
Objectives	**Expected Output**	**Activities / Work plan**	**MONTH**											
			1	2	3	4	5	6	7	8	9	10	11	12

1. To describe the status of Roxas Hall in terms of: 1.1 age of the building; 1.2 building occupancy; 1.3 number of floors; 1.4 vertical clearances; 1.5 earthquake history; and 1.6 total height of the building	Status of Roxas Hall in terms of: 1.1 age of the building; 1.2 building occupancy; 1.3 number of floors; 1.4 vertical clearances; 1.5 earthquake history; and 1.6 total height of the building	● Collection/gathering of data about the age of the building, building occupancy number of floors, vertical clearances, earthquake history, and total height of the building. ● Secure as-built plans and structural design of the Roxas Hall ● Conduct a non-destructive test on structural members ● Writing of chapter 1, the problem and its background, composed of an introduction, statement of the problem, the significance of the study, and scope and delimitations of the study												
2. To use MIDAS software and determine the possible outcomes of the analysis in terms of: 2.1 floor plans and elevations; 2.2 soil classification;	Data of the following as a result of using MIDAS software 2.8 floor plans and elevations; 2.9 soil classification; 2.10 concrete	● Input the results of the non-destructive testing and other data in the MIDAS software ● Writing of chapter 2, theoretical framework												

2.3 concrete and reverse strength; 2.4 utilization of each room; 2.5 dead load, live load, wind load, and earthquake load; 2.6 sizes of structural members; and 2.7 load combinations.	and reverse strength; 2.11 utilization of each room; 2.12 dead load, live load, wind load, and earthquake load; 2.13 sizes of structural members; and 2.14 load combinations.	consists of relevant theories, related literature, related studies, conceptual framework, assumptions of the study, and definition of variables												
3 To determine the response of the Roxas Hall using Response Spectrum Analysis considering the following factors: 3.1 building displacement; 3.2 structural members' 'internal stresses; 3.3 column PPM interaction ratio; 3.4 beam longitudinal shear and torsion rebars; and 3.5 column and beam rebar percentage.	Response of Roxas Hall using Response Spectrum Analysis considering the following factors: 3.1 building displacement; 3.2 structural members' internal stresses; 3.3 column PPM interaction ratio; 3.4 beam longitudinal shear and torsion rebars; and column and beam rebar percentage.	• Writing of chapter 3, Research methodology composed of research design, testing of structural components • Analysis of the factors in using Response Spectrum Analysis • Writing of chapter 4, presentation, analysis, and interpretation of data • Writing of chapter 5, summary of findings, conclusions, and recommendations												

Prepared and submitted by:

ENGR. MERRICRIS U.PANGILINAN
(Signature Over Printed Name)
Team Leader

Evaluated by:

(Signature Over Printed Name)
Academic Program Chair