

Research Attachment Program Report

University of Catania Italy

Student Name: Eric Joseph Pereira (22009727)

Supervisor: Dr Teh Hee Min

Host University Supervisors: Professor Pietro Scandura & Professor Daniele La Rosa

PhD Topic: Performance Characteristics of An Oscillating Water Column Integrated with A Decommissioned Offshore Oil Platform

Program Overview:

The Research Attachment Program (RAP) was initiated to assist and strengthen collaborative efforts between University Teknologi PETRONAS (UTP) and partner, University of Catania, Italy (UNICT) for joint research in coastal vulnerability assessment and marine renewable technologies. The institution in UNICT has a dedicated research center; Centre for the Protection and Management of Natural Environments and Agro-ecosystems (CUTGANA), which delved into new, emerging niche research iin Marine and Maritime Hydraulics Research. Field supervisors, Professor Scandura and Professor La Rosa have vast research experience in coastal planning and management, marine renewables and climate change. Over the span of the RAP, the students will discuss the research topics to acquire additional input to sharpen their research methodologies and gain exposure to the software, lab facilities and techniques best suited to their specific research topics.

Introduction:

Prof Pietro Scandura is an expert in the design of OWC's and numerical analysis of U-OWC attached to shoreline breakwaters, particularly a real example based in the Civitavecchia Port in Italy. His input to this PhD, project based on his experience in the field of numerical analysis of hydraulic structures, especially OWCs, will be a significant contribution the preliminary design stage of the OWC suited for application on offshore platforms. The wave climate and method for energy extraction at offshore locations differ from onshore locations because the wave energy approaches the offshore platforms in all directions and cannot be completely absorbed in shore based OWCs. The geometry and attachment method of the OWC for an offshore platform poses a research gap which will be the main focus of the RAP at UNICT. In order to develop a comprehensive and accurate method to evaluate an offshore OWC, proper design methodology and tools for numerical simulation for an oil platform will be identified. Discussions on literature review of the geometry and attachment method of existing offshore OWCs will be reviewed together with the field supervisor to identify the best geometry and its adaptation optimum performance in Malaysian wave climate. The abstract, objectives and outcomes of the RAP for this topic are detailed in this report including the daily log book of the activities executed over the 2 weeks in UNICT.

Abstract:

There are about 353 offshore oil rigs operating in Malaysia sea. Currently, 56% are operating beyond design life and 18% are operating more than 40 years. These ageing oil rigs are intended to be decommissioned shortly. The decommissioned oil rigs can be repurposed as floating restaurants, diving centers, meteorological stations, and marine research centers. Since the decommissioned oil rigs are unfunctional, a new source of electric supply is needed to power up these facilities. In addition, most of the oil rigs are located offshore where the waves are more energetic than onshore. Therefore, this study aims to provide a self-generated electricity device using oscillating water column (OWC) wave energy converter to be attached at a decommissioned oil rig. The current offshore OWCs were designed based on the wave power of more than 20kW/m to 50kW/m are unsuitable for application in Malaysia because the recorded wave power is less than 10kW/m.

In addition, most of the current developed offshore OWCs were fixed on the offshore structures and considered submerged all the time. In real condition in Malaysia, it is challenging to ensure that the OWC consistently submerged because the fixed device cannot be adjusted following the wide range of tidal variations that occur in Malaysia. Hence, the device should be allowed to move in heave motion with the tides to ensure it will be operating constantly at optimum draft and consistently give maximum power take-off for the device. Besides, the effect of the oil rig inclination on the OWC performance is uninvestigated yet.

Thus, the objectives of this study are to optimize the geometry of an OWC air chamber fixed to the oil rig legs subjected to regular wave actions to evaluate the performance characteristics of the OWC air chamber with the optimized design using both numerical and physical modelling. In addition, other factors influencing the performance such as the effect of platform batter and freedom in heave motion of the OWC will be investigated. This study will contribute to any development of offshore OWC integrated with decommissioned oil rig at low wave condition and provide information on the effect of heave motion and oil rig batter (inclination) on the OWC performance.

Scope of Study: What topics to cover during the 2 weeks attachment.

- 1. Investigate the properties of wave propagation in the deep-water region and its interaction with an OWC placed at the free surface with decommissioned oil platforms as supporting structures.
- 2. Optimization of the geometry of an OWC for low wave steepness climate in Malaysia offshore locations.
- 3. Numerical approaches for analyzing the geometry and attachment system of the OWC to an oil platform.
- 4. Discussion on critical literature reviews related to OWC attached to the leg and base of offshore platforms to propose methodologies and research gaps which could be explored.

Objective: What are the targeted outcomes from the RAP

- 1. To develop an OWC device with suitable geometry to be utilized at the leg/boat landing of an offshore platform
- 2. To study effect of allowance of heave motion to the OWC to determine overall power take off efficiency
- 3. Methodology for designing the OWC using numerical simulations and identification of the best software to be used for the simulation of offshore platforms

4. Understand research methods and laboratory facilities used in UNICT and different department backgrounds including materials engineering, town planning, architecture, and hydraulics engineering.

Outcomes: Output from Research Attachment

- 1. Plan out geometry validation of the OWC attached to offshore platform based on U-OWC approach of trapping wave energy and minimizing wave reflection
- 2. Attaching mechanism of OWC to the offshore platform:
 - a. Fixed: To allow for enhancement of wave energy extraction
 - b. Floating: To move along with tidal variations and the be fixed at intervals to enhance wave energy extraction
- 3. ANSYS Fluent was decided as the software to be utilized for the numerical simulation of the geometry
- 4. Introduction to the different Professors and team members from UNICT and explored potential avenues for future collaborations in different research topics within the scope of focus for Research Institutes in UTP as shown in Figure 1.



Figure 1: Research Institutes in Universiti Teknologi PETRONAS



RESEARCH ATTACHMENT PROGRAM (RAP) AT Department of Civil Engineering and Architecture, UNIVERSITY OF CATANIA

LOGBOOK

NAME: MATRIC ID: PROGRAM: RESEARCH TITLE:

SUPERVISOR (S):

ERIC JOSEPH PEREIRA 22009727 PhD IN CIVIL & ENVIRONMENTAL ENGINEERING PERFORMANCE CHARACTERISTICS OF AN OSCILLATING WATER COLUMN INTEGRATED WITH A DECOMMISSIONED OFFSHORE OIL PLATFORM

- 1. DR. TEH HEE MIN
- 2. PROF PIETRO SCANDURA

DAY: MONDAY

DATE: 20/03/2023

ACTIVITIES:

1. Meeting with Field supervisor Prof Pietro Scandura

- Brief discussion with Prof Pietro Scandura on the topic of OWC and what scope of work has been covered previously in his previous research paper.
- Understand functional concepts of OWC which is attached to the shoreline and methods which were used in estimation of its performance.
- 2. Overview of PhD topic to understand scope of work for 2 weeks.
 - Brief discussion with Prof Pietro Scandura on the current literature review related to OWC which is attached to the base of offshore platforms.
 - Presentation of Research Proposal to Prof Pietro Scandura for scope of work and objectives to be achieved over the two-week period.
 - 3 different aspects of the OWC were highlighted to be optimized:
 - i. Geometry
 - ii. Support System
 - iii. Ballasting Material

Field Supervisor Signature:

Piotro Scendur

DAY: TUESDAY

DATE: 21/03/2023

ACTIVITIES:

- 1. Discussion with Prof Pietro Scandura on the Design of OWC
 - Presentation of literature review and design concept to Prof Pietro Scandura on utilization of membrane in OWC pneumatic system.
 - Flexible membranes are proven to have lot of limitations and no significant increase in performance of the wave energy trapping mechanism.
 - Tensile strength and length of the material needs to be adequately designed to enable functionality in wide range of wave conditions.
- 2. Meeting with Professor Daniele La Rosa
 - Brief overview on the topic of coastal vulnerability
 - Discussion on scope of work for the period of the RAP
 - Obtain credentials for usage of Wi-Fi on campus.

3. Sharing Session with students from UniKL regarding topic of OWC

- Provided overview on numerical concepts which have been employed in numerical simulations for floating and fixed structure using VOF methods.
- Sharing of literature review related to numerical simulations of OWC.

Pietro Scoudero

DAY: WEDNESDAY

DATE: 22/03/2023

ACTIVITIES:

1. Attended Final Year Project Presentation by students of UNICT.

- Graduation ceremony of students where each student presents their FYP topic to an audience and their main supervisors.
- FYP topics covered the scope of building restoration in Italy, modular construction, Building Information Management and modelling of existing structures using AutoCAD.

2. Discussion with Prof Pietro Scandura on the Geometry of OWC attached to Oil Platform

- OWC attached to the leg of platforms commonly have a circular geometry and a piles support located in the centre which poses the problem of wave diffraction within the water column.
- Discussed impact of wave steepness and methods to partition and reconfigure the internal geometry to enhance energy extraction.
- Explored to usage of dual passage for air flow with valves to enhance energy extraction within the column- Head loss is a major factor to consider before applying such drastic approach. Better to explore different types of turbines instead.

3. Sharing Session with UniKL on methods for Numerical Simulation

- Provided UniKL FYP students with an overview of numerical modelling for a wave flume using software such as FLOW3D and also ANSYS Fluent.
- Discuss utilization of a moving boundary for generation of waves in a wave flume using User Defined Functions.
- Review the pros and cons of using 2D and 3D numerical simulations for different parameters to be investigated in hydrodynamic numerical simulations.

Field Supervisor Signature:

Pietro Scoudino

DAY: THURSDAY

DATE: 23/03/2023

ACTIVITIES:

- 1. Discussion with Prof Pietro Scandura on relationship of Air Pressure and Turbine Output
 - Energy in an OWC is mostly dependent upon the different type of power take off systems which are used to extract energy.
 - Impulse turbine has double the flowrate as compared to a Well's turbine which results in different rotation speed and resultant losses due to friction etc. One of the differences between the Well's and Impulse turbine is that the first has a higher peak efficiency but this drops very rapidly for large flow rates while the second has a lower peak efficiency, but it is maintained even for large flow rates.
 - Compression of air and formation of turbulent vortices within the OWC do not contribute significantly to the energy losses.

<i>L</i> .	Explanation of functional concept of U-OWC & methods to enhance energy extraction.
	• The front wall of the U-OWC is to enhance wave energy trapping by the device and
	reduce wave reflections at the front wall as compared to conventional OWC.
	• U-OWC is wave energy absorber to oscillations of the water column within the U-
	Shape and to the inlet placed close to the free surface which enhances height of oscillations and power take off
3	Discussion on Numerical Mathods used for simulation by Prof Pietro Scandura in U-
5.	OWC
	• Introduction to numerical software being used by Prof Pietro Scandura in his
	research such as FORTRAN and management of the system processor and database.
	• Explained the benefit and limitations of self-developed code vs software in the field
	of research.
	i. Self-developed codes require a lot of time to be developed, which can incur large resources and costs over time.
	 ii. Commercial software is more expensive and covers a wider scope of fields as compared to self-developed software.
	iii. Code which is used only for specific applications such as simulation of wave interaction within a U-OWC needs to be self-developed for higher clarity of
	the situation.
Field S	Supervisor Signature:
	Pietro Sconduro

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DAY: FRIDAY **DATE:** 24/03/2023

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ACTIVITIES:

- 1. Comparison between floating and fixed OWC performance efficiency
 - Fixed OWCs are more efficient (40% efficiency) as compared to floating OWCs (25% efficiency) due to the restrain in horizontal and vertical movement.
 - Downside of fixed OWC system is that it is unable to move along with tidal variation and will not be able to perform if water levels are too low or too high.

2. Design of mounting system in large tidal variation for optimum OWC efficiency

• Mounting system of OWC to be investigated with free motion and fixed motion in the vertical axis to compare the outcome of performance efficiency of the oil platform attached OWC.

3. Discussion of OWC Design which has been improved with Dr Teh Hee Min

- Presentation of current progress on OWC design improvement to supervisor based on discussion and input from Prof Pietro Scandura.
- Revision of methodology for PhD project to focus on geometry and mounting system of the OWC and keep output of the device as pressure variation and velocity of air at the outlet.

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DAY: SATURDAY

DATE: 25/03/2023

ACTIVITIES:

1. Review design which has been proposed based on supporting literature.

- Explore other designs of pile attached OWC to investigate diffraction parameter and performance of different types of geometry.
- Ensure that design being developed does not coincide with other existing literature and research gaps which have been addressed by other researchers.

2. Explore the feasibility of numerical software in simulating offshore platform OWC.

- Explore the different proposed software to carry out numerical simulations for preliminary results. Software which was reviewed includes:
 - i. FLOW3D
 - ii. ANSYS Fluent
 - iii. OPENFOAM
 - iv. Altair DEM

Field Supervisor Signature:

PiltroScandura

DAY: SUNDAY

DATE: 26/03/2023

ACTIVITIES:

1. Decide on software to be used for Numerical Simulation

- ANSYS Fluent was decided to be used as the preferred software for simulation as it has an easier operating system and student version of the license.
- Read up literature related to set up of 2D wave flume using VOF method for numerical simulation of OWC in a wave tank.

2. Wrap up of Week 1 activities and preparation of Logbook Report

- Compile activities which were carried out in Research Logbook Report
- Update supervisor Dr Teh Hee Min on current progress and research plan for following week.

Pietro Scanduro

DAY: MONDAY

DATE: 27/03/2023

ACTIVITIES:

1. Influence of wave diffraction & wave reflection around offshore platform piles

- OWC which are attached to the leg portion of an offshore platform are significantly influenced by wave diffraction and wave reflections of the pile surface.
- Evaluated method which can be used to enhance wave energy extraction and reduce wave reflections from the piles of the oil platform:
 - i. Half geometry of OWC
 - ii. Increase height of the backwall
 - iii. Explore utilization of U-OWC on existing cylindrical pile attached OWC.

2. Introduction Lecture about UTP and Teaching Methods by Dr Teh

• Dr Teh gave a brief introduction about the Civil and Environmental Engineering department in UTP and talked about the teaching methods employed in class.

Field Supervisor Signature:

Pietro Scandera

DAY: TUESDAY

DATE: 28/03/2023

ACTIVITIES:

- 1. Discussion on ANSYS Fluent and 2D Numerical Simulation methodology to be executed.
 - Planning of factors to include in the 2D Numerical simulation using ANSYS Fluent such as preparation of the sketch for the model and wave flume.
 - Determining physical parameters to include in the model and type of meshing to be used to ensure proper convergence and accuracy of reading.
- 2. Visit to Structural Engineering Department
 - Introduction to the department of Structural Engineering by Associate Prof Edoardo M. Marino.
 - Discussion of type of research projects which are currently being carried out and potential collaborations between UTP and UNICT.
 - Projects in Italy are mostly based on structural rehabilitation as well as construction on existing structure which is a potential area for collaboration.
- 3. Campus tour and Student Exhibition of different departments on Open Day
 - Open day for UNICT was carried out in the sports complex of the University where the different departments displayed their current R&D as well as the course structure which was offered for each program.
 - Viewed the booth for Coastal Engineering and Architecture which showcased the experimental facilities and projects which are available at UNICT.

Pietro Scandura

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DAY: WEDNESDAY

DATE: 29/03/2023

ACTIVITIES:

- 1. Installation of ANSYS Fluent and Sketch of OWC in 2D for preliminary simulation
 - Installed ANSYS Fluent student version on personal laptop and started modelling of the OWC Wave Flume.
 - Preparing details of experimental matrix for wave climate condition in Malaysia and for water depth in region of Oil Platforms.
- 2. Planning layout of experimental methodology for geometry optimization using numerical simulation
 - Discussion with Prof Pietro Scandura on steps to be taken in the physical experimentation phase once the numerical simulation outcomes are obtained.
 - Planned project workflow for the project to inculcate RAP student from UNICT in July 2023 and scope of work which will be covered during the 2 weeks related to the OWC project.

Field Supervisor Signature:

Pietro Sepudura

DAY: THURSDAY

DATE: 30/03/2023

ACTIVITIES:

- 1. Visit to Wind Tunnel and Mechanical Engineering Material Testing Lab
 - Lab tour conducted by Prof Giuseppe Mirone on the wind tunnel and the different types of turbines which are being tested in the lab.
 - Describe the experimental facilities which are being used for structural engineering and mechanical engineering such a tensile strength test, compression test, torsion test and also ballistic properties of the materials.
 - Provided brief history of the development of the different experimental testing machines and materials that are being tested in the lab in UNICT.
- 2. Simulation setup in ANSYS Fluent
 - Continued to develop simulation model and setup for ANSYS Fluent Wave Flume
 - Research more on methods to generate waves in the Numerical Wave Flume based on other literature review.
- 3. Wrap up on methodology for next 3 months and expected outcomes.
 - Discussing with Prof Pietro Scandura on current progress of research work and planned methodology to be taken for the different phases of the project.

PithoScoudura

DAY: FRIDAY

DATE: 31/03/2023

ACTIVITIES:

1. Final discussion with Prof Pietro Scandura and Associate Prof Daniele

- Wrap up discussion with both field supervisors Prof Pietro Scandura and Associate Prof Daniele on the outcome of the RAP for the two weeks at UNICT.
- Provided input on the potential projects which we can collaborate towards for RAP involving students from UNICT pending to be carried out in July 2023.

2. Final send off by field supervisor Prof Pietro Scandura

• Final photo taken with field supervisor and presentation of token of appreciation on behalf of UTP and JPS.

Field Supervisor Signature:

Pietro Scouduro

DAY: SATURDAY

DATE: 01/04/2023

ACTIVITIES:

- 1. Compilation of RAP Activities & Logbook reporting
 - Compilation of report and logbook for RAP over the two weeks.
- 2. Update with supervisor Dr Teh Hee Min on final project deliverables
 - Online discussion with supervisor to update on final outcomes of the project and requirements for the project reporting.

Field Supervisor Signature:

Ritteo Scenduro

DAY: SUNDAY

DATE: 02/04/2023

ACTIVITIES:

1. Presentation of final Logbook report to supervisor Dr Teh Hee Min for checking

• Submitted one page slide as well as RAP Logbook report to supervisor for final checking before submission to Field Supervisor.

2. Exploring around Catania city to view architecture and coastal area

- Explored how most of the development in the city such as roads and buildings utilized the igneous rock from the active volcano to redevelop the city.
- Viewed the coastline nearby Catania which consisted mainly of igneous rock formations due to the active volcano nearby.

Pillo Scenduro

<u>APPENDIX</u>

Campus Tour









Meeting with Students from UniKL



FYP Presentation by Students of UNICT





Lecture Presentation about UTP and Teaching Methods by Dr Teh Hee Min





Architecture and Engineering booths at the Student Fair in UNICT





Discussion with Associate Prof Edoardo M. Marino.



Lab tour by Prof Giuseppe Mirone



Picture with the Team from the department of Architecture



Picture with Field Supervisor Prof Pietro Scandura on the Final Day

