Progress report for the period of 22th January 2022-21th January 2024

Kailash Chan Swami
09/1026(13600)/2022-EMR-I

Under the supervision of
Prof. Santanu Koley

BITS Pilani
Hyderabad Campus

Department of Mathematics
BITS Pilani, Hyderabad Campus
Telangana - 500078

ENHANCEMENT REPORT

On Completion of Second Year

1. Name of the Fellow: **KAILASH CHAND SWAMI**

2. Email Address of the Fellow/Associate: kswami1096@gmail.com

3. Nature of Fellowship (JRF(NET)/SRF(NET)/SRF/RA): JRF(NET)

4. CSIR Award No.: 09/1026(13600)/2022-EMR-I

5. Name, designation and address of Guide: **Prof. Santanu Koley**
Associate professor
Dept. of Mathematics
Birla Institute of Technology and Science-Pilani,
Hyderabad Campus
Telangana-500078.

6. Place of work (Names of the Department/Institute/University/College, etc.):
Dept. of Mathematics
Birla Institute of Technology and Science-Pilani,
Hyderabad Campus
Telangana-500078.

7. Date of joining: 22/01/2022

8. Period up to which fellowship is tenable: 21/01/2027

9. Date of registration for higher degree (PhD): 22/01/2022

10. (a) Topic of Research: Mathematical Modelling for Water Wave Interactions with Various Coastal Structures.
(b) Broad Subject Area: Hydrodynamics, Integral Equation.

11. Objective in undertaking work: (See Annexure I)

Period of Report: From 22/01/2022 to 21/01/2024

12. Attendance: Full

(a) Total No. of working days during the period under report: All working days
(b) Out of these, total no. of days in which the Fellow/Associate was present and worked: All (excluding the 30 days)
(c) Number of days for which leave was sanctioned: (Casual Leave 30 days)

13. Detailed report about the research work done during the above-mentioned period. This should include quantitative results of research presented in Table(s)/Figure(s), discussion and conclusions drawn (separate sheets should be attached): (See Annexure II)

15 Summary of research work done during this period (in not more than 300 words: a separate sheet may be attached): (See Annexure III)

16. Plan of work for the next year (separate sheet may be attached): (See Annexure IV)

17. Research papers published/accepted for publication/communicated for publication (Details of authors, title, journal, volume, page number and reprints of published papers/preprints of accepted papers/and manuscripts papers must be sent): (See Annexure V)

18. It is affirmed that I have devoted my full time to research and that I did not take up any other paper paid or unpaid without taking written permission from CSIR. It is also certified that due acknowledgement of CSIR Financial assistance has been made in the published.

Kailash

Date: 06/02/2024 Signature of Fellow/Associate

19. Overall assessment and comment of the Guide:

Certified that the information provided in this report by Mr. Kailash Chand Swami, an individual JRF CSIR scholar (File No: 09/1026/(13600)2022-EMR-I) working under my supervision on "Mathematical modelling for water wave interactions with various costal structures" is correct to the best of my knowledge and belief. Mr. Kailash Chand Swami is a dedicated, sincere and hardworking research scholar. He has made satisfactory progress in the period for which the report is enclosed. This is clearly evident from the research papers communicated by him. He has done a very good literature survey on the research topic and completed successfully all the course works assigned to him by DAC constituted by the institute for him. Currently, he has been working in modeling of thick and thin porous bottom-standing/surface piercing breakwaters. I strongly recommend the extension of fellowship to Mr. Kailash Chand Swami.

It is certified that the information provided above and in separate pages enclosed with this report by the Fellow/Associate is correct to the best of my acknowledge and belief.

S. Koley

Date: 06/02/2024 Signature of the Supervisor

ANNEXURE- I

Objective of Undertaking Work

Nearshore hydrodynamics has a wide range of applications in the areas of marine engineering, military operations, shipping routes, shoreline, and environmental protection. In light of this, it becomes crucial to gain a more comprehensive understanding of the characteristics of oceanic fluids and coastal structures. In recent decades, the study on how water waves and currents interaction with coastal structures has proven to be an intriguing and important area of study. Among various coastal structures, breakwaters are the most widely used structures that are built near the coastlines is to provide shelter by minimizing the impact of wave energy transmitted to the lee side of the breakwater.

On the other hand, in ocean dynamics, wave currents, which are caused by the wind and other factors, involve horizontal water movement. These currents play a distinct role in ocean dynamics, as opposed to ocean surface waves, which involve vertical water particle motion and transmit energy across the ocean's surface. Thus, a proper in-depth analysis of the interaction of nearshore waves and currents with the breakwaters is essential for the calculation of the computation of sediment movement and depositions in the close proximity of these structures. Further, effective, low maintenance, and minimum construction costs are some of the important parameters that need to be considered for shoreline protection. In this regard, designing breakwaters in the influence of currents along with waves can be challenging. Due to unanticipated factors including the current profile, wave styles, and the angle between waves and currents, among others, the relationship between waves and currents is complex in nature. In order to effectively protect the shoreline and harbors, the breakwaters must be designed to withstand in presence of both ocean waves and currents.

The objectives are:

- Mathematical modeling of interaction of water waves with different kinds of breakwaters like such as porous or non-porous (thin or thick), rigid, or flexible using the numerical technique Boundary Element Method (BEM) under the regular and irregular incident wave environments.
- The effect of following and opposing ocean current on wave energy reflection, dissipation by breakwaters, and wave load on breakwaters due to incoming ocean waves.

Kailash
Signature of Fellow

Date: 06/02/2024

S. Koley
Signature of Supervisor

Date: 06/02/2024

ANNEXURE- II

Detailed report for 22th Jan 2022 to 21th Jan 2024

- I Joined as a CSIR individual research scholar at the **Department of Mathematics, Birla Institute of Technology and Science – Pilani, Hyderabad campus** on 22th Jan 2022. I have successfully completed the following course works during the period of Jan'2022 to Jan'2024.
    1. Research Methodology
    2. Mathematical Methods
    3. Mathematical Modeling
    4. Research Project I, II
    5. Research Practice
    6. Study in advanced topics
- As I am working on onshore/offshore coastal structures, I have gone through literature survey to understand the working mechanism of coastal structures.
- As mathematical tools are also a part of my research work, I have gone through some prescribed books and online platforms videos to clear the fundamentals of MATLAB, ANSYS.
- I have studied the basics of integral equation. Then I learned the implementation of the integral equation into BEM.
- I have taken the weekly tutorial classes of linear algebra, complex analysis, Multivariable Calculus which were assigned to me by the department. I have prepared the weekly tutorial sheets and their solutions.
- I have taken part in the invigilation duties along with exam copy checking.

Kailash
Signature of Fellow

Date: 06/02/2024

S. Koley
Signature of Supervisor

Date: 06/02/2024

ANNEXURE- III

Summary of research work done during 22th Jan 2022 to 21th Jan 2024

During the last two years, apart from completing the prescribed course work, the following research work has been pursued who's abstract and conclusions are highlighted in brief as below.

While doing the literature review, it seemed that when water waves interact with breakwater, the performance of breakwater is also affected by ocean current along with other effect parameters like porosity, friction coefficient etc. The stability of breakwater reduced while we are considering the ocean current along with propagating ocean waves. To understand the effect of ocean current and different structural and physical parameters a numerical technique Boundary Element Method (BEM) employed. After employing BEM results, based on different parameters, has been examined. It has been analyzed that ocean current enhance wave energy reflection and structural porosity enhance the wave energy dissipation. The wave load on structure shows an oscillatory pattern.

Kailash
Signature of Fellow

Date: 06/02/2024

S. Koley
Signature of Supervisor

Date: 06/02/2024

ANNEXURE- IV

Plan of Work for the Next Year

As a continuation of the ongoing research work pursued, the following research work will be pursued in the coming years.

- We will work on modeling of different kinds of coastal structures including rigid, flexible, porous/ non-porous using boundary element method (BEM).
- The study of the performance of coastal structures will extend for oblique and for irregular incident waves using the concept of wave spectrum.
- The current work will extend to two-layer fluid system.
- We will work on wave energy convertors devices for power extraction placed over coastline using BEM, ANSYS.
- Also, we will work on other simulation tools like ANSYS Fluent, ANSYS AQWA for some real-life physical problems.

Kailash
Signature of Fellow

Date: 06/02/2024

S. Koley
Signature of Supervisor

Date: 06/02/2024

ANNEXURE-V

Research papers and conference papers communicated

1. Dash SK, Swami KC, Trivedi K, Koley S., "Boundary Element Method for Water Wave Interaction with Semicircular Porous Wave Barriers Placed over Stepped Seabed". In International Conference on Mathematical Modeling and Computational Science 2023 Feb 23 (pp. 95-105). Singapore: Springer Nature Singapore. (https://doi.org/10.1007/978-981-99-3611-3_8) (ICMMCS 2023)
2. Kailash Chand Swami . Santanu Kumar Dash . Santanu Koley, "Scattering of Ocean Waves by Porous Membrane Type Wave Barriers Placed Over Undulated Seabed", J. Innovation Sciences and Sustainable Technologies, 3(4)(2023), 197 - 206. (https://doie.org/10.0101/JISST.2024716276)
3. Swami KC. and Koley S. 2023 "Wave Interaction with Porous Bottom Standing Breakwater in the Presence of Current". **(Accepted)** (ICAPSM 2023)
4. Swami KC., Koley S., Panduranga k. 2023 "Mathematical Modeling of Water Waves Interaction with Trapezoidal-shaped Breakwater in the Presence of Current". **(Communicated)**

A. Presented a paper entitled "Wave interaction with bottom standing breakwater in the presence of current." in **ICAPSM-2023**, KPR Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India, 17 - 18, August 2023.
B. Presented a paper entitled "Water wave trapping by porous barrier using boundary element method." in **ICIAM-2023**, Waseda University, Tokyo, Japan, August 20 – 25, 2023.

Kailash
Signature of Fellow

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S. Koley
Signature of Supervisor

Date: 06/02/2024

ANNEXURE-VI

References

1. Dalrymple RA, Losada MA, Martin PA. Reflection and transmission from porous structures under oblique wave attack. Journal of fluid mechanics. 1991, 224:625-44.
2. Madsen O.S. “Wave transmission through porous structures’’ Journal Waterway, Port, Coastal, and Ocean Engineering .1974, 100 (3):169–188.
3. Yu X. Diffraction of water waves by porous breakwaters. Journal of waterway, port, coastal, and ocean engineering. 1995, 121(6):275-82.
4. Sollitt C.K., Cross R.H. “Wave transmission through permeable breakwaters” Proceedings of the 13th Coastal Engineering Conference, Vancouver, 1972. 1827–1846.
5. Darwiche MK, Williams AN, Wang KH. Wave interaction with semiporous cylindrical breakwater. Journal of waterway, port, coastal, and ocean engineering. 1994, 120(4):382-403.
6. Liu Y., Li H.J., Li Y.C. “A new analytical solution for wave scattering by a submerged horizontal porous plate with finite thickness” Ocean Engineering.2012. 42:83–92
7. Liu Y., Li Y. C., Teng, B. “Interaction between oblique waves and perforated caisson breakwaters with perforated partition walls’’ European Journal of Mechanics-B/Fluids, (2016). *56*:143-155.
8. Panduranga K, Koley S, Sahoo T. Surface gravity wave scattering by multiple slatted screens placed near a caisson porous breakwater in the presence of seabed undulations. Applied Ocean Research. 2021, 111:102675.
9. Koley S, Panduranga K. Energy balance relations for flow through thick porous structures. International Journal of Computational Methods and Experimental Measurements. 2021, 9(1):28-37.
10. Koley S, Vijay KG, Nishad CS, Sundaravadivelu R. Performance of a submerged flexible membrane and a breakwater in the presence of a seawall. Applied Ocean Research. 2022, 124:103203.