A Dissertation

on

"An Experimental Investigation into the Effectiveness of Octahedron Structures as a Pro-Siltation Measure for Alluvial Rivers"

Submitted in Partial Fulfillment for the Requirements for the award of Degree of

MASTERS OF TECHNOLOGY IN CIVIL ENGINEERING

(With Specialization in Water Resources Engineering)

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CANDIDATE DECLARATION

We hereby certify that the work presented in the project entitled **"An Experimental Investigation into the Effectiveness of Octahedron Structures as a Pro-Siltation Measure for Alluvial Rivers"**is the authentic record of our own work carried out under the guidance of **Mrs. Rhitwika Barman**, Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari.The project is submitted in partial fulfillment of requirements for the award of the degree of **"Master of Technology in Civil Engineering"** under specialization on **Water Resources Engineering** to the Department of Civil Engineering, Assam Engineering College, Jalukbari , Guwahati-781013, Assam.

The matter embodied in this dissertation has not been submitted to any other institute for the award of any other degree. We have followed the guidelines provided by the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-781013,Assam. Whenever materials from other sources are used, due acknowledgement is given to them by citing them in the text of this project and giving their details in the references.

This is to certify that the above statement made is correct to the best of my knowledge.

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CERTIFICATE FROM THE SUPERVISOR

This is to certify that the dissertation report **entitled "An Experimental Investigation into the Effectiveness of Octahedron Structures as a Pro-Siltation Measure for Alluvial Rivers"** is submitted by **Abdul Wahid, Roll No 230620061001,** a student of 3rd semester in the Department of Civil Engineering, Assam Engineering College, Guwahati in partial fulfillment for the award of degree of **Masters of Technology** in Civil Engineering with specialization in **Water Resources Engineering** under **Assam Science and Technology University** has been carried out under my guidance.

The content of this report has not been submitted to any other university for the award of any degree.

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CERTIFICATE FROM HEAD OF THE DEPARTMENT

It is to certify that the project report entitled **"An Experimental Investigation into the Effectiveness of Octahedron Structures as a Pro-Siltation Measure for Alluvial Rivers"** is hereby accorded our approval as a study carried out and presented in a manner in their 3rd semester courses for acceptance in partial fulfillment for the award of Master of Technology in Civil Engineering under specialization on Water Resources Engineering degree for approval does not necessarily endorse or accept every statement made, opinion expressed or conclusion drawn as recorded in the report. It only signifies the acceptance of the project report for the purpose for which it is submitted.

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ABSTRACT

Flooding is a significant natural disaster that can cause extensive damage to both land and property. One of the key issues during floods is the scouring of riverbeds and banks, which can alter the river's course. To address this issue, a preventive measure known as the octahedron has been developed. Permeable structures such as porcupines and jack jetties act as sediment trap systems, capturing sediment within the river and thereby controlling scouring. These systems have been implemented in major Indian rivers like the Ganga, Brahmaputra, and Kosi, proving to be a cost-effective solution for river management, with positive outcomes in sediment capture.

This thesis presents an in-depth study of a newly developed sediment trap efficiency system called the Octahedron, a modified version of the Jack jetty. Various laboratory experiments were conducted, and trial octahedron models were designed and placed in channels with simulated riverbeds. The research focused on examining sediment deposition patterns under different configurations of the octahedron, with special attention to river discharge and sediment concentration. The findings provide valuable insights into the sediment trapping efficiency of octahedron systems, offering guidance for improving the design and deployment of such systems in rivers. Ultimately, this research contributes to reducing the impact of floods and protecting both land and property.

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CHAPTER-1

INTRODUCTION

1.1 GENERAL

Flooding is a pervasive natural disaster that inflicts substantial damage on both land and property, posing significant challenges to communities and infrastructure. A critical problem associated with floods is the scouring of riverbeds and banks, which can result in the alteration of the river's course, exacerbating the disaster's impact. Meandering rivers are highly susceptible to severe erosion, which can escalate into a catastrophic and uncontrollable situation if not properly managed. This issue becomes particularly acute during the monsoon season, when river erosion intensifies, and access to materials and labour is limited.

To address this, it is essential to adopt a proactive approach by studying the river's behaviour and implementing timely river training measures. These measures may include re-vegetation to reduce flow velocity and strategic bank or channel works to stabilize the river and protect its banks. Effective river training helps prevent excessive meandering, minimizes course shifts, and maintains navigability. The key to successfully mitigating scour lies in preventive action and the application of effective strategies tailored to the river's specific needs.

River bank protection is typically achieved through various river training works, including marginal embankments or levees, guide banks, guide bunds, groynes or spurs, submerged vanes, cut-offs, bank pitching, pitched islands, sills, closing dykes, and longitudinal dykes. The choice of these measures depends on their effectiveness, cost of construction, environmental impact, and aesthetics. Permeable structures are often the most cost-effective to build. The growing need for bank protection in many river stretches has highlighted the importance of developing economical river training solutions. Consequently, the use of framed structures has become increasingly significant as a cost-effective approach to river management. Badaling, board fencing, porcupines, jack-jetty systems, and tetrahedral frames are some of the cost-efficient methods employed in river training.

1.2 OBJECTIVE OF THE STUDY

1. To present the Octahedron structure, a modified version of the jack jetty, as a pro-siltation measure.

2. To develop and conduct laboratory experiments with trial octahedron models placed in channels with simulated riverbeds

3. To assess the sediment trapping efficiency of the Octahedron through laboratory flume experiments.

4. To examine sediment deposition patterns under various configurations of the octahedron.

5. To evaluate the system's efficiency across various octahedron configurations and different flow depths.

1.3CHAPTERWISE PLANNING

- **Chapter 2**: Provides a brief review of existing literature in the field.
- **Chapter 3**: Discusses the material and methodologies used throughout the experiments.
- **Chapter 4**: Experiment works and analysis of work.
- **Chapter 5**: Gives the summarised result and a brief conclusion.

1.4 JACK JETTY AS A RIVER TRAINING SOLUTION

Jack Jetty is an economical river training technique developed through experimental studies. Initially invented by H. F. Kellner in the early 1920s, the Jack Jetty served as a cost-effective, permeable form of bank protection, outperforming the non-permeable methods prevalent at the time. Kellner's first design consisted of three willow poles tied together at their midpoint and reinforced with wire to keep them extended. He later replaced the willow with steel angles, and eventually, a modified version was constructed using reinforced cement concrete (RCC).

Fig 1.1 Conventional RCC Jack jetty

(Source Location- Silbharal ,Brahmapurta Bank, Guwahati)

Functions of Jack Jetty:

- Directing the river along a predetermined path.
- Reducing the flow intensity at points of riverbank erosion.
- Creating slower flow areas to encourage silt deposition around the structures and downstream.
- Protecting the riverbank by decreasing the flow velocity along its edge.

Applications of Jack Jetty:

- Encourages silt deposition in and around the structure.
- Reduces river flow velocity.
- Prevents riverbank erosion.
- Aids in land reclamation by elevating scoured or low-lying areas to usable levels.
- Prevents bed scour and helps maintain the riverbed level.

1.5 OPEN CHANNEL FLOW (OCF)

An open channel is a conduit through which liquid flows with a free surface exposed to the atmosphere. This flow type, known as open channel flow or free surface flow, is primarily driven by gravity and is characterized by a hydrostatic pressure distribution. The free surface serves as the boundary between the liquid and the air and can either be stationary or in motion. The pressure within the liquid is hydrostatic, meaning it remains uniform throughout and is determined by the fluid's density and gravitational force. An example of open channel flow is shown in Figure 1.1. This type of flow is crucial in various natural and artificial systems, such as rivers, canals, and irrigation channels.

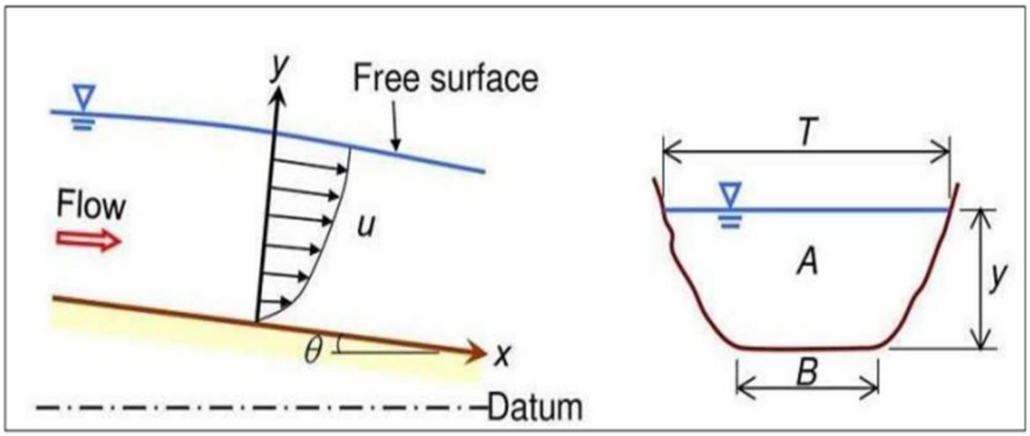

Fig 1.2: Open Channel Flow with hydrostatic pressure distribution.
(Source- ResearchGate article)

1.6 MECHANISM OF SEDIMENT TRANSPORT IN OPEN CHANNEL FLOW

Rivers transport sediments through different methods, including bed load, suspended load, and dissolved load.

Bed Load: This type of sediment transport occurs near the riverbed, where particles move by rolling, sliding, or hopping (saltation). Bed load typically accounts for 5-20% of the total sediment transport and includes heavier materials like sand, pebbles, gravel, and cobbles. In saltation, the current lifts particles off the bed, carrying them a short distance before they settle again, often causing a chain reaction that moves nearby particles.

Suspended Load: This consists of finer particles like clay, silt, and fine sand, which are carried within the water column. These particles are kept in suspension by the turbulent flow, which continuously mixes and exchanges fluid between different layers. The balance between sediment settling and the upward movement of fluid keeps the particles suspended. Suspended load contributes additional hydrostatic pressure on the riverbed.

Dissolved Load: This involves particles that are carried in solution within the water. It represents a smaller portion of the total sediment load compared to bed and suspended loads. Dissolved load includes materials that dissolve in water, often originating from rock dissolution in the channel or from tributaries joining the stream.

The amount of sediment transported significantly affects the channel's flow, cross-section, and overall behaviour. Although traditional channel design theories often overlooked sediment transport, it is now recognized as essential for effective channel design. Different types of sediment transport are illustrated in Figure 1.3.

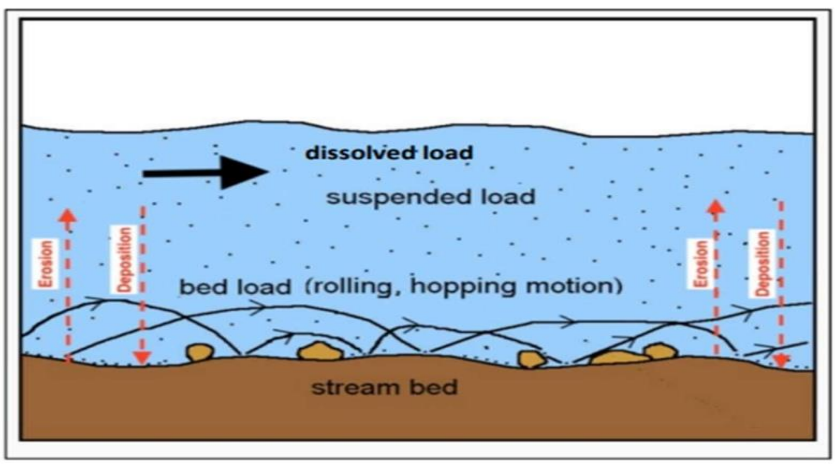

Fig.1.3: Sediment transport process

(Source- ResearchGate article)

1.7 RIVER BANK PROTECTION MEASURES

Riverbank protection refers to the measures and techniques used to stabilize and safeguard the banks of rivers from erosion, collapse, or degradation. These interventions aim to protect the riverbank from the forces of flowing water, rainfall, human activity, and natural processes that can weaken the soil or destabilize the bank. Riverbank protection is vital for maintaining ecological balance, protecting nearby infrastructure, and ensuring sustainable land and water management. Below are detailed measures for protecting riverbanks:

1.7.1 STRUCTURAL MEASURES

These involve engineered solutions designed to physically stabilize riverbanks.

a. **Riprap: -**Rocks or concrete chunks are placed along the riverbank to absorb and deflect the energy of flowing water. Durable, cost-effective, and allows some vegetation to grow between rocks. Used in high-flow areas prone to significant erosion.

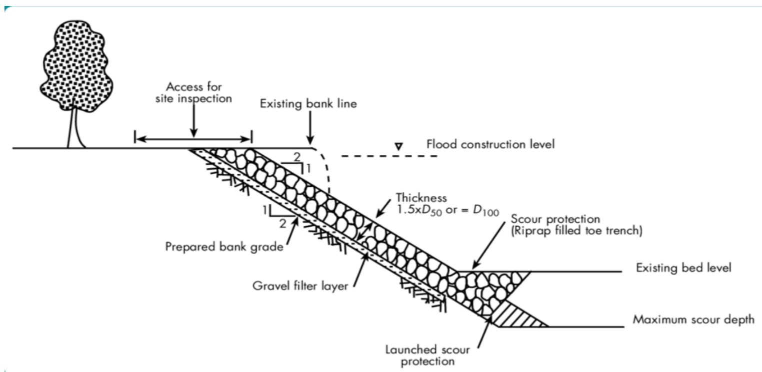

Fig.1.4: Riprap

(Source- ResearchGate article)

b. **Gabion Walls: -** Wire mesh cages filled with rocks or stones stacked along the riverbank. Flexible, permeable, and aesthetically adaptable. Effective for steep slopes and areas with moderate to high erosion risk.

Fig.1.5: Gabion Walls

(Source- https://www.slideshare.net/slideshow/gabionpptx/25)

c. **Retaining Walls: -** Vertical or near-vertical structures (concrete, wood, or masonry) built along riverbanks. Provides a high level of erosion control. Combined with vegetation or riprap for added support.

Fig.1.6: Retaining Walls

(Source- https://www.slideshare.net/slideshow/retainpptx/25)

d. **Porcupines: -** Porcupines are permeable, modular, and spiny structures made of materials such as concrete, steel, or wood. They are strategically placed along riverbanks or riverbeds to slow water flow, trap sediment, and reduce the erosive force of the river. Their design allows water to pass through while dissipating energy and encouraging sediment deposition.

Fig.1.7: Porcupines

(Source location- Silbharal, Brahmaputra Bank, Guwahati)

1.7.2 VEGETATIVE MEASURES

Using plants to stabilize riverbanks is an environmentally friendly approach that enhances biodiversity.

a. **Grass Seeding: -** Fast-growing grasses provide ground cover and root stabilization.

Fig.1.8: Grass Seeding

(Source- https://www.slideshare.net/slideshow/riverprotectionpptx/25)

b. **Tree Planting: -** Deep-rooted trees bind the soil, reducing erosion. Provide shade and enhance biodiversity.

Fig.1.9: Tree Planting

c. **Live Staking: -** Planting cuttings of woody plants directly into the soil.

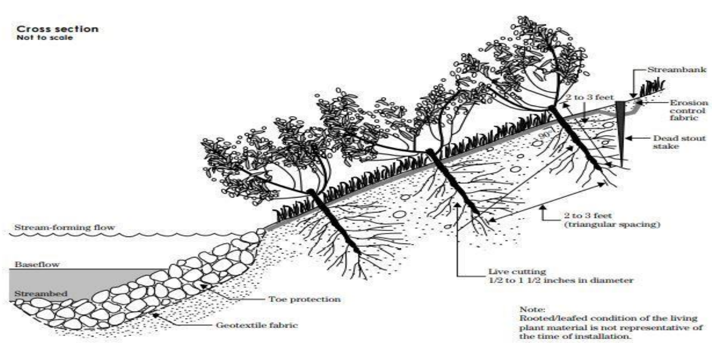

Fig.1.10: Live Staking

d. **Fascines: -** Bundles of branches placed along slopes to trap sediment and encourage plant growth.

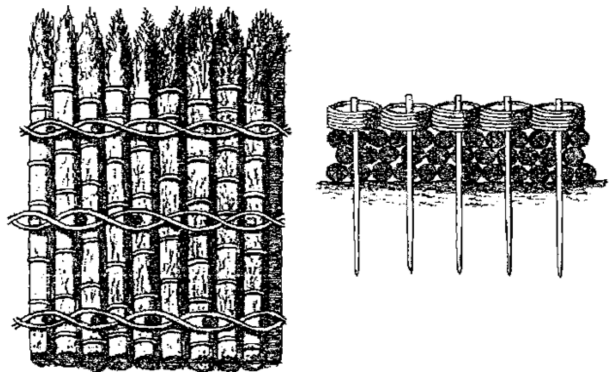

Fig. 1.11: Fascines

(Source- ResearchGate article)

3. Other riverbank protection measures include bioengineering techniques such as coir logs, brush layers; river training works such as channelization and flood embankments.

1.8 RELATED TERMINOLOGY

1.8.1 EROSION

Erosion involves the removal and transportation of soil, rock, or dissolved material from one location to another by surface processes such as water flow or wind. Erosion can be physical (mechanical), breaking down rock or soil into sediment, or chemical, where materials dissolve and are transported away. River erosion specifically erodes the riverbed and banks both vertically (deepening the channel) and laterally (widening the channel). The four primary erosion processes are:

- **Hydraulic Action**: The force of flowing water breaks and removes rock from the bed and banks.
- **Abrasion**: Rock fragments carried by the river grind against the bed and banks, deepening and widening the channel.
- **Attrition**: Rock fragments in the water collide, breaking into smaller, smoother pebbles.
- **Corrosion**: Water chemically reacts with soluble minerals in rocks, dissolving them.

1.8.2 ALLUVIAL RIVER

An alluvial river features a mobile bed and banks composed of sediment and soil. These rivers are shaped by the frequency and intensity of floods, which influence channel formation through erosion, deposition, and sediment transport. The shape and characteristics of alluvial rivers vary based on factors such as bank properties, flow patterns, riparian ecology, and sediment type.

1.8.3 PROPERTIES OF ALLUVIAL RIVERS

1. **Meandering Patterns**: Alluvial channels tend to follow paths of least resistance, resulting in winding, meandering flows.

2. **Dynamic Nature**: The loose sediment in alluvial channels can be transported and deposited by water, causing the channel's shape and course to change over time due to erosion and sedimentation.

CHAPTER-2

LITERATURE REVIEW

2.1 OVERVIEW

In recent years, extensive research has been conducted to address siltation and erosion in alluvial rivers, particularly in major rivers like the Ganga and Brahmaputra in India, and the Jamuna in Bangladesh. Various techniques have been employed, including RCC porcupines (in both triangular and prismatic forms), RCC Jack Jetties, submerged vanes, geo bags, and revetments. These measures aim to stabilize riverbanks, reduce sediment deposition, and protect surrounding areas from the adverse effects of erosion and flooding. A thorough review of the existing literature on open channel flow, the incipient motion condition of sediments, the sediment trapping efficiency of porcupines, and the development of cost-effective, rational design methodologies for river training structures has been carried out. Additionally, strategies for safeguarding Majuli Island from flood-related damages and riverbank erosion are discussed, highlighting innovative and practical solutions for managing river dynamics and ensuring long-term protection of vulnerable regions. This review will be detailed in the subsequent sections, providing insights into the latest advancements and their practical applications in river management.

2.2 GENERAL

- **Study on the Effectiveness of RCC Porcupines in Sediment Management:** In a study conducted by Gupta and Sharma (2018), the use of RCC porcupines for sediment management in river training works was explored in detail. The research focused on the Ganga River, where siltation poses significant challenges to navigation and flood management. RCC porcupines, designed in both triangular and prismatic forms, were installed along critical sections of the riverbank. The study revealed that the porcupines effectively reduced sediment deposition by creating localized zones of reduced flow velocity. This mechanism encouraged siltation near the structures, thereby stabilizing the riverbanks and preventing further erosion. The researchers also noted that the modular design of the porcupines allowed for easy installation and maintenance, making them a cost-effective solution for long-term river management.

- **Comparative Analysis of RCC Porcupines and Jack Jetty in River Training :**A comparative analysis by Banerjee et al. (2019) evaluated the effectiveness of RCC porcupines and Jack Jetty structures in sediment management in the Brahmaputra River. The study highlighted the advantages of both techniques, emphasizing their roles in promoting sediment deposition and reducing erosion. RCC porcupines were particularly effective in shallow water zones, where their permeable design facilitated the trapping of sediments. Conversely, Jack Jetty structures, with their robust construction, proved more suitable for deeper sections of the river. The study concluded that a combination of both methods could offer a comprehensive approach to river training, addressing varying sedimentation challenges across different river sections.

- **Impact of RCC Jack Jetty on Sediment Deposition Patterns:** Jain and Verma (2020) investigated the impact of RCC Jack Jetty structures on sediment deposition patterns in the Jamuna River. The research employed a combination of field observations and numerical modeling to assess how these structures influenced sediment transport dynamics. The findings indicated that Jack Jetties effectively altered the flow regime, creating slack water zones that promoted sediment deposition. This process not only stabilized the riverbanks but also contributed to the reclamation of eroded land. The study emphasized the importance of proper placement and design of Jack Jetties to maximize their sediment trapping efficiency, suggesting that tailored designs could further enhance their effectiveness in different riverine environments.
- **Long-term Performance of Porcupines in River Training Works:** A longitudinal study by Singh and Chatterjee (2021) examined the long-term performance of RCC porcupines in the Ganga River basin. Over a decade, the researchers monitored the structural integrity and sedimentation effects of the installed porcupines. The results demonstrated that RCC porcupines maintained their effectiveness in promoting sediment deposition and preventing erosion over extended periods. The study also highlighted the resilience of RCC materials against the harsh riverine environment, which contributed to the durability and sustainability of the structures. The findings underscored the potential of RCC porcupines as a reliable solution for long-term river training and sediment management.

- **Integrated Approach to River Training Using RCC Structures:** Mishra and Das (2022) explored an integrated approach to river training that combined RCC porcupines and Jack Jetty structures. The study focused on the Brahmaputra River, where complex sedimentation patterns required innovative solutions. The integrated approach aimed to harness the complementary strengths of both structures: RCC porcupines for sediment trapping in shallow areas and Jack

Jetties for stabilizing deeper sections. The research found that this combined strategy significantly improved sediment management, reducing siltation rates and enhancing riverbank stability. The study recommended the adoption of such integrated approaches in river training projects to address diverse sedimentation challenges effectively.

- **Sarker et al. (2011)** examined the increasing braiding intensity and widening of the Jamuna River over the past few decades. The river experiences a high annual rate of bank erosion, affecting several thousand hectares each year and impacting millions of people. The study primarily used satellite imagery to analyze the natural bank erosion processes on both sides of the river. Various bank protection measures, including guide bunds, revetments, and groynes/spurs, were implemented. Despite these efforts, riverbank erosion persists. Part of the reduction in erosion is due to natural processes, while another part is attributed to the protective structures, though precise quantification is currently unavailable. The study found that revetment structures are generally more stable in the Jamuna River compared to groyne-type structures.

These literature reviews collectively highlight the significant contributions of RCC porcupines and Jack Jetty structures in managing sedimentation and stabilizing riverbanks in river training works. The studies underscore the importance of site-specific designs and the potential benefits of combining different techniques to achieve optimal results in sediment management and riverine stability.

2.3 INCIPIENT MOTION CONDITION

- **Garde and Rangaraju (1977)** compiled and synthesized extensive information on sediment transport and issues related to alluvial streams, gathered from numerous journals, monographs, and other research publications. Their work addresses the theory of sediment transport, covering topics such as sediment properties, incipient motion condition, flow regimes, flow resistance, bed load transport, suspended load transport, and total load transport. They also explored practical issues, including sediment samplers and sampling, stable channels, alluvial streams, variations in stream bed elevation and plan forms, sediment control, river training, and other miscellaneous topics like model studies, mud flows, density currents, and sediment transport through pipes.
- **Rijn (1984)** introduced a method for calculating suspended load by integrating the product of local concentration and flow velocity over the depth. This approach is based on determining the

reference concentration from bed-load transport, with calibration performed using measured concentration profiles. New relationships were proposed to represent the gradation of bed material sizes and the damping of turbulence by sediment particles. A verification analysis using approximately 800 data points showed that about 76% of the predicted values fell within a range of 0.5 to 2 times the measured values.

- **Shields (1936)** laying the groundwork for understanding the dynamics of particle movement in open channel flows. Shields introduced the dimensionless Shields parameter, which relates the critical shear stress needed for particle movement to the characteristics of the sediment and fluid. This parameter has been widely used to determine the threshold of motion for different sediment types.

2.4 PORCUPINE

- **Amir and Sharma (2014)** investigated the use of porcupine systems as a cost-effective solution for river training, demonstrating their effectiveness in sediment capture. Their experiments were conducted in the Outdoor River Engineering laboratory of the Department of WRD&M, IIT Roorkee, near Toda Kalyanpur village, Roorkee. The study examined the relationship between trap efficiency and PFDI (Porcupine Field Density Index) while maintaining a fixed sediment concentration and varying PFSI (Porcupine Field Submergence Index). Results indicated that trap efficiency decreases with increased submergence but increases with higher sediment concentration. The findings highlighted that densely configured porcupines are more efficient in sediment capture. However, considering economic factors, a balance between density and cost-effectiveness is necessary. These porcupines are particularly effective in conditions of low submergence and high sediment concentration.
- **Amir and Sharma (2015)**, Aamir and Sharma assessed the performance of triangular and prismatic porcupines for erosion control. This study also took place at the Outdoor River Engineering laboratory at IIT Roorkee. The relationship between trap efficiency and PFDI was explored with fixed sediment concentration (q_s) and varying PFSI. The results showed that trap efficiency decreases with increased submergence and increases with higher sediment concentration. The findings revealed that triangular porcupines exhibited higher trap efficiency compared to prismatic porcupines under the same sediment concentration. This indicates that

triangular porcupines are more effective in capturing sediment than prismatic ones, though the latter still provides a cost-effective option.

- **Brahmaputra Board, Guwahati (2012)** studied that Majuli Island has been under serious attack by the mighty Brahmaputra. Loss of land mass on account of erosion of Brahmaputra River right bank has been regular feature for Majuli Island. Brahmaputra Board prepared a scheme in November 1999 for "Protection of Majuli Island from floods and erosion" at the estimated cost of Rs. 86.56 crores. The work was carried out in three phases- Phase 1 started in March 2005 and was completed in April 2011. Phase 2 and Phase 3 were on progress till 2012. During Phase 1, casting and laying of permeable RCC porcupine screen/spurs/dampeners at various locations were done due to which erosion got arrested substantially in the severely affected reaches. During Phase 2 and 3, casting and laying of 1,27,396 porcupines were done which encouraged heavy siltation. Area of Majuli Island increased from 502.21 sq. km (2004) to 520.21 sq. km (2011). Further remaining protection works, such as completion of 5 spurs, river bank revetment, laying porcupines at vulnerable locations, contemplated under Phase 2 and Phase 3 were targeted to be completed by March 2014.

2.5 JACK JETTY

- **Grassel (2002)** notes that the first jetty systems on the Arkansas River were installed by the Albuquerque District of the U.S. Corps of Engineers in the early 1950s. These included five systems on the Arkansas River and two on the Rio Grande, with seven more added to the Rio Grande by 1953. Shortly after installation, high flow events tested two of these projects—one on the Purgatorie River in Higbee, Colorado, and the other on the Arkansas River in Manzanola, Colorado. Despite these high flows, the permeable jetty systems remained undamaged, and the bank protection functioned effectively, demonstrating the efficiency of the systems.

  In Kansas, the State Highway Department used jetties to protect the bridge across the Cimarron River at Sitka. Before the installation of the jetty in 1950, the bridge had been extended twice after its abutment washed away during floods. Following the jetty installation, the Department was able to remove the bridge extension.

  In Nebraska, a 1947 Santa Fe Railway bridge protection project utilized jetties to establish a new bank along a river curve. This project involved 980 units of jacks, including 12.2 meters of retards, 550 meters of double diversion lines, and 14 backup retard lines, all aimed at creating a stable new bank.

In Oklahoma, the railroad company installed a jetty system in 1942 to stabilize a high bank in a deep channel, which deviated from the typical use of jetties for low to moderate height banks. The project involved grading the slope to a 1:2 ratio, then placing the jetty system in its standard pattern with tightly spaced retard lines arranged in a gridiron formation for added resistance.

In New Mexico, the Santa Fe Railroad successfully used a jetty system beginning in 1936 to protect embankments along the Rio Galisteo. These embankments had previously been reinforced with heavy riprap, but it was consistently washed away during floods. A jetty field was installed to build up an auxiliary bank, followed by another row of jacks placed directly against the embankment where the river's attack was most intense.

- **Sharma Nayan and Nayak Anupama (2015)** conducted an experiment on the Ganga River in India at the Nakhwa Site, using RCC Jack Jetties and bamboo submerged vanes. The right bank of the Ganga River near Varanasi is a concave shape, making it more prone to bank erosion during floods, which continually reduces the depth of inland navigation. During the dry season, from December to June, the navigation depth was typically insufficient. Through laboratory and field studies, the deployment of modified RCC Jack Jetties, supported by bamboo submerged vanes, resulted in significant improvements. The secondary left channel became almost completely obstructed, redirecting flow to the navigation channel along the right bank, while also preventing further erosion on the right bank. These changes were evident in satellite images and topographical surveys, showing the development and maintenance of a sustainable inland navigation waterway along the right bank. The successful outcomes of this pilot study on the Ganga River suggest that this cost-effective technology could be applied to other river systems worldwide, with necessary adjustments for specific site conditions.

CHAPTER-3

METHODOLOGY OF THE EXPERIMENT

3.1 MATERIALS DESCRIPTION

3.1.1 MODEL

In this study, we used a modified jack jetty, referred to as the Octahedron. A typical jack jetty consists of six members joined at a single point. In our experiment, we enhanced its stability and functionality by connecting additional members to the outer points of the jack, transforming its shape into an octahedron, as depicted below.

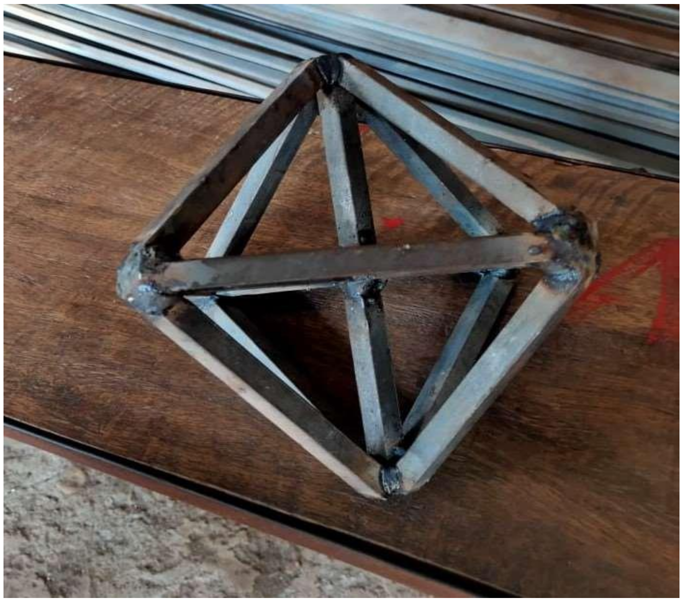

Fig 3.1: Octahedron made of MS Rod

- The modified Jack models in this study were scaled to fit the laboratory channel's dimensions.
- The models were made from MS rods with a thickness of 10mm, featuring inner members of 10 cm in length and outer members of 14 cm.
- A figure is provided to visually represent these typical models.
- These scaled-down models served as representations of full-sized jacks to assess their performance in the laboratory environment.

- This approach offered a cost-effective and efficient method for studying the effectiveness of the modified Jack Jetty in controlling erosion and facilitating river channelization.

3.1.2 BED MATERIAL

- The laboratory channel in this study was filled with bed materials sourced from the River Brahmaputra, specifically from the Pandu Port area in Maligaon, Guwahati, Assam.
- The collected bed materials were air-dried and analyzed for particle size distribution to determine the proportions of fine and medium-grained sand, as well as fines in the sample.
- The specific gravity of the sample was measured using a pycnometer.
- To replicate the natural river bed conditions, the laboratory channel, with a depth of 0.49 meters, was prepared by maintaining the same relative proportions of fine and medium sand as found in the original riverbed material. This ensured the laboratory setup closely resembled real-world conditions, providing a more accurate assessment of the porcupine system’s ability to control erosion and assist with river channelization.

3.1.2 BANK MATERIAL

- The laboratory channel in this study was lined with bank materials sourced from the River Brahmaputra, specifically from the Pandu Port area in Maligaon, Guwahati, Assam.
- This material was used to replicate the natural riverbank conditions, ensuring an accurate representation of the performance of various erosion control methods and bank stabilization techniques in the laboratory.

3.1.3 EXPERIMENTAL CHANNEL DESCRIPTION

All experiments for this study were conducted in the Hydraulics Laboratory Channel at Assam Engineering College, Guwahati.

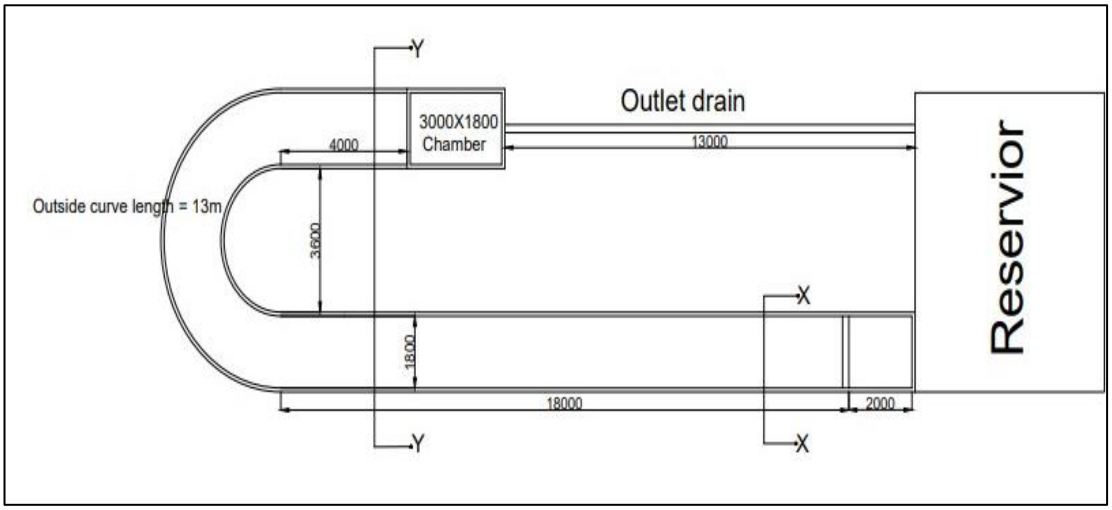

Fig.3.2: Experimental channel

Fig.3.2: Experimental channel of Hydraulics Lab.,AEC

- The channel has a length of 35 meters, a width of 1.8 meters, and a depth of 1.275 meters, with a sand bed thickness of 0.49 meters.
- The water flow in the channel was maintained byutilizingtwopumpsof5 HP and 10 HP.
- Water from the pumps was collected in a tank, passed through a combined arrangement of energy dissipater and wire mesh screens to reduce turbulence, and then fed into the channel through an inlet.
- The water at the outlet was collected in a rectangular tank and the flow rate into the channel was controlled using a discharge valve at the inlet.

- The slope of the channel bed was taken 1:250 and the slope of the bank was taken as 1.5H:1V. This setup provided a controlled environment to study the performance of the erosion control measures and bank stabilization techniques in the laboratory setting.

3.2 EXPERIMENTAL PROCEDURE

- The experiments were conducted in the Hydraulics Laboratory Channel of Assam Engineering College in Guwahati. The channel was first levelled and the flow was gradually introduced into it by releasing the discharge valve slowly until reaching the point at which the bed materials just tend to lift, representing incipient motion condition. The valve was then readjusted back a little to maintain a flow velocity less than the critical velocity.
- A clear water run was continued for 45 minutes before starting the experimentation with the Octahedron field models. The rectangular weir was then removed to allow the water to drain out gradually from the channel without disturbing the sand bed. The position of the discharge valve was fixed and kept constant for the rest of the experiments. Sand bed levels were measured with the help of point gauge.
- After placing the first trial model of the Octahedron field, the sediment bed of the channel was again levelled around the field and the flow was introduced. A fixed quantity of sediment was injected into the channel 2 meters upstream of the jack jetty field for 3 hours. The motor was then shut down and the rectangular weir removed to allow the water to drain out gradually from the channel. After the water had completely drained, the sand bed levels were again measured with the help of point gauge.
- The same procedure was followed for the rest of the model Octahedron fields studied in this work.

Fig.3.3: Point Gauge

CHAPTER-4

EXPERIMETAL WORKS AND ANALYSIS

4.1 RESULTS OF EXPERIMENTS DONE WITH OCTAHEDRON FIELD MODELS

Trial octahedron field models were prepared and laid on the channel with the simulated river bed. Relevant observations were made to study the sediment deposition of these trial field models as per the methodology laid down and described in the third chapter of this report. After each experimental run, the bed profiles were measured in the form of 0.50 m x 0.50 m grid with point gauge along three imaginary lines (A, B & C) on the channel bed along the flow, as shown in figure 4.1. shows typical layout of octahedron field.

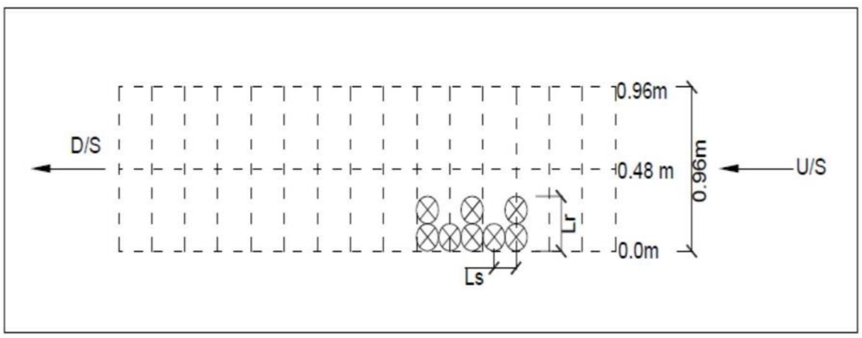

Fig 4.1: Line diagram of channel grid

4.2 INDICES

Some indices were obtained from previous research works which have been calculated for the present study as follows:

a) Octahedron Field Density Index (OFDI) = Length of one retard / Spacing between the two retards = Lr/Ls
b) Octahedron Compartment Density Index (OCDI) = Length of retard / Total length of compartment = Lr/Lc

c) Octahedron Field Length Factor (OFLF) = Length of one compartment of porcupine field / Total length of compartments = Ls/Lc

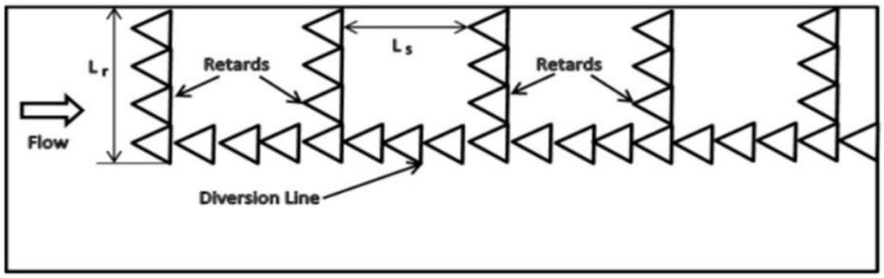

Fig 4.2: Typical layout of model field

(Source: Aamir and Sharma, 2014)

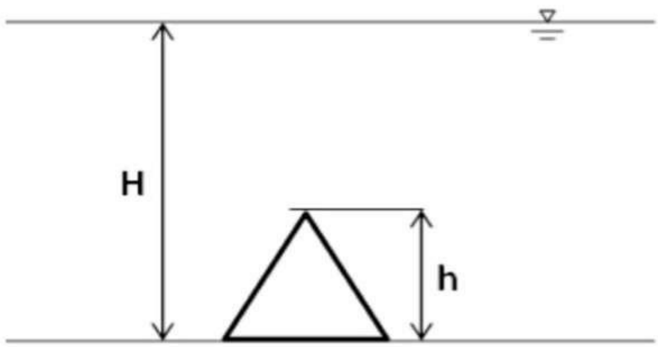

Fig 4.3: Sketch of model submerged in water

(Source: Aamir and Sharma, 2014)

- In the present study, a new index has been introduced, known as the Submergence Depth ratio (SDR). It is a ratio between the height of the octahedron and the total depth of water in the channel i.e.
- Submergence Depth Ratio (SDR)= Height of octahedron (h) /Total depth of water(H)
- Since the height of a Octahedron remains constant for a particular model or set of models, SDR depends on the depth of a water flowing through the channel and are inversely related.
    - For low depth of flow, SDR>1
    - For medium depth of flow, SDR<1
    - For high depth of flow, SDR<<1

4.3 ESTIMATION OF SEDIMENT DEPOSITION

In this project for a particular type of pattern or arrangement of model we have changed the submergent depth of the field. We have done 3 different submergent depth for one set up. In one set up we have two set of arrangement.

4.3.1 FIRST SET OF EXPERIMENTS

In the first set of experiment, there are two successive arrangements, one at the inner bank and another at the outer bank each having an angle of inclination of diversion line to the retard as 10 degrees. The sediment deposition has been recorded for two depths of flow (Medium and high).

Table 4.1: Measurement of sediment deposition for medium depth of flow (set 1, arrangement 1)

Distance along the length of the channel (m)	Point gauge reading without Octahedron field (m)		Point gauge reading with Octahedron field (m)		Height of ripple of sand (m)	
	A	B	A	B	A	B
0	0.920	0.925	0.915	0.920	0.005	0.005
0.5	0.920	0.925	0.913	0.922	0.007	0.003
1	0.921	0.925	0.910	0.923	0.01	0.002
1.5	0.923	0.926	0.912	0.920	0.003	0.006

Fig 4.4: octahedron field for arrangement 1, set1, before experiment, (Medium depth)

Figure 4.5: octahedron field for arrangement 1, set1, after experiment, (High Depth depth)

Table 4.2: Measurement of sediment deposition for low depth of flow (set 1, arrangement 2)

Distance along the length of the channel (m)	Point gauge reading without Octahedron field (m)		Point gauge reading with Octahedron field (m)		Height of ripple of sand (m)	
	A	B	A	B	A	B
0	0.970	0.975	0.950	0.956	0.020	0.019
0.5	0.970	0.975	0.954	0.958	0.016	0.017
1	0.971	0.975	0.960	0.964	0.014	0.011
1.5	0.968	0.972	0.965	0.968	0.003	0.004

Figure 4.6: Channel bed during experimental run for medium depth of flow in Arrangement 2, set 1

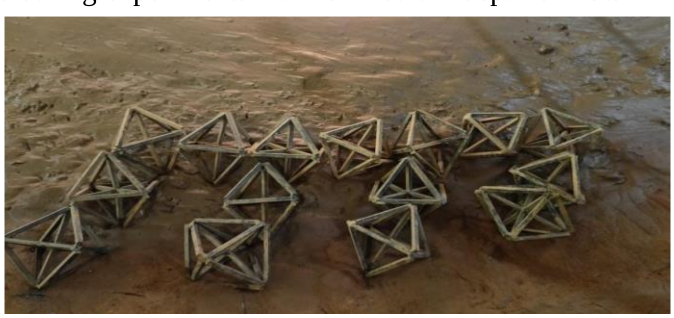

Fig 4.7: Channel bed after experimental run for high depth of flow in Arrangement 2, set 1

Table 4.3: Measurement of sediment deposition for High depth of flow (set 1, arrangement 1)

Distance along the length of the channel (m)	Point gauge reading without Octahedron field (m)		Point gauge reading with Octahedron field (m)		Height of ripple of sand (m)	
	A	B	A	B	A	B
0	0.93	0.935	0.925	0.918	0.005	0.017
0.5	0.935	0.94	0.928	0.935	0.007	0.005
1	0.94	0.942	0.935	0.93	0.005	0.012
1.5	0.938	0.945	0.935	0.935	0.003	0.01

Table 4.4: Measurement of sediment deposition for High depth of flow (set 1, arrangement 2)

Distance along the length of the channel (m)	Point gauge reading without Octahedron field (m)		Point gauge reading with Octahedron field (m)		Height of ripple of sand (m)	
	A	B	A	B	A	B
0	0.93	0.935	0.925	0.918	0.005	0.017
0.5	0.935	0.94	0.928	0.935	0.007	0.005
1	0.94	0.942	0.935	0.93	0.005	0.012
1.5	0.938	0.945	0.935	0.935	0.003	0.01

4.4 CALCULATION OF SEDIMENT DEPOSITION FOR EACH TRIAL

For Arrangement 1 of set 1 of octahedron field model layout for low depth of flow

Table 4.5: Estimation of sediment deposition in the octahedron field for Arrangement 1 of set 1 for medium depth of flow

Arrangement	Distance along the length of the channel (m)	Ripple Height	Radius of Cone (r)	Total Volume of sand	Volume of sand taking porosity into considerati on(m³)	Weight of sand trapped (kg)
		'h' (m)	in (m) r=h/tan Ø	V= (∏r² h)/3 E=10^	V' = V - 35% V	W= ∂ V' ∂ = 2040 Kg/m³
	0	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
	0.5	0.007	0.007890499	4.55702E-08	2.96206E-08	6.04261E-05
	1	0.01	0.011272142	1.32858E-07	8.63575E-08	0.000176169
A	1.5	0.003	0.003381643	3.58716E-09	2.33165E-09	4.75657E-06
	0	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
	0.5	0.003	0.003381643	3.58716E-09	2.33165E-09	4.75657E-06
	1	0.002	0.002254428	1.06286E-09	6.9086E-10	1.40935E-06
B	1.5	0.006	0.006763285	2.86973E-08	1.86532E-08	3.80526E-05

Table 4.6: Estimation of sediment deposition in the octahedron field for Arrangement 2 of set 1 for Medium depth of flow

Arrangement	Distance along the length of the channel (m)	Ripple Height	Radius of Cone (r)	Total Volume of sand	Volume of sand taking porosity into considerati on(m³)	Weight of sand trapped (kg)
		'h' (m)	in (m) r=h/tan Ø	V= (∏r² h)/3 E=10^	V' = V - 35% V	W= ∂ V' ∂ = 2040 Kg/m³
	0	0.2	0.225442838	0.001062862	0.00069086	1.409354626
	0.5	0.016	0.018035427	5.44185E-07	3.5372E-07	0.00072159
	1	0.014	0.015780999	3.64562E-07	2.36965E-07	0.000483409
A	1.5	0.003	0.003381643	3.58716E-09	2.33165E-09	4.75657E-06
	0	0.019	0.02141707	9.11271E-07	5.92326E-07	0.001208345
	0.5	0.017	0.019162641	6.5273E-07	4.24274E-07	0.00086552
	1	0.011	0.012399356	1.76834E-07	1.14942E-07	0.000234481
B	1.5	0.004	0.004508857	8.50289E-09	5.52688E-09	1.12748E-05

Table 4.7: Estimation of sediment deposition in the octahedron field for Arrangement 1 of set 1 for High depth of flow

Arrangement	Distance along the length of the channel (m)	Ripple Height	Radius of Cone (r)	Total Volume of sand	Volume of sand taking porosity into considerati on(m^3)	Weight of sand trapped (kg)
		'h' (m)	in (m) r=h/tan Ø	V= (∏r² h)/3 E=10^	V' = V - 35% V	W= ∂ V' ∂ = 2040 Kg/m³
	0	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
	0.5	0.007	0.007890499	4.55702E-08	2.96206E-08	6.04261E-05
	1	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
A	1.5	0.003	0.003381643	3.58716E-09	2.33165E-09	4.75657E-06
	0	0.017	0.019162641	6.5273E-07	4.24274E-07	0.00086552
	0.5	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
	1	0.012	0.01352657	2.29578E-07	1.49226E-07	0.000304421
B	1.5	0.01	0.011272142	1.32858E-07	8.63575E-08	0.000176169

Table 4.8: Estimation of sediment deposition in the octahedron field for Arrangement -2 of set 1 for High depth of flow

Arrangement	Distance along the length of the channel (m)	Ripple Height	Radius of Cone (r)	Total Volume of sand	Volume of sand taking porosity into consideration (m^3)	Weight of sand trapped (kg)
		'h' (m)	in (m) r=h/tan Ø	V= (∏r² h)/3 E=10^	V' = V - 35% V	W= ∂ V' ∂ = 2040 Kg/m³
	0	0.01	0.011272142	1.32858E-07	8.63575E-08	0.000176169
	0.5	0.02	0.022544284	1.06286E-06	6.9086E-07	0.001409355
	1	0.018	0.020289855	7.74826E-07	5.03637E-07	0.00102742
A	1.5	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
	0	0.005	0.005636071	1.66072E-08	1.07947E-08	2.20212E-05
	0.5	0.006	0.006763285	2.86973E-08	1.86532E-08	3.80526E-05
	1	0.004	0.004508857	8.50289E-09	5.52688E-09	1.12748E-05
B	1.5	0.002	0.002254428	1.06286E-09	6.9086E-10	1.40935E-06

CHAPTER-5

RESULT AND CONCLUSION

5.1 RESULTS

This chapter presents the analysis of the experiments. The data recorded and calculated in Chapter 4 of this report has been analyzed here to draw conclusions from the experimental work.

Table 5.1: Trap Efficiency for Arrangement 1

Arrangement	Inclination of diversion line to retard (in degrees)	SDR	Depth of flow	Weight of sand deposited (Kg)	weight of sand injected (Kg)	trap Efficiency (%)
1	10	0.752	Medium	0.01477365	3	0.492455
	10	0.545	High	0.03296113	3	1.098704333

Table 5.2: Trap Efficiency for Arrangement -2

Arrangement	Inclination of diversion line to retard (in degrees)	SDR	Depth of flow	Weight of sand deposited (Kg)	weight of sand injected (Kg)	trap Efficiency (%)
1	10	0.752	Medium	0.027077203	3	0.902573433
	10	0.545	High	0.142884002	3	4.762800067

5.2 SUMMARY AND CONCLUSION

- The project involves modifying the existing Jack Jetty structure into a new model named "Octahedron" to improve stability and enhance sediment trap efficiency.
- The experiment was conducted using one setup with two arrangements.
- Setups were designed based on the angle of inclination of the diversion line of the octahedron field relative to the retard of the octahedron field which is 10^0
- Water flow depth was varied across two levels: medium, and high for each setup.

- Sediment deposition was measured in a gridded pattern for both arrangements in each setup.
- Sediment trap efficiency was calculated using the deposition data.
- The analysis included factors such as submergence depth ratio (SDR) and the degree of inclination of the diversion line with the retard.
- Trap efficiency depend on Submergence depth ratio (SDR) which is a function of depth
- of flow. Thus, it can be concluded that trap efficiency is also a function of depth of flow.

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