



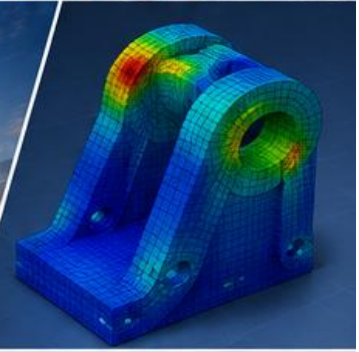
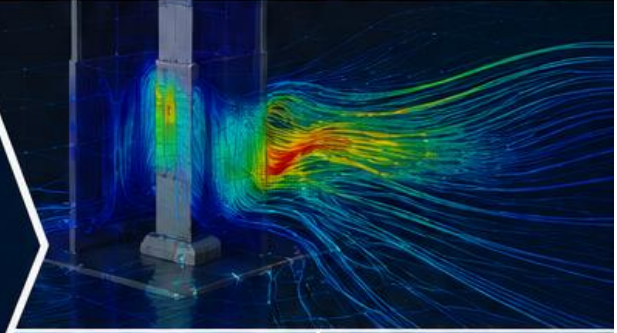
ARIYATECH
AI ENGINEERING

COMMERCIAL ENGINEERING PORTFOLIO

Selected Computational Engineering,
Scientific Computing & Applied AI Experience



Engineering Evidence Behind
Reliable Technical Decisions



ENGINEERING
SIMULATION



SCIENTIFIC COMPUTING
& APPLIED AI



TECHNICAL R&D
CONSULTING



TECHNICALLY RIGOROUS
& RELIABLE



DECISION-RELEVANT
SOLUTIONS

AriyaTech AI Engineering LLC

Computational Engineering & Applied AI Consultancy

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VERSION 1.1

August 2026

01 | TECHNICAL FOUNDATION & PORTFOLIO CONTEXT

AriyaTech AI Engineering provides specialist computational engineering services through three integrated pillars: Engineering Simulation, Scientific Computing & Applied AI, and Technical R&D Consulting. This portfolio converts selected prior engineering, research and computational work into client-facing evidence of the methods, technical judgement and delivery capabilities that support those services.

The technical foundation presented here draws on multidisciplinary engineering projects, collaborative research activities and specialist computational work developed through an established technical and research environment, together with direct technical leadership by Shahriyar Shemshaki. Projects predating the establishment of AriyaTech AI Engineering LLC are presented as prior technical experience and are not represented as contracts delivered by the company.



EVIDENCE PRINCIPLE

Each case study is structured around the engineering challenge, computational approach, quantitative or technical evidence, tools used and the capability demonstrated. Source project terminology and reported numerical results have been retained where they are material to technical credibility.

| CAPABILITY AT A GLANCE



NUMERICAL & COMPUTATIONAL ENGINEERING

FEA • CFD • nonlinear dynamics • hydrodynamics • fracture/fatigue • sediment transport • morphodynamics • V&V



SCIENTIFIC COMPUTING

Python • MATLAB • Fortran • C++ • numerical methods • automation • batch simulation • post-processing • reproducible workflows



APPLIED AI FOR ENGINEERING

ANN • machine learning • Gaussian process regression • surrogate modelling • optimization • uncertainty analysis • predictive modelling

| PORTFOLIO DOMAINS



01–05

OFFSHORE & MARINE STRUCTURES



06–10

HYDRAULIC & SEDIMENT SYSTEMS



11–15

AI & DATA-DRIVEN ENGINEERING



16–18

COMPUTATIONAL & NUMERICAL MODELING



19–20

REMOTE SENSING & GEOSPATIAL INTELLIGENCE



02

CAPABILITY & EXPERIENCE ARCHITECTURE

The twenty projects are retained to demonstrate both technical depth and breadth. For commercial clarity, they are organized into six engineering-oriented experience groups and mapped to AriyaTech's three service pillars and five core services. Titles are shortened where useful for client-facing readability; technical scope and reported evidence remain grounded in the supplied Academic Engineering Portfolio.



EXPERIENCE GROUP	PROJECTS	REPRESENTATIVE FOCUS
 A — Offshore, Marine & Energy Systems	01–05	WEC, jacket fatigue/control, ship collision, semi-submersible and Spar hydrodynamics
 B — Hydraulic, Sediment & Coastal Systems	06–10	Scour, dam-break morphodynamics, pipeline pigging, XBeach and SPH accuracy
 C — Infrastructure Risk, Resilience & Engineering AI	11–12	Seismic pipeline risk, groundwater impact and water-network resilience
 D — AI-Assisted Engineering Design & Prediction	13–15	Sea-level prediction, soil improvement and CFRP optimization
 E — Advanced Computational & Water-Resources Modelling	16–18	LBM, groundwater forecasting and conjunctive-use simulation-optimization
 F — Remote Sensing & Geospatial Engineering	19–20	Sentinel-2 land-use/change detection and MODIS-based PM10 estimation

THREE INTEGRATED SERVICE PILLARS

01 ENGINEERING SIMULATION



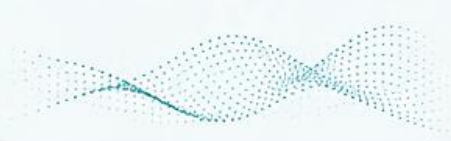
Physics-based numerical modelling, simulation, troubleshooting, assessment and validation.



02 SCIENTIFIC COMPUTING & APPLIED AI



Scientific programming, automation, data analytics, machine learning, surrogate modelling and optimization.



03 TECHNICAL R&D CONSULTING



Computational methodology, model strategy, V&V planning, independent review and research-to-engineering translation.



FIVE CORE COMMERCIAL SERVICES

SERVICE	COMMERCIAL ROLE
 S01 — Engineering Simulation Audit & Model Review	Independent review, troubleshooting and reliability assessment of existing numerical models.
 S02 — Engineering Simulation Solutions	Development, correction or extension of numerical models for defined engineering questions.
 S03 — Scientific Python & Engineering Automation	Scientific programming, automation, batch analysis, post-processing and reproducible computational workflows.
 S04 — Engineering Data Analytics & Applied AI	Prediction, surrogate modelling, optimization and interpretable engineering insight from technical data.
 S05 — Technical R&D Consulting	Methodology, validation strategy, independent technical review and complex computational R&D support.



03 | SELECTED COMMERCIAL ENGINEERING CASE STUDIES

Each case study states the engineering challenge, computational approach, source-supported technical evidence, engineering contribution, tools/methods, demonstrated capability and the AriyaTech services to which that experience is most directly relevant. Service mapping is capability-based and does not imply that historical projects were contracted under AriyaTech.



A — OFFSHORE, MARINE & ENERGY SYSTEMS

Projects 01–05 | hydrodynamics, offshore structures, fatigue, impact and wave-energy systems

PROJECT 01

WAVE ENERGY CONVERTER OPTIMIZATION & SITE-SPECIFIC PERFORMANCE ASSESSMENT

OFFSHORE & MARINE STRUCTURES | WAVE ENERGY CONVERTER DESIGN | OPTIMIZATION | MULTI-PHYSICS SIMULATION



ENGINEERING CHALLENGE

Design and performance optimization of a rotational wave energy converter (WEC) under real marine conditions, considering both environmental variability and structural parameters across multiple deployment sites in the southern Caspian Sea.



COMPUTATIONAL APPROACH

A multi-stage computational framework was developed integrating meta-ocean data analysis, Grey Wolf Optimization (GWO) in MATLAB for site selection and parameter tuning, geometric modeling in Abaqus, and dynamic simulation using WEC-Sim to evaluate hydrodynamic response and energy extraction performance.



SELECTED TECHNICAL EVIDENCE

- Optimal deployment site identified: Noshahr
- Energy conversion efficiency improved by up to ~63%
- Optimal flap length determined in the range of 18–22 m
- ~42 candidate locations evaluated and reduced through optimization



ENGINEERING CONTRIBUTION

Development of an integrated optimization–simulation framework combining data-driven site selection with multiphysics modeling for enhanced performance of wave energy systems, demonstrating the strong influence of radiation damping and environmental conditions on wave energy converter performance.



TOOLS / METHODS

MATLAB (GWO), Abaqus, WEC-Sim (Simulink), Meta-Ocean Data Analysis



CAPABILITY DEMONSTRATED

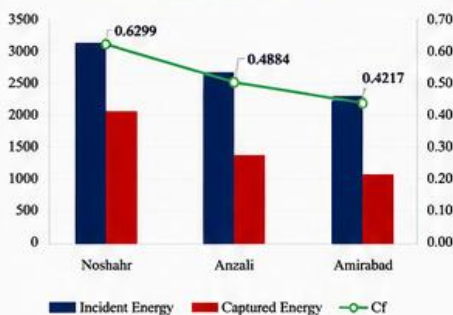
Wave Energy Converter Design • Optimization • Multi-Physics Simulation



RELEVANT ARIYATECH SERVICES

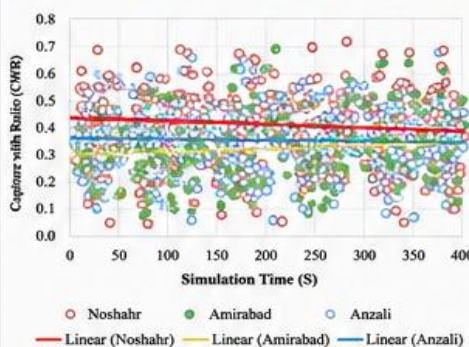
S02 Engineering Simulation Solutions • S04 Engineering Data Analytics & Applied AI • S05 Technical R&D Consulting

Energy Extraction Comparison Across Selected Ports



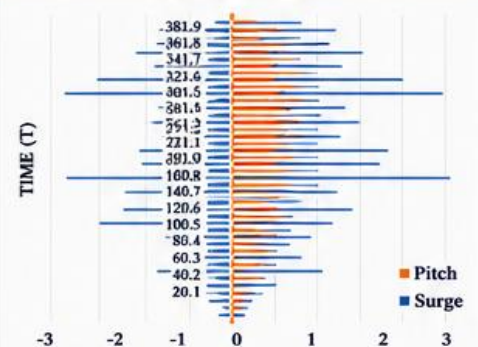
Incident and captured energy (kJ) and conversion efficiency (Cf) for the three selected ports. Noshahr shows the highest Cf value (0.6299).

Temporal Variation of CWR Across Selected Ports



Capture with ratio (CWR) time histories for the three ports. Linear trend lines indicate average performance levels; Noshahr provides the highest average CWR.

Displacement and Rotation of the Converter Flap at the Optimal Location (Noshahr Port)



Time histories of flap rotation (pitch, deg) and displacement (surge, m) showing dynamic response under optimal operational conditions at Noshahr.



PROJECT
02

FATIGUE PERFORMANCE ENHANCEMENT OF OFFSHORE JACKET PLATFORMS USING TLCD CONTROL

OFFSHORE & MARINE STRUCTURES | OFFSHORE STRUCTURAL CONTROL | FATIGUE ANALYSIS | NUMERICAL MODELING



ENGINEERING CHALLENGE

Assessment of fatigue-critical behavior in aging fixed offshore jacket platforms under cyclic wave loading, with the objective of improving service life through TLCD-based passive and semi-active vibration control.



COMPUTATIONAL APPROACH

A coupled numerical framework was developed for the SPQ1 jacket platform using OpenSees for structural analysis and MATLAB for wave loading generation, TLCD force computation, and fatigue-processing routines. The platform was analyzed under 10 marine states representative of Persian Gulf conditions. Wave kinematics were derived using fifth-order Stokes theory, hydrodynamic forces were computed through the Morison equation, and fatigue life was evaluated for 12 primary joints using the Hot Spot Stress approach and S-N relationships. TLCD performance was assessed under both passive and semi-active control strategies.



SELECTED TECHNICAL EVIDENCE

- The most fatigue-critical joints in the uncontrolled model were J1–J4, with service lives ranging from 8.78 to 10.04 years.
- Under passive TLCD control, the corresponding fatigue-life range improved to 9.23–10.71 years.
- Under semi-active TLCD control, the fatigue-life range further improved to 9.73–10.98 years.
- For the most critical joint (J1), service life increased from 8.78 years to 9.89 years with passive control and 10.11 years with semi-active control.



ENGINEERING CONTRIBUTION

Development of a coupled MATLAB–OpenSees framework for fatigue-sensitive offshore structural assessment under cyclic wave loading, demonstrating that TLCD-based control can improve the service life of critical jacket-platform joints, with semi-active control generally providing the strongest fatigue mitigation among the evaluated strategies.



TOOLS / METHODS

OpenSees, MATLAB, time-domain wave loading, TLCD modeling, Hot Spot Stress fatigue analysis



CAPABILITY DEMONSTRATED

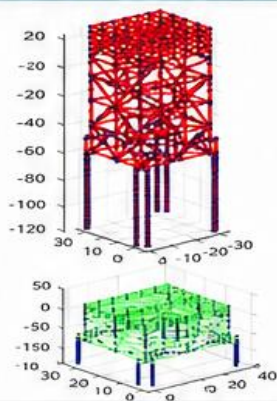
Offshore Structural Control • Fatigue Analysis • Numerical Modeling



RELEVANT ARIYATECH SERVICES

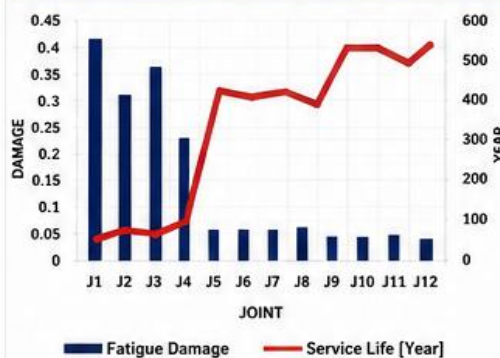
S02 Engineering Simulation Solutions • S05 Technical R&D Consulting

Jacket Platform: Nodes & Elements Configuration



3D numerical model of the SPQ1 jacket platform (upper: complete model, lower: submerged portion).

Fatigue Analysis of Main Joints With and Without Passive TLCD Vibration Control



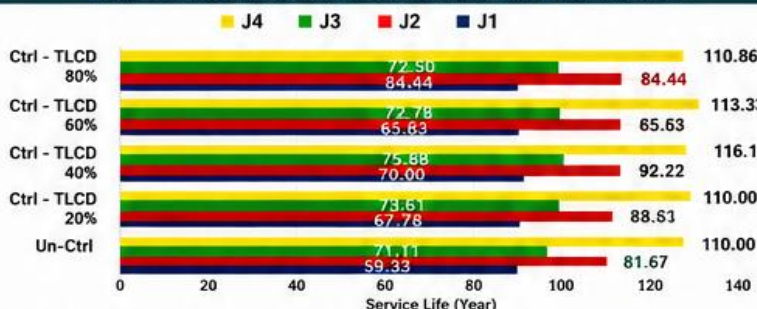
Fatigue damage (bars) and service life (line) for 12 main joints in the uncontrolled model.

Fatigue Analysis of Main Joints With Passive TLCD Vibration Control



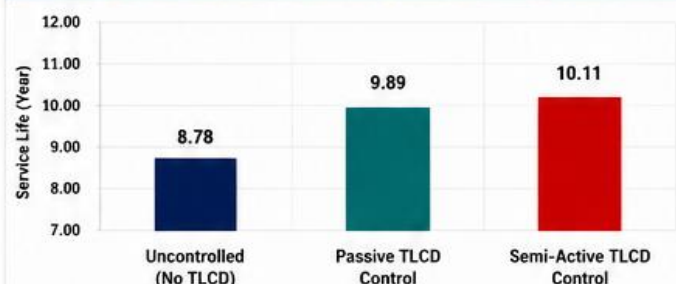
Fatigue damage (bars) and service life (line) for critical joints J1–J4 under passive TLCD control.

Fatigue Life of Joints Under Different TLCD Orifice Opening Levels



Effect of TLCD orifice opening level on service life of critical joints. Semi-active control (lower opening ratios) provides the highest service life.

Fatigue Life of Most Critical Joint (J1): Control Strategies Comparison



Service life improvement for the most critical joint (J1) under passive and semi-active TLCD control strategies.



PROJECT
03

SHIP-COLLISION ASSESSMENT OF CORRODED OFFSHORE JACKET PLATFORMS

OFFSHORE & MARINE STRUCTURES | OFFSHORE STRUCTURES |
IMPACT MECHANICS | FINITE ELEMENT MODELING | CORROSION EFFECTS



ENGINEERING CHALLENGE

This project investigates the structural performance of offshore jacket platforms subjected to dynamic impact loading induced by supply vessel collisions. The study focuses on the combined effects of corrosion-induced degradation and boundary condition variations on the structural integrity of tubular members. A full-scale numerical model of an 8-leg offshore jacket structure was developed to simulate realistic impact scenarios and evaluate post-collision structural capacity.



COMPUTATIONAL APPROACH

A nonlinear dynamic analysis was conducted using Abaqus/Explicit to simulate ship-platform collision. The model includes an 8-leg jacket structure and a 5000-ton supply vessel represented as a rigid body. Corrosion effects were incorporated through thickness reduction based on service-life data. The analysis considers large deformation, contact interaction, and elastic-plastic material behavior under four critical scenarios combining healthy/corroded states and different boundary conditions.



SELECTED TECHNICAL EVIDENCE

- Maximum Von Mises stress reached ~435 MPa during peak impact phase
- Corrosion increased local deformation (dent depth) by approximately 10%
- Plastic strain in corroded members increased up to 6% compared to intact state
- Boundary condition modification reduced plastic strain by ~40% in healthy members
- Energy dissipation was predominantly plastic (>70%), confirming severe nonlinear response
- Structural capacity assessment based on NORSOK N-004 showed:
 - Intact members: structurally safe under impact
 - Corroded members: loss of load-bearing capacity and structural vulnerability



ENGINEERING CONTRIBUTION

This study develops a realistic impact model by simultaneously incorporating dynamic collision and corrosion effects, addressing limitations in simplified analyses. The work integrates practical corrosion modeling with nonlinear finite element simulation and evaluates structural performance under varying boundary conditions. Results are directly interpreted using offshore design standards, providing engineering-relevant insight into the safety and reliability of deteriorated offshore structures.



TOOLS / METHODS

Abaqus (Explicit),
Finite Element Modeling,
Nonlinear Dynamic Analysis,
Offshore Design Codes
(DNV, NORSOK)



CAPABILITY DEMONSTRATED

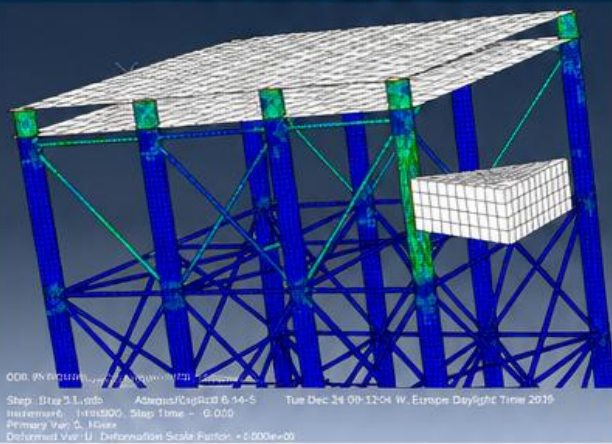
Offshore Structures •
Impact Mechanics •
Finite Element Modeling •
Corrosion Effects



RELEVANT ARIYATECH SERVICES

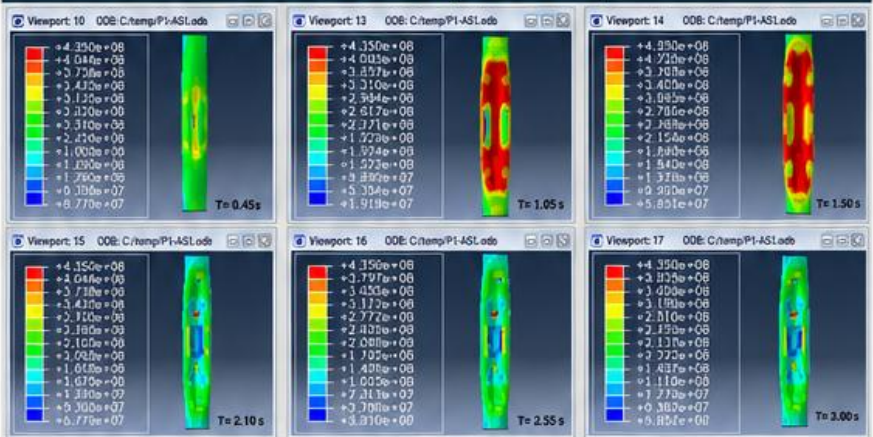
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S05 Technical R&D
Consulting

NUMERICAL MODEL OF BASELINE JACKET PLATFORM UNDER SHIP-COLLISION SCENARIO



Baseline 8-leg jacket platform model in Abaqus/Explicit with a 5000-ton supply vessel (rigid body) in ship-collision configuration.

VON MISES STRESS EVOLUTION IN JACKET TUBULAR MEMBERS DURING SHIP IMPACT (TIME HISTORY)



Von Mises stress (Pa) distribution in a critical jacket tubular member at selected time instants during ship impact, showing stress concentration and propagation.



MAX. VON MISES STRESS
AT PEAK IMPACT

~435 MPa



CORROSION INCREASED
LOCAL DEFORMATION
(DENT DEPTH)

~10%



PLASTIC STRAIN INCREASED
IN CORRODED MEMBERS

UP TO 6%



BOUNDARY CONDITION MODIFICATION
REDUCED PLASTIC STRAIN (HEALTHY)

~40%



ENERGY DISSIPATION
PREDOMINANTLY PLASTIC

>70%



PROJECT
04

HYDRODYNAMIC STABILITY ASSESSMENT OF SEMI-SUBMERSIBLE OFFSHORE PLATFORMS

OFFSHORE & MARINE STRUCTURES | OFFSHORE STRUCTURES | HYDRODYNAMICS
STABILITY ANALYSIS | MOORING DESIGN | ANSYS AQWA



ENGINEERING CHALLENGE

This project investigates the dynamic behavior and stability performance of semi-submersible offshore platforms under realistic marine conditions. Three platform configurations (A, B, C) were analyzed across multiple sea states, focusing on the influence of environmental loading, draft variation, and wave characteristics on structural response and operational stability. The study also extends to the evaluation and design considerations of the mooring system to ensure reliable station-keeping under operational conditions.



COMPUTATIONAL APPROACH

A numerical modeling framework was developed using ANSYS AQWA to simulate hydrodynamic interactions. The analysis includes four representative sea conditions (Caspian Sea and North Sea wave spectra). Platform A was evaluated under three draft conditions (14.5 m, 15.5 m, 17.5 m) to assess stability sensitivity. Dynamic response parameters (heave, pitch, roll, displacement, rotation) were extracted and compared with industrial reference data for validation. In addition, the study incorporates design-oriented evaluation of the mooring system, analyzing its role in controlling platform motion and improving stability performance under varying environmental loads.



SELECTED TECHNICAL EVIDENCE

- Increasing draft from 14.5 m to 17.5 m reduced motion amplitudes and improved stability
- Wave propagation angle significantly affected peak structural response
- Response amplitudes under Caspian Sea conditions remained within ~0.32–0.72 range
- Spectral wave loading produced higher displacement and rotation compared to regular waves
- Moorings system effectiveness was critical in reducing displacement and maintaining stability
- Optimized positioning and draft selection significantly improved operational performance
- Numerical results showed high agreement with industrial benchmark data (Global Maritime)
- Model reliability confirmed through consistency between simulation and reference data



ENGINEERING CONTRIBUTION

This study develops a validated hydrodynamic analysis framework that integrates environmental loading, draft variation, and mooring system performance. It provides a practical methodology for both stability assessment and mooring design, offering engineering-level insights for optimizing offshore platform safety and operational efficiency under real sea conditions.



TOOLS / METHODS

ANSYS AQWA,
Hydrodynamic Modeling,
Offshore Stability Analysis,
Mooring System Design



CAPABILITY DEMONSTRATED

Offshore Structures •
Hydrodynamics •
Stability Analysis •
Mooring Design •
ANSYS AQWA



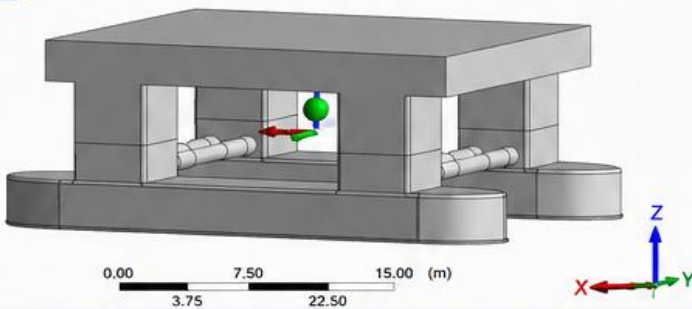
RELEVANT ARIYATECH SERVICES

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RESULTS & TECHNICAL EVIDENCE (ANSYS AQWA)

1

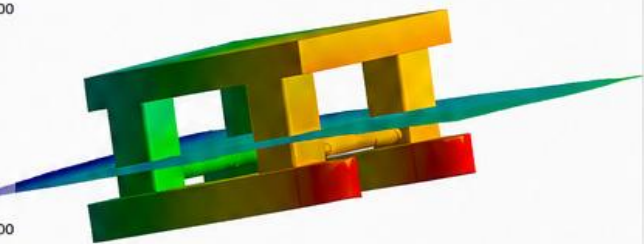
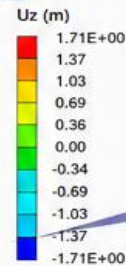
Semi-Submersible Platform Configuration (Typical Model)



Typical semi-submersible platform model used in hydrodynamic simulation (ANSYS AQWA).

2

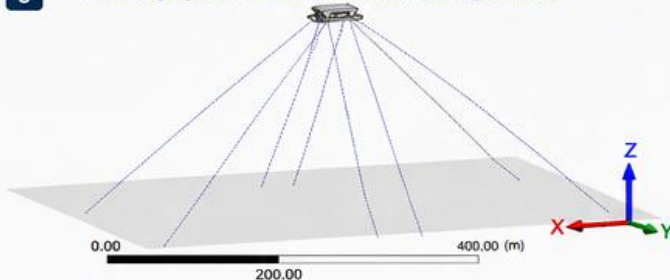
Instantaneous Vertical Displacement (U_z)



Instantaneous vertical displacement (U_z) of the platform under wave loading (ANSYS AQWA).

3

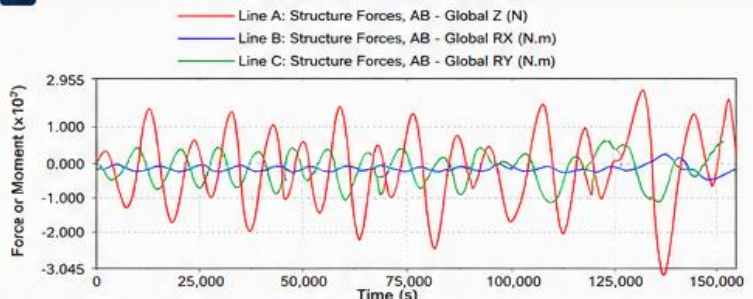
Moorings System Model (Multi-Line Configuration)



Moorings system model with multiple lines for station-keeping under environmental loads.

4

Structural Forces & Moments at a Critical Location (Time History)



Time history of structural forces and moments at a critical location during ship–platform impact event.



PROJECT 05

DEEP-WATER OPERATIONAL ASSESSMENT OF A SPAR OFFSHORE PLATFORM

OFFSHORE & MARINE STRUCTURES | OFFSHORE STRUCTURES | HYDRODYNAMICS
STABILITY ANALYSIS | MOORING DESIGN | ANSYS AQWA



ENGINEERING CHALLENGE

This project addresses the critical challenge of ensuring hydrodynamic stability and operational reliability of Spar-type offshore platforms under wave loading in deep-water conditions. The study focuses on evaluating platform performance by analyzing hydrostatic and hydrodynamic behavior, response under different wave environments, and the influence of mooring system dynamics, while also comparing performance across varying geographical sea conditions to support safe and efficient offshore deployment.



COMPUTATIONAL APPROACH

A numerical model was developed in ANSYS AQWA to simulate wave-structure interaction for a Spar platform under multiple environmental conditions, including Caspian Sea (average, extreme, spectral) and Malaysian offshore waves. The study involved hydrostatic and hydrodynamic analyses, along with evaluation of mooring system influence on platform stability. Model outputs were validated against a benchmark case (Kikeh Spar platform) to ensure reliability.



SELECTED TECHNICAL EVIDENCE

- Stable platform performance observed under all simulated sea conditions
- Caspian Sea conditions resulted in lower motion response and higher stability compared to Malaysian sea
- Spectral wave conditions produced higher dynamic responses than regular wave cases
- Numerical results showed strong agreement with benchmark study (Kikeh Spar) → validated model accuracy
- Platform response remained within acceptable operational limits for deep-water deployment



ENGINEERING CONTRIBUTION

This work establishes a validated numerical framework for evaluating Spar platform performance under varying wave conditions. It provides comparative insight into environmental effects and highlights the role of mooring systems and regional sea states in offshore stability design.



TOOLS / METHODS

ANSYS AQWA,
Hydrodynamic Analysis,
Offshore Numerical Modeling,
Irregular Wave Analysis
(Spectral Waves)



CAPABILITY DEMONSTRATED

Offshore Structures •
Hydrodynamics •
Stability Analysis •
Mooring Design •
ANSYS AQWA •



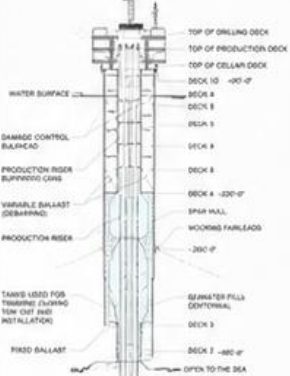
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Consulting

RESULTS & TECHNICAL EVIDENCE (ANSYS AQWA)

1

INBOARD PROFILE CLASSIC SPAR – STEEL HULL



Inboard profile of the classic Spar steel-hull platform.

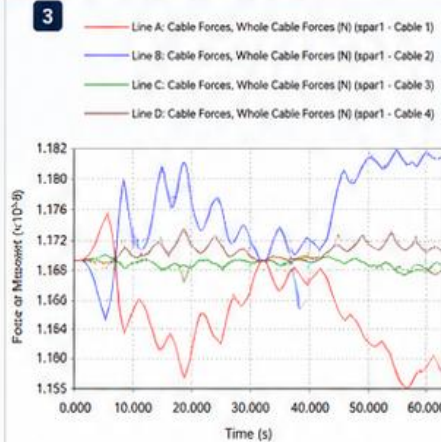
2

MOORING SYSTEM MODEL (MULTI-LINE CONFIGURATION)



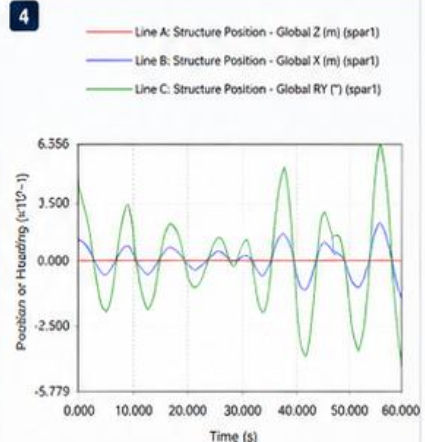
Mooring system model with multiple lines for station-keeping under environmental loads.

3



Time history of structural forces and moments in mooring cables during wave loading.

4



Platform position and heading responses under wave loading.



STABLE PERFORMANCE
IN ALL SEA CONDITIONS



LOWER MOTION RESPONSE
IN CASPIAN SEA COMPARED
TO MALAYSIAN SEA



HIGHER DYNAMIC RESPONSE
UNDER SPECTRAL WAVE
CONDITIONS



VALIDATED AGAINST
KIKEH SPAR BENCHMARK
(STRONG AGREEMENT)



RESPONSE WITHIN ACCEPTABLE
OPERATIONAL LIMITS FOR
DEEP-WATER DEPLOYMENT



PROJECT 06

SEDIMENT TRANSPORT & SCOUR MODELLING AROUND PARALLEL SPUR DIKES

HYDRAULIC & SEDIMENT SYSTEMS | HYDRAULIC MODELING
SEDIMENT TRANSPORT | SPH | FLOW-3D | MORPHODYNAMICS



ENGINEERING CHALLENGE

Accurate prediction of sediment transport and local scour around hydraulic structures such as parallel spur dikes remains a critical challenge due to the nonlinear behavior of free-surface flow, moving boundaries, and complex sediment–fluid interactions. Conventional mesh-based numerical methods face limitations in handling large deformations and evolving geometries, leading to reduced accuracy and computational inefficiency in modeling riverbed morphological changes.



COMPUTATIONAL APPROACH

A multi-stage numerical framework was developed based on the SPH (meshless) method, progressing from validated 2D flow modeling to a fully developed 3D sediment transport model. To ensure robustness and engineering reliability, the results were systematically validated against both experimental data and a high-fidelity CFD model (Flow-3D). This dual-validation strategy enabled direct comparison between meshless and mesh-based approaches under identical hydraulic conditions.



SELECTED TECHNICAL EVIDENCE

- SPH results showed strong agreement with experimental data, with deviations generally within 3–5%.
- Model accuracy was comparable to—and in some cases exceeded—Flow-3D, particularly in capturing localized scour patterns.
- Stable and consistent performance was maintained under high transport conditions (up to ~30% normalized).
- Superior handling of moving boundaries and morphodynamic evolution was achieved without the need for remeshing.
- Validation results confirmed overall model reliability across different hydraulic scenarios, with velocity discrepancies limited to ~0.02–0.04.



ENGINEERING CONTRIBUTION

This study introduces a validated dual-framework modeling approach (SPH + Flow-3D) for sediment transport and scour analysis, combining the flexibility of meshless methods with the benchmark reliability of CFD-based simulations. The results demonstrate that SPH can serve as an accurate and computationally efficient alternative to conventional methods for complex morphodynamic problems.



TOOLS / METHODS

SPH (Smoothed Particle Hydrodynamics), Flow-3D (CFD), 2D–3D hydraulic modeling, sediment transport simulation, morphodynamic analysis



CAPABILITY DEMONSTRATED

Hydraulic Modeling •
Sediment Transport •
SPH • Flow-3D •
Morphodynamics

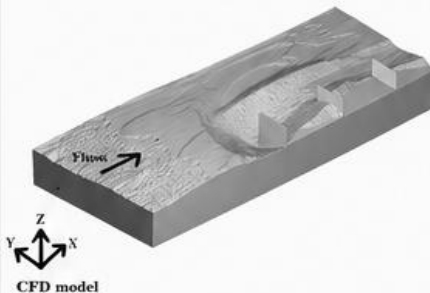


RELEVANT ARIYATECH SERVICES

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Consulting

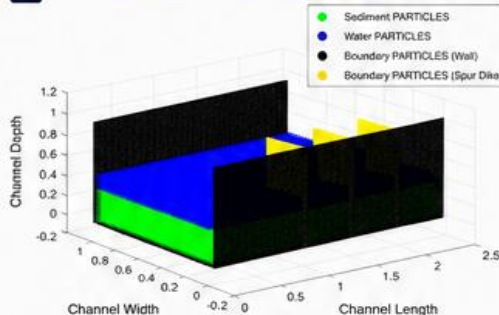
RESULTS & TECHNICAL EVIDENCE

1 SPH MODEL SETUP (CFD DOMAIN)



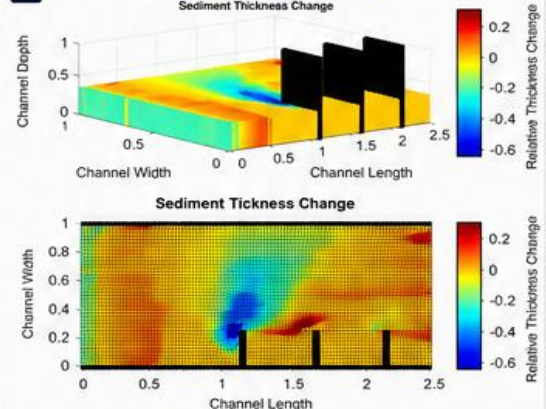
3D computational domain of the parallel spur dike system used for SPH simulation.

2 PARTICLE DISTRIBUTION (3D VIEW)



3D particle layout including sediment, water, and boundary particles in the computational domain.

3 SEDIMENT THICKNESS CHANGE



3D and 2D distributions of relative sediment thickness change around spur dikes.



PROJECT 07

EXPERIMENTAL-CFD ASSESSMENT OF DAM-BREAK SEDIMENT MORPHODYNAMICS

HYDRAULIC & SEDIMENT SYSTEMS | HYDRAULIC MODELING | DAM BREAK |
SEDIMENT TRANSPORT | CFD (ANSYS FLUENT) | MORPHODYNAMICS



ENGINEERING CHALLENGE

Accurate prediction of sediment transport and downstream bed evolution under dam-break conditions remains a significant challenge due to highly unsteady turbulent flow, multiphase interactions, and rapid morphodynamic changes. While most existing studies focus on instantaneous failure and fixed-bed assumptions, the combined influence of failure mechanism (instantaneous vs. gradual) and sediment characteristics on bed response has not been systematically quantified, limiting the reliability of predictive models for real-world flood-induced erosion and sediment redistribution.



COMPUTATIONAL APPROACH

Acoupled experimental-numerical framework was developed to address this gap. Controlled laboratory experiments were conducted in a 10 m flume using coarse and fine sediments, with bed evolution captured via high-resolution laser profiling. In parallel, a high-fidelity CFD model was implemented in ANSYS Fluent using a multiphase Eulerian approach. The model was rigorously calibrated and validated against experimental data through sensitivity analyses on mesh resolution (0.5–2 cm) and turbulence modeling (k-ε Standard and RNG). Gradual dam failure was realistically simulated through a dynamic mesh with a time-dependent moving gate, enabling accurate representation of progressive breach behavior.



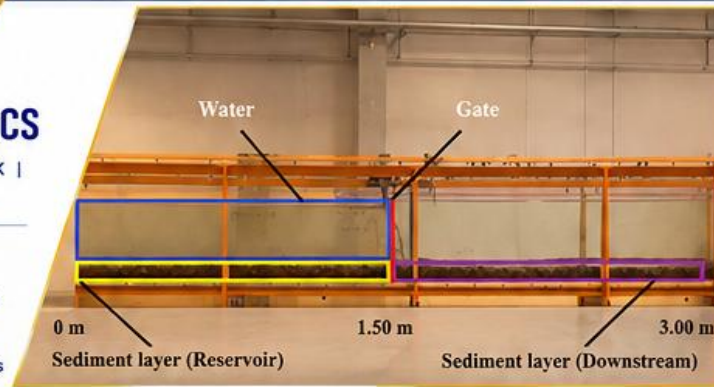
SELECTED TECHNICAL EVIDENCE

- Optimal mesh size (1 cm) achieved high numerical accuracy with average error $\approx 2.41\%$ relative to experiments.
- The k-ε Standard turbulence model outperformed RNG, reducing modeling error to $\approx 2.75\%$ (vs $\approx 6.40\%$).
- Overall CFD model accuracy remained below 5%, confirming strong agreement with experimental measurements.
- Maximum sediment deformation occurred within the first 2 seconds, concentrated within ± 1.5 m of the breach location.
- Sediment transport intensity in gravel beds was $\approx 18.6\%$ higher than in sand beds due to larger particle size effects.
- Gradual dam failure produced significantly higher sediment transport compared to instantaneous failure: (Gravel: +7.47%, Sand: +19.35%, Intermediate: +11.52%).
- Mean sediment thickness reduction confirmed stronger erosion in gradual failure (e.g., sand bed reduced from 6.25 cm to 5.04 cm).



ENGINEERING CONTRIBUTION

This study presents a rigorously validated experimental-CFD framework for analyzing sediment transport under different dam-break mechanisms. The results provide quantitative evidence of the dominant role of failure type in controlling sediment dynamics, highlighting that gradual failure induces more severe morphodynamic changes due to prolonged flow-sediment interaction and increased pressure fluctuations. The framework offers a reliable basis for advanced flood modeling, dam safety assessment, and sediment management in hydraulic engineering systems.



TOOLS / METHODS

ANSYS Fluent (CFD),
Multiphase Eulerian Modeling,
Dynamic Mesh, k-ε Turbulence Models,
Experimental Flume Testing,
Laser Bed Profiler,
Morphodynamic Analysis



CAPABILITY DEMONSTRATED

- Hydraulic Modeling
- Dam Break
- Sediment Transport
- CFD (ANSYS Fluent)
- Morphodynamics

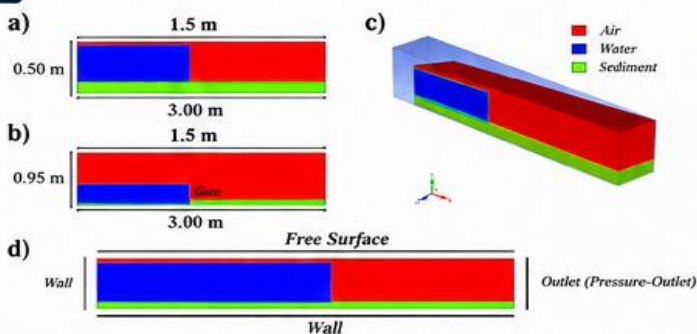


RELEVANT ARIYATECH SERVICES

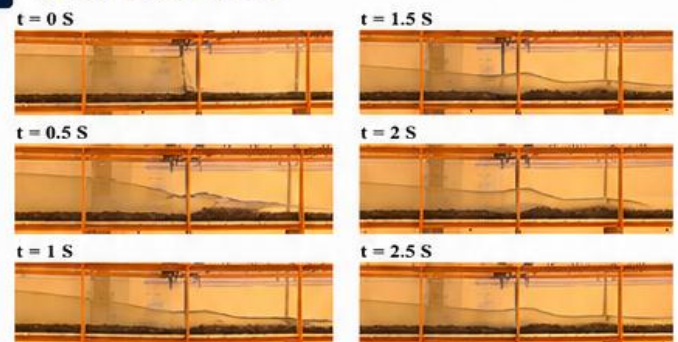
- S01 Simulation Audit & Model Review
- S02 Engineering Simulation Solutions
- S05 Technical R&D Consulting

RESULTS & TECHNICAL EVIDENCE

1 Geometry of numerical models

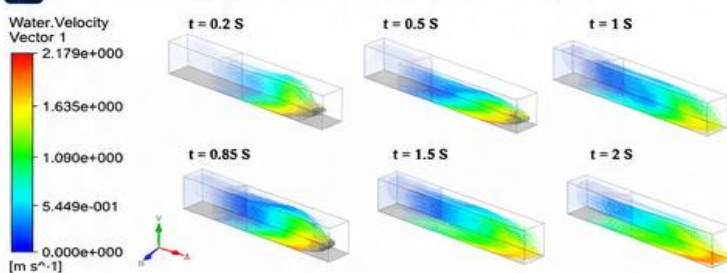


2 Experimental Test Results

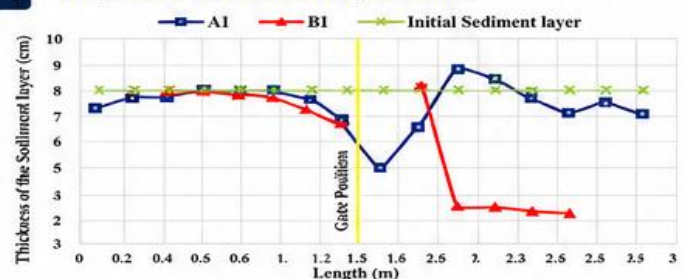


Experimental test results (time sequence) showing dam-break flow propagation and sediment movement.

3 3D Flow Velocity Vectors and Bed Sediment Contour Comparison



4 Comparison of the sediment bed profile results



PROJECT
08

SPH SIMULATION OF MOVING PIGS IN PRESSURIZED PIPELINES

HYDRAULIC & SEDIMENT SYSTEMS | HYDRAULIC MODELING | MULTIPHASE FLOW | SPH | PIPELINE ENGINEERING | TURBULENT FLOW SIMULATION



ENGINEERING CHALLENGE

Accurate prediction of pigging operations in pressurized pipelines remains a complex engineering challenge due to highly unsteady turbulent flow, strong fluid-structure interaction, and the presence of moving internal boundaries. Conventional CFD approaches face limitations in capturing flow discontinuities, turbulence structures around bypass pigs, and dynamic force variations, particularly under transient conditions. Additionally, numerical instability and convergence issues in meshless methods such as SPH have historically limited their application in confined pressurized flows.



COMPUTATIONAL APPROACH

A high-fidelity numerical framework was developed based on the Smoothed Particle Hydrodynamics (SPH) method to simulate pigging operations in pipelines. The governing equations of fluid flow and pig dynamics were systematically derived and reformulated within the SPH framework and implemented in a Fortran-based computational model. The study included identification and integration of all key physical parameters affecting pig motion, followed by simulation of both stationary and moving pig conditions under turbulent flow regimes. Model validation was performed through comparison with experimental data and benchmark CFD results from previous studies, ensuring consistency in flow patterns, force distributions, and dynamic response of the pig.



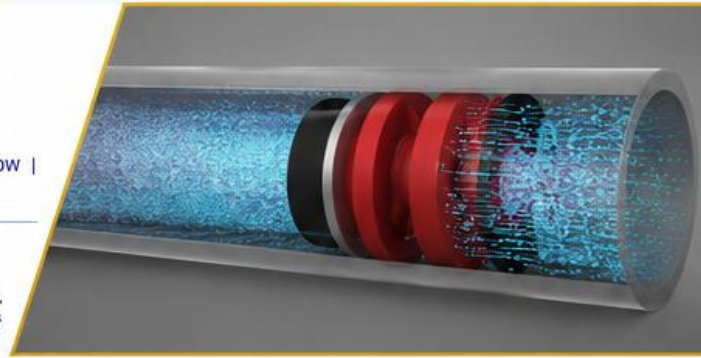
SELECTED TECHNICAL EVIDENCE

- The SPH model achieved strong agreement with experimental and numerical benchmarks, with computational errors approximately 5.2% (vs. experimental) and 6.02% (vs. numerical models).
- Hydrodynamic force trends, acceleration, and velocity profiles of the moving pig showed consistent temporal behavior aligned with validated physical expectations.
- The model successfully captured turbulent flow structures and complex wake patterns around bypass pigs, one of the main challenges in pigging simulations.
- SPH demonstrated robust performance in handling moving boundaries without mesh distortion or remeshing requirements.
- Comparative analysis confirmed that SPH provides reliable prediction of flow-pig interaction mechanisms under both steady and transient conditions.
- The framework accurately reproduced force balance dynamics, enabling realistic simulation of pig acceleration and motion evolution.



ENGINEERING CONTRIBUTION

This study introduces a validated meshless numerical framework for simulating pigging operations in pressurized pipelines using SPH, addressing key challenges related to turbulence modeling and moving boundary dynamics. The developed model demonstrates that SPH can serve as a reliable and flexible alternative to conventional CFD approaches for complex internal flow systems involving dynamic objects and transient hydrodynamic interactions.



TOOLS / METHODS

SPH (Smoothed Particle Hydrodynamics), Fortran-based numerical modeling, turbulent flow simulation, multiphase pipeline analysis, fluid-structure interaction modeling, validation against CFD and experimental data



CAPABILITY DEMONSTRATED

Hydraulic Modeling •
Multiphase Flow •
SPH •
Pipeline Engineering •
Turbulent Flow Simulation

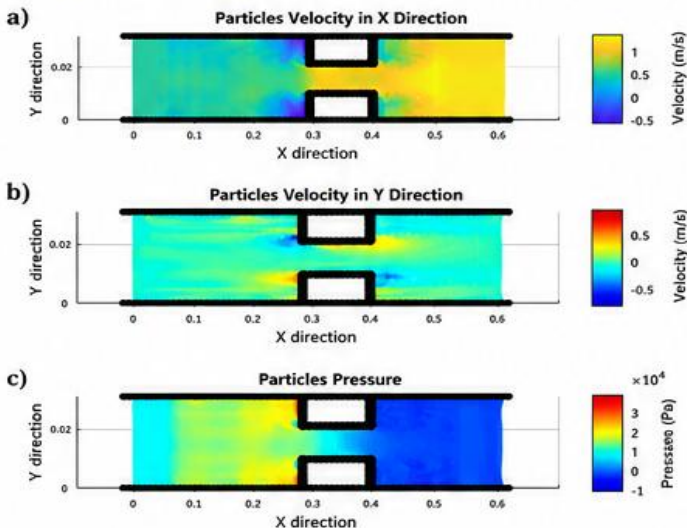


RELEVANT ARIYATECH SERVICES

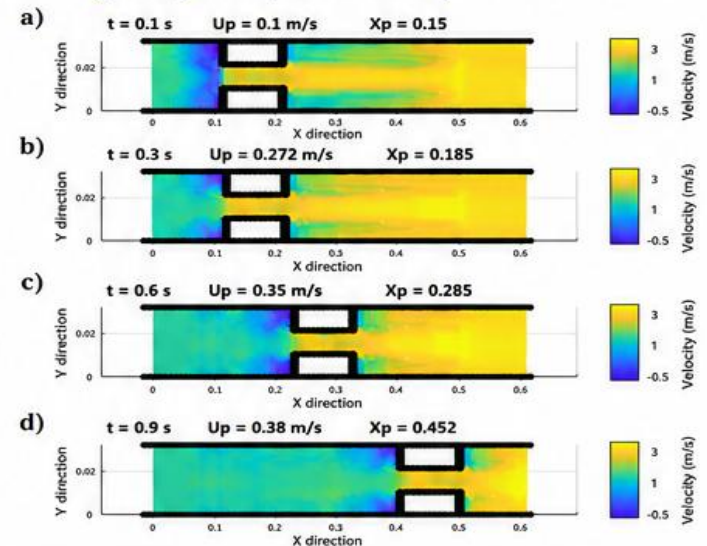
S02 Engineering Simulation Solutions •
S03 Scientific Python & Engineering Automation •
S05 Technical R&D Consulting

RESULTS & TECHNICAL EVIDENCE

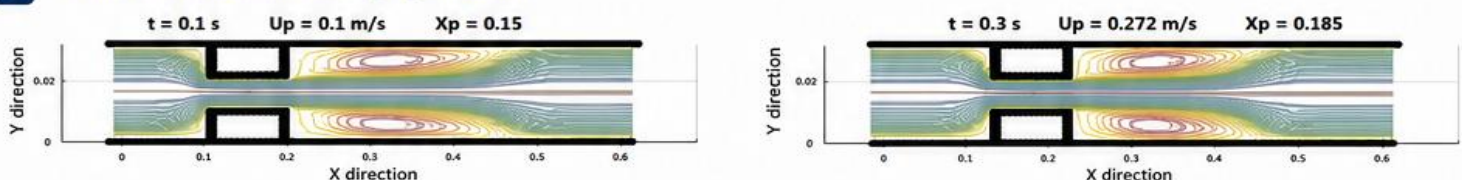
1 SPH Results (Static Pig): a) Axial Fluid Particle Velocity (x), b) Vertical Velocity, c) Pressure



2 Time-Dependent Simulation Results of Pigging: Pig Velocity, Position, and Fluid Velocity



3 Flow Pattern Evolution in Moving Pig Simulation



PROJECT
09

ENHANCED XBEACH MODELLING OF SWASH-ZONE MORPHODYNAMICS

HYDRAULIC & SEDIMENT SYSTEMS | COASTAL ENGINEERING | MORPHODYNAMICS |
SEDIMENT TRANSPORT | XBEACH | SWASH ZONE DYNAMICS



ENGINEERING CHALLENGE

Accurate prediction of sediment transport and morphological evolution in coastal environments, particularly within the swash zone, remains a major challenge due to complex nonlinear interactions among short waves, infragravity waves, flow, sediment dynamics, and groundwater processes. Standard XBeach configurations often exhibit limitations in capturing these coupled processes with sufficient accuracy under transient and high-energy conditions.



COMPUTATIONAL APPROACH

An enhanced process-based numerical framework was developed using XBeach (SB and NH modules), with targeted model improvements in wave energy balance, momentum equations, wetting-drying treatment, and sediment transport formulations. The model was further extended to explicitly account for groundwater presence and water table interactions, improving the representation of saturated coastal conditions. The modified framework was validated against experimental data across multiple gauge locations to ensure robustness and accuracy.



SELECTED TECHNICAL EVIDENCE

- The enhanced model showed strong agreement with experimental data, validating the implemented improvements.
- Accuracy in predicting free surface elevation and wave transformation in the swash zone was significantly improved.
- Mean water level (η) predictions remained within ~1–3% deviation from measured values.
- The model provided improved representation of sediment transport and rapid bed evolution processes.
- Incorporation of groundwater effects enhanced physical realism under saturated coastal conditions.
- Refined wetting-drying schemes improved numerical stability and convergence behavior.
- The modified framework demonstrated superior performance compared to the standard XBeach configuration, particularly in swash zone dynamics.



ENGINEERING CONTRIBUTION

This study advances coastal morphodynamic modeling through the development and enhancement of the XBeach framework, with a key innovation in incorporating groundwater and water table effects under saturated coastal conditions. The proposed modifications significantly improve the model's capability to simulate swash zone processes and coupled wave-sediment-groundwater interactions, providing a more physically consistent and reliable tool for coastal engineering applications.



TOOLS / METHODS

XBeach (SB & NH – enhanced), process-based modeling, sediment transport simulation, morphodynamic analysis, swash zone modeling, groundwater interaction modeling, numerical model development and validation



CAPABILITY DEMONSTRATED

- Coastal Engineering
- Morphodynamics
- Sediment Transport
- XBeach
- Swash Zone Dynamics



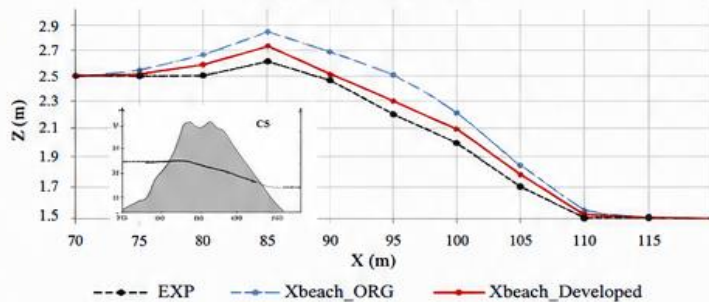
RELEVANT ARIYATECH SERVICES

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- S02 Engineering Simulation Solutions
- S03 Scientific Python & Engineering Automation
- S05 Technical R&D Consulting

RESULTS & TECHNICAL EVIDENCE

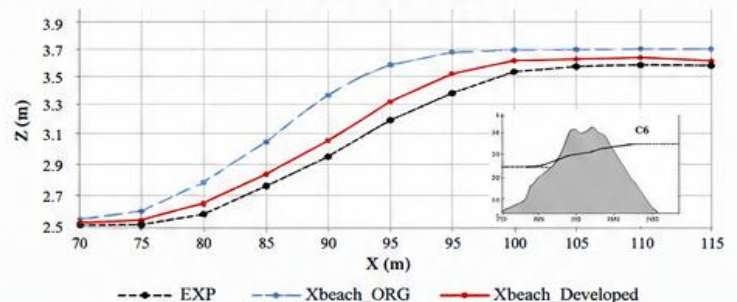
1 Test C5 – Groundwater Level

Test C5 : Groundwater Level



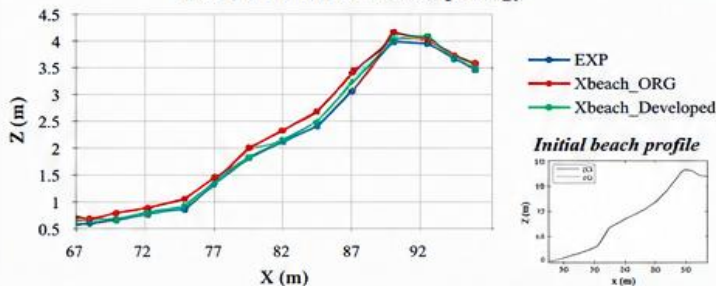
2 Test C6 – Groundwater Level

Test C6 : Groundwater Level



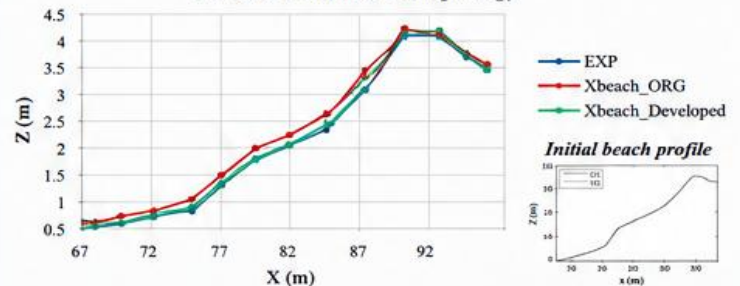
3 Test C5 – Final beach morphology

Test C5 : Final beach morphology



4 Test C6 – Final beach morphology

Test C6 : Final beach morphology



PROJECT 10

ACCURACY ENHANCEMENT OF SPH FREE-SURFACE HYDRAULIC SIMULATIONS

HYDRAULIC & SEDIMENT SYSTEMS | SPH | WCSPH | FREE-SURFACE FLOW |
PARTICLE SHIFTING | HYDRAULIC BENCHMARK MODELING



ENGINEERING CHALLENGE

Accurate SPH simulation of hydraulic free-surface flows is strongly affected by particle disorder, interpolation errors, and numerical instability. This project focused on improving SPH accuracy by systematically evaluating the effects of initial particle arrangement and periodic particle redistribution in three benchmark hydraulic problems: dam-break flow, wave generation and breaking, and tsunami wave propagation.



COMPUTATIONAL APPROACH

A developed WCSPH-based numerical framework was implemented using the open-source SPHysics model, extended through MATLAB/FORTRAN coding to support six particle initialization schemes: SC, Triangular, WVT, Greedy, Hexagonal, and Fibonacci. The model was validated against experimental datasets for dam-break flow, coastal wave breaking, and tsunami generation. After identifying the best-performing particle layouts, a modified Particle Shifting Technique (PST) was implemented for WCSPH using neighborhood-density-based redistribution instead of constant reference density, enabling more stable particle spacing during time integration.



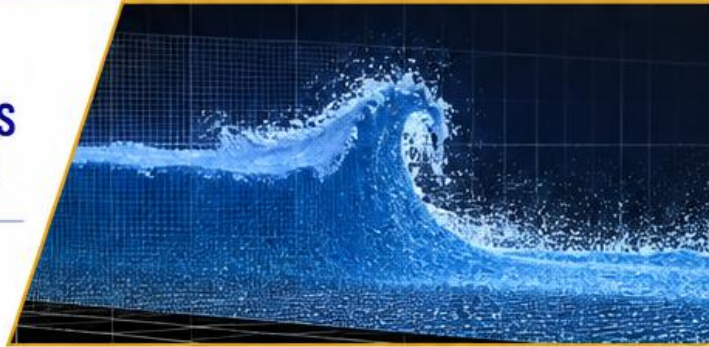
SELECTED TECHNICAL EVIDENCE

- For dam-break simulation, Fibonacci and Hexagonal layouts achieved the best accuracy, with mean errors of 2.53% and 2.56%, compared with 8.07% for the conventional SC layout.
- For wave generation and breaking, Hexagonal and Fibonacci layouts reduced mean modeling errors to 9.07% and 9.37%, while SC, Triangular, and Greedy layouts produced errors above 13%.
- For tsunami simulation, Hexagonal and Fibonacci layouts again provided the best performance, with errors of 8.50% and 9.09%, compared with 12.24–13.15% for weaker layouts.
- Applying PST to the dam-break model reduced error from 2.56% to 2.21%, while increasing computational time from 1.8 h to 2.10 h.
- Periodic PST every 10 iterations was identified as an efficient compromise, reducing dam-break error to 2.35% with moderate computational cost.
- In the wave-breaking model, PST reduced Fibonacci-layout error from 9.37% to 8.17% when applied at every iteration.



ENGINEERING CONTRIBUTION

This study introduced an accuracy-oriented SPH enhancement framework by combining optimized particle initialization with a modified WCSPH-compatible particle redistribution algorithm. The work provides practical guidelines for selecting particle layouts and redistribution frequency in free-surface hydraulic simulations, improving numerical stability and predictive accuracy across dam-break, wave-breaking, and tsunami benchmark problems.



TOOLS / METHODS

SPHysics, WCSPH, MATLAB/FORTRAN programming, Particle Shifting Technique (PST), Fibonacci and Hexagonal particle initialization, free-surface hydraulic modeling, experimental validation.



CAPABILITY DEMONSTRATED

SPH • WCSPH •
Free-Surface Flow •
Particle Shifting •
Hydraulic Benchmark
Modeling



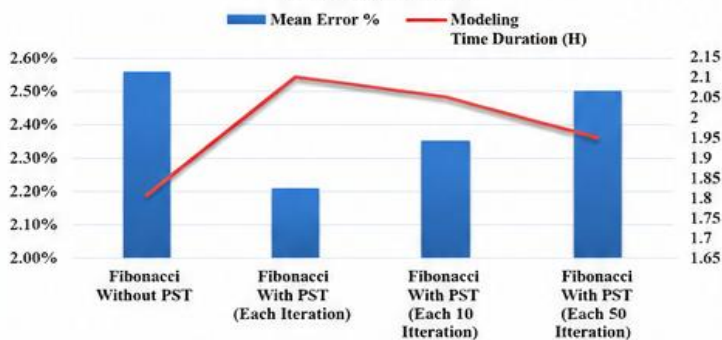
RELEVANT ARIYATECH SERVICES

S01 Simulation Audit &
Model Review
S02 Engineering Simulation
Solutions
S03 Scientific Python &
Engineering Automation
S05 Technical R&D
Consulting

RESULTS & TECHNICAL EVIDENCE

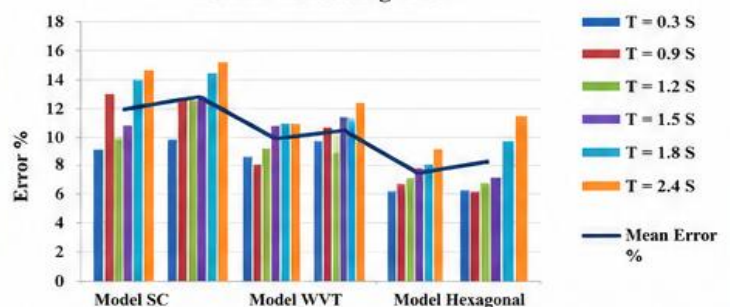
1 Sensitivity of Particle Redistribution (Error & Time) in Fibonacci Dam-Break Model

Dam Break Model



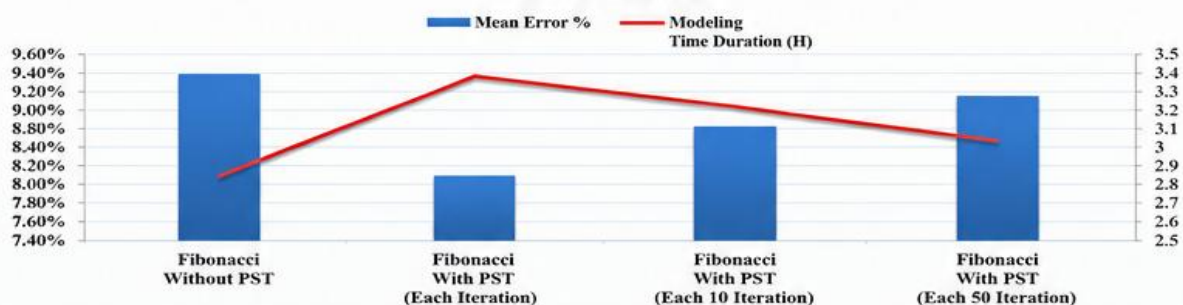
2 SPH Tsunami Modeling Error Evaluation Across Initial Particle Configurations

T-sunami Modeling Error



3 Wave Generation–Breaking Model (Error & Time) for Different Particle Redistribution Intervals

Wave Maker Model



PROJECT 11

AI-BASED SEISMIC RISK & GROUNDWATER IMPACT ASSESSMENT FOR FUEL PIPELINES

AI & DATA-DRIVEN ENGINEERING | SEISMIC RISK ANALYSIS | FUEL PIPELINE LEAKAGE | GROUNDWATER CONTAMINATION | ANN/ML | DRASTIC | MONTE CARLO | ROBUST STRATEGY



ENGINEERING CHALLENGE

Fuel transmission pipelines in Tehran are highly vulnerable to earthquake-induced damage due to active faults, dense urban infrastructure, buried pipeline networks, and the strategic importance of groundwater resources. Pipeline rupture or leakage after seismic events can release petroleum hydrocarbons such as TPH and BTEX into soil and groundwater, creating severe environmental, public-health, and water-security risks. Therefore, a comprehensive uncertainty-based framework was required to assess seismic damage in fuel pipelines, evaluate its potential impact on groundwater contamination, and formulate robust mitigation strategies.



COMPUTATIONAL APPROACH

A comprehensive risk-assessment and strategic decision-support framework was developed for Tehran's buried fuel transmission network. First, pipeline, seismic, geotechnical, groundwater, land-use, and fault-related spatial data were compiled in GIS. Seismic damage prediction models were developed using Artificial Neural Networks (ANN) and Machine Learning (ML). Monte Carlo simulation was applied to incorporate uncertainty in key input parameters, and three seismic scenarios with Mw = 5, 6, and 7 were analyzed. The resulting leakage and rupture outputs were coupled with the DRASTIC model to map contamination potential. Finally, mitigation strategies were evaluated using robust strategy planning and Minimax Regret theory.



SELECTED TECHNICAL EVIDENCE

- Tehran's fuel pipeline network was divided into 834 segments and evaluated under uncertainty.
- ANN-based results: 15 leaks/2 ruptures (Mw=5), 25 leaks/7 ruptures (Mw=6), 27 leaks/9 ruptures (Mw=7).
- ML-based results: 15 leaks/2 ruptures (Mw=5), 24 leaks/6 ruptures (Mw=6), 27 leaks/8 ruptures (Mw=7).
- ANN stress prediction: 12 hidden layers, MSE = 0.584, R = 0.9975.
- ANN seismic vulnerability prediction: 9 hidden layers, MSE = 1.83×10^{-3} , R = 0.97.
- Exponential GPR (pipe stress): MSE = 1.08×10^{-5} , R = 0.999.
- Rational Quadratic GPR (seismic damage): MSE = 4.97×10^{-6} , R = 0.999.
- DRASTIC assessment: 18% high vulnerability, 20% medium vulnerability.
- Minimax Regret: smart seismic shut-off system identified as the most robust strategy.



ENGINEERING CONTRIBUTION

Development of an integrated AI-GIS-DRASTIC framework for assessing earthquake-induced fuel pipeline damage and its environmental consequences on urban groundwater systems. The project links seismic risk modeling, uncertainty simulation, groundwater vulnerability mapping, and robust strategic planning into a transferable decision-support platform for critical infrastructure and environmental risk management.



TOOLS / METHODS

MATLAB, Python, ANN, Machine Learning, Gaussian Process Regression, Monte Carlo Simulation, GIS/ArcGIS, DRASTIC Model, Seismic Scenario Analysis, Minimax Regret Theory



CAPABILITY DEMONSTRATED

- Seismic Risk Analysis
- Fuel Pipeline Leakage
- Groundwater Contamination
- ANN/ML
- Monte Carlo
- Robust Strategy

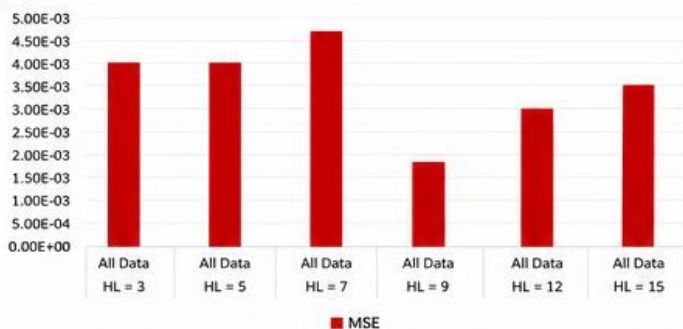


RELEVANT ARIYATECH SERVICES

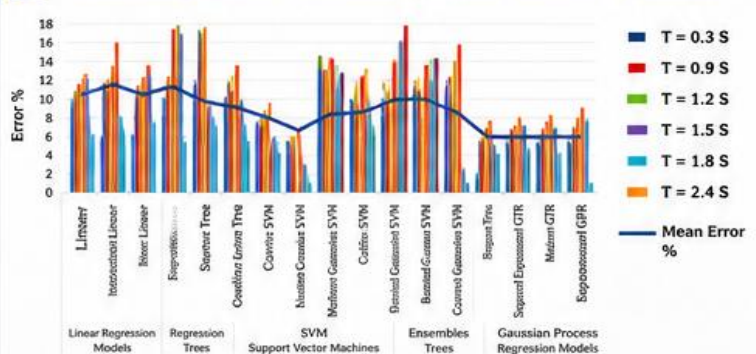
- S04 Engineering Data Analytics & Applied AI
- S05 Technical R&D Consulting

RESULTS & TECHNICAL EVIDENCE

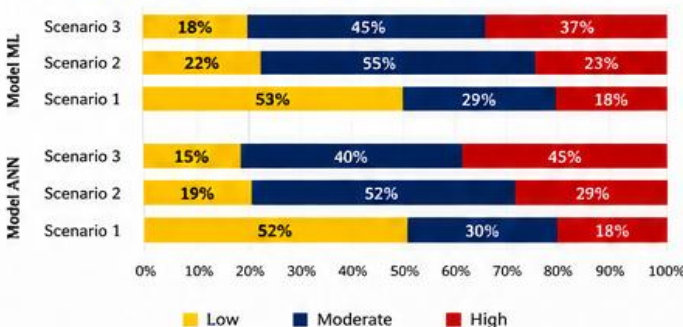
1 MSE Error Evaluation of ML-Based Pipeline Stress Prediction Models



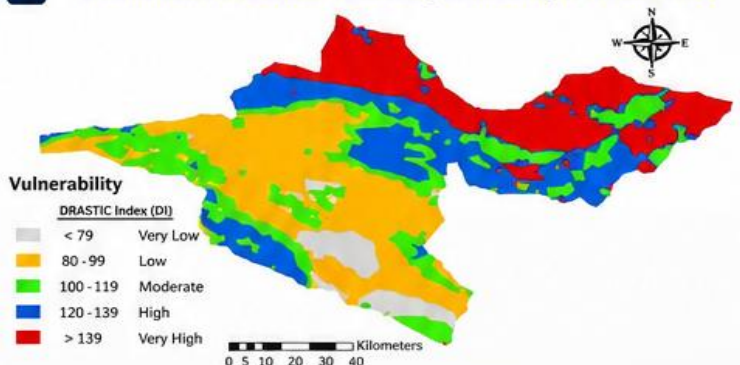
2 Statistical Evaluation of ANN Model for Pipeline Vulnerability Prediction



3 Assessment of Tehran Aquifer Contamination Due to Seismic Damage of Fuel Pipelines Under Multiple Earthquake Scenarios



4 DRASTIC-Based Groundwater Vulnerability Zonation Map of Tehran Province



PROJECT 12

SEISMIC RESILIENCE ASSESSMENT OF URBAN WATER DISTRIBUTION NETWORKS

AI & DATA-DRIVEN ENGINEERING | SEISMIC RESILIENCE | WATER INFRASTRUCTURE | FEM | ABAQUS | ANN | MACHINE LEARNING | MONTE CARLO SIMULATION | RECOVERY PLANNING



ENGINEERING CHALLENGE

Urban water distribution and transmission networks are critical lifeline infrastructures whose seismic failure can severely disrupt emergency water supply, post-earthquake recovery, and urban crisis management. In Tehran, high seismic hazard, dense population, aging buried pipelines, and complex soil-pipe interaction make accurate assessment of seismic vulnerability and recovery capacity essential. Therefore, a comprehensive AI-based framework was required to evaluate seismic damage, quantify network resilience through resistance-recovery indicators, and formulate practical strategies for improving the seismic resilience of the water supply system.



COMPUTATIONAL APPROACH

A comprehensive numerical-AI framework was developed for seismic resilience assessment of Tehran's water transmission and distribution network. A finite element model of buried pipeline behavior was developed in Abaqus and validated against experimental results, then used to generate 720 seismic variables, Meneris. ANN simulation with 1,000,000 samples was used to incorporate uncertainty. Finally, seismic damage, break/leak distribution, minimum emergency water demand, recovery time, and resilience improvement strategies were evaluated for Tehran districts 1 to 4.



SELECTED TECHNICAL EVIDENCE

- Abaqus FEM model validated with average error of 9.3221%, MSE = 0.000443, RMSE = 0.021048.
- Generated 720 numerical scenarios for AI-based damage prediction.
- ANN model (15 hidden layers): MSE = 3.01, R = 0.969.
- Squared Exponential GPR (best ML model): MSE = 3.0564, R = 0.94.
- Five seismic scenarios: Kern County, Parkfield, Borrego Mountain, Tabas, Imperial Valley.
- Monte Carlo simulation with 1,000,000 samples for uncertainty analysis.
- Emergency water demand for districts 1-4 reached 312,113.6 m³ (first 3 days).
- Recovery time for District 1 ranged from 351 h to 435 h depending on the scenario.
- Five resilience improvement strategies were identified.



ENGINEERING CONTRIBUTION

Development of an integrated FEM-AI-resilience framework for seismic performance assessment of urban water infrastructure, combining pipeline damage prediction, uncertainty modeling, emergency demand estimation, recovery-time analysis, and strategy formulation. The framework provides a transferable decision-support tool for improving the seismic resilience of lifeline water networks in earthquake-prone cities.



TOOLS / METHODS

Abaqus, Python, MATLAB, ANN, Machine Learning, Gaussian Process Regression, Monte Carlo Simulation, GIS/ArcGIS, Seismic Record Processing, FEM, Resilience Assessment.



CAPABILITY DEMONSTRATED

- Seismic Resilience
- Water Infrastructure
- FEM
- Abaqus
- ANN
- Machine Learning
- Monte Carlo Simulation
- Recovery Planning

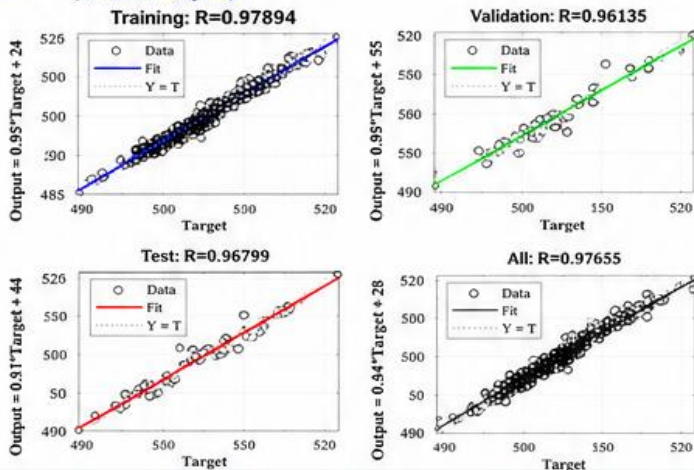


RELEVANT ARIYATECH SERVICES

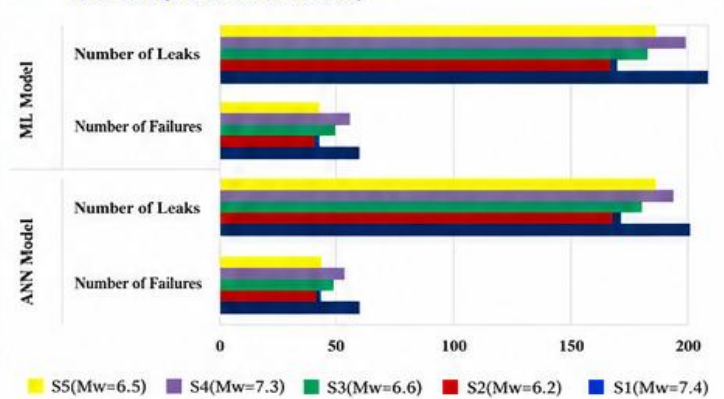
- S02 Engineering Simulation Solutions
- S03 Scientific Python & Engineering Automation
- S04 Engineering Data Analytics & Applied AI
- S05 Technical R&D Consulting

RESULTS & TECHNICAL EVIDENCE

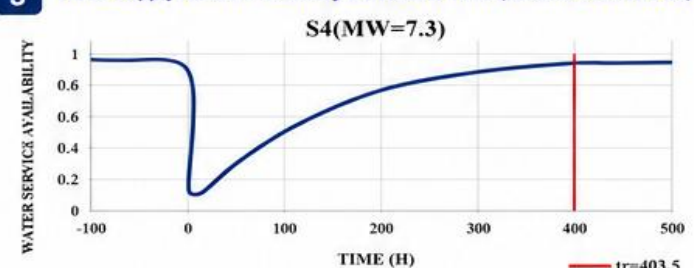
1 Evaluation of ANN Model for Buried Pipeline Strain Prediction (15 Hidden Layers)



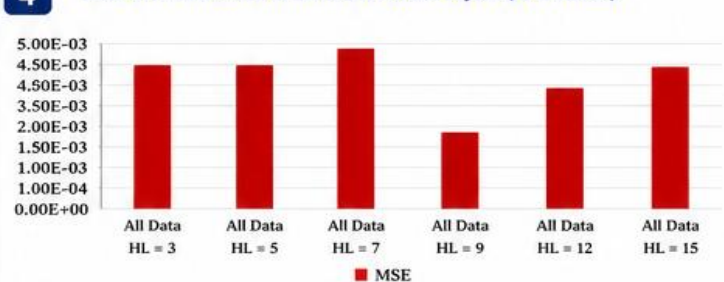
2 Seismic Vulnerability Comparison of Water Transmission Networks (Scenarios vs. Models)



3 Water Supply Network Recovery Curve Over Time (Seismic Scenario S4)



4 MSE Error Evaluation of Different Hidden Layers (ANN Model)



PROJECT 13

AI PREDICTION OF CASPIAN SEA-LEVEL FLUCTUATIONS

AI & DATA-DRIVEN ENGINEERING | CASPIAN SEA | SEA-LEVEL PREDICTION | WAVELET ANALYSIS | ANN | MACHINE LEARNING | TIME-SERIES ANALYSIS



ENGINEERING CHALLENGE

Accurate prediction of Caspian Sea level fluctuations remains a major challenge due to its closed-basin hydrology, strong sensitivity to climatic drivers, and historically significant multi-meter oscillations. These fluctuations have caused substantial impacts on coastal infrastructure, ecosystems, and groundwater systems. Conventional hydrological and time-series models often struggle to capture the nonlinear interactions governing sea-level dynamics or require extensive datasets, highlighting the need for a robust data-driven predictive approach.



COMPUTATIONAL APPROACH

A comprehensive AI-based framework was developed to predict monthly sea level variations using key climatic and hydrological variables. Observational data (1995–2017) from Bandar Anzali, including SST, air temperature, Volga discharge, and sea level, were analyzed using statistical correlation and wavelet-based methods to extract time–frequency relationships. Based on these insights, ANN and multiple ML models were implemented, with sensitivity analysis performed on network architecture and comparative evaluation across regression techniques. Model performance was rigorously validated using data from 24 stations across the Caspian Sea.



SELECTED TECHNICAL EVIDENCE

- Used 276 monthly observations over a 23-year period from 1995–2017.
- Identified SST, air temperature, Volga River discharge, and previous-month sea level as main predictors.
- SST and air temperature had stronger correlation with sea level than Volga discharge (0.4433, 0.4396, and 0.2510, respectively).
- Wavelet coherence: SST = 0.6070 (strongest), air temperature = 0.5849, Volga discharge = 0.3398.
- Previous-month sea level wavelet correlation = 0.8034.
- ANN (7 hidden layers): MSE = 2.79×10^4 , R = 0.954.
- Exponential GPR (best ML): MSE = 3.26, R = 0.97.
- Validation across 24 stations: ML outperformed ANN (MSE = 1.5584, MAE = 0.9378).



ENGINEERING CONTRIBUTION

Development of a comprehensive AI-based sea-level prediction framework for the Caspian Sea by integrating statistical analysis, wavelet-based feature evaluation, ANN modeling, and machine learning regression. The framework provides an efficient and transferable tool for predicting climate-driven sea-level fluctuations and supporting coastal planning, environmental risk assessment, and adaptive management of Caspian coastal zones.



TOOLS / METHODS

MATLAB, Wavelet Transform (Cross, Coherence), ANN, ML, Time-Series Analysis



CAPABILITY DEMONSTRATED

Caspian Sea • Sea-Level Prediction • Wavelet Analysis • ANN • Machine Learning • Time-Series Analysis

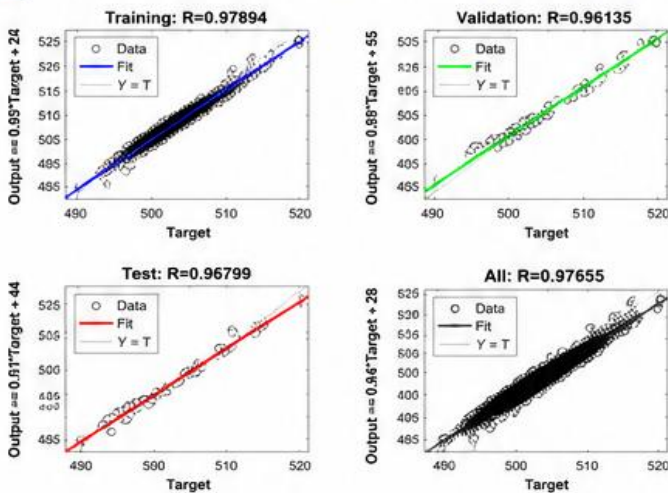


RELEVANT ARIYATECH SERVICES

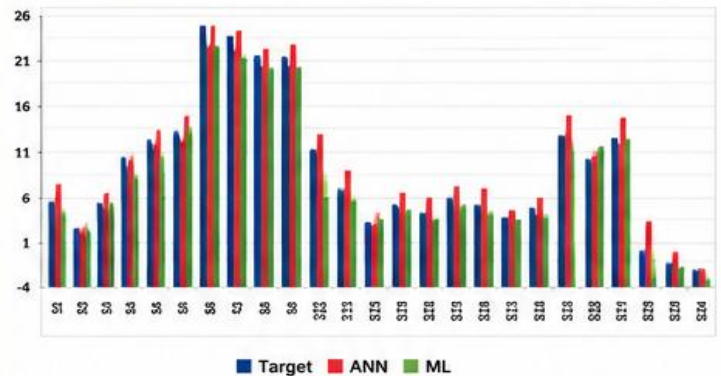
S04 Engineering Data Analytics & Applied AI
S05 Technical R&D Consulting

RESULTS & TECHNICAL EVIDENCE

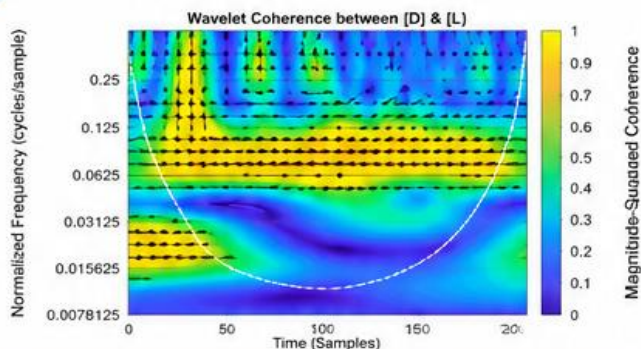
1 ANN Results for Sea Level Fluctuation Prediction (7 Hidden Layers)



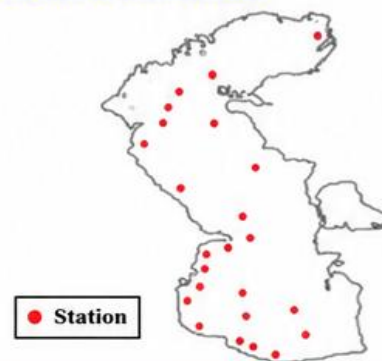
2 ANN vs. ML Performance Comparison for Sea Level Prediction (24 Stations)



3 Cross-Wavelet Results (D – L)



4 Station Locations for Model Evaluation



PROJECT 14

OPTIMIZED SOIL-CEMENT COLUMN DESIGN FOR SEISMIC SOFT-SOIL STABILIZATION

AI & DATA-DRIVEN ENGINEERING | SOFT COASTAL DEPOSITS | SOFT SOIL STABILIZATION | SEISMIC LOADING | FEM | ABAQUS | ANN | GWO



ENGINEERING CHALLENGE

Soft soils in coastal and seismic regions exhibit low bearing capacity, excessive settlement, and high seismic vulnerability. Although soil-cement (SC) columns are widely applied for ground improvement, optimal design under earthquake loading remains challenging due to complex nonlinear interactions among soil properties, column characteristics, overburden conditions, and seismic inputs, necessitating a robust evaluation and optimization framework.



COMPUTATIONAL APPROACH

A two-phase framework was developed for seismic performance evaluation and optimal design of SC columns. First, laboratory tests were conducted on non-stabilized and SC column-stabilized loose soil under rigid and ductile overburden conditions. The experimental models were then reproduced in Abaqus using 3D and 2D FEM models, calibrated against measured settlement responses, and extended to five seismic scenarios. In the second phase, a surrogate ANN model was developed using 780 Abaqus-Python simulation samples, and Grey Wolf Optimization (GWO) was coupled with the trained ANN model to extract optimal SC column parameters by minimizing seismic settlement.



SELECTED TECHNICAL EVIDENCE

- SC columns reduced settlement by **55%** (rigid) and **75%** (ductile) in experiments.
- 3D Abaqus models: average errors of 5.78%, 9.63%, 5.66%, and 6.63% for F1-F4 models.
- 2D models: maximum error of 7.1% against experimental results.
- Dynamic FEM validation: 9.44% error under seismic loading.
- Across five scenarios: 54.13% (rigid) and 71.63% (ductile) average settlement reduction.
- Database of 780 numerical simulations for ANN-based prediction.
- Best ANN model (15 hidden layers): MSE = 0.301, R = 0.969.
- Optimized SC columns reduced seismic settlement by 62.7% (up to 66.06% in Imperial Valley).



ENGINEERING CONTRIBUTION

Development of an integrated experimental-FEM-ANN-GWO framework for the performance-based seismic design of soil-cement columns in soft soils, enabling **efficient prediction and optimization** of SC column parameters and providing a **practical decision-support tool** for reducing **seismic settlement** and improving the stability of soft ground.



TOOLS / METHODS

Abaqus, Python, MATLAB, FEM, ANN, Seismic Record Analysis, Experimental Testing



CAPABILITY DEMONSTRATED

Soft Coastal Deposits • Soft Soil Stabilization • Seismic Loading • FEM • Abaqus • ANN • GWO



RELEVANT ARIYATECH SERVICES

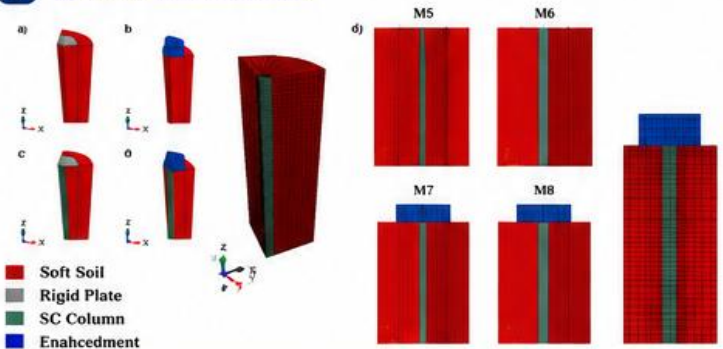
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RESULTS & TECHNICAL EVIDENCE

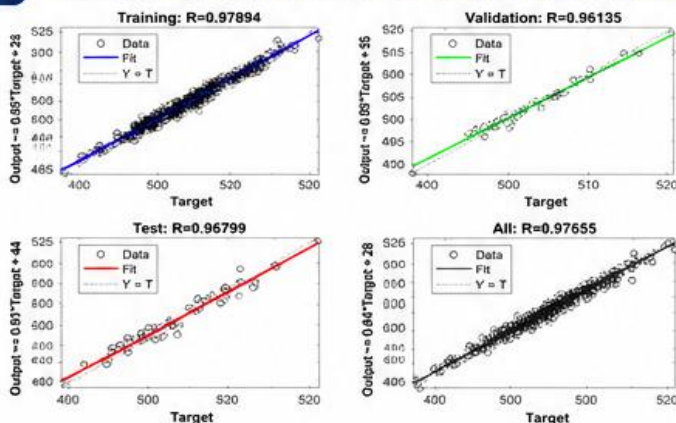
1 Experimental Models



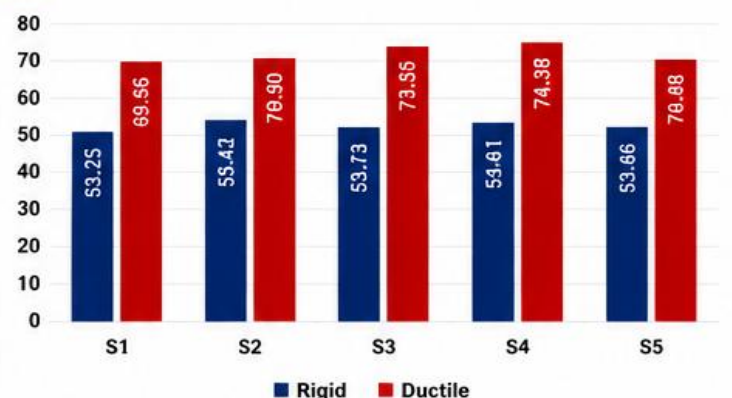
2 2D and 3D Numerical Models



3 Performance Evaluation of Developed ANN for Soil Settlement Prediction



4 Settlement Comparison (Rigid vs. Ductile, S1 - S5)



PROJECT 15

OPTIMIZED CFRP RETROFITTING OF RC SLAB-COLUMN CONNECTIONS

AI & DATA-DRIVEN ENGINEERING | SEISMIC RETROFITTING | CFRP | SLAB-COLUMN CONNECTION | PUNCHING SHEAR | FEM | ANN | GWO



ENGINEERING CHALLENGE

RC slab-column connections in flat slab systems are highly susceptible to punching shear and brittle failure under seismic cyclic loading due to stress concentration and limited shear reinforcement. Although CFRP retrofitting is effective, conventional design approaches rely on empirical configurations, making it difficult to achieve cost-efficient and damage-optimized solutions. This necessitated an integrated framework for accurate damage prediction and optimal CFRP design.



COMPUTATIONAL APPROACH

A multi-stage numerical-AI framework was developed combining FEM, ANN, and Grey Wolf Optimization (GWO). A validated 3D model in Abaqus was used to simulate RC slab-column behavior with CFRP strengthening under cyclic loading. Parametric analyses of multiple CFRP configurations were conducted to assess key design variables. A large simulation dataset was generated via automated Abaqus-Python runs, and an ANN model was trained to predict seismic damage. The trained ANN was then coupled with GWO to optimize CFRP design parameters, minimizing damage under seismic loading.



SELECTED TECHNICAL EVIDENCE

- FEM validation under unstrengthened punching shear achieved an average modeling error of 5.2%.
- CFRP-strengthened punching shear validation produced average error below 6.5%.
- CFRP-strengthened cyclic loading validation remained below 7% error.
- Parametric analysis of 33 CFRP strengthening configurations under monotonic and cyclic loading.
- 824 high-fidelity FEM simulations generated via Abaqus-Python automation for ANN training.
- CFRP plates with 2 mm thickness achieved up to 98.91% damage reduction compared with baseline.
- Larger CFRP dimensions (400x400 mm) reduced slab damage by more than 98% in selected cases.
- Fiber orientation of 0°/45°/90°/0° showed the best performance in cyclic energy dissipation.
- ANN (10 hidden layers) achieved best performance ($R^2 > 0.95$), reducing computational cost by >92% vs. FEM.
- Optimized ANN-GWO design reduced damage by more than 27% compared with baseline strategies.



ENGINEERING CONTRIBUTION

Development of a hybrid FEM-ANN-GWO framework for rapid seismic damage prediction and optimized CFRP retrofitting of RC slab-column connections. The proposed approach replaces repeated finite element simulations with an accurate ANN surrogate model and enables efficient identification of optimal CFRP configurations, providing a scalable decision-support tool for performance-based seismic rehabilitation of flat slab systems.



TOOLS / METHODS

Abaqus, Python, MATLAB, FEM, Concrete Damaged Plasticity, CFRP Composite Modeling, Cohesive Interface Modeling, ANN, Grey Wolf Optimization, SAC Cyclic Loading Protocol.



CAPABILITY DEMONSTRATED

Seismic Retrofitting • CFRP • Slab-Column Connection • Punching Shear • FEM • ANN • GWO

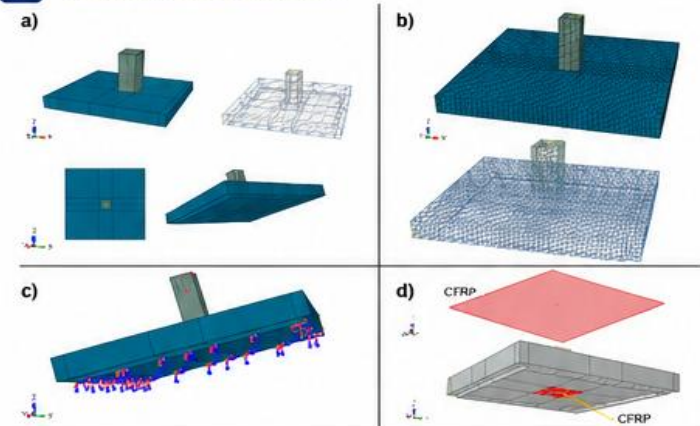


RELEVANT ARIYATECH SERVICES

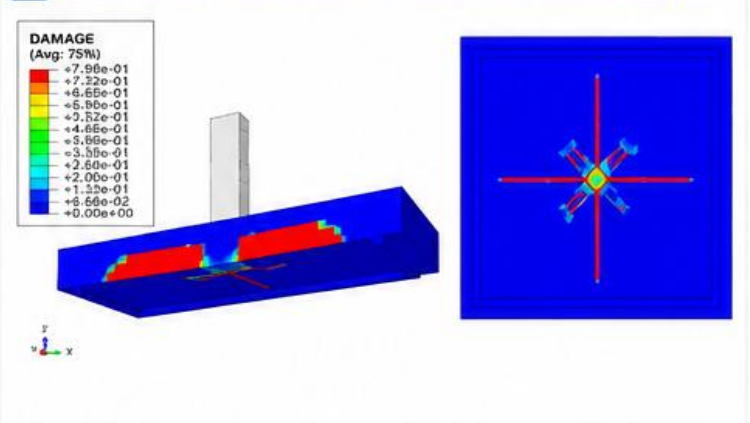
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RESULTS & TECHNICAL EVIDENCE

1 Numerical Model Specifications

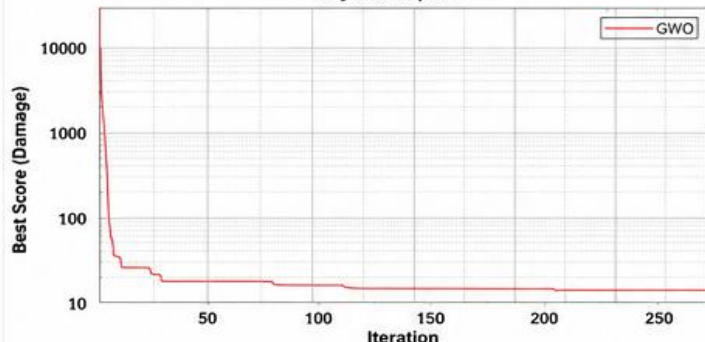


2 Stress Distribution Patterns from Numerical Simulation of Laboratory Model

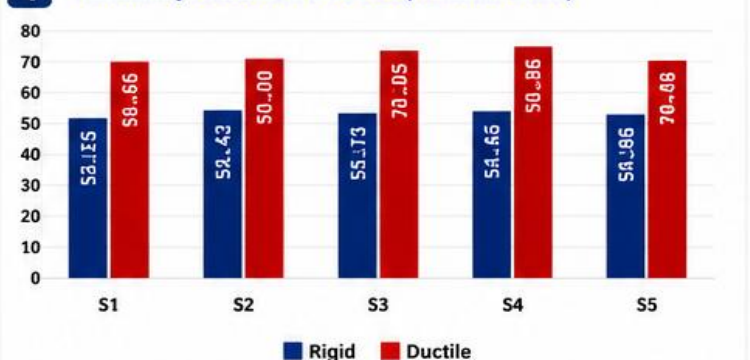


3 Optimization Procedure for the CFRP Plate Design

Objective space



4 Vulnerability Assessment of RC Slab (Numerical Model)



PROJECT
16

3D LBM SIMULATION OF FREE-SURFACE FLOW & SOLUTE TRANSPORT IN COMPOUND CHANNELS

COMPUTATIONAL & NUMERICAL MODELING | LATTICE BOLTZMANN METHOD (LBM) | OPENLB | C++ | FREE-SURFACE FLOW | SOLUTE TRANSPORT | TURBULENCE MODELING



ENGINEERING CHALLENGE

Hydrodynamic behavior and solute transport in compound open channels are governed by highly complex interactions between the main channel and floodplains, leading to strong momentum exchange, secondary flow structures, and three-dimensional turbulent mixing. These processes significantly influence salinity dispersion and water quality. Classical CFD approaches based on Navier–Stokes equations face major limitations in handling such multi-scale, free-surface turbulent flows due to high computational cost and difficulty in resolving complex geometries and secondary currents.



COMPUTATIONAL APPROACH

A high-resolution numerical framework based on the Lattice Boltzmann Method (LBM) was developed and implemented in OpenLB (C++) to simulate 3D free-surface flow and solute transport in compound channels. The approach employed a mesoscopic collision–streaming formulation, enabling coupled modeling of flow and scalar transport within a unified 3D multi-component framework. The model accurately captured free-surface dynamics, complex boundary conditions, and secondary flow structures, while incorporating turbulence effects through extended LBM schemes. A fully parallelized implementation enhanced computational efficiency, and the model was validated against experimental and numerical studies.



SELECTED TECHNICAL EVIDENCE

- Successful development of a 3D OpenLB-based simulation framework.
- Accurate reproduction of secondary flow cells and shear layer interactions.
- Effective simulation of salinity transport and dispersion patterns.
- LBM significantly reduces computational complexity compared to traditional CFD.
- Improved numerical stability and scalability through parallelization (OpenLB).
- Validation results confirm strong agreement with experimental data and prior studies.



ENGINEERING CONTRIBUTION

This project establishes a next-generation CFD framework based on OpenLB for simulating free-surface turbulent flows and scalar transport in complex hydraulic systems. The work advances the application of LBM in hydraulic engineering, particularly for modeling secondary flows and pollutant transport in compound channels, and provides a scalable, high-performance alternative to Navier–Stokes-based solvers.



TOOLS / METHODS

OpenLB (C++), Lattice Boltzmann Method (LBM), CFD modeling, parallel computing, free-surface flow simulation, solute transport modeling, turbulence analysis.



CAPABILITY DEMONSTRATED

Lattice Boltzmann Method (LBM) • OpenLB • C++ • Free-Surface Flow • Solute Transport • Turbulence Modeling

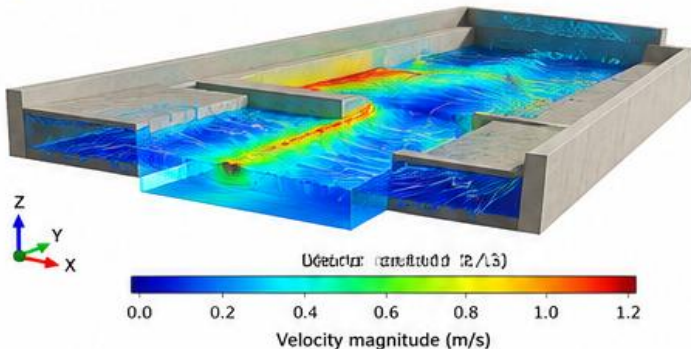


RELEVANT ARIYATECH SERVICES

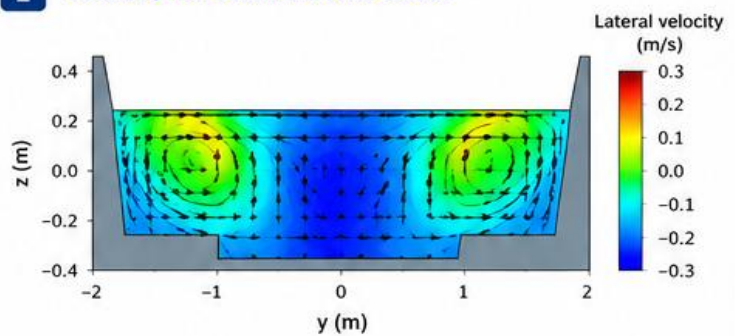
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RESULTS & TECHNICAL EVIDENCE

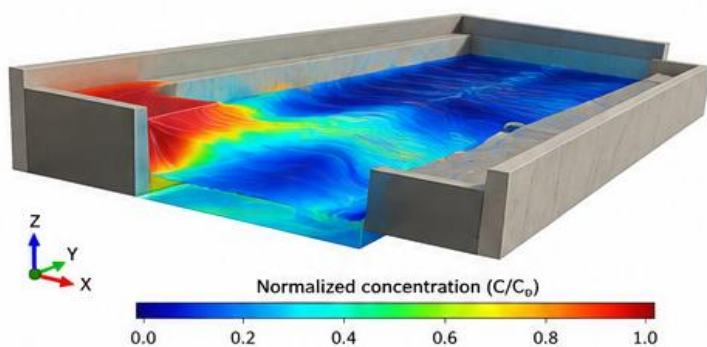
1 3D Free-Surface Flow in Compound Channel (LBM – OpenLB)



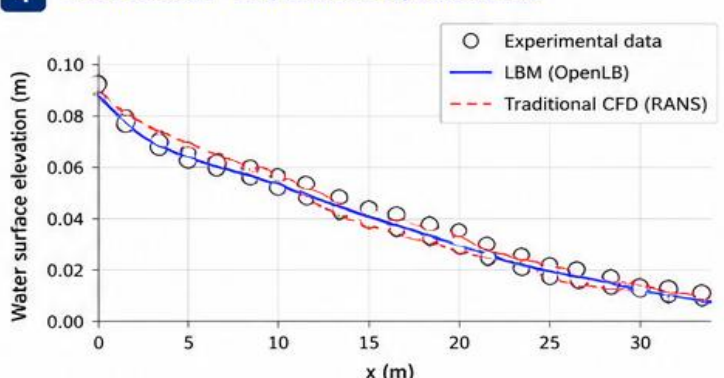
2 Secondary Flow Structure in Cross-Section



3 Solute (Salinity) Transport and Dispersion



4 Model Validation – Comparison with Experimental Data



PROJECT 17

WAVELET-ML GROUNDWATER-LEVEL PREDICTION UNDER CLIMATE VARIABILITY

COMPUTATIONAL & NUMERICAL MODELING | WAVELET TRANSFORM | MACHINE LEARNING |
TIME-SERIES ANALYSIS | SDSM | GROUNDWATER MODELING | CLIMATE IMPACT ASSESSMENT | RCP SCENARIOS



ENGINEERING CHALLENGE

Accurate prediction of groundwater level fluctuations under climate variability is challenged by the nonlinear and non-stationary behavior of hydro-climatic systems. Conventional models often fail to capture multi-scale temporal correlations between climatic variables (temperature and precipitation) and groundwater dynamics, leading to limited predictive reliability for sustainable water resource management.



COMPUTATIONAL APPROACH

A hybrid data-driven framework was developed integrating wavelet-based time-frequency analysis with machine learning regression modeling. Climatic variables (T_{max} , T_{min} , T_{mean} , P) were preprocessed through normalization and noise handling, followed by application of Cross Wavelet Transform (XWT) and Wavelet Coherence (WTC) to extract dominant multi-scale correlations and identify key influencing parameters for each well. These selected features were then used as inputs to a polynomial regression-based ML model, where optimal model structure (degree 1-10) and parameters were estimated using Gradient Descent optimization. The model was trained and validated using an 80/20 split with iterative resampling.



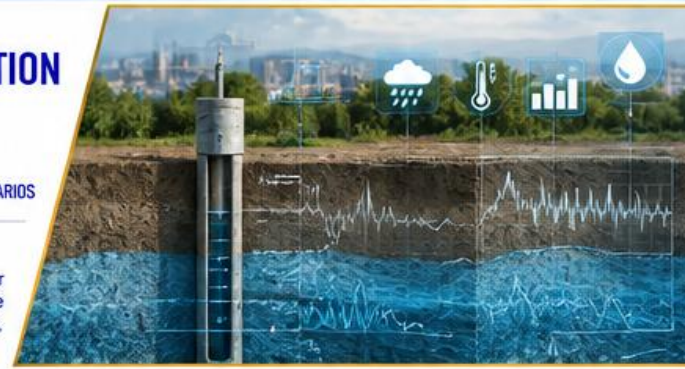
SELECTED TECHNICAL EVIDENCE

- Identification of dominant climatic drivers (primarily T_{mean} , T_{min} , and P) controlling groundwater variations.
- Detection of strong time-frequency-dependent correlations and phase-lag relationships via wavelet analysis.
- Achieved prediction error < 10% across all wells, with best-case accuracy ~3.2%.
- Improved model robustness through wavelet-based feature selection, reducing overfitting.
- Effective modeling of nonlinear and non-stationary groundwater dynamics.



ENGINEERING CONTRIBUTION

Development of a hybrid Wavelet-ML framework enabling accurate, scalable, and transferable prediction of groundwater levels under climate variability, advancing data-driven approaches in hydro-environmental systems.



TOOLS / METHODS

MATLAB, Wavelet Transform (XWT, WTC), Machine Learning (Regression, Gradient Descent), Time-Series Analysis, Representative Concentration Pathway (RCP) Scenarios



CAPABILITY DEMONSTRATED

Wavelet Transform • Machine Learning • Time-Series Analysis • SDSM • Groundwater Modeling • Climate Impact Assessment • RCP scenarios

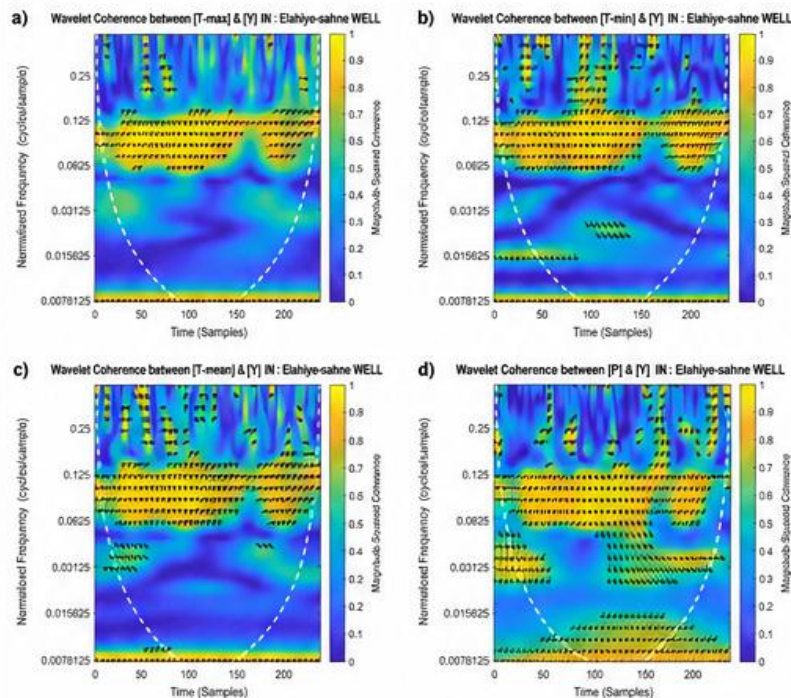


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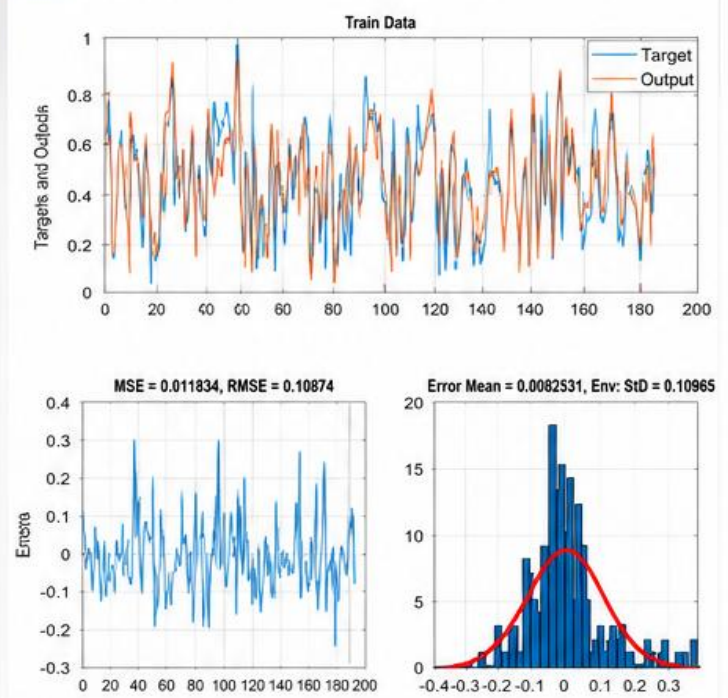
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RESULTS & TECHNICAL EVIDENCE

1 Wavelet Coherence Analysis between Climatic Variables and Groundwater Level



2 ANN Model Performance: Prediction Accuracy and Error Analysis



PROJECT
18

SIMULATION-OPTIMIZATION OF CONJUNCTIVE SURFACE-WATER/GROUNDWATER USE

COMPUTATIONAL & NUMERICAL MODELING | GROUNDWATER MODELING | MODFLOW | GMS | ANN | GWO | DOLPHIN ECHOLLOCATION | WATER RESOURCES OPTIMIZATION



ENGINEERING CHALLENGE

Sustainable water allocation in the Ardabil Plain is challenged by increasing agricultural, domestic, and industrial water demand, uneven spatial-temporal water availability, excessive groundwater abstraction, and continuous decline of groundwater levels. Conventional single-source management approaches are insufficient; therefore, an integrated conjunctive-use strategy is required to jointly manage surface water and groundwater resources while minimizing groundwater drawdown and improving long-term water security.



COMPUTATIONAL APPROACH

A simulation-optimization framework was developed using GIS, MODFLOW (GMS), ANN, and metaheuristic algorithms (GWO, Dolphin Echolocation and hybrid). Spatial, hydrological, geological and climatic data were compiled and a transient groundwater model was developed, calibrated and validated. An ANN surrogate model was trained using 10 years of monthly MODFLOW outputs to predict groundwater level variations. Finally, optimization scenarios were evaluated to determine the most effective conjunctive-use strategy for sustainable water resources management.



SELECTED TECHNICAL EVIDENCE

- MODFLOW model developed and validated using 37 observation wells.
- Transient calibration accuracy: $R^2 = 0.9995$.
- 10-year simulation (120 months) with 132-month validation period.
- Average groundwater level decline of ~3.71 m during historical period.
- Evaluated 12 management-optimization scenarios (4 strategies $\times$ 3 algorithms).
- Hybrid H(GWO,DE) algorithm performed best.
- Under M1: groundwater level improvement of 0.5984 m (GWO), 0.6416 m (DE), 0.7202 m (H(GWO,DE)).
- Under M2: groundwater level improvement of 0.0525 m (GWO), 0.1231 m (DE), 0.1976 m (H(GWO,DE)).
- Optimal policy: M1 with H(GWO,DE) (surface water dominant strategy).



ENGINEERING CONTRIBUTION

An integrated decision-support framework for sustainable conjunctive use of surface water and groundwater in the Ardabil Plain, combining physically based groundwater simulation, ANN-based surrogate modeling, and hybrid metaheuristic optimization. The framework provides a practical tool for water allocation planning, groundwater-level recovery, and long-term aquifer management.



TOOLS / METHODS

GMS, MODFLOW, MATLAB, ANN, Grey Wolf Optimizer (GWO), Dolphin Echolocation (DE), Hybrid Optimization, GIS/ArcMap, Time-Series Modeling



CAPABILITY DEMONSTRATED

Groundwater Modeling • MODFLOW • GMS • ANN • GWO • Dolphin Echolocation • Water Resources Optimization

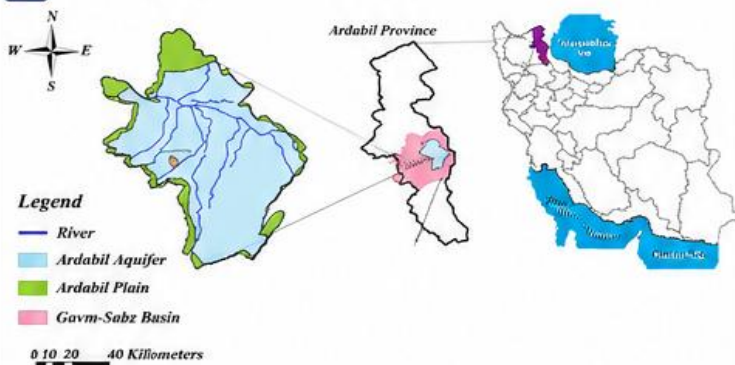


RELEVANT ARIYATECH SERVICES

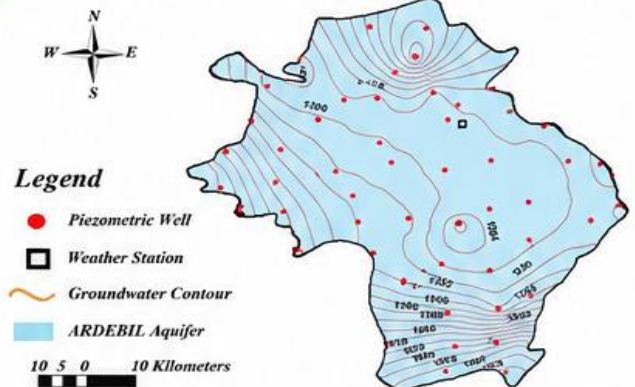
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RESULTS & TECHNICAL EVIDENCE

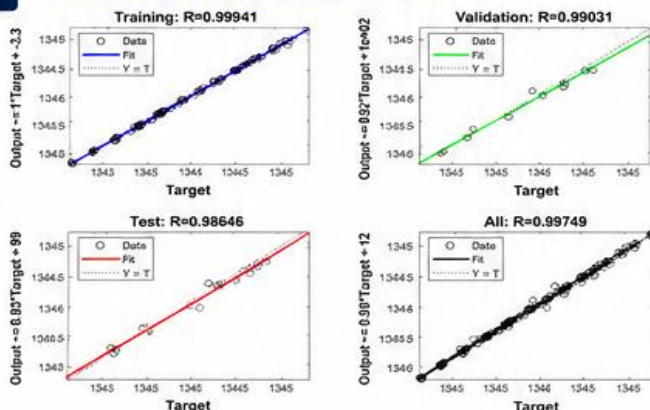
1 Study Area Location (Ardabil Plain, Iran)



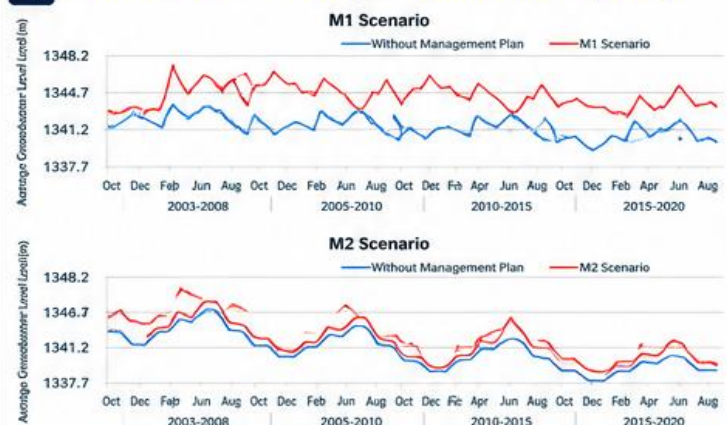
2 Location of Piezometric Wells in Ardabil Plain



3 ANN Prediction Results for Groundwater Level



4 Groundwater Level under Management Model Scenarios (M1 & M2)



PROJECT 19

OBJECT-BASED LAND-USE CLASSIFICATION & CHANGE DETECTION FROM SENTINEL-2

REMOTE SENSING & GEOSPATIAL INTELLIGENCE | REMOTE SENSING | SENTINEL-2 | SUPERPIXEL SEGMENTATION | IMAGE ANALYSIS | LAND-USE CHANGE DETECTION



ENGINEERING CHALLENGE

Accurate land-use classification and change detection from high-resolution satellite imagery is a critical task for urban monitoring, environmental management, and spatial planning. Conventional pixel-based classification methods often suffer from spectral confusion and limited correspondence between individual pixels and real-world objects, particularly in heterogeneous urban environments. This project addressed this limitation by developing an object-based remote sensing workflow using superpixel segmentation to improve the representation of land-cover objects and support more reliable land-use change detection.



COMPUTATIONAL APPROACH

A remote sensing and image-analysis framework was developed using Sentinel-2 satellite images acquired for two different years, 2017 and 2019, over the urban and surrounding land areas of Tabriz. The raw Sentinel-2 datasets were preprocessed using SNAP, followed by implementation of the SLIC superpixel algorithm in MATLAB to generate spatially coherent image objects based on spectral and spatial similarity. Multiple spectral bands and band combinations were evaluated, and different SLIC parameter scenarios were tested to determine the optimal segmentation configuration. The resulting superpixel layers were then imported into eCognition, where object-based segmentation and classification were performed. Finally, the classified land-use maps for 2017 and 2019 were compared to identify land-use changes over the study period.



SELECTED TECHNICAL EVIDENCE

- Developed and implemented a SLIC-based superpixel segmentation workflow for Sentinel-2 imagery.
- Evaluated multiple spectral bands and band combinations (visible, NIR, SWIR).
- Tested different SLIC parameter scenarios and identified optimal segmentation settings.
- Generated object-based land-use classification maps for Tabriz for 2017 and 2019.
- Classified land-use patterns into three main classes and compared the maps to detect land-use changes.
- Demonstrated that superpixel-based segmentation provides a more structured and object-consistent input compared with pixel-based processing.
- Identified relatively limited land-use changes between 2017 and 2019.



ENGINEERING CONTRIBUTION

Development of an integrated remote sensing workflow combining Sentinel-2 imagery, SLIC superpixel segmentation, object-based image analysis, and change detection. The study demonstrated how superpixel-based preprocessing can improve the spatial organization of satellite image classification and provides a transferable framework for urban land-use monitoring, environmental change assessment, and geospatial decision support.



TOOLS / METHODS

Sentinel-2 Satellite Imagery, SNAP, MATLAB, SLIC Superpixel Algorithm, eCognition, Object-Based Image Analysis, Land-Use Classification, Remote Sensing Change Detection



CAPABILITY DEMONSTRATED

Remote Sensing • Sentinel-2 • Superpixel Segmentation • Image Analysis • Land-Use Change Detection



RELEVANT ARIYATECH SERVICES

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RESULTS & TECHNICAL EVIDENCE

1 Superpixel Segmentation of Sentinel-2 Image (2017)

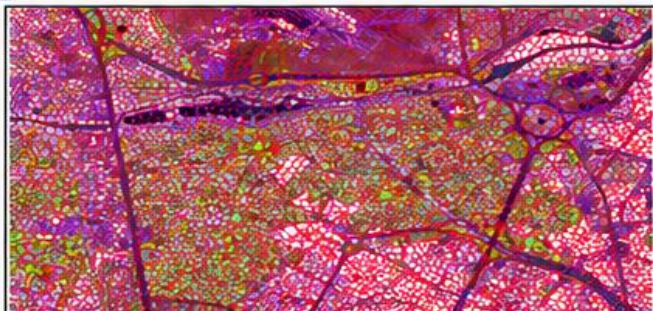


Image 1 (2017) n=3500 m=35 it= 100 Sentinel-2 MSI Agriculture

2 Superpixel Segmentation of Sentinel-2 Image (2019)

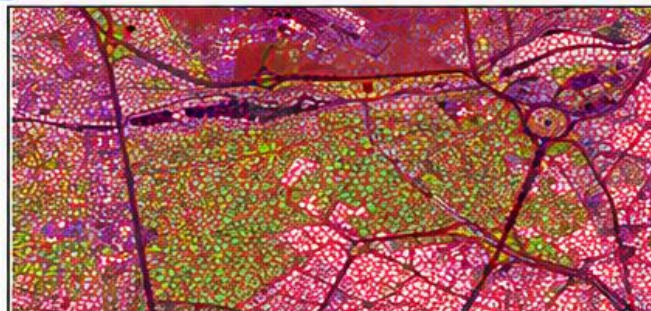


Image 1 (2019) n=3500 m=35 it= 100 Sentinel-2 MSI Agriculture

3 Land-Use Classification Maps (2017 vs. 2019)



Land Use Map of Tabriz, Iran (2017)

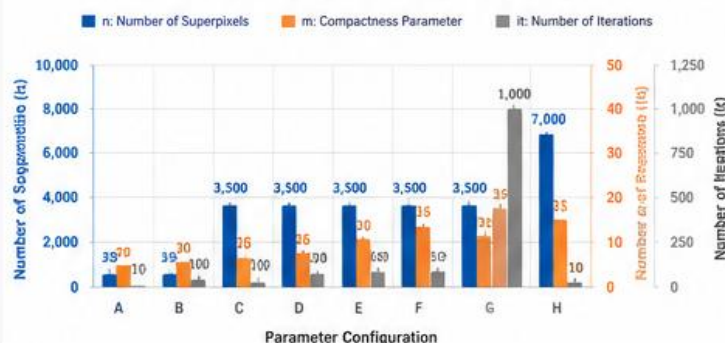


Land Use Map of Tabriz, Iran (2019)



4 Optimized SLIC Algorithm Parameters

Evaluation of Superpixel Segmentation Configurations



PROJECT
20SATELLITE-BASED PM₁₀ ESTIMATION
USING MODIS AEROSOL PRODUCTSREMOTE SENSING & GEOSPATIAL INTELLIGENCE | REMOTE SENSING | AIR QUALITY MONITORING |
MODIS | AEROSOL OPTICAL DEPTH (AOD) | GEOSPATIAL ANALYSIS

ENGINEERING CHALLENGE

Accurate monitoring of atmospheric particulate matter is essential for environmental protection, public health assessment, and sustainable urban management. Conventional air-quality monitoring relies on ground-based stations, which provide highly accurate measurements but suffer from limited spatial coverage and high installation and maintenance costs. This project addressed these limitations by developing a satellite-based framework for estimating PM₁₀ concentrations using MODIS aerosol products combined with ground observation data, enabling spatially continuous air-quality assessment across the Tehran metropolitan area.



COMPUTATIONAL APPROACH

An integrated remote sensing workflow was developed using Level-2 MODIS aerosol products (MOD04-L2) together with PM₁₀ observations collected from the Tehran Air Quality Monitoring Network. Satellite imagery was acquired and preprocessed, including HDF product extraction, georeferencing, and AOD retrieval. Ground measurements were spatially interpolated using GIS-based techniques to generate continuous concentration surfaces. Satellite-derived AOD values were matched with corresponding ground measurements, and regression analysis was performed under different atmospheric conditions. The developed model was validated using independent observations to evaluate its estimation capability.



SELECTED TECHNICAL EVIDENCE

- Developed an integrated satellite-based framework for estimating PM₁₀ using MODIS Level-2 products.
- Processed and analyzed NASA MODIS HDF datasets, including georeferencing and aerosol product extraction.
- Integrated satellite observations with multiple ground-based air-quality monitoring stations across Tehran.
- Applied GIS-based spatial interpolation to generate continuous PM₁₀ concentration maps.
- Established statistical relationships between AOD and ground-measured PM₁₀ under different atmospheric conditions.
- Evaluated model performance for polluted, clean, and intermediate air-quality scenarios.
- Demonstrated the feasibility of satellite remote sensing as a cost-effective alternative for large-scale air-quality monitoring.



ENGINEERING CONTRIBUTION

Development of an integrated geospatial framework combining satellite remote sensing, atmospheric aerosol retrieval, GIS analysis, and statistical modeling for urban air-quality assessment. The methodology enables spatially continuous estimation of PM₁₀ concentrations while reducing dependence on dense ground-based monitoring infrastructure, providing a transferable tool for environmental monitoring, pollution management, and climate-related decision-making.



TOOLS / METHODS

MODIS Level-2 (MOD04-L2), NASA Earthdata, Aerosol Optical Depth (AOD), Remote Sensing, ArcGIS, ArcMap, GIS Spatial Interpolation, HDF Processing, Geospatial Analysis, Statistical Regression, Environmental Monitoring

CAPABILITY
DEMONSTRATED

Remote Sensing • Air Quality Monitoring • MODIS • Aerosol Optical Depth (AOD) • Geospatial Analysis



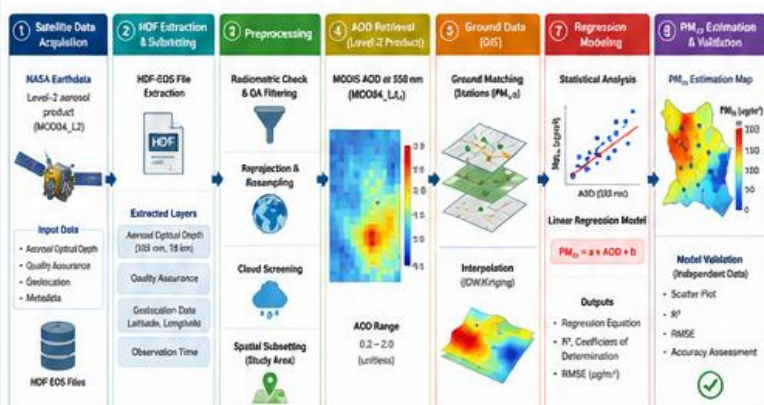
RELEVANT ARIYATECH SERVICES

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RESULTS & TECHNICAL EVIDENCE

1 Satellite-Based PM₁₀ Estimation WorkflowSatellite-Based PM₁₀ Estimation Workflow

Integration of MODIS Level-2 Data and Ground Observations for Air Quality Monitoring



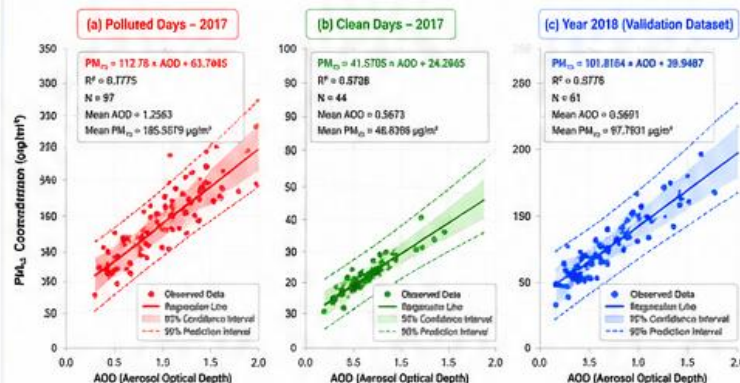
Abbreviations

MODIS: Moderate Resolution Imaging Spectroradiometer AOD: Aerosol Optical Depth

PM₁₀: Particulate Matter (≤ 10 µm)

HDF: Hierarchical Data Format GIS: Geographic Information System

QA: Quality Assurance RMSE: Root Mean Square Error

R²: Coefficient of Determination RMSE: Root Mean Square Error2 Relationship Between AOD and Ground-Measured PM₁₀Relationship Between Aerosol Optical Depth (AOD) and Ground-Measured PM₁₀ Concentrations
MODIS Level-2 AOD vs. PM₁₀ from Ground Stations in Tehran

Summary of Statistical Results

Dataset	Condition	Number of Data (N)	Mean AOD	Mean PM ₁₀ (µg/m³)	Regression Equation (PM ₁₀ = a + AOD * b)	R ²	RMSE (µg/m³)
Polluted Days - 2017	High Pollution	97	1.2563	185.5879	PM ₁₀ = 112.78 + AOD * 63.746	0.7775	29.82
Clean Days - 2017	Low Pollution	44	0.5673	48.9368	PM ₁₀ = 41.5705 + AOD * 24.2345	0.6728	7.81
Year 2018 (Validation)	Mixed Conditions	61	0.5691	97.7931	PM ₁₀ = 101.6184 + AOD * 39.9467	0.8778	14.38



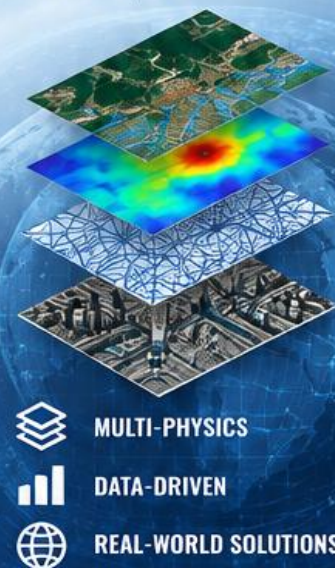
04 | CROSS-PROJECT CAPABILITY & SERVICE MATRIX

The matrix below provides a compact cross-project view of the principal computational capabilities evidenced in the supplied project descriptions. A mark indicates explicit evidence in the source material. The accompanying service map links that evidence to AriyaTech's current commercial architecture; it is a capability mapping rather than a historical contracting claim.

Project	FEA	CFD / Hydro	SPH / LBM	AI / ML	Optimization	GIS / RS	V&V
01	●	●	—	●	●	—	—
02	—	●	—	—	—	—	—
03	●	—	—	—	—	—	—
04	—	●	—	—	—	—	●
05	—	●	—	●	—	—	●
06	—	●	●	●	—	—	●
07	—	●	—	●	—	—	●
08	—	●	●	●	—	—	●
09	—	●	—	●	—	—	●
10	—	—	●	●	—	—	●
11	—	—	—	●	●	●	—
12	●	—	—	●	—	●	●
13	—	—	—	●	—	—	●
14	●	—	—	●	●	—	●
15	●	—	—	●	—	—	●
16	—	●	●	●	●	—	●
17	—	—	—	●	●	—	●
18	—	—	—	●	●	●	●
19	—	—	—	●	—	●	—
20	—	—	●	●	—	●	●

FROM DIVERSE PROJECTS TO A UNIFIED ENGINEERING CAPABILITY

Multi-disciplinary expertise.
Real-world impact.



05 | COMPUTATIONAL METHODS, PLATFORMS & EVIDENCE PRACTICES

Representative methods and environments evidenced across the project set include Abaqus, ANSYS AQWA, ANSYS Fluent, FLOW-3D, XBeach, OpenSees, OpenLB, SPHysics, GMS/MODFLOW, MATLAB, Python, Fortran, C++, ArcGIS/ArcMap, SNAP and eCognition, together with FEM, CFD, SPH, LBM, ANN, Gaussian Process Regression, Grey Wolf Optimization, Monte Carlo simulation, wavelet analysis, remote sensing and numerical verification/validation workflows. Software is presented as evidence of delivery capability; the engineering problem and required evidence determine the method and platform.

KEY PLATFORMS & METHODS



EVIDENCE & QUALITY PRACTICES

	Practice	Representative evidence across the portfolio
🔍	Verification / benchmark comparison	Comparison with analytical, experimental, industrial-reference or established numerical benchmarks where available.
📊	Validation / calibration	Use of experimental observations, field/reference data or independent datasets to evaluate model behaviour where supported by the project.
📈	Sensitivity / uncertainty	Mesh/discretization studies, parameter sensitivity, Monte Carlo analysis, scenario testing or uncertainty-aware evaluation where relevant.
🔄	Model comparison	Cross-comparison of numerical methods, turbulence models, ML algorithms or alternative modelling strategies.
📋	Engineering interpretation	Results interpreted against physical behaviour, system performance, risk, resilience, design or operational objectives rather than solver output alone.

06 | FROM DEMONSTRATED EXPERIENCE TO CLIENT DELIVERY

The portfolio evidence connects directly to AriyaTech's current service model. Historical experience demonstrates methods, workflows, verification practices and technical judgement; AriyaTech converts those capabilities into controlled client engagements with defined scope, assumptions, deliverables and acceptance criteria.

01



Engineering Simulation Audit & Model Review

Model formulation, discretization, boundary conditions, solver behaviour, result plausibility, verification, validation and sensitivity evidence.

02



Engineering Simulation Solutions

FEA, CFD, hydrodynamics, nonlinear analysis, sediment/morphodynamic modelling, offshore response and other project-specific numerical analyses.

03



Scientific Python & Engineering Automation

Custom computational workflows, numerical implementation, batch simulation, preprocessing, post-processing and simulation-data generation.

04



Engineering Data Analytics & Applied AI

Prediction, surrogate modelling, regression, model comparison, optimization, uncertainty-aware analysis and engineering interpretation.

05



Technical R&D Consulting

Computational methodology, validation strategy, hybrid simulation-data workflows, independent technical reasoning and research-to-engineering translation.



07 | SERVICE-EVIDENCE BRIDGE

Turning proven technical experience into tangible client value

*From
Engineering Insight
to Real-World Impact*

The table below links AriyaTech's service portfolio to representative evidence from the projects presented in this document. It demonstrates how demonstrated capabilities translate into client-ready solutions.

AriyaTech service	Representative portfolio evidence	Example project domains (from this portfolio)
 S01 — Simulation Audit & Model Review	Validated simulation frameworks, benchmark comparison, sensitivity analysis, numerical-method comparison and model-reliability assessment.	 - Offshore structures - Coastal & hydraulic systems - Geotechnical modelling
 S02 — Engineering Simulation Solutions	Offshore dynamics, nonlinear impact, hydrodynamics, CFD, SPH, LBM, coastal morphodynamics, buried-pipeline and water-system modelling.	 - Offshore & coastal engineering - Pipeline & geotechnics - Water resources modelling
 S03 — Scientific Python & Engineering Automation	Fortran/C++ numerical implementations, MATLAB/Python computational workflows, automated scenario generation, processing and model development.	 - Scientific computing - Parametric studies - Custom automation tools
 S04 — Engineering Data Analytics & Applied AI	ANN, GPR, predictive modelling, optimization, uncertainty analysis, remote sensing, GIS and data-fusion workflows.	 - ML for engineering systems - Remote sensing & GIS - Optimization & decision support
 S05 — Technical R&D Consulting	Methodology development, V&V strategy, coupled computational frameworks, comparative method assessment and research-to-engineering translation.	 - Research to engineering - Technical advisory - Innovation & feasibility studies



From technical depth to practical impact



Evidence, Confidentiality & Representation

This portfolio is a capability-evidence document. Historical academic, research, collaborative and technical projects are used to demonstrate relevant engineering experience; they are not automatically represented as projects contracted to AriyaTech AI Engineering LLC. Client-specific names, proprietary data and restricted materials should only be included where confidentiality and usage permissions allow. Future projects formally delivered by AriyaTech may be identified separately in subsequent portfolio revisions.



Document Control

Field	Value
Document	AriyaTech AI Engineering — Commercial Engineering Portfolio
Version	1.1 FINAL
Date	August 2026
Status	Client-facing proof-of-capability portfolio
Evidence basis	Engineering Portfolio — Shahriyar Shemshaki v2; commercial reframing aligned with AriyaTech service architecture
Representation rule	Historical experience is identified as prior technical/research experience unless a project is explicitly documented as delivered by AriyaTech AI Engineering LLC.



Start a Technical Conversation

Have a simulation, engineering-data or computational R&D challenge? Share the technical problem, existing model or project requirements for an initial scope assessment. AriyaTech can identify the most appropriate next step and, where suitable, provide a defined technical proposal.

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"Engineering Knowledge → Practical Solutions → Real-World Value"

