

# pipeline under the ocean

**Pipeline under the ocean** technology plays a crucial role in the global energy landscape, enabling the transportation of oil, natural gas, and other vital resources across vast underwater distances. These submerged pipelines are engineering marvels that connect offshore resource extraction sites to onshore processing facilities, ensuring a steady supply of energy to meet worldwide demand. In this comprehensive guide, we will explore the intricacies of underwater pipelines, including their design, construction, challenges, and significance in the energy sector.

## Understanding Underwater Pipelines

### What Are Underwater Pipelines?

Underwater pipelines, also known as submarine pipelines, are extensive networks of pipes laid on or buried beneath the ocean floor. They facilitate the transportation of hydrocarbons from offshore extraction points—such as oil rigs and gas fields—to land-based facilities for processing and distribution.

### Types of Underwater Pipelines

Underwater pipelines can be classified based on their design and application:

- **Oil Pipelines:** Designed specifically for transporting crude oil from offshore wells to onshore refineries.
- **Gas Pipelines:** Used for natural gas transmission, often at high pressure to facilitate long-distance flow.
- **Product Pipelines:** Carry refined petroleum products like gasoline and diesel.
- **Flowlines and Risers:** Smaller pipelines that connect individual wells to the main pipeline system or platform.

## Design and Engineering of Underwater Pipelines

## Material Selection

The durability and longevity of underwater pipelines depend heavily on material choice:

- **Steel:** Most common due to strength, flexibility, and corrosion resistance when properly coated.
- **Polymer Composites:** Used in specific applications, especially for smaller or specialized pipelines.

## Pipeline Construction Process

Constructing an underwater pipeline involves several meticulous steps:

1. **Design and Planning:** Assessing route, environmental conditions, and capacity requirements.
2. **Material Fabrication:** Manufacturing pipeline sections in onshore facilities.
3. **Transportation and Launching:** Moving pipeline segments to the installation site.
4. **Installation:** Laying the pipeline on the seabed, either through trenching or direct burial techniques.
5. **Testing and Inspection:** Ensuring integrity through pressure tests, non-destructive evaluation, and coating checks.

## Methods of Laying Undersea Pipelines

### Sinking and Trenching

The most common method involves directly laying the pipeline onto the seabed and, if necessary, trenching to bury it, protecting it from external damage and corrosion.

### Horizontal Directional Drilling (HDD)

For crossing under sensitive areas like shipping lanes or environmentally protected zones, HDD allows pipelines to be installed beneath obstacles without disturbing the surface.

## **Remote Operated Vehicles (ROVs)**

Robots equipped with cameras and tools assist in underwater inspection, connection, and maintenance of pipelines.

## **Challenges in Underwater Pipeline Deployment**

### **Environmental Factors**

- Corrosion: Continuous exposure to seawater leads to corrosion, requiring protective coatings and cathodic protection systems.
- Seismic Activity: Earthquakes can cause displacement or damage to pipelines.
- Marine Life: Potential impacts on ecosystems and the need for environmentally friendly installation practices.

### **Technical and Logistical Challenges**

- Deepwater Conditions: High pressure and low temperatures at great depths complicate construction.
- Route Planning: Navigating complex seabed terrains, avoiding existing infrastructure, and minimizing environmental impact.
- Maintenance and Repair: Difficulties in accessing and fixing pipelines located kilometers offshore.

## **Safety and Environmental Considerations**

### **Risk Management**

Proper risk assessment involves:

- Monitoring for leaks or ruptures using sensors and surveillance systems.
- Implementing emergency response plans for spill containment.
- Regular inspection and maintenance routines.

### **Environmental Impact Mitigation**

- Careful route selection to minimize ecological disruption.
- Use of environmentally friendly materials and construction methods.
- Continuous environmental monitoring during and after installation.

# **The Significance of Undersea Pipelines in the Global Economy**

## **Energy Security**

Underwater pipelines enable the reliable and efficient transportation of vital energy resources, supporting national energy security and economic stability.

## **Cost-Effectiveness**

Compared to alternative transport methods like tankers or liquefied natural gas (LNG) ships, pipelines offer lower operational costs and reduced environmental footprint over the long term.

## **Facilitating Global Trade**

Undersea pipelines connect resource-rich regions with consumer markets, fostering international trade and economic development.

## **Future Trends in Underwater Pipeline Technology**

### **Advancements in Materials and Coatings**

Development of stronger, corrosion-resistant materials will extend pipeline lifespan and reduce maintenance costs.

### **Automation and Remote Monitoring**

Integration of IoT sensors and AI-driven analytics will improve real-time monitoring, predictive maintenance, and safety management.

### **Deepwater and Ultra-Deepwater Projects**

As technological capabilities expand, pipelines will reach greater depths, unlocking previously inaccessible resources.

### **Sustainable and Eco-Friendly Practices**

Innovations aim to minimize environmental impacts, including biodegradable coatings and environmentally sensitive installation techniques.

# **Conclusion**

The pipeline under the ocean represents a vital artery in the global energy infrastructure, enabling efficient and reliable transportation of hydrocarbons across vast underwater expanses. Despite the numerous technical and environmental challenges, continuous advancements in engineering, materials, and monitoring technologies are enhancing the safety, durability, and sustainability of these underwater networks. As the world increasingly seeks sustainable energy solutions, underwater pipeline technology will remain a cornerstone of resource transportation, supporting economic growth and energy security for decades to come.

## **Frequently Asked Questions**

### **What is an underwater pipeline and what is it used for?**

An underwater pipeline is a pipe laid on or beneath the ocean floor to transport substances like oil, natural gas, or other fluids from offshore extraction sites to onshore facilities or between offshore locations.

### **How are underwater pipelines installed in the ocean?**

Installation typically involves laying the pipeline from specialized vessels using methods like trenching, plowing, or jetting to protect it from environmental and mechanical damage, followed by burial or anchoring on the seabed.

### **What are the main challenges in laying pipelines under the ocean?**

Challenges include dealing with high pressure and temperature conditions, avoiding damaging marine ecosystems, preventing corrosion, managing underwater currents, and ensuring pipeline stability in uneven seabed terrains.

### **How do engineers prevent corrosion in underwater pipelines?**

Corrosion prevention methods include applying protective coatings, cathodic protection systems, using corrosion-resistant materials, and implementing regular monitoring and maintenance protocols.

### **What environmental impacts do underwater pipelines**

**have?**

Potential impacts include disturbance to marine habitats during installation, risk of leaks or spills contaminating the water, and long-term effects on marine life, which are mitigated through careful planning and environmental assessments.

## **How do underwater pipelines detect leaks or damages?**

Detection methods include real-time sensors, pressure monitoring systems, underwater robotics, and acoustic or electromagnetic surveys to identify and locate leaks or structural issues promptly.

## **What are the safety measures involved in underwater pipeline construction?**

Safety measures involve thorough environmental impact assessments, use of advanced materials, real-time monitoring, emergency response protocols, and adherence to international standards and regulations.

## **How long can underwater pipelines last before needing replacement or major repairs?**

With proper maintenance, underwater pipelines can last 25 to 50 years, though factors like corrosion, mechanical damage, and environmental conditions influence their lifespan.

## **Are underwater pipelines a sustainable option for energy transportation?**

They are considered efficient for large-scale energy transport but pose environmental risks; ongoing advancements aim to improve their sustainability through better materials and leak prevention technologies.

## **What innovations are emerging in the field of underwater pipeline technology?**

Emerging innovations include self-healing materials, advanced robotics for inspection and repair, real-time monitoring using AI, and environmentally friendly installation techniques to reduce ecological impact.

## **Additional Resources**

Undersea Pipeline: The Backbone of Global Energy and Resource Transport

In the complex world of energy, water, and resource transportation, undersea

pipelines stand as some of the most impressive feats of engineering. These submerged conduits form the backbone of modern infrastructure, enabling the efficient and safe transfer of oil, natural gas, water, and other vital commodities across vast oceanic expanses. This article delves into the intricate details of undersea pipelines, exploring their design, construction, operational challenges, innovations, and their critical role in the global economy.

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## **Understanding Undersea Pipelines: An Overview**

Undersea pipelines are long, continuous conduits laid on or buried beneath the ocean floor, designed to transport fluids—primarily hydrocarbons or water—over distances ranging from a few kilometers to thousands of kilometers. Their importance stems from their ability to connect offshore extraction sites to onshore processing facilities, facilitate cross-border energy trade, and support underwater infrastructure projects like aqueducts and cooling systems.

Key Functions of Undersea Pipelines:

- Transport of oil and natural gas from offshore fields to land-based refineries.
- Distribution of water for industrial, agricultural, or municipal use.
- Supply of raw materials for subsea manufacturing or energy generation.

Global Significance

According to industry reports, over 400,000 kilometers of undersea pipelines are currently in operation worldwide, underpinning the global energy network. Countries like Russia, the United States, Norway, and Qatar heavily rely on these pipelines to meet domestic and international demands.

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## **Design and Engineering of Undersea Pipelines**

Designing an undersea pipeline requires meticulous planning, considering environmental, geological, and operational factors. The goal is to ensure durability, safety, and economic efficiency over the pipeline's lifespan, often exceeding 30 years.

## Material Selection

Materials must withstand harsh underwater conditions, including high pressure, corrosive seawater, temperature variations, and mechanical stress. Common materials include:

- Steel: The most prevalent due to its strength, ductility, and ability to be coated for corrosion protection.
- Plastic Composites: Used in smaller or specialized pipelines, especially for water or low-pressure applications.
- Concrete: Often used as weight coating or in specific structural components.

## Pipeline Diameter and Wall Thickness

These are determined by flow requirements, pressure conditions, and material strength. Larger diameters allow higher throughput but increase installation costs.

## Corrosion Protection and Coatings

Corrosion poses a significant threat to pipeline integrity. Protective measures include:

- External coatings: Polyethylene, concrete weight coating, or epoxy layers.
- Cathodic protection: Sacrificial anodes or impressed current systems to prevent electrochemical corrosion.
- Internal coatings: To reduce friction and prevent internal corrosion.

## Structural Design Considerations

- Flexibility: To accommodate seabed movement and thermal expansion.
- Buoyancy control: Using weight coatings or concrete to keep pipelines anchored.
- Redundancy: Incorporating features like pigging facilities for maintenance.

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## Construction of Undersea Pipelines

Constructing an undersea pipeline is a complex, multi-phase process that combines offshore engineering, transportation logistics, and deep-sea

technology.

## **Pre-Construction Planning**

- Route Selection: Using seismic surveys, geological studies, and environmental impact assessments.
- Permitting: Securing approvals from international and national authorities.
- Design Finalization: Engineering detailed plans considering seabed conditions.

## **Fabrication and Onshore Preparation**

- Pipeline Welding: Sections are fabricated onshore in specialized facilities, often in lengths of 12-30 meters.
- Coating: Applying anti-corrosion coatings before transportation.
- Testing: Hydrostatic testing to verify pipeline integrity.

## **Installation Methods**

**There are primarily two installation techniques:**

- **Sinking or Trenching:** Using specialized ships (pipelay vessels) that weld sections on deck and lay them sequentially on the seabed.
- **Jacket and Platform Installation:** For deepwater projects, pipelines are sometimes installed from floating platforms or via trenching operations.

## **Major Equipment Used:**

- **J-lay and S-lay vessels:** For pipeline deployment.
- **Rov (Remotely Operated Vehicles):** For inspection and precise placement.
- **Trenching Machines:** To bury pipelines beneath the seabed for protection.

## **Embedding and Burial Techniques**

- **Dredging and Trenching:** To bury pipelines for protection against external damage.
- **Rock Placement:** To stabilize pipelines in high-current areas.
- **Horizontal Directional Drilling (HDD):** For crossing navigational channels or environmentally sensitive zones.

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## **Operational Challenges and Maintenance**

Once operational, undersea pipelines face numerous challenges that threaten their integrity and safety.

### **Corrosion and Material Degradation**

Despite protective coatings, corrosion remains a persistent issue, especially at joints and vulnerable sections. Regular cathodic protection maintenance and internal coatings are essential.

### **Seabed Movements and Earthquakes**

Tectonic activity, sediment shifts, and seabed

erosion can cause pipeline deformation or rupture. Engineering designs incorporate flexibility and reinforcement to mitigate these risks.

## External Damage Risks

- **Fishing Activities:** Anchors and fishing gear can physically damage pipelines.
- **Ship Anchoring:** Improper anchoring can cause severe impacts.
- **Natural Disasters:** Hurricanes, tsunamis, and seismic events pose threats.

## Leak Detection and Monitoring

Advanced monitoring systems are vital for early leak detection and quick response:

- **Inline Inspection Tools (Smart Pigs):** Devices that travel inside pipelines to detect corrosion, dents, or other anomalies.
- **Remote Sensor Networks:** Using fiber optics, pressure sensors, and acoustic detectors.
- **Satellite and Aerial Surveillance:** Monitoring surface activities and potential threats.

## Maintenance Strategies

- **Pigging Operations:** Regular cleaning and

inspection.

- **Repair and Replacement:** Using trenching or subsea robotic techniques for repairs.
- **Corrosion Management:** Continual application and adjustment of cathodic protection.

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## **Innovations and Future Trends in Undersea Pipelines**

The industry is continually evolving to address environmental concerns, technological limitations, and the need for higher efficiency.

### **Advanced Materials and Coatings**

Developments include:

- **Self-healing coatings:** That can repair minor damages autonomously.
- **Corrosion-resistant alloys:** To extend lifespan and reduce maintenance.

### **Deepwater and Ultra-Deepwater Pipelines**

- **Challenges:** High pressures, low temperatures, and

complex seabed geology.

- Solutions: Use of flexible pipe systems, riserless systems, and dynamic positioning vessels.

## Digitalization and Automation

- Real-time Monitoring: AI-powered predictive maintenance.

- Autonomous Inspection Robots: Underwater drones capable of detailed inspections.

## Environmental and Safety Enhancements

- Route Optimization: Minimizing ecological impact.

- Leak Prevention Technologies: Such as double-hulled pipeline segments and smart materials.

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## The Critical Role of Undersea Pipelines in the Global Economy

Undersea pipelines are more than just infrastructure—they are vital arteries that sustain economies and energy security. They facilitate:

- International Energy Trade: Connecting producer regions like the Middle East, Russia, and West Africa to consumption markets in Europe, Asia, and North America.

- **Energy Transition:** Supporting natural gas as a bridge fuel in the shift to renewable energy.
- **Water and Resource Management:** Providing crucial water supplies and raw materials in arid regions.

## **Environmental Considerations**

While undersea pipelines are generally safer and more efficient than other transport methods like tankers, they pose risks of leaks and environmental damage. The industry invests heavily in safety protocols and environmental safeguards to minimize these risks.

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## **Conclusion**

Undersea pipelines exemplify human ingenuity and engineering prowess, enabling the seamless transfer of vital resources across the globe's vast oceans. Their design demands a harmonious blend of materials science, geotechnical engineering, and innovative construction techniques, all tailored to withstand the challenging marine environment. As technology progresses, these pipelines are becoming smarter, safer, and more environmentally friendly, ensuring they remain integral to the world's energy and resource infrastructure for decades to come.

Understanding the complexities behind undersea

**pipelines underscores their importance—not just as physical structures but as symbols of global interconnectedness and technological advancement. Future developments promise even more resilient and sustainable systems, reinforcing their role as the arteries of the modern world.**

## **Pipeline Under The Ocean**

**pipeline under the ocean: Pluto** A. J. Clements, 2005-01-01

**pipeline under the ocean: Ocean Express Pipeline Project** , 2003

**pipeline under the ocean:** *Library of Congress Subject Headings* Library of Congress. Cataloging Policy and Support Office, 2009

**pipeline under the ocean:** *Petroleum Resources Under the Ocean Floor* National Petroleum Council. Committee on Petroleum Resources Under the Ocean Floor, 1969

**pipeline under the ocean:** *Library of Congress Subject Headings* Library of Congress, 2009

**pipeline under the ocean: Mechanics of Offshore Pipelines: Volume I** Stelios Kyriakides, Edmundo Corona, 2023-01-11 *Mechanics of Offshore Pipelines, Second Edition, Volume One: Buckling and Collapse* gives engineers fundamental knowledge on principles surrounding the mechanical behavior of pipelines and long tubular structures in the oil and gas industry. Addressing common challenges pertaining to buckling and collapse under various offshore loads, the authors go through each challenge experimentally, with supporting and analyzing data to present the main limits encountered. Helpful to both the practicing engineer and the graduate level, the combined effort of analysis supplemented with numerical modeling helps engineers design procedures and guidelines to reproduce the best solution or solve problems using a nonlinear finite element code. Custom formulations are also included to help users gain a deeper understanding of each challenge. Rounding out with helpful appendices, including a glossary of terms, this book continues to deliver critical research and data to engineers that need to design, install and maintain efficient and safe offshore pipelines. - Updated to include more practical aspects, such as failure of corroded pipes under external pressure and response of bi-material under bending - Delves into cost-effective materials and installation techniques - Covers guidelines, practicing methods and recommendations on maintenance and design - Recommended as the bible for offshore pipelines - Explains the full spectrum of classical challenges, such as inelastic structural mechanics and the newest technological demands

**pipeline under the ocean: Pluto** Adrian Searle, 2004-05-01

**pipeline under the ocean:** Proceedings of 11th International Conference on Coastal and Ocean Engineering Dong-Sheng Jeng, Baoping Cai, 2025-02-27 This book includes original and peer-reviewed research papers presented at 11th International Conference on Coastal and Ocean Engineering, which was held during August 9–11, 2024. The conference is sponsored by China University of Petroleum (East China), Shandong, China, co-sponsored by Qingdao University of Technology, China, technically supported by Concordia University, Montreal, QC, Canada and Griffith University, Australia, which aims to bring together innovative academics and industrial

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**pipeline under the ocean:** *Ocean State Power Project, Ocean State Power and Tennessee Gas Pipeline Company (NY,MA,RI)* , 1988

**pipeline under the ocean: Coastal Geohazard and Offshore Geotechnics** Dong-Sheng Jeng, Jisheng Zhang, V.S. Ozgur Kirca, 2021-05-18 With rapid developments being made in the exploration of marine resources, coastal geohazard and offshore geotechnics have attracted a great deal of attention from coastal geotechnical engineers, with significant progress being made in recent years. Due to the complicated nature of marine environments, there are numerous natural marine geohazard present throughout the world's marine areas, e.g., the South China Sea. In addition, damage to offshore infrastructure (e.g., monopiles, bridge piers, etc.) and their supporting installations (pipelines, power transmission cables, etc.) has occurred in the last decades. A better understanding of the fundamental mechanisms and soil behavior of the seabed in marine environments will help engineers in the design and planning processes of coastal geotechnical engineering projects. The purpose of this book is to present the recent advances made in the field of coastal geohazards and offshore geotechnics. The book will provide researchers with information regarding the recent developments in the field, and possible future developments. The book is composed of eighteen papers, covering three main themes: (1) the mechanisms of fluid-seabed interactions and the instability associated with seabeds when they are under dynamic loading (papers 1-5); (2) evaluation of the stability of marine infrastructure, including pipelines (papers 6-8), piled foundation and bridge piers (papers 9-12), submarine tunnels (paper 13), and other supported foundations (paper 14); and (3) coastal geohazards, including submarine landslides and slope stability (papers 15-16) and other geohazard issues (papers 17-18). The editors hope that this book will function as a guide for researchers, scientists, and scholars, as well as practitioners of coastal and offshore engineering.

**pipeline under the ocean:** *Advances in Computational Environment Science* Gary Lee, 2012-02-01 2012 International Conference on Environment Science and 2012 International Conference on Computer Science (ICES 2012/ICCS 2012) will be held in Australia, Melbourne, 15-16 March, 2012. Volume 1 contains some new results in computational environment science. There are 47 papers were selected as the regular paper in this volume. It contains the latest developments and reflects the experience of many researchers working in different environments (universities, research centers or even industries), publishing new theories and solving new technological problems on computational environment science. The purpose of volume 1 is interconnection of diverse scientific fields, the cultivation of every possible scientific collaboration, the exchange of views and the promotion of new research targets as well as the further dissemination, the dispersion, the diffusion of the environment science, including but not limited to Ecology, Physics, Chemistry, Biology, Soil Science, Geology, Atmospheric Science and Geography We are sure that the efforts of the authors as well as the reviewers to provide high level contributions will be appreciated by the relevant scientific community. We are convinced that presented volume will be a source of knowledge and inspiration for all academic members, researchers and practitioners working in a field of the topic covered by the book.

**pipeline under the ocean: Turbulence and Flow-Sediment Interactions in Open-Channel Flows** Roberto Gaudio, 2021-06-04 The main focus of this Special Issue of Water is the state-of-the-art and recent research on turbulence and flow-sediment interactions in open-channel flows. Our knowledge of river hydraulics is deepening, thanks to both laboratory/field experiments related to the characteristics of turbulence and their link to erosion, transport, deposition, and local

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**pipeline under the ocean: Governing Ocean Resources** Jon M. van Dyke, Sherry P. Broder, Seokwoo Lee, Jin-Hyun Paik, 2013-05-08 This collective work of a renowned group of scholars, *Governing Ocean Resources: New Challenges and Emerging Regimes*, edited by Jon M. Van Dyke, Sherry P. Broder, Seokwoo Lee and Jin-Hyun Paik, examines the current state of the Law of the Sea today, offers a variety of new approaches to the field, and serves as a tribute to the late Judge Choon-ho Park, whose profound depth of learning and indomitable spirit of optimism regarding the possibilities of reform and improvement comprised an immense contribution to the study of the Law of the Sea. The wide range of topics covered includes Maritime Boundary Delimitations, Claims to the Extended Continental Shelf, the International Tribunal for the Law of the Sea, Military Activities in the Exclusive Economic Zone, Piracy, Fishery Management, and Climate Change. Published under the auspices of the Law of the Sea Institute (LOSI), this important collection will be of considerable interest to scholars in the area of ocean law and marine resource management.

**pipeline under the ocean: Office of Ocean and Coastal Resource Management's Review of Amendments of the Alaska Coastal Management Program** , 2005

**pipeline under the ocean: Phase III/Hubline Project, Maritimes & Northeast Pipeline L.L.C., Algonquin Gas Transmission Company and Texas Eastern Transmission Corporation** , 2001

**pipeline under the ocean: New Achievements in Mechanics** Wolfgang H. Müller, Alfons Noe, Ferdinand Ferber, 2024-05-26 This book presents various solutions modeling in the performance and behavior of advanced materials and engineering structures. In this book, famous scientists in the field of materials mechanics share their knowledge in honor of the late Professor of Mechanics Klaus-Peter Herrmann from the University of Paderborn. This book discusses in particular topics like fracture and damage mechanics, numerical mathematics and computational simulations, and mechanics and thermodynamics of advanced materials.

**pipeline under the ocean: Proposed Method for Placing Freshly Mixed Concrete in the Deep Ocean** R. D. Rail, H. H. Haynes, 1979 Potential applications for placing concrete in the deep ocean are basically in three areas: in situ construction of seafloor structures, foundations and massive anchors for fixed ocean facilities, in situ hardening of objects on the seafloor, and containment of hazardous substances for environmental protection. This report presents a method for in situ placement of fresh concrete on the seafloor in which concrete is mixed on a surface platform and transported to the seafloor via a pipeline suspended from the platform. The proposed development integrates existing technologies of the concrete, oilwell, and marine industries and extends them to new applications in a new environment, and would require a modest development effort as well as simulated tests to verify engineering assumptions based on extrapolation of existing knowledge to the new conditions. The proposed method would greatly extend the Navy's capability to place concrete in the deep ocean for the above applications which would require concrete to be placed underwater in quantities of hundreds and thousands of cubic yards in water depths of many thousands of feet. (Author).

**pipeline under the ocean: *Port of London*** , 1925

**pipeline under the ocean: Handbook Of Coastal And Ocean Engineering (Expanded Edition) (In 2 Volumes)** Young C Kim, 2017-12-21 The handbook contains a comprehensive compilation of topics that are at the forefront of many of the technical advances in ocean waves, coastal, and ocean engineering. More than 110 internationally recognized authorities in the field of coastal and ocean engineering have contributed articles in their areas of expertise to this handbook.

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**pipeline under the ocean: Poro-Elastic Theory with Applications to Transport in Porous Media**  
Dong-Sheng Jeng, Lin Cui, 2023-04-20 This book treats the subject of porous flow and its applications in three engineering and scientific problems. The first major part of the book is devoted to solute transport in unsaturated porous media. Dynamic hydraulic conductivity and degree of saturation associate with pore pressures are also included in the consolidation-induced solute transport process. The second part of this book focuses on tidal dynamics in coastal aquifers, including shallow water expansion for sloping beaches, two-dimensional problem in estuarine zone and leaky confined aquifers. The final part of the book summarizes the recent development of porous model in the field of liquefaction around marine infrastructures including fundamental mechanisms of momentary and residual seabed liquefaction, two-dimensional and three-dimensional porous models for fluid-seabed interactions around breakwaters, pipelines and piled foundations in marine environments. The authors' aim is to describe in detail the applications of porous models for several engineering problems. This book will provide academic researchers and industry an overview of recent development in the field of porous models and the applications. The Open Access version of this book, available at <http://www.taylorfrancis.com>, has been made available under a Creative Commons Non Commercial-No Derivatives (CC-BY-NC-ND) 4.0 license. Funded by Qingdao University Technology, China

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