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Critical Success Factors in Building the Immersed Tunnel and Making it a Dynamic Factor for Maritime Trade and an International Development Route

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Abstract. In conclusion, the study aimed to identify the critical success factors in the construction of the immersed tunnel and make it a dynamic factor for maritime trade and an international development path. The current study relied on the descriptive analytical approach by designing an electronic questionnaire and distributing it to a sample of 100 employees working in the port of Faw in Iraq. The data were collected and analyzed using the SPSS program and the results were extracted. The study concluded that the tunnel design takes into account environmental aspects to ensure sustainability. The project also relies on the latest engineering technologies in design and construction. The project plans also include accurate economic feasibility studies. The project is being implemented according to an accurate timetable, and sufficient human resources are available to implement the project. The necessary funding for the project is also adequately allocated, and the budget is regularly updated based on developments in the project. In terms of safety and quality, workers receive the necessary training on safety procedures, and periodic inspections are conducted to ensure that the project adheres to quality standards. In terms of the economic and social impact, the project will contribute to increasing commercial activity in the region, and then the project will provide new job opportunities for members of the local community.

Keywords: Critical success factors, Dynamic factor, Immersed tunnel, International development, Maritime trade, Port of Fao.

1. INTRODUCTION

Underwater tunneling projects pose many engineering challenges and face delays between different disciplines and specializations. In recent years, these projects have become a focus of interest for women and investors due to their role in improving information and communication technology, facilitating maritime trade, and developing economic services. In this context, the experience of Iraq stands out as a model in which we should seek to develop an eastern network that contributes to achieving significant development (Rangarajan, 2012). Iraq has faced a number of challenges due to its geographical location and political and economic climate. However, your investment in underwater tunnels can help you turn these challenges into opportunities. These tunnels are an effective means of facilitating movement, freedom, and Iraq's ability to compete in a diverse labor market. Tunneling can also help improve the infrastructure of nerve cells and reduce congestion in the shipping and export process (Luciani, 2019). Working to mitigate the risks of underwater tunnels requires a radical assessment of all elements, including engineering, the military alliance used, and social contributions between public entities. The imbalance between these factors can lead to impressive results, such as lower costs and increased implementation. Understanding the clear socio-economic component of tunneling projects can help to leverage local benefits and options (Fang, 2022). In addition, the project must take into account many options, such as temporal and spatial changes in the marine environment. Modern planning and modern technologies can help ensure that there are not too many and ensure the project is long-term. The use of modern construction techniques, such as Newtonian magnetic analogues, can help to share the success of the project with the negative impact on the environment (Tsantis, 2023). Ultimately, underwater tunneling in Iraq represents a better opportunity for free trade and an economic vision for development. By critically examining success, you can leverage your success and the success of these projects to achieve the desired development. Investing in these projects is not only a step towards improving the nerve fibers, but also an investment in the future of Iraq as a link between specialized professionals.

1.1. Problem Statement

Iraq faces huge challenges in developing its maritime and land infrastructure to activate its role in international trade The construction of the submerged tunnel is an important project to remove geographical and logistical barriers and facilitate international trade, especially Challenges related to financing through its port, advanced technology, regulatory environment, environmental challenges, and other challenges The problem of the study here arises in identifying the critical success factors to achieve for the success of this submerged tunnel construction and it contributes to economic growth in making the country a dynamic factor and enhances Iraq's position as a center of maritime trade and international development.

1.2. Study Question

What are the critical factors that must be addressed to ensure the success of the construction of a submerged tunnel in Iraq, and how can this tunnel effectively contribute as a support for trade routes and international

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development?

1.3. Significance of Study

The significance of this study stems from the important role that submarine tunnels can play in enhancing Iraq's position as a link for international trade, as this project represents a strategic opportunity to develop logistics infrastructure in Iraq, who contribute to facilitate the movement of maritime trade and enhance the country's ability to attract foreign investment. By focusing on the critical success factors of a project, those technical, financial and environmental challenges Uber can, in addition, this study provide model that can benefit other countries facing similar challenges in the construction of major infrastructure projects, increasing its importance at national and international levels.

2. LITERATURE REVIEW

The literature on critical success factors in submarine tunneling and their potential impact on maritime trade and international development routes reveals a multifaceted approach to understanding the complex dynamics of infrastructure development. The development of concepts of sustainability in transportation, as discussed by Rangarajan (2012), provides a basis for considering how submarine tunnels will function as sustainable infrastructure supporting economic growth. (Rangarajan, 2012) emphasizes the importance of project selection and strategic planning, crucial to ensuring that development activities are sustainable and benefit both communities and ecosystems. This basic perspective is essential when examining the role of submerged tunnels in enhancing communication and trade efficiency.

2.1. History and Development of the Immersed Tunnel

In 1854 Charles Dickens, in his weekly journal "Household Words" wrote: "...Of all bores, one of the strangest, if it ever come to anything, will be the purposed tunnel or tube to be laid along the bed of a river or sea, or at any rate to be immersed in the water of the river or sea – not like the Thames Tunnel". We are not quite sure which of the proposed tubes he referred to. At the time there were several proposals of tunneling The Thames, and some of them suggested laying the tubes on the river bed. When Dickens wrote his words, the famous Thames Tunnel had been in use for some ten years, and underwater drilling was not an established practice yet. In fact boring in hard rock seemed to be so natural; the miners had been practicing it for centuries, but drilling in soft soil, like under The Thames, was something different. Marc Brunel, probably the most celebrated engineer of all times, found a solution; it was a protective shield that was pushed forward by hydraulic jacks. Brunel used to say that he was in-spired by a worm making holes in the planks of wooden ships in the London docks. Those worms used to line their tunnels with an excretion hardening in 98 Sławomir ŁOTYSZ time and thus forming a kind of stiff shield. If the immersed tunnel technology was to be based on an example from nature, there should be a creature making such shield in pieces ashore, sinking them and then joining underwater

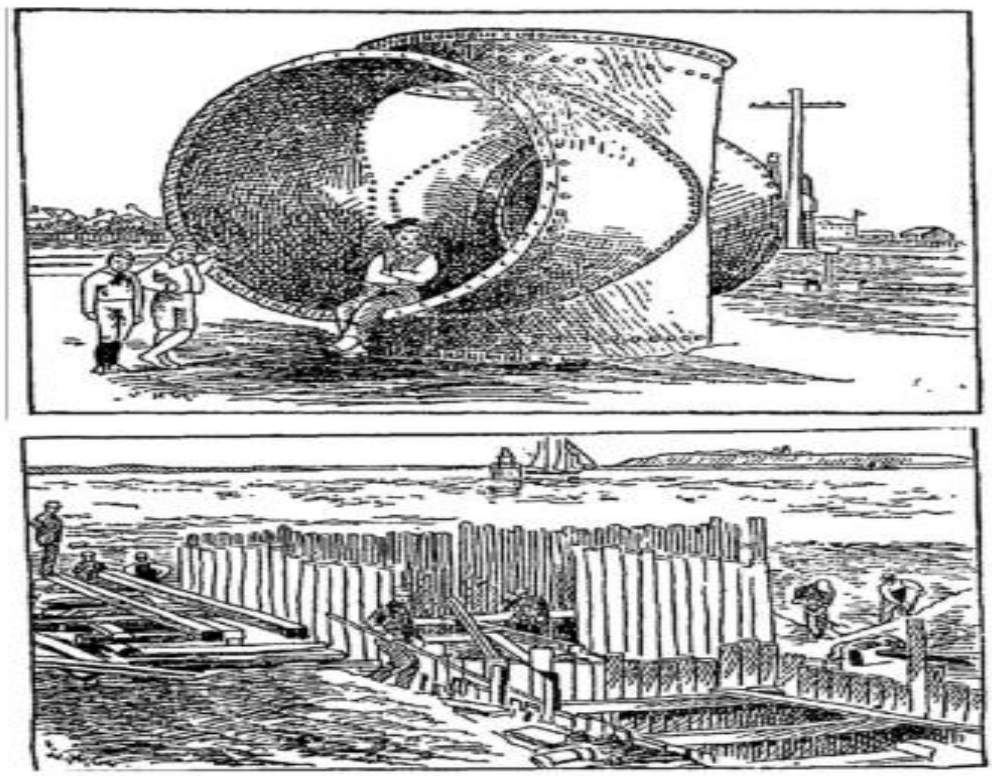


Figure 1: Boston's Shirley Gut was the site of the first submerged tube [Deer Island Dam 1893].

When a two-track railroad tunnel was built in 1910 to across the Detroit River between the United States and Canada, the history of immersed tunneling officially started. But build-and-sink technology has been around for a lot longer. During a dry season, Babylonian engineers excavated a new course for a powerful river and then built a trench over the exposed riverbed. In 1803, British engineer Henry Motray suggested building a submerged iron tube to connect England and France (Łotysz, 2010). Many ideas for submerged tunnels were proposed, and patents for enhancements were awarded. Although it wasn't the first immersed underwater tube constructed, the Detroit River tunnel was the first to be finished for both passenger and freight traffic. Fifteen years prior, a smaller iron tube was constructed beneath Boston Harbor to separate Deer Island from the main land and transport sewage to an exit. The project proceeded despite the fact that many doubters thought it was impossible to place the tube across Shirley Gut (Łotysz, 2010).

2.2. Immersed Tunnels' Significance in Boosting Maritime Trade

Through ports and an intricate transportation network, vast amounts of products are being transported interior from maritime trade. Compared to other overland or air modes, sea-based transportation can safely manage bigger and heavier cargo unit movements; but, for overland freight arrival, cargo must be transferred onto considerably smaller vehicles in the form of containers, break bulk, and heavy-lift loads. Ports and transportation links function as a single, enormous logistical system (Rana & Akbar, 2023). Cargo that must partially travel overland from the sea to remote locations is overwhelming the transportation network that connects these major ports. This is also the reason that nations who are strategically located near sea routes are the ones that depend on these resources to support a sizable economy. Immersed tunnels provide as direct access points between the ports on peninsulas, which are positioned along sea routes (Yu et al., 2023). The commercial objectives of new sea ports begin to operate efficiently with the existing deep-sea routes, leading to the expected financial growth. In addition to directing commerce to the home nation, capturing a portion of this growing maritime traffic at anchoring nodes might result in the same high returns. Immersed tunnels help traders reach the commercial and industrial center directly from the deep-sea belts in a quicker and more efficient manner. These submerged tunnels serve more than just the main site; they also offer moorings close to the seaports that are already in use. Today's traders may ship out over the same channels both inland and offshore, and the current sea traffic routes of the nearby port are accommodated (Bugnot et al., 2021).

2.3. Enhanced Accessibility and Connectivity

Trade throughout the world's coasts has relied heavily on immersed tunnels. Direct access to these regions eliminates the need for ships to travel through straits or sail around the cape in order to link port to market. While enhanced accessibility leads to faster processing of container boats, tunnel roads are much shorter for big vessels and result in lower journey times (Castagnino Berlinghieri, Antonioli, & Bailey, 2020). Both of these factors work together to reduce the cost of sailing through the tunnel. In addition to being the most direct route within the tunnel, an immersed road has a more consistent traffic flow than surface ships and a shorter weather exposure period, which means that bad weather won't cause as much interruption. Additionally, the capacity to draw shipping firms to utilize a tunnel, hence lowering transit time and operating costs, is a significant element determining the appeal of an immersed tunnel as a container transport route (Chen et al., 2020). The full submerged length of the immersed portion must be covered following ecological and geotechnical examination in order to permit additional land use development beyond that on top of the immersed part. Any ecological problems arise when light penetration through a tunnel's water reservoir is impeded. One potential advantage is that the tunnel's covering depth may be increased to make the area more habitable. Another advantage is that the tunnel's construction reduces traffic density, which lessens its impact and leads to a quantitative increase in the number of species (Chen et al., 2020). The quality of chances to reach or be reached by other networks inside the system is referred to as connectivity. A stronger connection may open up more chances for system users. Conversely, investment opportunities are referred to as economic development. Sea transport businesses anticipate spending less on vessel equipment and on contingencies like longer demurrage and direct bunkering opportunities as a result of the reduced risks associated with reaching important ports and terminals. Reducing time, expenses, and planning for operational tasks like loading cranes, transportation, and warehouse staffing is another benefit of improved accessibility inside a port region (Chen et al., 2020).

2.4. Lower Transportation Expenses

The fact that immersed tunnels lower transit costs is one of the strongest justifications for their use in marine commerce. These tunnels are responsible for reduced fuel consumption and, as a result, cheaper ship charter prices by offering a quicker and more effective path. Ports along the main shipping lanes may anticipate that ships may slow down or stop when they approach because of this reduced expense (Lin, Tian, & Cassidy, 2023).

Clientele will profit from the seeming excess of cargo transport as ports along the main international shipping lanes will be frequented more frequently. Individuals in the importing nation will generally gain from this. As a result, reduced transportation expenses, including time, boost market competitiveness and provide

industry with better choices when it comes to commodity sourcing and marketing decisions. As a result, the importing nation's industry benefits greatly, and these benefits are then transferred to consumers in the form of improved products, increased output, and decreased commodities prices. It results in increased output and employment prospects (Xie et al., 2021).

2.5. Types of Immersed Tunnels

2.5.1. Single-Cell Immersed Tunnels

The cross-sectional geometry of single-cell submerged tunnels is often uniform throughout their length, and they are typically streamlined in design. Single-cell tunnels are frequently utilized on routes with lower traffic volumes, when only a small number of vessels are anticipated to transit beneath the tunnel or via the adjacent canal. A number of factors related to the waterway's navigational characteristics, including the number of vessels following a particular route for regional trade, the serving ports, the competition between different ports, and regional economic growth, influence the determination of a threshold traffic flow value for selecting the appropriate tunnel type based on the number of vessels expected to pass under a tunnel structure (Ebrahimi & Gholamzadeh, n.d.). Compared to multicellular tunnels, single-cell immersed tunnel construction is comparatively simpler and less expensive. Single-cell tunnels can be built in a variety of locations, including below sea level, through a valley, or beneath or inside a hill. It is anticipated that the beach and tide currents would alter very little or not at all as a result of this tunnel. Additionally, constructing this kind of bridge can cut down on travel time and accidents by connecting two disjointed areas of an industrial estate, a pristine beach, a new settlement, or the outskirts of a city. This kind of maritime infrastructure is used by many tiny boats. Therefore, it is advised to use an extra navigation channel beyond the limit of the passage to cut down on travel time and operating difficulties (Patil & Karmakar, 2022).

2.6. Twin-Cell Immersed Tunnels

Due to their distinctive construction, twin-cell immersed tunnels are appropriate for major trade routes since they can handle a greater amount of marine traffic. Large ships may pass through these tunnels at the same time since they are made up of two parallel tubes. They are essential for port efficiency, especially in floating facilities, offshore wind farms, and fish farms, while being more difficult to construct than single-cell versions. In addition to offering redundancy in the event of an outage, twin-cell tunnels let smaller ships to pass through in the event that they are disabled. All things considered, they provide trade channels with more effective and scalable solutions (He, Tang, & Zhou, 2024). The submerged tunnel is located in Basra Governorate and is a major part of the Grand Faw Port project, which aims to enhance Iraq's logistical capabilities and make it an important center for international maritime trade. It is considered the first submerged underwater tunnel in Iraq and the region, and connects the highway that reaches the Khor Al-Zubair and Khor Abdullah areas to the port of its construction, the following: Grand Faw, and allows ships to pass over it without the need to close the sea channels. It consists of parts that were manufactured off-site and then submerged and installed underwater. It is part of a broader project that aims to transform the Grand Faw Port into one of the largest ports in the Middle East and connect it to the international trade route between Europe and Asia. One of the most prominent goals of

Improving the logistics infrastructure The submerged tunnel aims to facilitate the movement of land and sea transport between the Faw Port and the rest of the logistical areas in Iraq, which helps improve the flow of goods and reduce transportation times. The tunnel is about 2,800 meters long, and the submerged part is 1,260 meters long. It consists of two sides for going and returning, and each side has three lanes designated to accommodate heavy traffic of trucks loaded with containers and very large weights. Modern technologies were employed in building submerged tunnels under water. Supporting maritime navigation: By building the tunnel under financial channels, the tunnel allows ships to pass over it without the need to stop maritime navigation.



Figure 2: A Picture of the Immersed Tunnel in Faw Port.

The immersed tunnel is one of the most important projects of the Grand Faw Port. Its first phase was completed in 2022, by completing the manufacturing basin project for the basic parts that make up the tunnel, with an area of (95200 m) and a depth of (16.2 m). As for the current second phase, it was started in August 2021, by Daewoo Engineering and Construction Company and under the supervision of the Italian company Technital with the General Company for Iraqi Ports. The construction of the immersed road tunnel began with the approach ramps and connection to the road linking the Grand Faw Port and Umm Qasr with a length of 24 meters, and a width of three lanes in each direction. The second phase included the construction of the immersed tunnel pieces and the approaches, which number ten pieces with a length of 126 meters, and a width of (346) meters, while the number of approaches that make up the entrances and exits of the tunnel is (56) pieces on both sides, the first side from the side of Umm Qasr city, and the other side from the side of Faw city, and the length of The piece is (21) meters long and (346) meters wide, and by connecting it, the immersed tunnel will be formed with a length of 2444 meters.



Figure 3: 10 Pieces of the Immersed Tunnel at the Work Site and Pouring Before Transporting Them.

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2.7. Making the Immersed Tunnel as a Dynamic Factor

Engineering and construction factors in the construction of the immersed tunnel in Faw Port

The construction of the immersed tunnel in Faw Port in Basra is considered one of the most important ambitious engineering projects in Iraq. This tunnel is a vital part of the Grand Faw Port Project, which aims to transform Basra into a global commercial and logistics center. Achieving this project requires facing many engineering and construction challenges to ensure the safety and efficiency of the tunnel in the long term.

2.8. Influential Engineering Factors

Engineering design the design of the tunnel is one of the most important factors affecting the success of the project. The accurate design requires taking into account the geological and environmental factors surrounding the construction site. The design must be able to withstand the great pressures resulting from heavy traffic and surrounding waters, as the design and planning were carried out by the Ministry of Transport and the General Company for Iraqi Ports, in consultation with European countries and Iraqi, foreign and Arab engineering cadres.

2.9. Soil And Geology Study

Studying the soil and geology at the tunnel construction site is of utmost importance. This study requires knowledge of the quality of the soil and the level of groundwater, as well as potential seismic effects. This study helps in choosing the appropriate materials and designing the tunnel in a way that ensures its long-term stability.

Water Level Control Controlling the water level surrounding the tunnel is a major engineering challenge. Advanced techniques must be used to ensure that water does not seep into the tunnel, which could affect its structural integrity. Concrete injection and waterproofing systems are typically used to ensure no water seepage. As part of coordinating complex logistics and regulatory compliance, Ejteach, a leading engineering services

company using advanced technology to monitor soft soils and structural variables, was tasked with monitoring the engineering construction of the project. During the construction of the immersed tunnel, it was necessary to monitor groundwater and its decline due to excavation, which prompted the company to install pressure gauges and groundwater level gauges and connect them to wireless remote sensing devices as follows: (70) analog data loggers, (40) wired loggers. The implementation of the automated data collection and remote monitoring system provided significant benefits to both the construction company and the local community. As for the company, it provided it with real-time data on groundwater levels and potential risks, which enabled appropriate decisions and actions, and helped in speeding up completion and reducing costs. As for the benefits to the local community, it helped ensure safety by mitigating the environmental impacts associated with construction. One of the positives of employing these technologies in the work is that they contribute to improving transparency and building trust with stakeholders by demonstrating a commitment to proactive risk management. Environmental care.

2.10. Influential Construction Factors

Construction materials Choosing the right construction materials plays a crucial role in the success of the project. The materials used must be able to withstand the high pressures resulting from traffic and surrounding water. Reinforced concrete and stainless steel are usually used in the construction of immersed tunnels. The stage that started from the foundations to the walls to the ceilings was transported and distributed regularly. We organized and divided the work due to its magnitude in order to control all the works. We also used the hydraulic wooden formwork system to carry out the concrete works that runs on a railway to move from one stage to another, and it was a practical and successful system for this work. The time that took reached one thousand cubic meters of concrete pouring works. The Turkish company specializes in pouring and reinforcing the construction pieces in the immersed tunnel project, as a subcontractor with Daewoo Company. Aykut Olmzer, the construction manager of the Turkish company Tuval, says that their main tasks in the project include reinforced concrete works, immersed tunnel steel assembly works, wooden formwork assembly works and casting operations, in addition to carrying out some operations related to implanting some construction pieces for the age operations. He explains that the volume of concrete used in constructing the ten elements amounted to (290) thousand cubic meters of concrete for all pieces. For our work, we relied on the existing detailed construction plans to implement the work despite its enormity, as we divided the work, so we established a workshop to make the bends with reinforcing steel, and each process of implementing each construction piece (33) days of reinforcement and casting work, and work continued on all ten construction pieces for about two years. He added that among the work requirements was the availability of special temperatures for the casting process that must not be followed and may not be exceeded, so we worked to ensure that all construction pieces are equipped with a central cooling system, as there are pipes inside each construction element, and we also followed changing the casting time, for example in the winter and fall seasons.

Ikon Olmzer, Construction Project Manager at Al-Wafa 2024, Ports Magazine, Issue 470.

There are some challenges that faced the workers in the submerged tunnel, the most important of which is the presence of war remnants, and as the project engineer for the tunnel, Engineer Salam Yaqoub, said that there are three main challenges that faced their work, the first of which is the presence of war remnants, mines and unsealed bombs at the work site from Al-Faw towards Umm Qasr, as well as inside the canal. Specialized companies were called upon to remove them. He pointed out that there were some marine pieces, with the help of the Marine Rescue Department crews, the Director of the Ma'mur Tunnel Project, that were sunken in the Khor Al-Zubair Canal, and that they were recovered by the CCR, which is affiliated with the General Company for Iraqi Ports.

After the only crossing, crossing the Khor Al-Zubair navigational canal, and shortening the distance, the tunnel also has several benefits, including reducing the fuel consumption of trucks and vehicles, whether leaving or entering the port, and therefore it has an economic return. In addition to reducing congestion within cities and thus reducing environmental pollution, its importance also lies in the fact that it is safer and more stable than bridges, especially since it passes through the Khor Al-Zubair navigational canal, Engineer Salam Yaqoub, leading to the Khor Al-Zubair economic and oil port.

2.11. An Explanation of the Construction of the Submerged Tunnel and its Significance for Marine Commerce

International trade depends on marine transportation networks, and sustaining their position requires a competitive and logical maritime trade infrastructure. In order to connect land and marine transportation routes, port complexes—which include both dry and marine accesses—are essential. When an immersed tunnel is built near a port's entrance, operating circumstances are altered and a new cycle of spatial effects and consequences is created. As companies meet the demands of proximity and collectivization, there is a greater need for workers and a rising port user base (Wang, Zhang, & Bai, 2020).

2.12. Factors Influencing the Construction of the Submerged Tunnel and Recognizing Them as a Dynamic Component

Twelve important dynamic elements influencing construction mistakes in Taiwanese immersed tunnels are identified in this study. Worker skill and experience, rebar framework mistakes, batch and placement joints, soils, BTRC formalization, support techniques, financial risks, waterproof membrane errors, grout errors, control errors, and atypical placement are some of these variables. By understanding potential construction mistakes in immersed tunnel projects, these findings can assist researchers, owners, and contractors in improving their construction plans and reducing errors. This will enhance building methods and investigate the performance of submerged tunnels more effectively (Zhou et al., 2022).

2.13. Analysis of Experimental and Scientific Data Demonstrating the Submerged Tunnel's Function as a Dynamic Component

Under all geo-ecological circumstances, modern urban amenities must be maintained at an engineering level, particularly in ecologically adverse areas like tunnels. Strength and temperature changes must be balanced while building permanent massive mass concrete. Sectional features are taken into account in the design envelope for optimal strength and energy efficiency. A crucial component of tunnel design is thermal analysis, which addresses resistance of building materials and dynamic behavior. About 30% of the entire amount of study on the features of the prototype tunnel has been carried out through a well-coordinated system of research, which includes direct participation from scientists and design engineers (Lin, Lin, Liu, Yin, & Gao, 2022).

2.14. Success Criteria for the Submerged Tunnel's Construction

This research lists the key elements to take into account while constructing a submerged tunnel, such as the material type, success factors, and present and future advantages. With a fully submerged tunnel length of almost 7 km, the existing underwater tunnel is more than 109 km long. To guarantee a lucrative investment, the tunnel is constructed between 10 and 60 meters deep. The two-layer aluminum alloy tube submerged tunnel, which is frequently utilized for sea-crossing bridges, is the subject of the study. Underwater tunnel development has led to an increase in tunnel length, number, and building methods. In order to shorten transit times for international travel, the subterranean tunnel is essential (Zhang & Broere, 2023).

2.15. Environmental and Physical Elements Influencing the Submerged Tunnel

This study examines the variables influencing the cost of building underwater tunnels, a recent development in Thailand and other coastal areas. The study focuses on how the cost of building a submerged tunnel is affected by ground conditions, marine life, architectural choices, and environmental solutions. These elements have a significant impact on the project's economic feasibility, which aims to lower building costs. The research also emphasizes the value of beach lifestyles, coastal ecosystems, aquatic life, fish populations, local attractions, and the transformation of wave energy. Submarine tunnel development that is affordable fosters regional effects and economic growth (Chen, Min, & Wang, 2022).

The construction of the immersed tunnel at Faw Port is a major engineering project that requires several criteria to be met to ensure its success and long-term sustainability. These criteria include design, construction, operational, and environmental aspects, which must be carefully considered to ensure the project is implemented efficiently and effectively.

2.15.1. Design Criteria

Integrated Design Successful design of the immersed tunnel requires the integration of engineering, geological, and hydraulic aspects. The tunnel must be designed to suit the geological and environmental conditions of the site, taking into account all potential factors such as water pressures, traffic, and environmental impacts Accuracy in planning Planning must be accurate and comprehensive to avoid any unwanted surprises during implementation. This includes conducting detailed feasibility studies, risk analysis, and developing emergency plans.

The project provides two roads, each road with three lanes going and one returning for vehicles, as there will be a road towards the Grand Faw Port and the other towards Umm Qasr, separated by a service lane. The specialist designer carried out the design and structural analysis process on these structural pieces, so that they would be balanced during pouring and during the movement of transporting and fixing them in their designated places. In addition, from a constructional perspective, each piece includes

Research and studies to reach the most appropriate choice regarding the technical details of the immersed tunnel project. (Francesco Pansera, Middle East Projects Manager at the Italian consulting company (Technetal) says, There was a deep vision from the senior management of the ports to work on the Faw Port project and link it to a road leading to Umm Qasr, and then extending to the highway, so that it would start on the development path from the design of the immersed tunnel. From a technical perspective, the choice fell on implementing a immersed tunnel extending (2444) meters, including ten construction pieces with a length of (1260) meters, submerged under the Khor Al-Zubair Canal at a depth of (30) meters. Pansera explains that each of these ten

construction elements is (34.6) meters wide, with a height of approximately (11) meters. These ten construction elements were manufactured and their reinforcing steel was assembled inside the manufacturing basin

Fire systems, electrical systems, fire treatment systems, and ventilation systems. All of these were challenges in The design and installation process was studied to ensure that each piece was placed in the right place. He continues: At the beginning, deep and successive tests were conducted on the soil before the structural designer began work. We conducted many tests and soil investigations, studied the behavior of the soil, the behavior of the water present in Iraq, in addition to the soil's bearing capacity. Francisco Balsera, Middle East Project Manager at Technital, Ports Magazine 2024, Issue 470.

2.16. Construction Standards

Right Material Selection The material selection being a very important factor for the tunnel construction. The material has to be of very good quality and durable against water pressure and corrosion. This includes reinforced concrete and stainless steel with some insulating materials to prevent leakage from surrounding water. New Construction Techniques The use of new advanced methods of construction by drilling, lifting, and installation is one major step towards making the process very easy and eliminating many engineering errors. The workforce must be exposed to new and advanced types of equipment to ensure the accuracy and efficiency of its work. Correct Installation and Continuous Monitoring Installing the pipes accurately constitutes one of the most relevant phases in tunnel construction since it should be continuously monitored during the process of setting them according to the technical specifications that help guarantee the structure and the operation safety of the tunnel.

2.17. Operational Standards

Electrical and Mechanical Systems Immersed tunnels need sophisticated electrical and mechanical systems for safe and efficient operations. Ventilation, lighting, and monitoring systems should be installed and designed to assure safety users and ease in maintenance safety, and Maintenance The operating plan for the tunnel must outline detailed safety and periodic maintenance procedures. Establish regular schedules for the maintenance and periodic inspection of all the components of the tunnel to make sure that it works in such a way that does not bring any of the material damages and corrosion.

2.18. Environmental Standards

Environmental Preservation An immersed tunnel should be constructed with a view to ensuring that certain environmental standards are maintained in preserving the marine environment. This will ensure the application of sustainable construction techniques and the minimization of pollution both during and after the construction process. The tunnel should also not affect marine life and the surrounding ecosystem. Pollution Control The pollution during the construction of the immersed tunnel should have proper and effective action to avoid pollutions in each stage. It covers dust, emissions, and other pollutants generated during the construction phase by measures using pollution control equipment and dust in.

2.19. Economic and Social Benefits

Improving the operational efficiency of the port The immersed tunnel contributes to improving the operational efficiency of the Faw Port by facilitating the movement of goods and trucks between the various parts of the port. This enhances the port's ability to accommodate more ships and goods, leading to increased economic returns. Creating job opportunities The construction and operation of the immersed tunnel provides new job opportunities for local residents in the fields of engineering, construction, maintenance and operation. This contributes to improving the standard of living and strengthening the local economy.

2.20. Technical and Engineering Aspects of the Underwater Tunnel's Construction.

This study investigates the connection between construction dangers during tunnel boring operations and the subsurface characteristics of submerged concrete tunnels employing bored tunneling construction in Portuguese geology. The research focuses on the depths of construction of these buildings as well as the increasing significance of marine trade. Due to its potential for medium productivity and little environmental effect, automated tunneling is of importance as geotechnical issues in the constrained environment of mega excavations of subways, submerged tunnels, and station caverns are becoming more prevalent. However, controlling these structures is made more difficult by the existence of less geotechnical competent soil with intercalated and non-cohesive layers (de Jong, n.d.).

2.21. Social and Economic Aspects Influencing the Underwater Tunnel's Success.

With many economic and environmental concerns ranging across various projects and application locations, the economics of submerged tunnels is still in its infancy. These elements are impacted by available tunnel design and construction technology, as well as strategic, architectural, and geographic alignment. Site-specific restrictions and needs govern critical conditions, including depth and diversion, mass and form of system

components, and the transition from underwater to sub- or above-water structures (Lei et al., 2023).

2.22. The Undersea Tunnel's Effects and Implications for Marine Commerce

The 25-kilometer Hajer-Fredrikshamn and 18-kilometer Fredrikshavn-Rødby marine tunnels will be included into Western Europe's TENs networks. Given that 80% of heavy traffic in Europe takes place on a north-south axis, these tunnels are essential. Analyzing the functions connecting two metropolitan regions on different territories, identifying transportation axes, and evaluating densities of transportation movements are all part of the economic reasons for tunnel development (Shao, Shao, Li, & Qiu, 2021).

2.23. The Submerged Tunnel's Effect on Increasing Marine Trade's Efficiency.

Globalization and worldwide rivalry have had a major impact on the expansion of marine trade and transportation. A major factor in this expansion is containerized transportation, which provides cheap prices, minimal inventory, and great loading efficiency. Both local economic growth and foreign trade are directly impacted by transportation efficiency. Submerged tunnel building along the coast can increase the effectiveness of marine trade, lessen conflict, and advance global peace and prosperity. If this building is successful, it may also create positive trade links along the 21st Century Maritime Silk Road and the Eurasian Economic Belt, guaranteeing the security of both local and international economic cooperation (Zou, Bricker, & Uijttewaal, 2020).

2.24. Improved Movement of Goods

Reduced movement time: The tunnel facilitates the movement of goods between different parts of the port, reducing the time required to move between docks and storage warehouses.

2.25. Increased Logistical Efficiency

Thanks to the advanced infrastructure of the tunnel, goods can be transported more quickly and efficiently, improving overall logistics operations.

Reduced traffic congestion: The tunnel helps relieve pressure on surface roads within the port, reducing traffic congestion and improving the flow of truck traffic.

2.26. Enhanced Safety and Security

Reduced accidents: Thanks to the safe tunnel passages, the possibility of accidents resulting from the interference of truck and ship traffic is reduced.

Improved visibility and weather conditions: The tunnel provides a controlled and stable environment, reducing the negative effects of weather conditions such as fog and rain.

2.27. Increased Capacity

Accommodating a larger number of ships: Improving the movement of goods within the port contributes to increasing the number of ships that can dock at the port at the same time.

Enhanced storage capacity: Efficiency in transporting goods increases storage capacity, enabling the port to handle a larger volume of goods.

2.28. Economic Benefits

Attracting Investments: The tunnel enhances the attractiveness of Faw Port to international investors, increasing foreign and local investment in the region.

Enhancing Revenues: High efficiency increases port revenues by increasing the volume of goods handled.

Improving Iraq's Trade Image: The port, with its submerged tunnel, shows the world that Iraq is capable of implementing advanced infrastructure projects, enhancing Iraq's reputation as a trade and logistics hub.



2.29. Technology of Transporting Immersed Tunnel Parts Using the Archimedes Method

Technology of transporting immersed tunnel parts using the Archimedes method is based mainly on the principle of buoyancy, and is an effective and safe way to transport heavy objects through water. Here is a detailed description of this process:

2.29.1. Preparation in the Factory

Preparing the parts for transportation First, the tunnel parts are manufactured in special factories equipped for this type of project. Each part undergoes careful inspection to ensure its quality and safety. After ensuring its cohesion and the absence of any leakage, it is prepared for transportation from the factory to the marine site.



2.30. Preparing for Floatation

Preparing the air tanks Each tunnel piece is equipped with inflatable air tanks. These tanks are connected to air pumps to control the amount of air entering and thus control the degree of buoyancy. These tanks are checked for leaks.

Air intake and lifting of the pieces the process of gradually introducing air into the tanks begins, which increases the buoyancy of the pieces. The process is carefully monitored to ensure that the pieces are stable and free from any damage. Lifts and support equipment are used to control the buoyancy process and ensure that the pieces are lifted safely.



Figure 4: Submerging 10 immersed tunnel segments to apply Archimedes' principle in lifting the tunnel segments and preparing them for transport to the required location by sea.

2.31. Sea Transportation

After attaining the necessary buoyancy, the parts are towed to their sea transportation by tugboats. This phase is very important and sensitive since it demands the right coordination between parties of sea transportation to keep safety for the parts while moving in the water.

Guiding the parts to the site. Part are guided precisely within the specified location through Advanced Navigation Systems and Hydraulic Steering Devices. Sensors monitor the movement of parts to ensure they arrive safely at the installation site.



2.32. On-site Installation

Unloading and Installing the Parts Once the parts reach where they are required, the air tanks are slowly released to let the parts sink to their place. Precision steering systems and hydraulic controls guide where exactly the parts are meant to be placed. The parts are then fastened with construction materials—for example, with concrete—to secure them and create stability by all means.

Quality and Safety Tests After the components are mounted in place, quality tests are done to ascertain the safety of the mounting and the performance of the tunnel. It ensured that all parts are tight, stable, and leak-free.

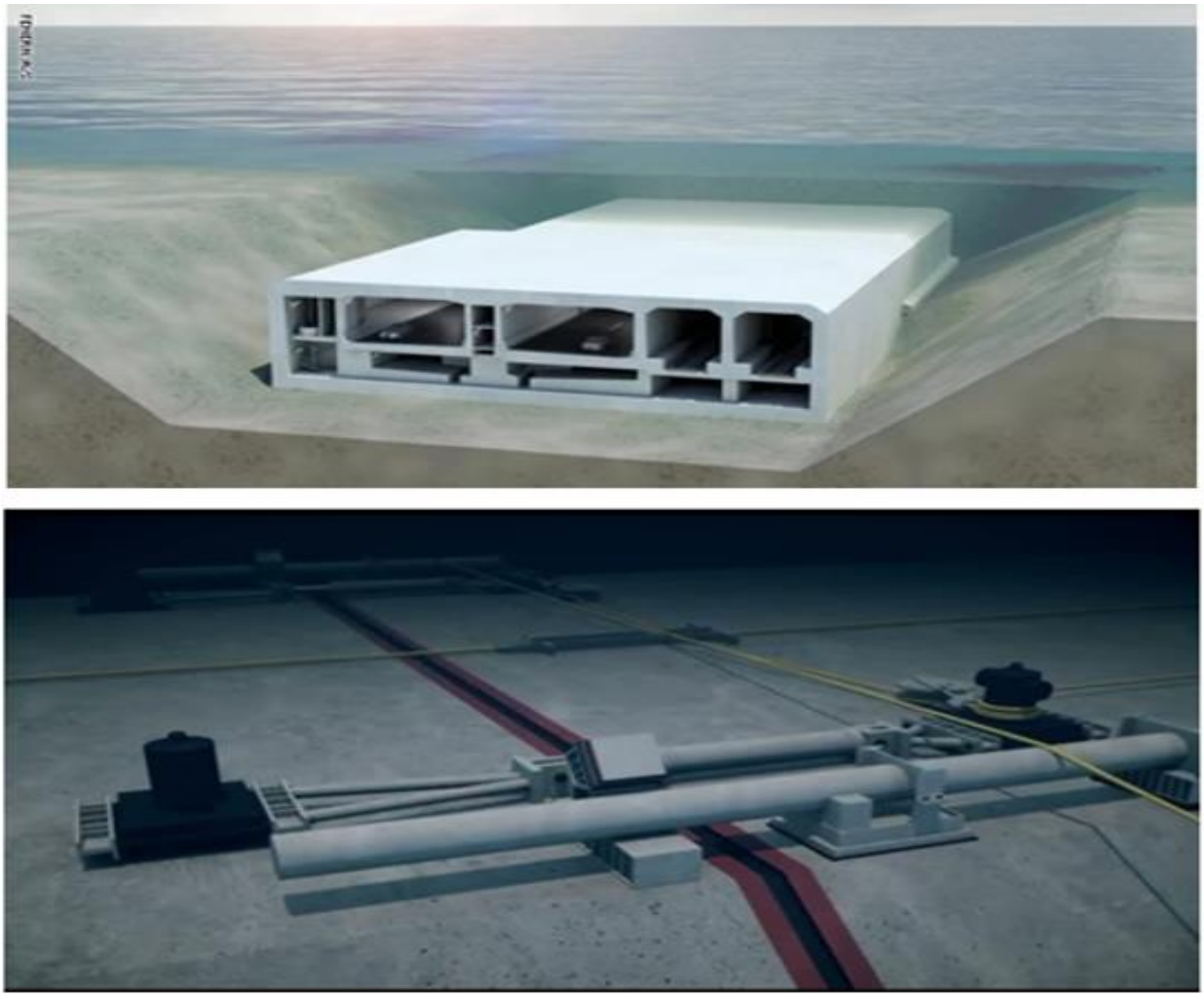


Figure 5: Pictures showing the method of installing the immersed tunnel pieces together in a tight hydraulic way in Jeddah without any problems or water leakage.

2.32.1. Advantages of Archimedes Technique

Cost and effort reduction The Archimedes method of transporting tunnel parts is low cost and less effort as compared to conventional methods of transportation. The process can enable buoyancy and air to reduce the labor of heavy lifting equipment and depend more on nature during transportation.

Safety and stability this technique provide very high degrees of safety and stability during the transport and handling of parts. Buoyancy control using air tanks enables control that is so very fine, almost to the point that the process is actually too easy to control to prevent any accident or damage.

Adaptation to environmental conditions the technique is inflexible and would work under any environment. The quantity of air in the tanks can be varied to keep all parts stable in the water. Appropriate for all seas and climatic conditions.

2.32.2. Challenges and Solutions

Weather Is Not Always the Best Work teams might have problems arising due to bad weather during the process of sea transportation. The work would be precariously planned during the periods that the weather conditions are favoring as a means to circumvent such challenges. Should the weather experience abrupt changes, there would be contingency plans to ensure both the parts and the team's safety.

Maintaining the safety of the parts During the transportation process, parts may be subjected to pressure or unexpected movements. To avoid this, specialized support systems and cranes are used to precisely monitor and stabilize the parts throughout the transportation stages. Using Archimedes' principle in transporting immersed tunnel parts provides innovative and effective solutions to complex engineering challenges. This technique not only reduces cost and effort, but also ensures a high degree of safety and stability of the parts during transportation and installation. Through careful planning and perfect coordination between specialized teams, impressive results can be achieved that contribute to the successful completion of marine infrastructure projects.

2.33. The Underwater Tunnel's Effect on Enhancing Marine Trade's Safety and Security

In the marine industry, subsea roads are utilized to move cargo between cities and suburbs. Increased

merchant vessel occupancy and the avoidance of collisions involving coast defense ships, cruise ships, and oceangoing boats are the goals of these routes. Submerged tunnel preliminary designs have proven effective, and the project has grown to be a major building construction project. To reduce the length of undersea bridges and berth sites, conventional techniques include trench digging and underwater tunneling; nevertheless, these techniques have sparked worries about labor costs, environmental contamination, and safety. Three years of study have led to the development of a revolutionary dynamic factor for submerged tunnels that replaces the traditional approach by utilizing the navigation determination index. Submarine tunnel development can be facilitated by this innovative building technique, which can also establish a continuous barrier of defense against (Xiang, Chen, Shen, & Yang, 2023).

2.34. The International Development Path and the Underwater Tunnel

In order to transfer products, services, or passengers in an efficient, safe, timely, and economical manner, transport routes use the path of least resistance. Although underwater tunnel technologies were devised to circumvent restricting obstacles, ferries have always been an essential component of marine commerce routes. The tunnel ensures continuous passenger and freight liner traffic by providing efficient facilitation irrespective of weather and other external transportation conditions. This system is a useful benchmark in security or political talks and has strategic significance (Niu et al., 2022).

Because it offers a fresh and dynamic element for global development, the submerged tunnel system has aided in Hong Kong's economic growth. By boosting the amount of residential and commercial property in the new town, the tunnel's design and construction have directly stimulated economic activity throughout the region. Wu Kai Sha is now a new business and financial hub as a result of the commercial and business sectors' growth (Fan, Jiang, Guo, Lin, & Wang, 2022).

Additionally, the subterranean tunnel contributes significantly to the advancement of global collaboration. The growth of marine trade necessitated the safe and effective traversal of straits dividing the various nations' territorial surfaces. The tunnel's below the sea connection feature, which permits the movement of cargo under predetermined security circumstances, now guarantees the continuation of marine trade regardless of sea conditions (Jin & Kim, 2021).

There are enough unique aspects of the tunnel's construction to warrant the use of unique architectural solutions that will ensure the tunnel's construction and operation for millennia to come. Since all project development in growing sectors involves one or more water-separated nations, attempts relying on international cooperation patterns have a significant chance of success (Moan & Eidem, 2020).

2.35. The Development Road Project: Economic, Security and Geopolitical Dimensions

Turkish President Recep Tayyip Erdogan's visit to Iraq, for the first time in 13 years, witnessed the signing of a quadripartite memorandum of understanding on the Development Road project, which brings together Iraq, Turkey, Qatar and the UAE, and aims to establish a strategic trade route linking the city of Basra to the Turkish border via a 1,200-kilometer railway. The project aims to achieve integration in the supply and transportation chain, and is considered geopolitically an alternative to the traditional trade route through the Bab al-Mandab Strait and the Suez Canal, which will provide a more efficient and less costly route. Economically, the project enhances the welfare levels in the region by providing new job opportunities and revitalizing sectors such as construction, health and tourism, while its success requires the provision of sustainable security, as the stability of the region is essential for the success of the project and ensuring the achievement of its development goals (Zaman, 2024).



Figure 6: Development path with Iraq.

2.36. The Submerged Tunnel: A Strategic Project to Boost Transport and International Trade

2.36.1. The Immersed Tunnel in Iraq

2.36.1.1. Length, Width and Depth

- Length: estimated at about 13 kilometers.
- Width: ranges between 12 and 15 meters.
- Depth: reaches a depth of about 30 meters below sea level.

2.36.1.2. When Did Construction Begin and What is the Percentage of Completion?

- Start of construction: Construction began in 2015.
- Percentage of completion: As of the latest reports in 2023, the percentage of completion is estimated at about 80%.

2.36.1.3. Engineering Factors

- The design of the tunnel requires the use of modern drilling and reinforcement techniques.
- The use of materials that are resistant to water and pressure.
- Consideration of the geological factors and soil present in the region.

2.36.1.4. Natural Factors

- The terrain of the region: the presence of groundwater and soil diversity.
- Climate: climatic effects such as floods and heat.

2.36.1.5. Its Relationship to the Development Road

- The tunnel is part of the development road project that aims to connect different regions of Iraq.
- The road seeks to improve infrastructure and promote trade.

2.36.1.6. What is the Development Road, Where Does it Start and Where Does It End?

- The development road: It is a project that aims to establish a road network linking Iraq with neighboring countries.
- Path: It starts from Basra and ends in Türkiye, passing through several major cities.

2.36.1.7. Economic Impact of the Submerged Tunnel

- It will contribute to reducing transportation and shipping costs.
- Enhancing trade between Iraq and neighboring countries.
- Improving access to markets and increasing investments (Alhurra-Washington, 2024) .

2.37. International Development Road: A Global Vision for Promoting Trade and Development

Introduction The International Development Road is one of the most prominent global projects that aims to enhance infrastructure and cross-border trade. The project seeks to improve economic ties between countries and facilitate the movement of goods and services, thus contributing to promoting economic growth and sustainable development globally. In this paper, we will review the strategic importance of the International Development Road, the engineering and construction factors, the challenges facing the project, the economic and social benefits, and examples of similar projects around the world.

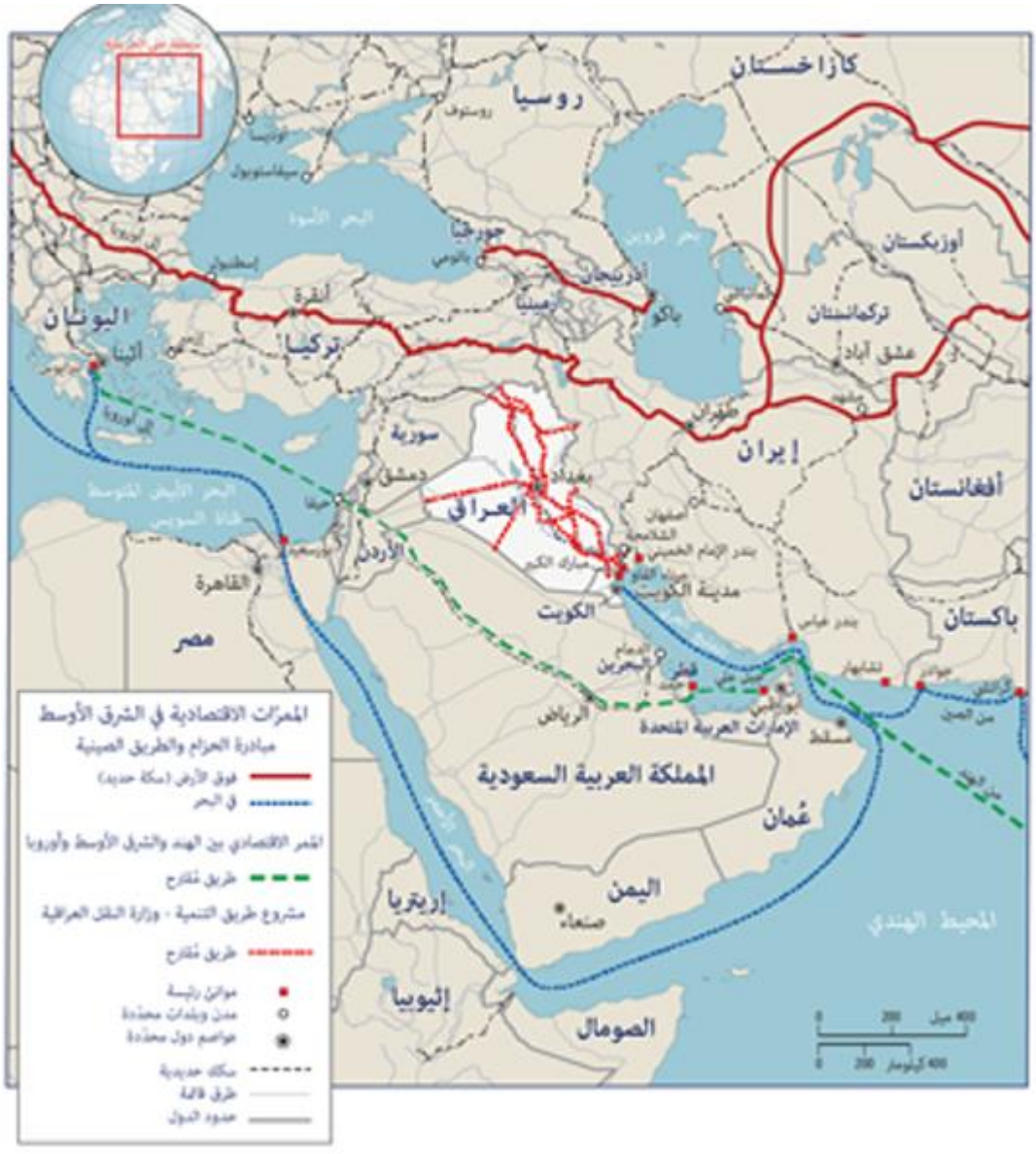


Figure 7: Image showing the international development path and its connection in Iraq.

2.38. The Strategic Importance of the International Development Road

Promoting international trade The International Development Road is a key axis for promoting trade between countries. By providing smooth and fast transport corridors, goods can be easily and efficiently transported between different markets, reducing transportation costs and increasing the volume of international trade. This contributes to increased economic growth and creating new job opportunities.

Promoting regional and global cooperation The International Development Road promotes cooperation between countries by improving economic ties and shared infrastructure. This cooperation enhances political and economic stability in participating regions, and supports efforts to achieve long-term sustainable development.

Contribution to sustainable development the project makes improved infrastructure and economic efficiency which are key ingredients for any development. The projects create new openings for jobs and ensure market access, thus promoting inclusive economic growth and poverty reduction in both benefiting areas.

2.39. Engineering and Construction Factors

Planning and engineering design The International Development Road Construction requires careful

planning and integrated engineering design considering geographical, environmental, and economic aspects of enforcing the factor. Construction should be able to support heavy traffic and safety with the comfort of users. In addition, flexibility should be maintained in the design to take up any future challenges.

Materials used in construction Selection of materials is, of course, one of the most important things in a successful project. It should be confirmed and assured that strong material is applied to stand variations in weather and pressure created by heavy vehicles' movements. In highway construction, usually, the roads are made up of reinforced cement concrete and good quality asphalt to keep the road in all sustainable conditions by in taking all environmental conditions.

Modern construction techniques are very efficient and cost-effective since modern technologies reduce the effort and save time in every aspect. This involves the adoption of 3D modeling systems in the design work and using sophisticated construction equipment for accuracy and speed in work execution. In addition, it enables quality monitoring of construction works to implement the engineering standards required.

Project management Managing an International Development Road project requires very strong organizational skills and the ability to manage people and financial resources effectively. Planning scheduling and costing in detail is necessary in addition to monitoring progress on a regular basis so as to ensure that the specified timetables are adhered to and no unnecessary delays take place.

2.40. Project Challenges

Geographical challenges. The International Development Road project faces a host of geographical challenges. From rough terrains to deserts to some of the harshest climate areas on earth, such require innovative engineering to beat continuation and safety for the road. May require bridging mountains and valleys with Tunnels or using some special techniques to stabilize the soil in sandy areas.

Environmental Challenges The impacts of biodiversity conservation and climate change due to the road construction are important. There should be offset projects and sustainable construction techniques for such negative impacts to be reduced. Monitoring of the environmental impacts of the project also has to be done on a regular basis so that it meets the international standard of the environment.

Financial Challenges One of the major challenges is to finance the undertaking because of its hugeness and high expense. The venture requires that legislatures, private segments, and global monetary organizations cooperate to back up the essential assets. There should also be solid financing plans for the sustainability of the project in the long term.

Logistic Challenges The implementation of the project demands a very high level of logistic coordination for transport of all necessary materials and equipment to its various construction sites. This would include providing suitable means of transportation and coordinating the transportation operations among the different regions involved in the project.

2.41. Economic and Social Benefits

Increasing GDP the International Development Road is expected to contribute to increasing the GDP of the participating countries by promoting trade and investment. Improving infrastructure can attract more foreign investment and boost local economic growth, which contributes to improving the standard of living for citizens.

Creating new job opportunities the construction and operation of the road contributes to creating new job opportunities in the fields of construction, maintenance and logistics. This contributes to improving the standard of living and reducing unemployment rates in the beneficiary areas, which enhances social and economic stability.

Improving access to global markets By improving transportation links, companies can reach new markets faster and easier. This contributes to expanding business scope and increasing sales volume and revenue, which enhances the competitiveness of companies in global markets.

Promoting regional development the international development road contributes to promoting regional development by improving infrastructure and providing investment opportunities. Improving connections between cities and villages can improve public services and boost economic growth in rural and less developed areas.

2.42. Examples of Similar Projects

China's Belt and Road Initiative the Belt and Road Initiative launched by China is a prominent example of international road projects aimed at promoting trade and investment. This initiative involves building networks of roads, railways and ports that connect Asia, Europe and Africa. By improving interconnections, the initiative contributes to promoting international trade and economic cooperation among participating countries.

Trans-Africa Road the Trans-Africa Road project is one of the major projects aimed at improving infrastructure and transportation on the African continent. This project aims to connect African countries through a network of highways that contribute to promoting inter-trade and economic development. By improving interconnections, African countries can boost regional trade and attract more investment.

The New Silk Road the New Silk Road project, which extends from Asia to Europe, aims to boost trade and

investment between continents. The project involves building networks of roads, railways and ports that will help improve trade links between participating countries. The project can promote economic growth and sustainable development by improving infrastructure and facilitating the movement of goods and services.

2.43. Steps to Ensure Project Success

International cooperation the international development road should involve close cooperation between governments, international institutions and the private sector. This requires establishing joint agreements and coordinating efforts to ensure that the project is implemented efficiently and effectively.

Sustainable financing Solid financing plans should be put in place to ensure the long-term sustainability of the project. This could include using multiple sources of financing such as international loans, grants and public-private partnerships.

Effective management Managing a project of the size of the international development road requires strong organization and effective management of human and financial resources. Detailed timeline and cost plans should be developed, and progress should be monitored regularly to ensure adherence to the specified timelines and avoid any undue delays.

Community participation the project should involve broad community participation to ensure that the needs of the local population are met and their expertise is utilized. This can help improve project acceptance and avoid any local opposition.

Compliance with environmental standards the construction of the international development road should include compliance with international environmental standards to preserve the environment and minimize negative environmental impact. This could include implementing offset projects and using sustainable construction techniques.

2.44. Economic Analysis of the International Development Road

Cost-benefit analysis a careful cost-benefit analysis should be conducted to ensure the project's long-term viability. This includes assessing the direct and indirect costs of the project, and estimating the expected returns from improved trade and investment. Economic Estimates the success of the project requires accurate economic estimates including forecasts of economic growth and expected revenues from the project. This may include the use of economic models to analyze the expected economic impacts of the project at the national, regional and international levels.

2.45. Study Methodology

The current study relies on the descriptive analytical approach by designing an electronic questionnaire and distributing it to a sample of 100 employees working in Faw Port in Iraq. The data were collected and analyzed using SPSS and the results were extracted.

3. RESULTS

3.1. Section One: Demographic Data

Table 1: Demographic data of the study sample.

Variable	Class	N	%
Age	Less than 25 years	25	25
	25 to 34 years	18	18
	35 to 44 years	35	35
	45 to 54 years	10	10
	55 years and above	12	12
Educational level	High school diploma or less	12	12
	Diploma	15	15
	Bachelor's	54	54
	Postgraduate studies	19	19
Professional experience in the construction or ports sector	Less than 5 years	7	7
	5 to 10 years	12	12
	11 to 15 years	49	49
	More than 15 years	32	32

The study sample is divided according to the age variable into 25% less than 25 years, 18% between 25 and 34 years, 35% between 35 and 44 years, 10% between 45 and 54 years, and finally 12% from 55 years and older.

According to the educational level, the study sample was divided into 12% secondary school and less, 15% diploma, 54% bachelor's degree, and 19% postgraduate studies.

According to the variable of practical experience in the field of construction or ports, the sample was divided into 7% less than 5 years, 12% between 5 to 10 years, 49% between 11 to 15 years, and 32% over 15 years.

3.2. Section Two: Study Axes

3.2.1. Axis One: Planning and Design

Table 2: Planning and Design.

Statement	Mean	Standard deviation	Rank
The project is characterized by careful planning that is consistent with the objectives of maritime development.	3.7	1.4	5
The project plans include accurate economic feasibility studies.	4.1	1.0	3
The tunnel design takes into account environmental aspects to ensure sustainability.	4.3	0.9	1
The tunnel design reflects the current and future needs of maritime trade.	3.8	1.1	4
The project relies on the latest engineering techniques in design and construction.	4.2	0.9	2

The first planning and design phrases came with an arithmetic mean of 4.3, which was that the tunnel design takes into account environmental aspects to ensure sustainability, followed by the phrase that the project relies on the latest engineering technologies in design and construction with an average of 4.2, followed by the phrase that the project plans include accurate economic feasibility studies with an average of 4.1, and in fourth place came the phrase that the tunnel design reflects the needs of current and future maritime trade. With an average of 3.8, and in last place came the phrase that the project is characterized by accurate planning that is consistent with the objectives of maritime development with an average of 3.7.

3.2.2. Axis Two: Management and Implementation

Table 3: Management and Implementation.

Statement	Mean	Standard deviation	Rank
The project is implemented according to a precise time plan.	4.7	0.6	1
Sufficient experienced human resources are available to implement the project.	4.5	0.8	2
Advanced technologies are used to monitor the project implementation.	4.1	1.0	3
The project receives support from senior management to ensure the progress of work.	4.0	0.8	5
Administrative obstacles are resolved quickly to avoid project delays.	4.0	1.0	4

As for the management and implementation axis, it was represented by the fact that the project is being implemented according to an accurate time plan with an average of 4.7, followed by the fact that human resources with sufficient experience are available to implement the project with an average of 4.5, followed by the fact that advanced technologies are being used to follow up on the implementation of the project with an average of 4.1, followed by the fact that administrative obstacles are being resolved quickly to avoid delaying the project with an average of 4.0, and in last place came the phrase that the project receives support from senior management to ensure the progress of work with an average of 4.0.

3.2.3. Axis Three: Cost and Financing

Table 4: Cost and Financing.

Statement	Mean	Standard deviation	Rank
The project is adequately funded.	3.9	1.1	1
Financial spending is monitored to ensure that it adheres to the specified budget.	3.7	1.2	3
The project provides economic returns that justify the high cost.	3.3	1.3	5
Financial support is provided from various sources to ensure the continuity of the project.	3.6	1.2	4
The budget is updated regularly based on developments in the project.	3.7	1.1	2

The first cost and financing phrases were that the necessary funding for the project is adequately allocated with an average of 3.9, followed by the phrase that the budget is updated regularly based on developments in the project with an average of 3.7. This was followed by the phrase that financial spending is monitored to ensure its adherence to the specified budget with an average of 3.7. In fourth place came the phrase that financial support is provided from various parties to ensure the continuity of the project with an average of 3.6. In last place came the phrase that the project provides economic returns that justify the high cost with an average of 3.3.

3.2.4. Axis Four: Safety and Quality

Table 5: Safety and Quality.

Statement	Mean	Standard deviation	Rank
The highest safety standards are applied at the project site.	3.7	1.4	5
Periodic tests are conducted to ensure the quality of the materials used.	4.1	1.0	3
Workers receive the necessary training on safety procedures.	4.3	0.9	1
The project relies on a specialized team for quality control.	3.8	1.1	4
Periodic inspections are conducted to ensure the project adheres to quality standards.	4.2	0.9	2

In the fourth axis, safety and quality, the phrase that workers receive the necessary training on safety

procedures came in first place with an average of 4.3. In second place came the phrase that periodic inspections are conducted to ensure the project's adherence to quality standards with an average of 4.2. In third place came the phrase that periodic tests are conducted to ensure the quality of the materials used in first place with an average of 4.1. In fourth place came the phrase that the project relies on a specialized team to monitor quality with an average of 3.8. In last place came the phrase that the highest safety standards are applied at the project site with an average of 3.7.

3.2.5. Fifth Axis: Economic and social impact

Table 5: Economic and social impact.

Statement	Mean	Standard deviation	Rank
The project will contribute to increasing commercial activity in the region.	4.0	0.8	2
The project will provide new job opportunities for local community members.	4.0	1.0	1
The tunnel will enhance trade connectivity between Iraq and other countries.	3.9	1.1	3
The project will positively impact the social and economic development of the region.	3.7	1.2	4
The project will enhance Iraq's position as a regional maritime trade hub.	3.6	1.2	5

With regard to the economic and social impact, the project will contribute to increasing commercial activity in the region with an average of 4, then the project will provide new job opportunities for members of the local community with an average of 4, followed by the tunnel will enhance trade links between Iraq and other countries with an average of 3.9. Then the project will have a positive impact on social and economic development in the region. In last place came the phrase the project will enhance Iraq's position as a regional maritime trade center with an average of 3.6.

4. CONCLUSION

In conclusion, the immersed tunnel at Faw Port represents a crucial step towards enhancing the efficiency of maritime trade on the international development path, which will positively impact the local and global economy. This ambitious project is not just a new infrastructure, but a symbol of the development and sustainability that can be brought about by the planning and implementation of major engineering projects.



Enhancing Logistics Efficiency One of the most significant impacts of the immersed tunnel is the significant improvement in logistics efficiency. By reducing the time it takes to move goods within the port, logistics operations are accelerated, which improves the flow of goods and increases the efficiency of supply chains. This directly impacts the reduction of transportation costs, and enhances the competitiveness of Faw Port at the regional and international levels.

Reducing traffic congestion and enhancing safety Reducing traffic congestion by providing underground passages for trucks and heavy vehicles improves the flow of traffic within the port and reduces delays. In addition, the tunnel contributes to enhancing safety by reducing the possibility of traffic accidents, providing a safer working environment for port workers and improving working conditions in general.

Enhancing local and international investments improving the logistics infrastructure thanks to the immersed tunnel makes Faw Port an attractive destination for investments. Investors can see the added value that the tunnel provides by improving operational efficiency and increasing the port's capacity. This attracts more local

and international investments, contributing to the sustainable economic growth of the region.

Enhancing capacity and increasing trade volume the submerged tunnel can increase the capacity of Faw Port, allowing it to receive a larger number of ships and cargoes. This enhances the port's role as a major commercial hub on the international development road, and increases the volume of international trade passing through it. This, in turn, enhances economic relations between countries and strengthens Iraq's position as an important trade and logistics center.

Supporting economic and social development the project contributes significantly to supporting economic and social development in the region. By creating new job opportunities in the fields of construction, maintenance and logistics, the standard of living of local residents is improved and unemployment rates are reduced. The project also enhances local economic growth and increases government revenues by increasing trade and investment volume.

Addressing engineering and environmental challenges despite the engineering and environmental challenges associated with tunnel construction, the use of modern technologies and careful planning can help overcome these challenges. This includes selecting appropriate materials and structural design that can withstand different environmental conditions. Environmental factors must also be taken into account by implementing compensation projects and using sustainable construction techniques that minimize negative environmental impacts.

Future Role in the International Development Road The immersed tunnel enhances the ability of Faw Port to be a vital part of the international development road. By improving logistics efficiency and reducing transportation costs, the port can contribute significantly to promoting international trade and economic cooperation between countries. This enhances Iraq's position on the global economic map and supports efforts to achieve sustainable development.

Innovation and engineering development implementing a project of this size and complexity require a high level of innovation and engineering development. The use of modern technologies in design and construction through 3D modeling and smart monitoring techniques. ensure the highest levels of quality and efficiency. This enhances Iraq's engineering capabilities and makes it a model for ambitious engineering projects in the region.

Awareness and Training Success of the project also depend on awareness and continuous training for port workers. Specialized training programs need to be introduced for workers in the field of operation and maintenance to bring efficiency and safety in operations. This can also help in developing local capacity building and technical/ engineering skills of the local people.

In simple words, the immersed tunnel at Faw Port is a strategic step, not just an infrastructure project, towards improving efficiency in maritime trade and fostering sustainable economic growth. Improved logistics efficiency would transform Faw Port into a global trade and logistics hub if combined with decongestion, safety, and investment measures. With careful studies in the risks and benefits plus new technologies, this project will realize success in the long run and maintain its life. This makes the immersed tunnel at Faw Port a symbol of development and innovation for long-term economic and social benefits to Iraq and the wider region.

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