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The Root Causes of Steel Construction Shortage in Afghanistan and its Impact on Infrastructural Development: A Comprehensive Study

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Abstract

The construction industry plays a critical role in a country's development, impacting both its aesthetics and economic growth. This industry in Afghanistan has been experiencing a shortage of steel construction that has hindered infrastructural development. The current study aims to identify the root causes of this shortage, its negative impact on infrastructural development, and potential solutions to promote steel construction within the country. A qualitative approach has been adopted through questionnaires and interviews with over 100 licensed-structural engineers and steel manufacturers in major provinces of the country. The findings reveal that the lack of government attention towards the construction industry, the absence of professional firms and engineers, and the dominance of concrete in the construction industry of Afghanistan contribute to the shortage of steel construction. This has had adverse effects on the country's economy and environment. However, promoting steel construction can improve infrastructural development due to its strength, cost effectiveness, efficiency, sustainability, versatility, safety, and speed that invite the engineers to create innovative structural designs. The study contributes to the understanding of the challenges faced by the construction industry in Afghanistan and offers practical recommendations for promoting steel construction, which can significantly impact infrastructural development and economic growth. Moreover, the research provides insights into potential policy changes, investment strategies, and educational initiatives that can address the shortage of steel construction and promote sustainable development in the country.

Keywords: Steel Construction, Construction industry, Sustainability, Infrastructural development, Economic growth

Introduction

Steel is an essential component in all aspects of construction, from supporting slabs to complete building skeletons. It comes in a variety of shapes, sizes, chemical compositions, and mechanical properties, allowing for versatile applications in different industries. Whether serving as compression or tension members, steel demonstrates its adaptability and functionality in various structural roles [1], [2]. Its widespread use extends to transportation, energy, gadgets, and packaging, highlighting its diverse capabilities.

Furthermore, steel's recyclability adds to its appeal as a sustainable material. Composed of elements such as iron, carbon, manganese, chromium, and vanadium, steel offers exceptional strength and cost effectiveness, making it a top choice for construction projects [3]. Steel is explicitly the most widely used and flexible material in construction. When it comes to building, steel is incomparable in providing a structure with quality that exceeds any other material [4]. The mechanical properties of steel such as exceptional hardness, yield strength, tensile strength, ductility, and malleability, set it apart from all other construction materials. Furthermore, steel structures are lighter in weight compared to concrete structures, resulting in reduced health hazards, waste, energy usage, emissions and overall environmental impact [5].

In recent years, the steel industry has experienced extraordinary growth, driven by the high demand for real estate, infrastructure development, and automobiles. Steel is a vital component in the construction of developing infrastructures and is of significant economic importance [4], [6]. Despite historical development in the steel industry, Afghanistan's progress was hindered by frequent wars. However, after 40 years of conflict, Afghanistan began its journey toward development in 2003. Geological research has discovered that Afghanistan has an estimated \$3 trillion in mineral reserves, including 2.3 billion tons of iron reserves in provinces such as Baghlan, Badakhshan, and Bamyan. Although these reserves have not been fully explored, the steel industry has used steel scraps from decades of war to produce new steel material. Steel has been a key material in large-scale infrastructure projects around the world, including bridges, tunnels, airports, train stations, and stadiums, due to its sustainability and versatility in construction [7], [8].

In Afghanistan, steel structures are used for military bases, warehouses, and small sports complexes, with concrete being the main material for the development of infrastructure [15]. However, it is crucial to recognize the significant role that steel structures play in improving and strengthening our infrastructures. Therefore, this study aims to analyze and investigate the root causes of the shortage of steel construction and its impact on infrastructural development.

1.1 Problem Statement

The steel industry in Afghanistan is facing a serious problem as it lacks a comprehensive plan and strategy for promoting standard steel construction and integrating it into society. This absence of steel construction poses a significant sustainability and environmental challenge, as concrete has become the dominant material in the country's construction industry. Concrete structures cannot be reused or recycled at the end of their life cycle, leading to permanent waste and negative environmental impact. Additionally, a lack of awareness and knowledge about the benefits of steel construction has stalled its adoption in Afghanistan, impeding infrastructure development and causing stagnation for several decades.

1.2 Significance of the Study

In today's world, developing countries are progressively turning to steel structures for their efficiency, sustainability, and ability to advance infrastructural development. Steel is the only material that can be recycled at the end of its life cycle, making it an environmentally friendly choice. These structures offer numerous advantages that have a significant impact on society, including reduced costs, shorter construction timelines, longer spans, and lower pollution levels. Furthermore, these benefits also have

implications for the government, such as improved environmental efficiency, improved recyclability, and greater sustainability. In addition, the application of such structures contributes to the strengthening of infrastructural development. Hence, investigation and research in this area play a vital role in the evolution of Afghanistan's infrastructure and construction industries. It is essential to understand the significance of promoting steel construction in Afghanistan and its potential to bring about positive change for society, the government, and the environment.

1.3 Study Purpose

The purpose of this study is to carefully examine the fundamental factors that contribute to the shortage of steel construction in Afghanistan and its detrimental effects on infrastructural development. It will propose effective solutions to address existing challenges and barriers that hinder steel construction.

The following are the specific objectives of the study:

1. To identify the primary factors leading to the shortage of steel construction in Afghanistan.
2. To assess the impact of the steel construction shortage on the pace and quality of infrastructural development in Afghanistan.
3. To increase awareness of the benefits of steel construction among the public.
4. To explore potential solutions and strategies for addressing the steel construction shortage in Afghanistan and improving infrastructural development.
5. To provide recommendations for policymakers, industry stakeholders, and international organizations to mitigate the impact of the steel construction shortage on infrastructural development in Afghanistan.

2. Literature Review

A comprehensive literature review has been conducted on the use of steel buildings, its parameters, environmental impact, advantages, performance, seismic behavior on different soil types, and its role in sustainable construction within Afghanistan. Relevant data has been sourced from international conferences, esteemed engineering journals, and industry codes.

2.1 The Domination of Concrete Structures Over Steel Structures in Afghanistan

In today's construction market in Afghanistan, concrete has taken over as the dominant material, largely due to several challenges. The government has invested less in the steel sector, leading to a focus on importing steel from other countries. Additionally, despite the abundance of natural resources in Afghanistan, most mines remain unexploited and manufacturers mainly focus on scrap metals. The lack of experienced designers and skilled labor further exacerbates the situation. Furthermore, there is a shortage of technology in the country, and a general lack of awareness of the benefits of steel has led to 95% of customers to prefer concrete structures over steel ones [15].

2.2 Advantages of Steel Structures in The Context of Sustainable Construction

The construction industry has a substantial impact on the environment, with negative effects on human health, ecological balance, and the conservation of natural resources throughout the building life cycle. To address these issues, the concepts of sustainability and construction sustainability have become increasingly important. Material selection in construction must prioritize environmental suitability, while promoting material recovery at the end of the life cycle is essential for overall sustainability. Taking a complete approach to building assessment across all life cycle stages is crucial [9]. Steel structures offer numerous advantages within the context of sustainable construction. Steel exhibits notable environmental characteristics, including high recyclability, reduced natural resource consumption, limited waste generation, and the potential for material reuse. Additionally, sustainable construction practices involve energy-efficient building designs and the integration of renewable energy sources. Steel structures play an essential role in achieving sustainable construction objectives, fostering a responsible and environmentally cognizant construction industry [10].

2.3 Performance of Steel over Concrete

Steel beats concrete in numerous crucial aspects, demonstrating its undeniable prominence. First, steel's exceptional strength-to-weight ratio allows for the construction of lightweight structures, providing a clear advantage. Additionally, its remarkable durability ensures resilience against corrosion, weathering, and degradation over time. The recyclability of steel further increases its superiority, enabling sustainable construction practices and minimizing environmental impact [11]. Notably, steel's high ductility allows for considerable deformation without fracturing, providing irreplaceable flexibility and resilience in structural applications. In contrast to concrete, steel maintains constant strength without gaining additional strength over time. Its biodegradability also sets it apart as a material capable of being reused or recycled at the end of its useful life, making significant contributions to sustainability efforts. Furthermore, the predictive precision of elastic theory allows for accurate estimates of steel's performance under working loads, facilitating precise design and analysis. With its economic viability, strength, ductility, and various characteristics, steel is the ideal choice for load-bearing members in a wide array of fabricated structures. Steel's lightweight construction potential, durability, recyclability, ductility, fixed strength, biodegradability, predictability, and adaptability make it a material that outperforms concrete in terms of performance [12].

2.3.1 Environmental Performance

The environmental performance of steel in construction far exceeds that of concrete, making it the superior choice for sustainable building practices. Unlike concrete, steel structures can be effectively reused, minimizing construction waste and providing a more environmentally friendly option [13]. In recent years, steel has become synonymous with energy efficiency and is now the top choice for architects, engineers, and contractors that prioritize sustainability. Steel production emits 20% less greenhouse gas emissions than reinforced concrete, and its recyclability and material efficiency help reduce waste and the need for raw materials. In addition, steel structures offer improved energy efficiency, design flexibility, and long-term durability, making them the ideal choice for professionals aiming to achieve sustainable goals and minimize environmental impact.

In essence, the environmental advantages of steel make it the preferred material for modern construction practices [14].

2.3.2 Seismic Performance

When structures are subjected to earthquakes, the waves interact with the soil and the foundation, causing the ground shaking to affect the movement of the structure [16]. Predicting the seismic behavior of buildings during an earthquake has always been a major concern for structural engineers. In addition to earthquakes, the behavior of soil and its impact on the seismic response of buildings, known as the soil-structure interaction (SSI), add complexity to this concern [17]. The effect of soil-structure interaction is a crucial aspect of building analysis and design and must be considered at this stage. Research indicates that the soil-structure interaction of steel moment frames on soft soil is more significant and influential than on stiff soil types. These effects can be greatly influenced by maximizing the slenderness ratio of the structures and the softening of the subsurface soil. Furthermore, it has been observed that considering soil-structure interaction in low-rise steel frames on stiff and soft soil has minimal impact on all floors [18].

3. Methodology

3.1 Research Method

The study adopted a qualitative and analytical approach to thoroughly investigate the root causes of steel shortage in the construction industry in Afghanistan. Using questionnaires and interviews, data was collected to identify the barriers and challenges behind this shortage. The questionnaire, which consists of twelve questions, was designed to gather information on the main causes of the shortage and to gather recommendations for feasible solutions. The interviews were conducted in steel mill factories, and more than 100 structural engineers from some of the relatively developed provinces of the country responded to the questionnaires, in line with Krejcie and Morgan's sample size recommendations. The information collected from the questionnaires was meticulously analyzed using SPSS software, providing a strong foundation for in-depth discussions and analysis.

4. Result and Discussion

4.1 The Main Causes Behind the Consistency of Afghanistan's Construction Sector

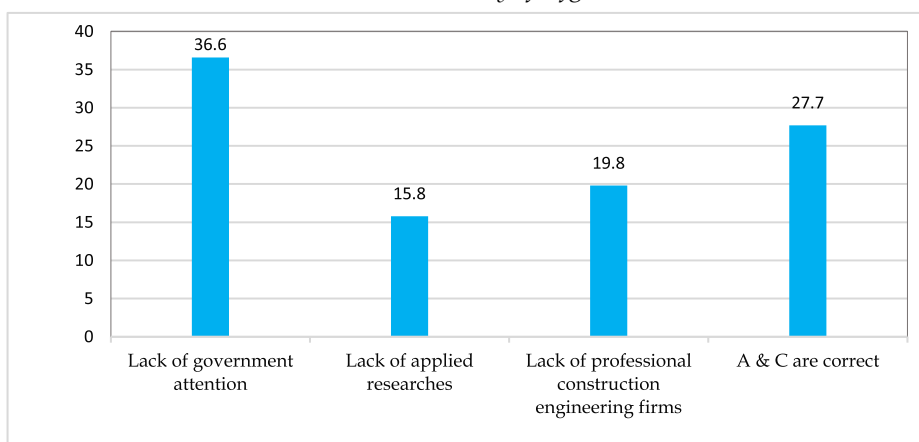


Figure 1: The Main Causes Behind the Consistency of Afghanistan's Construction Sector

The consistency of Afghanistan's construction sector has been a pressing concern, with limited progress and persistent challenges impeding the country's development. This critical analysis delves into the primary causes behind this issue such as the lack of government attention, insufficient emphasis on applied research, and the absence of professional construction engineering firms. The interplay of these factors creates a detrimental cycle that delays the growth and effectiveness of the construction industry in Afghanistan, requiring urgent attention and corrective actions. According to these findings, the leading contributor to the ongoing struggles of the construction sector in Afghanistan is the lack of attention from the government. Unstable politics coupled with insufficient resource allocation, has resulted in a dearth of strategic planning, regulatory frameworks, and policy executions required for industry progress. Without a strong commitment from the government to prioritize and invest in the construction industry, progress will remain stagnant, exacerbating the country's developmental challenges. Furthermore, the industry's dependence on outdated methods and traditional practices delays its ability to keep pace with global advancements and adopt innovative approaches. The lack of applied research restricts the sector's potential for efficiency gains and compromises the long-term durability of infrastructure projects. The absence of professional construction engineering firms further worsens the challenges faced by the sector. Afghanistan suffers from a scarcity of specialized firms equipped to handle complex projects competently and with expertise. The limited availability of skilled professionals and the absence of engineering construction firms have prevented the construction sector of Afghanistan from meeting international standards, leading to its consistent deficit for decades. By actively addressing the lack of government attention, the absence of applied research, and the shortage of professional construction engineering firms, Afghanistan can reveal the potential of its construction sector. This, in turn, will pave the way for sustainable development, economic growth, and improved living conditions for its citizens.

4.2 Suitability of Steel for Sustainable Construction in Afghanistan

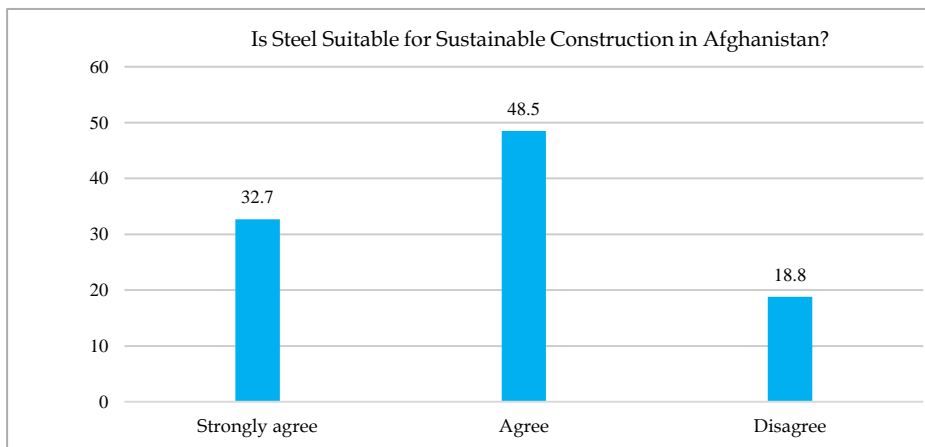


Figure 2: Suitability of Steel for Sustainable Construction in Afghanistan

Given the overwhelming consensus among structural engineers regarding the suitability of steel for sustainable construction in Afghanistan, steel will play a key role in achieving the sustainable development goals (SDGs) of the construction industry in the country. In fact, it may even replace concrete in the future. This is because steel is a recyclable, reusable, and durable material, making it the preferred choice for structural engineers

who prefer environmental sustainability. In contrast, the waste material from concrete, which currently accounts for 95% of constructions in Afghanistan, poses a permanent threat to the environment. Therefore, steel emerges as the environmentally friendly choice for the country's environmental sustainability.

4.3 Effects of Steel Construction Shortage on Infrastructural Development

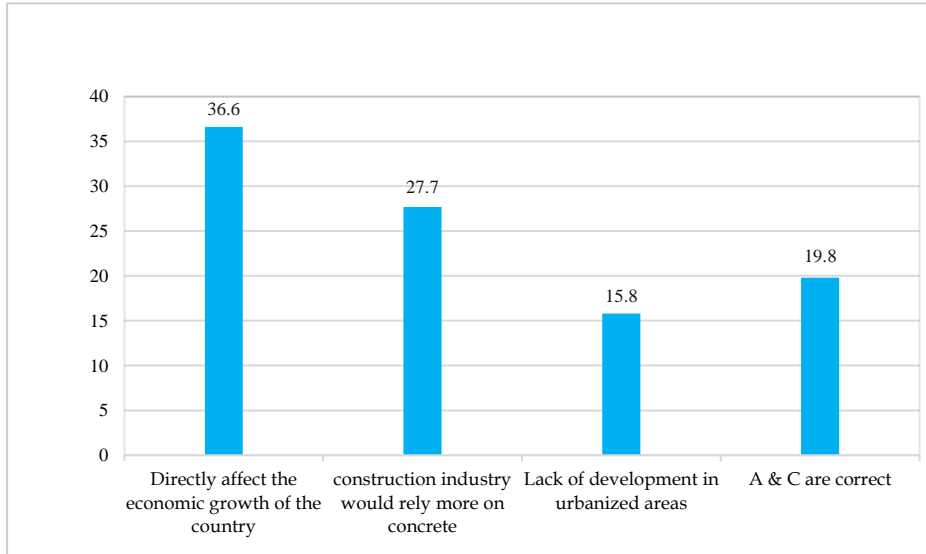


Figure 3: Effects of steel construction shortage on infrastructural development

Steel has established itself as a sustainable and essential material for the construction industry in developed countries well into the 21st century. Its use in major infrastructure projects, such as long-span bridges, railways, industrial structures, and tunnels, has directly contributed to their economic growth. However, Afghanistan's infrastructure profoundly relies on concrete materials, and the lack of steel construction has significantly obstructed its development. According to the survey, 36.6% of respondents believe that the shortage of steel construction directly impacts the country's economic growth. Given the pivotal role of infrastructure in driving economic activity, the absence of steel construction has slowed down development, thus reducing economic opportunities. The sustainability and affordability of steel are crucial factors that directly contribute to economic activity, making it an essential consideration for the construction industry. Moreover, the shortage of steel construction often leads to project delays, as concrete structures require more time and resources compared to their steel counterparts. Structural engineers emphasize the significant economic importance of steel due to its sustainability and eco-friendly nature. Furthermore, steel plays a critical role in the construction of long-span structures, skyscrapers, tunnels, and rails, which are the backbone of a developing country's infrastructural development. Additionally, the use of steel in Afghanistan's construction industry provides employment opportunities for many people, from steel production to construction commencement, thereby contributing to the overall economic growth of the country. Most significantly, incorporating steel into Afghanistan's construction industry paved the way to an improvement in the quality of life for its people by providing excellent transportation systems, housing, and other essential facilities. By utilizing steel in infrastructural development, the lifespan of structures can be extended beyond that of other materials.

4.4 Steel's Contribution to the Environment

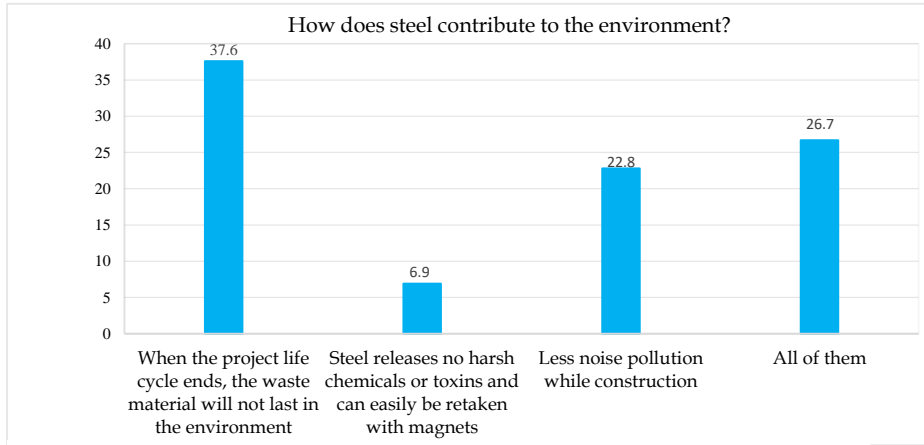


Figure 4: Steel's contribution to the environment

37.6% of structural engineers strongly believe that the use of steel in Afghanistan's construction industry will have a positive impact on the environment by ensuring that waste materials do not remain in the environment at the end of a project's life cycle. This shift from concrete to steel structures will contribute to environmental sustainability through energy efficiency, sustainable construction practices, and the reduction of carbon footprints. The steel industry's continuous improvement in environmental performance through innovation and technology makes it the best option for promoting sustainable construction in Afghanistan. By choosing steel, not only will infrastructural development be facilitated, but also the impact of waste on the environment will be minimized, leading to a more sustainable future for the country.

4.5 Barriers and Challenges to The Shortage of Steel Construction

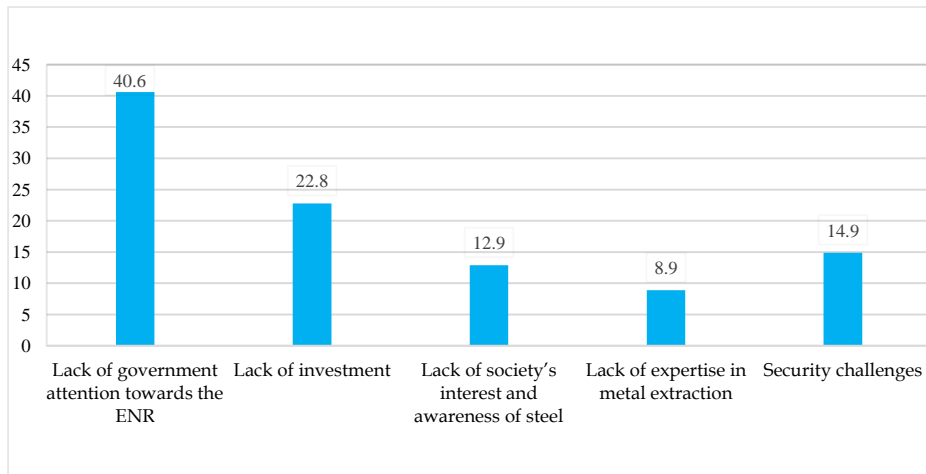


Figure 5: Barriers and Challenges to the Shortage of Steel

Most of structural engineers and steel mills have identified the lack of government attention towards the extraction of natural resources as a key barrier and challenge leading to the shortage of steel structures in construction industry. Additionally, interviews conducted with steel experts from steel mills have revealed a potential insufficiency of steel scraps within the next few years. Consequently, there is a looming possibility of reduced steel production or even a complete ending of steel production in

Afghanistan's construction industry within the mentioned timeframe. To ensure sustainable operations and maximize social benefits, it is imperative for the government to cautiously regulate the extraction of natural resources. By addressing this issue, the government can mitigate the impending challenges faced by the steel industry, foster a stable supply of steel, and support the growth of the construction sector. These findings highlight the significance of government attention towards the extraction of natural resources in Afghanistan. By implementing effective principles and strategies, the government can safeguard the availability of essential resources, sustainably support the construction industry, and contribute to the overall development of the nation.

4.6 The Dominance of Concrete Structures Over Steel Structures

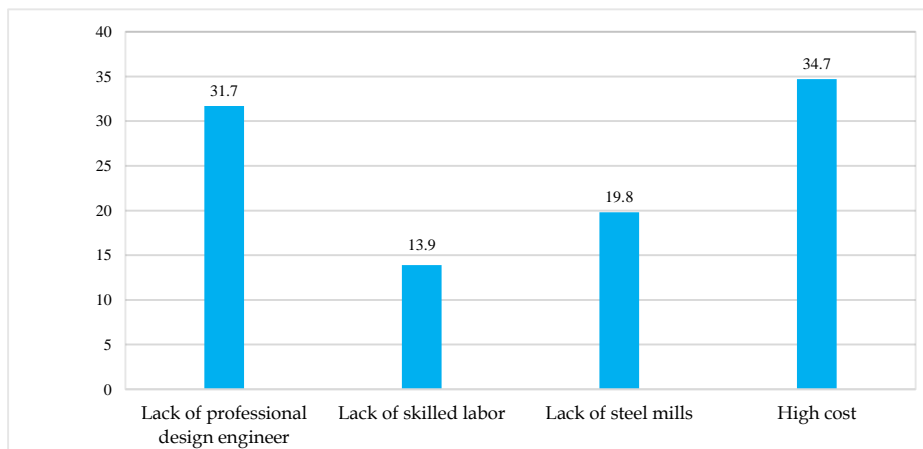


Figure 6: Causes of the dominance of concrete structures over steel structures

Despite Afghanistan boasting a significant number of iron mines, most of them remain untapped, resulting in the bulk of required steel sections being imported from foreign countries. It is imperative for the government to support the use of steel structures within Afghanistan's construction industry. Furthermore, the high cost of steel construction intensifies the dominance of concrete structures. The country's economic challenges, including the expense of importing steel materials and the scarcity of skilled labor, make concrete a more cost-effective and readily available option.

By fully harnessing the potential of our iron mines through extraction, we can effectively shift the reliance on concrete to steel material in construction. This transition would bring about amplified reliability and enable the construction of steel structures at comparable costs. Additionally, Afghanistan's construction industry faces a shortage of specialized engineers, leading to a greater reliance on concrete rather than steel. To address this issue, the government must prioritize the training and development of professionals specializing in steel design. By doing so, a balance can be achieved between steel and concrete structures.

The government's focus on extracting iron from the mines and promoting the use of steel structures is crucial for the advancement of Afghanistan's construction industry. It presents an opportunity to control our own resources, reduce dependency on imports, and foster economic growth. Simultaneously, investing in the training and professionalization of steel design engineers will enhance the expertise available within the industry, leading to a more sustainable and balanced approach to construction. By addressing the cost challenges, promoting local resource utilization, and developing a

skilled workforce, the country can unlock the untapped potential of the steel industry and elevate the construction sector to new heights.

4.7 Ways to Promote the Steel Construction in Afghanistan

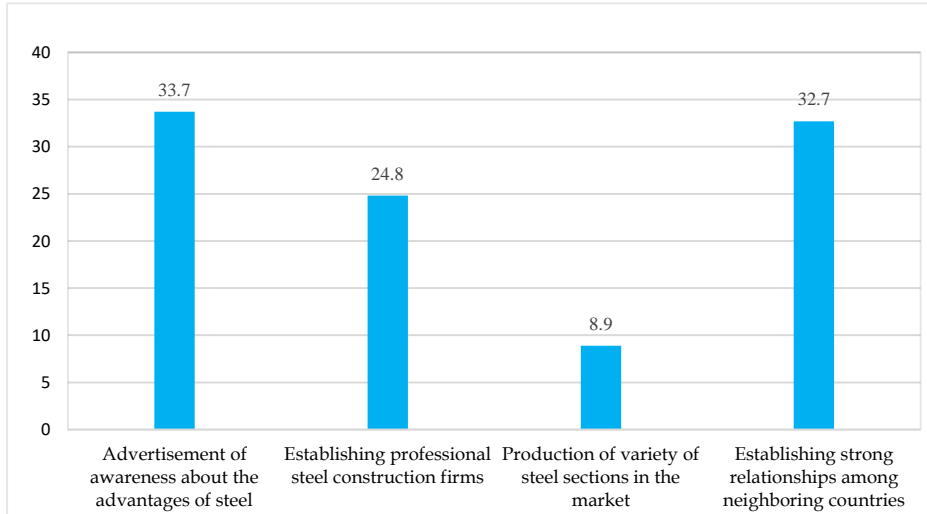


Figure 7: Ways to promote the steel construction in Afghanistan

Every developed nation recognizes the fundamental role of the construction sector in driving national development. As the backbone of developing nations, the construction industry is crucial for building essential infrastructure such as roads, bridges, airports, and buildings. Considering this significance, structural engineers were consulted to recommend effective solutions for promoting steel construction within Afghanistan's construction industry. The engineers devastatingly recommend establishing strong relationships with developed countries as the first key solution. Through these relationships, the government can initiate workshops and seminars aimed at enhancing the capacity of structural engineers and steel building techniques. Additionally, such collaborations present an opportunity to train skilled labor in the steel construction sector, addressing the essential need for a qualified workforce in the industry. Another significant solution proposed by the engineers is the promotion and awareness about the advantages of steel structures through mass media and social media platforms. The government can conduct awareness sessions through these channels, as they are widely accessible to most people in Afghanistan. By effectively communicating the benefits and positive impacts of steel, there is a potential to generate public interest and inclination toward the construction of steel structures.

Furthermore, the establishment of ASCA (Afghanistan Steel Construction Association) is crucial for the development and expansion of Afghanistan's steel construction sector. Majority of respondents strongly believe that the formation of this association will not only raise the skills of structural engineers in the construction industry, but also make a significant contribution to the sector's progress, competitiveness, and overall impact on the country's infrastructure development and economic growth. This Association can establish and promote international standards, guidelines, and best practices for steel construction in Afghanistan.

It is imperative for the government to recognize the significance of these recommendations and take proactive measures to implement them. By doing so,

Afghanistan can unlock the full potential of the steel construction sector, driving economic growth, and establishing a solid foundation for sustainable development.

5. Conclusion and Recommendations

In conclusion, the study has identified several root causes and challenges of the steel construction shortage in Afghanistan and highlighted its significant impact on infrastructural development.

The government neglect is the main cause of the construction sector stagnation in Afghanistan. To promote sustainable and environmentally friendly infrastructure development, there needs to be a focus on steel construction. This includes investing in professional design engineers, reducing costs, and paying attention to raw material extraction. The government should invest in research, education, and public-private partnerships (PPPs) to promote steel construction.

To promote steel structures, the report recommends advertising through mass media and social networks, as well as establishing relationships with developed countries to launch workshops and training sessions for engineers.

The government should invest in training programs for design engineers specialized in steel construction and establish the Afghanistan Steel Construction Association (ASCA). By collaborating with international partners and providing incentives for professional development and certification in steel construction, Afghanistan can create an environment favorable to the use of steel in construction.

The government needs to focus on extracting raw materials to address the shortage of steel in Afghanistan's construction sector. Encouraging public-private partnerships (PPPs) and investing in resource investigation will help accelerate the development of the mining sector and ensure the availability of raw materials for steel production.

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