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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

## 1. Introduction

Steel is an indispensable and essential foundation in all aspects of construction, serving as the fundamental support for slabs and the construction of entire building frameworks. With its extensive range of shapes, sizes, chemical compositions, and mechanical properties, steel provides unparalleled adaptability for multifaceted deployment in diverse 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, the 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, distinguish it from all other construction materials. Furthermore, steel structures are lighter in weight compared to concrete structures, resulting in a reduction in health hazards, waste, energy use, 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. According to the World Steel Association, the utilization of steel across various sectors is as follows: 52% in buildings and infrastructure, 3% in the realm of electrical equipment, 10% in the production of metal products, 16% in the fabrication of mechanical equipment, 12% in the automotive industry, 2% in domestic appliances, and 5% in various modes of transportation. These statistics vividly illustrate the prevalent influence and crucial role of steel in a wide array of vital sectors [6]. Steel is a vital component in the construction of developing infrastructures and is of significant economic importance [4], [7]. Despite the historical development in the steel industry, Afghanistan's progress was hindered by frequent wars. However, after 40 years of conflict, Afghanistan began its path 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 [8], [9].

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 [18]. 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 to promote standard steel construction and integrate 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 a negative environmental impact. Additionally, a lack of awareness and knowledge about the benefits of steel construction has stalled its adoption in Afghanistan, preventing 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 levels of pollution. 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 development the strengthening of infrastructural development. Therefore, research and investigation in this area play a vital role in the evolution of Afghanistan's infrastructure and construction industries. It is essential to understand the importance 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 the 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 demonstrate the impact of the steel construction shortage on the pace and quality of infrastructural development in Afghanistan.
- .3 To explore potential solutions and strategies for addressing the steel construction shortage in Afghanistan and improving infrastructural development.
- .4 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. Review of Literature*

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 the current Afghanistan construction market, 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 lack of technology in the country, and a general lack of awareness of the benefits of steel has led 95% of customers to prefer concrete structures over steel structures [18].

### *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. The selection in construction must prioritize environmental suitability, while the promotion of material recovery at the end of the life cycle is essential for overall sustainability. Taking a complete approach to building assessment across all stages of the life cycle is crucial [10]. Ensuring

sustainability is the shared obligation of every individual and a vital objective for our society. It involves fulfilling our present needs while protecting the capacity of future generations to meet their own needs. The steel industry understands the imperative of addressing sustainability concerns and has actively undertaken various initiatives and programs to fulfil its unwavering dedication towards building a sustainable society [11]. Steel structures offer numerous advantages in 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. Furthermore, sustainable construction practices involve energy-efficient building designs and the integration of renewable energy sources. Steel structures play an essential role in the achievement of sustainable construction objectives, fostering a responsible and environmentally aware construction industry [12].

### *2.3. Performance of Steel over Concrete*

Steel beats concrete in numerous crucial aspects, demonstrating its undeniable prominence. First, the exceptional strength-to-weight ratio of steel allows for the construction of lightweight structures, providing a clear advantage. In addition, 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 [13]. Notably, steel's high ductility allows for considerable deformation without fracturing, providing irreplaceable flexibility and resilience in structural applications. Unlike 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 [14].

#### *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 [15]. Moreover, there is a growing trend in designing steel buildings for reusability. The reuse of steel within these structures not only contributes to resource conservation but also yields significant reductions in CO<sub>2</sub> emissions. Estimates suggest that reusing steel within buildings can result in CO<sub>2</sub> emissions savings of approximately 1 to 1.5 kg of CO<sub>2</sub> per kilogram of steel [16]. In recent years, steel has become synonymous with energy efficiency and is now the top choice of 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. The environmental advantages of steel make it the preferred material for modern construction practices [17].

### 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 [19]. 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 the soil and its impact on the seismic response of buildings, known as the soil-structure interaction (SSI), add complexity to this concern [20]. Hybrid cold-formed steel (HCFS) structures represent an innovative revolution in the light steel construction industry, ushering in a new era of seismic performance, especially in Ordinary Moment Resisting Frames (OMRF). The structural analysis of these systems unequivocally demonstrates that the hybrid system outperforms traditional methods, showcasing superior structural performance in terms of story shear and drift [21]. 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 in 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 soils has minimal impact on all floors [22].

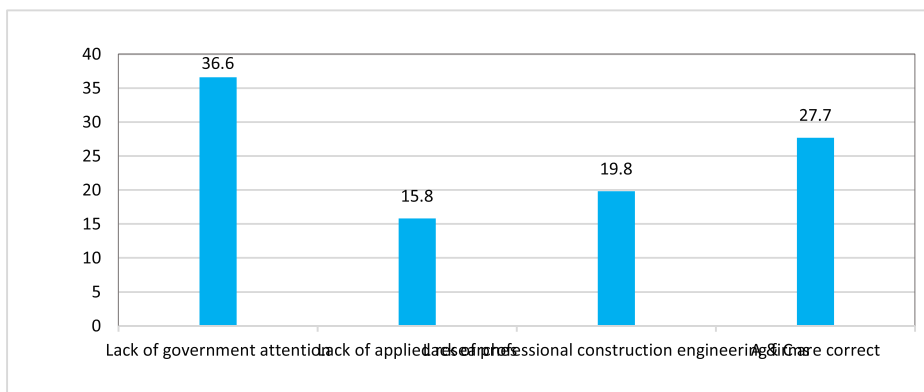
## 3. Methodology

### 3.1. Research Method

The study adopted a qualitative and analytical approach to thoroughly investigate the root causes of the steel shortage in the construction industry in Afghanistan. Data was collected using questionnaires and interviews to identify the barriers and challenges behind this shortage. The questionnaire, which consists of 12 questions, was designed to gather information on the main causes of the shortage and to gather recommendations for feasible solutions. The interviews were carried out 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. Results and Discussion

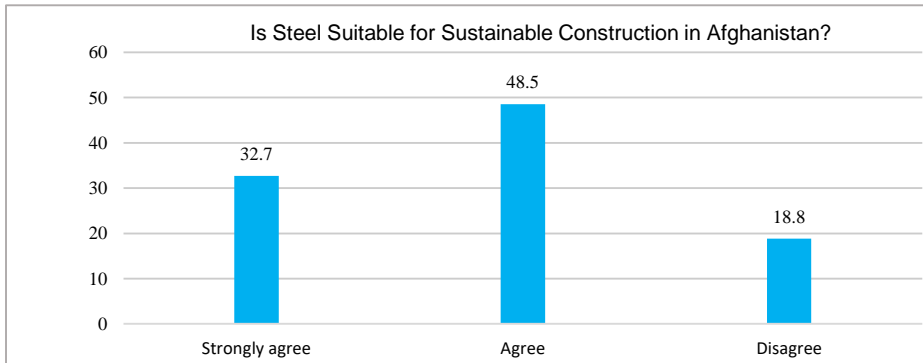
### 4.1. The Main Causes Behind the Consistency of Afghanistan's Construction Sector



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

The lack of government attention toward the construction industry and the absence of professional construction engineering firms are indeed significant factors contributing to 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 that impair 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 main contributor to the ongoing struggles of the construction sector in Afghanistan is the lack of government attention. 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 constant 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 better living conditions for its citizens.

#### 4.2. Suitability of Steel for Sustainable Construction in Afghanistan



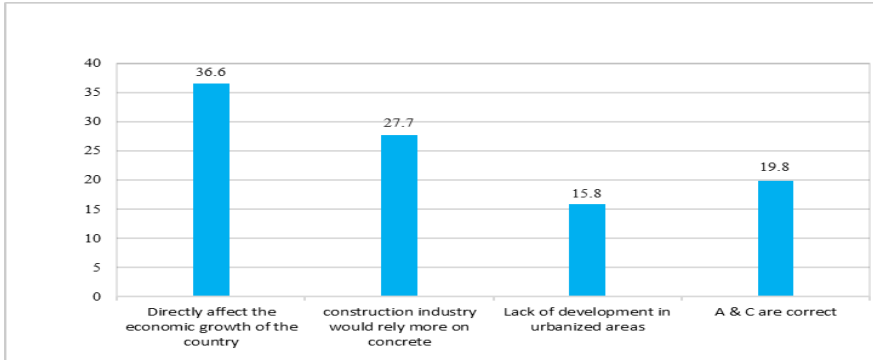
**Figure 2:** Suitability of Steel for Sustainable Construction in Afghanistan

Figure 2 indicates that a notable portion of structural engineers (32.7% strongly agree and 48.5% agree) believe that steel is suitable for sustainable construction in Afghanistan. This division of professional opinions requires an urgent and rigorous critical examination to thoroughly unravel the underlying factors and the far-reaching implications involved. Further, given the overwhelming consensus among structural engineers on the suitability of steel for sustainable construction in Afghanistan, steel will play a key role in achieving the Sustainable Development Goals (SDG) of the country's construction industry. 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. The waste material from concrete, which currently accounts for 95% of constructions in Afghanistan, poses a permanent threat to the environment. If the belief in the suitability for sustainable construction is embraced and acted upon, it can positively impact the future of infrastructure development in Afghanistan. Steel strength, durability, and design flexibility can contribute to the construction of more resilient and efficient buildings and infrastructure, improving the country's overall development. Therefore, steel emerges as the environmentally friendly choice for the country's environmental sustainability.

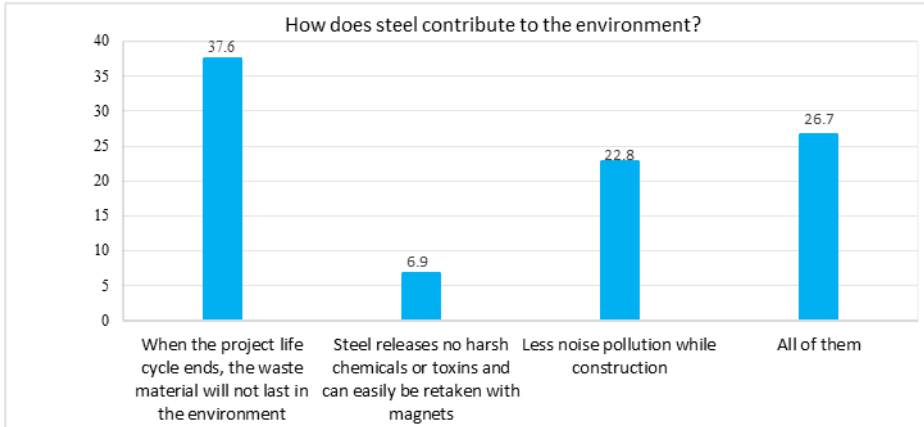
#### 4.3. Effects of Steel Construction Shortage on Infrastructural Development



**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 is profoundly dependent on concrete materials, and the lack of steel construction has significantly obstructed its development. According to the survey, 36.6% of the 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. Steel sustainability and affordability 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 country's overall economic growth. Most significantly, the incorporation of steel into Afghanistan's construction industry paves the way for an improvement in the quality of life of 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

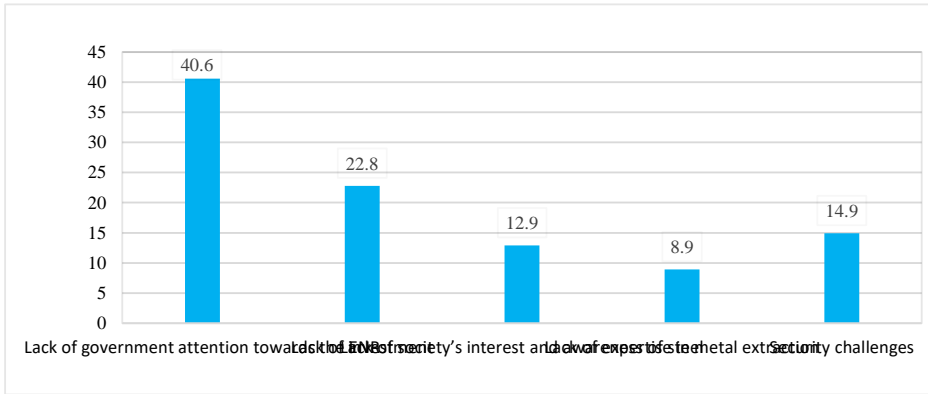
37.6% of structural engineers strongly believe that the use of steel in Afghanistan's construction industry will have a positive impact on the environment by ensuring that waste materials do not remain in the environment at the end of a project's life cycle. The inherent durability and recyclability of steel ensure that its waste materials do not persist indefinitely in the environment, distinguishing it from other construction materials such as plastics or specific types of concrete. Steel waste exhibits a comparatively diminished long-term environmental footprint. The recyclability of steel presents a pathway to sustainable resource utilization, as recycling steel waste decreases the necessity for extracting and processing fresh raw materials, thereby preserving Afghanistan's precious natural resources. 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 continuous improvement in environmental performance through innovation and technology makes it the best option to promote 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*

Most 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 the construction industry. Additionally, interviews with steel experts from steel mills have revealed a possible insufficiency of steel scraps over 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 time frame. To ensure sustainable operations and maximize social benefits, it is imperative for the government to carefully regulate the extraction of natural resources. By addressing this issue, the government can mitigate the impending challenges faced by the steel industry, promote a stable supply of steel, and support the growth of the construction sector. These findings highlight the importance of government attention towards the extraction of natural resources in Afghanistan. By implementing effective principles and strategies, the government can protect the availability of essential resources, sustainably support the construction industry, and contribute to the nation's overall development.

#### *4.6. The Dominance of Concrete Structures Over Steel Structures*

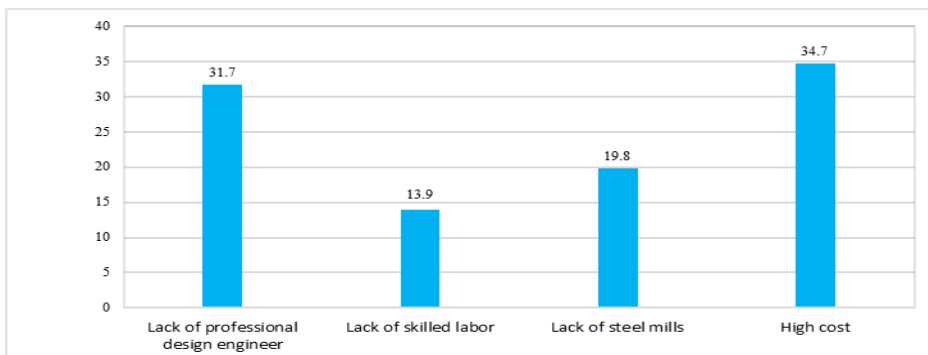
As shown in Figure 6, the construction industry in Afghanistan has witnessed the predominance of concrete structures over steel, mainly due to two major factors: the scarcity of professional design engineers and the high cost associated with steel construction. The limited availability of skilled engineers specialized in steel design and construction has created a knowledge gap, leading to a natural inclination towards the more familiar and accessible option of concrete. Additionally, the higher upfront cost of steel structures poses a significant barrier, as financial resources are often limited in the Afghan context. As a result, concrete structures have emerged as the preferred choice, offering a more affordable alternative with readily available materials and simplified construction techniques.



**Figure 5: Barriers and Challenges to the Shortage of Steel**

Although Afghanistan boasts 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 that the government supports 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 greater reliability and enable the construction of steel structures at comparable costs. In addition, Afghanistan's construction industry faces a shortage of specialized engineers, leading to a greater dependence 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.

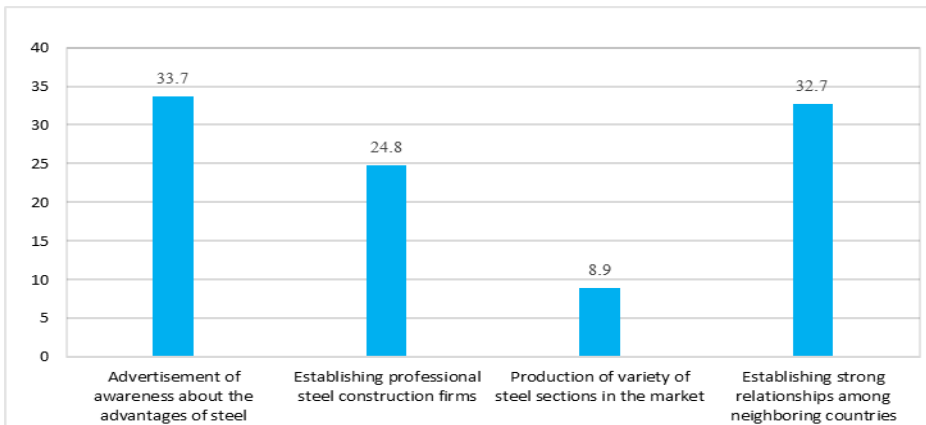


**Figure 6: Causes of the domination of concrete structures over steel structures**

The government's focus on extracting iron from the mines and promoting the use of steel structures is crucial to the advancement of Afghanistan's construction industry. It presents an opportunity to control our resources, reduce dependence on imports, and foster economic growth. At the same time, investing in the training and professionalization of steel design engineers will improve 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 shows that structural engineers are increasingly advocating for the promotion of steel construction in Afghanistan, recognizing that two major factors can play a pivotal role in this effort: advertising awareness about the advantages of steel and establishing strong relationships among developed countries. 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 to promote steel construction within the Afghan construction industry. Through these relationships, the government can initiate workshops and seminars to improve 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 engineers is the promotion and awareness of the advantages of steel structures through social 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 towards the construction of steel structures.



**Figure 7:** Ways to promote the steel construction in Afghanistan

Furthermore, the establishment of ASCA (Afghanistan Steel Construction Association) is crucial to the development and expansion of Afghanistan's steel construction sector. Most of the 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 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**

In conclusion, the study has pinpointed several root causes and challenges that contribute to the steel construction shortage in Afghanistan, emphasizing its substantial impact on infrastructural development.

- The government's insufficient attention to the construction industry and the lack of professional construction engineering firms are key factors that significantly prolong the challenges facing Afghanistan's construction sector.
- Structural engineers are firmly convinced that incorporating steel into Afghanistan's construction industry will explicitly benefit the environment by effectively preventing the accumulation of waste materials at the end of a project's life cycle.
- The government's neglect of natural resource extraction and inadequate investment in the steel industry are significant contributors to the formidable barriers and challenges facing the shortage of steel construction.
- The construction industry in Afghanistan has predominantly favored concrete structures over steel, mainly due to two major factors: the scarcity of professional design engineers and the high costs associated with steel construction.

To overcome persistent challenges in Afghanistan's construction sector and unleash the full potential of steel construction, the government should prioritize the industry, promote environmental sustainability, invest in natural resource extraction, address cost and expertise barriers, establish the Afghanistan Steel Construction Association (ASCA), find competent steel construction firms, and establish strong partnerships with developed countries.

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