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ANALYSIS OF ASIAN COUNTRIES IN CONSTRUCTION WASTE RECYCLING AND INTRODUCTION IN KAZAKHSTAN

The article presents a review of the experience of construction waste recycling in Asian countries, with a focus on the examination of successful strategies and practices that have been implemented in Japan, South Korea, and Singapore. As a consequence of the ongoing process of urbanization and the concomitant increase in construction activities in the region, the problem of construction waste management is becoming increasingly urgent. As reported by the World Bank, the Asia-Pacific region generates more than 1.5 billion tons of construction waste on an annual basis, necessitating the urgent implementation of recycling and reuse solutions. In comparison with Asian countries, the article also examines the problem of construction waste recycling in Kazakhstan, emphasizing the relevance of this topic in the context of a growing construction sector and increasing waste volumes. The quantity of construction waste generated in the country is reaching a considerable magnitude, with only a modest proportion of it being recycled, thereby creating significant environmental and economic challenges. The article examines existing recycling practices and technologies, including concrete recycling, wood and metal waste use, and examples of successful recycling implementation. The article identifies the challenges faced by construction companies, including a need for more infrastructure, low awareness, and economic barriers.

Keywords: construction waste, recycling, concrete, wood, metal.

Introduction

In light of the accelerated urbanization and construction expansion across Asia, the issue of construction waste management is assuming greater significance. In a region where populations are constantly growing and infrastructure projects are underway at all levels, recycling construction waste offers not only sustainable solutions but also economic benefits and contributes to the mitigation of environmental degradation. It is estimated that Asia generates in excess of 1.5 billion tons of construction waste on an annual basis, representing a substantial proportion of the total solid waste generated in the region [1].

As the construction sector in Kazakhstan continues to expand, the issue of waste management has become increasingly complex. The rapid growth of cities and the concomitant increase in construction activity have resulted in a significant rise in the volume of waste generated. As indicated by the Ministry of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan, the proportion of construction waste in the total volume of solid domestic waste is estimated to be as high as 30 % [2]. It is crucial to acknowledge that the majority of these materials are not recyclable and frequently end up in landfills, which has a detrimental impact on the environment. The recycling of construction waste is not only a necessity but also an opportunity for Kazakhstan to reduce the environmental burden and improve the economic efficiency of the construction sector.

As the construction sector in Kazakhstan continues to expand, the issue of waste management has become increasingly complex. The rapid growth of cities and the concomitant increase in construction activity have resulted in a significant rise in the volume of waste generated. As indicated by the Ministry of Ecology, Geology, and Natural Resources of the Republic of Kazakhstan, the proportion of construction waste in the total volume of solid domestic waste is estimated to be as high as 30 % [2]. It is crucial to acknowledge that the majority of these materials are not recyclable and frequently end up in landfills, which has a detrimental impact on the environment. The recycling of construction waste is not only a necessity but also an opportunity for Kazakhstan to reduce the environmental burden and improve the economic efficiency of the construction sector. This article presents a review of the current state of construction waste management in Kazakhstan, with a focus on examples of successful recycling initiatives and the principal challenges and prospects for advancement in this domain.

Materials and methods

This article presents a review of the experience of various Asian countries in the field of construction waste recycling, including an analysis of their strategies, successful practices, and results.

Furthermore, it examines the present state of construction waste management in Kazakhstan, illustrative examples of successful recycling initiatives, and the principal challenges and prospects for advancement in this domain.

Results and discussion

Construction waste, including concrete, bricks, wood, and metals, represents up to 30% of the total municipal solid waste in most Asian countries [3]. In light of the growing volume of construction activities, it is imperative to implement expedient solutions to recycle and reuse these wastes. The environmental impact of construction waste is significant, with contamination of soil, water, and the atmosphere, as well as an increased burden on landfills, being particularly notable concerns. The United Nations Environment Programme states that the lack of effective waste management results in the loss of valuable resources. This underscores the necessity for a transition towards sustainable methods of recycling and management of construction waste, both from an environmental and economic standpoint [3]. To illustrate, we may consider the successful implementation of recycling construction waste from Asian countries.

Japan

Japan is one of the world leaders in construction waste management. In the aftermath of the 1995 Kobe earthquake, the Japanese government implemented measures to enhance waste management practices. The key strategies that have been identified include:

- Legislative initiatives: Strict regulations on construction waste recycling have been introduced, including mandatory requirements for waste management companies [4];
- Recycling Infrastructure: Japan has developed efficient waste collection and recycling systems, including specialized recycling plants [5];
- Education and Awareness: The implementation of active educational programs for both construction companies and the general public on the paramount importance of recycling.

The Ministry of the Environment of Japan reports that the country's recycling rate for construction waste exceeds 90 % [5].

South Korea

Similarly, construction waste recycling technologies in South Korea are also being actively developed. The primary considerations are as follows:

- government programs: In order to encourage the recycling of waste materials, the government has introduced subsidies and tax incentives for companies engaged in recycling activities [5];
- innovative Technologies: South Korean companies are actively developing new recycling technologies, including methods for recycling concrete and asphalt [6];

- collaboration with private sector entities: The formation of collaborative relationships between government agencies and private companies to facilitate the exchange of knowledge and resources.

Statistical data indicates that the recycling rate of construction waste in South Korea has reached 80 % [5].

Singapore

Singapore serves as an exemplar of efficacious construction waste management in tight space constraints. It has developed strategies to optimize the utilization of available resources:

- Zero Waste Strategy: a comprehensive approach to waste management that aims to eliminate waste at its source. The Singaporean government is implementing a waste reduction program to achieve zero waste by 2030 [7];

- Concrete recycling: Singapore has demonstrated effective waste management strategies. Concrete waste is actively recycled and subsequently utilized as an aggregate for the production of new building materials [8];

- Innovation and Technology: Innovative technologies, such as 3D-printing, are being implemented to reduce waste in the construction industry.

As indicated in a report published by the Environmental Protection Authority of Singapore, the recycling rate of construction waste is approximately 90 % [9].

Despite successful practices, numerous Asian countries need help recycling construction waste:

- Lack of infrastructure: Some countries need a developed system for collecting and recycling construction waste [10];

- Lack of awareness: A significant number of construction companies and contractors need to recognize the importance and advantages of recycling [11];

- Economic barriers: The initial investment required for recycling can present a significant financial obstacle for small and medium-sized enterprises.

To enhance the efficacy of construction waste recycling in Asia, it is necessary:

- To improve legislation: A crucial step is to formulate transparent regulations and benchmarks for the administration of construction waste [3];

- To invest into infrastructure: It is recommended that both public and private investment be made in the establishment of recycling facilities [11];

- To educate and inform: It is recommended that educational programs elucidate the advantages of recycling for construction companies and the general public [10].

In Kazakhstan, construction waste is generated from a variety of materials, including concrete, bricks, wood, metal, and plastic products. The study «The State and Management of Waste in Kazakhstan» revealed that approximately 75 % of construction waste is disposed of in landfills, which are not subject to recycling [12]. Conversely, the recycling of concrete and other construction materials has the

potential to reduce the environmental impact significantly. For instance, recycled concrete can be utilized as an aggregate for new building materials and road bases. This reduces the volume of waste and the demand for primary resources, as evidenced by the findings of D. Adilova (2024) [13], who underscores the necessity of integrating recycling technologies for sustainable construction.

One illustrative example of successful reuse is the recycling of wood waste. Waste ends and old wooden structures can be repurposed as wood composites, such as particleboard and OSB, which can effectively contribute to the reduction of deforestation. Similarly, metal waste represents a valuable category for recycling. A study published in the journal *Ecology and Industry of Kazakhstan* (2021) [14] indicates that recycling metal waste can reduce the carbon footprint by 75 % compared to the production of new metal from primary resources. Nevertheless, in order to attain these outcomes, it is essential to allocate resources toward the establishment of dedicated recycling facilities and the expansion of supporting infrastructure.

Nevertheless, Kazakhstan encounters a number of challenges that impede the effective management of construction waste. One of the principal challenges is the need for a developed infrastructure for recycling. To date, the number of enterprises engaged in the recycling of construction materials in the country remains limited. As R. Tusupov (2023) [15] notes, less than 15 % of waste is recyclable, while the majority is sent to landfills. Furthermore, the need for more awareness among construction companies about recycling opportunities represents a significant barrier. A study by A. Kobeyeva (2022) [16] demonstrated that less than 30 % of companies are aware of the advantages of recycling and existing technologies. The high initial costs of recycling processes make them less financially attractive for businesses.

To address these issues, it is essential to establish a system that incorporates both public and private initiatives. The development of infrastructure for the recycling of construction waste should be designated as a priority within the state policy agenda. Investments in creating recycling facilities and waste collection points will assist in reducing the burden on landfills and improve the country's environmental situation (N. Sagadiyev, 2023) [17]. Furthermore, educational programs for construction companies will promote awareness and the adoption of recycling practices. As demonstrated by the research of D. Masanchi (2022) [18], the implementation of effective educational initiatives has the potential to significantly enhance the number of companies demonstrating interest in recycling their waste.

Conclusions

The recycling of construction waste in Asia constitutes a significant stride towards sustainable development in the region. The experience of countries such as Japan, South Korea, and Singapore illustrates that substantial environmental and economic benefits can be realized by implementing effective waste management

strategies. The collaboration of government, business, and society is essential for advancing sustainable construction waste management. This joint effort will facilitate overcoming existing barriers and establishing a sustainable system that will contribute to environmental conservation and the rational use of resources.

The recycling of construction waste in Kazakhstan has the potential to significantly enhance the construction sector's environmental situation and economic efficiency. The development of effective waste management systems, the creation of specialized infrastructure, the raising of awareness among construction companies, and the improvement of legislation represent pivotal steps towards the realization of sustainable development. The combination of efforts from all stakeholders, including government agencies, businesses, and society at large, can facilitate the transformation of construction waste from a problematic entity to a valuable resource. Such measures will mitigate the adverse effects on the environment and facilitate the creation of new economic opportunities for the country. In light of the expanding volume of construction activity, Kazakhstan is well-positioned to emerge as a frontrunner in sustainable construction waste management. This development will undoubtedly significantly contribute to sustainable development's future.

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ҚҰРЫЛЫС ҚАЛДЫҚТАРЫН ҚАЙТА ӨңДЕУ ЖӘНЕ ҚАЗАҚСТАНДА ЕНГІЗУ АЗИЯ ЕЛДЕРІНІҢ ТАЛДАУЫ

Мақалада Жапонияда, Оңтүстік Кореяда және Сингапурда жүзеге асырылған сәтті стратегиялар мен тәжірибелерді зерттеуге назар аудара отырып, Азия елдеріндегі құрылыс қалдықтарын қайта өңдеу тәжірибесіне шолу берілген. Өңірде жүріп жатқан урбандалу үдерісі және құрылыс жұмыстарының ілесіне ұлғаюы нәтижесінде құрылыс қалдықтарын басқару мәселесі өзекті бола түсуде. Дүниежүзілік банк хабарлағандай, Азия-Тынық мұхиты аймағында жыл сайын 1,5 млрд. т. астам құрылыс қалдықтары пайда болады, бұл қайта өңдеу және қайта пайдалану шешімдерін шұғыл енгізуді қажет етеді. Мақалада Азия елдерімен салыстыра отырып, Қазақстандағы құрылыс қалдықтарын кәдеге жарату мәселесі де қарастырылып, құрылыс секторының өсіп келе жатқаны және қалдықтар көлемінің ұлғаюы жағдайында бұл тақырыптың өзектілігіне баса назар аударылады. Елде түзілетін құрылыс қалдықтарының мөлшері айтарлықтай мөлшерге жетіп, оның аз ғана бөлігі ғана қайта өңделеді, осылайша елеулі экологиялық және экономикалық қиындықтар тудырады.

Мақалада бетонды қайта өңдеу, ағаш және металл қалдықтарын пайдалану және қайта өңдеуді сәтті енгізу мысалдарын қоса алғанда, қайта өңдеу тәжірибесі мен технологиялары қарастырылады. Мақалада құрылыс компанияларының алдында тұрған қиындықтар, соның ішінде инфрақұрылымды арттыру қажеттілігі, хабардарлықтың төмендігі және экономикалық кедергілер анықталған.

Кілтті сөздер: құрылыс қалдықтары, қайта өңдеу, бетон, ағаш, металл.

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АНАЛИЗ СТРАН АЗИИ ПО ПЕРЕРАБОТКЕ СТРОИТЕЛЬНЫХ ОТХОДОВ И ВНЕДРЕНИЕ В КАЗАХСТАНЕ

В статье представлен обзор опыта переработки строительных отходов в странах Азии с акцентом на изучение успешных стратегий и практик, которые были реализованы в Японии, Южной Корее и Сингапуре. В результате продолжающегося процесса урбанизации и сопутствующего увеличения строительной деятельности в регионе проблема управления строительными отходами становится все более актуальной. По данным Всемирного банка, в Азиатско-Тихоокеанском регионе ежегодно образуется более 1,5 млрд. т. строительных отходов, что требует срочного внедрения решений по переработке и повторному использованию. В сравнении со странами Азии в статье также рассматривается проблема переработки строительных отходов в Казахстане, подчеркивая актуальность этой темы в контексте растущего строительного сектора и увеличения объемов отходов. Количество строительных отходов, образующихся в стране, достигает значительных величин, при этом лишь незначительная их часть перерабатывается, что создает значительные экологические и экономические проблемы. В статье рассматриваются существующие практики и технологии переработки, включая переработку бетона, использование отходов древесины и металла, а также примеры успешной реализации переработки. В статье рассматриваются проблемы, с которыми сталкиваются строительные компании, включая потребность в дополнительной инфраструктуре, низкую осведомленность и экономические барьеры.

Ключевые слова: строительные отходы, переработка, бетон, древесина, металл.

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