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Comparing the Benchmarks of Chapter 19 of National Building Regulations with the Benchmarks of the DGNB Evaluation System to Evaluate Tabriz's Aseman Residential Complex*

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ABSTRACT

Sustainability evaluation systems help to evaluate buildings. Given the different circumstances of each country, no single common version can be prescribed for all countries. Recently, Chapter 19 of National Regulations has been focused on Iran as the standard for optimizing building energy consumption. By selecting the German Building Evaluation System of DGNB[1], this article aimed to compare its benchmarks with those outlined in Chapter 19 and to identify similarities and differences between the two [systems], which would develop national regulations and achieve a local building evaluation system. This study fell under comparative research and meticulously investigated and compared the two systems to provide a checklist of shared criteria, as noted in Tabriz's Aseman Residential Complex (Iran). Based on the six qualities prescribed by the suggested Chapter 19 system, technical qualities were more focused, followed by some social-functional criteria and processes, with other qualities discarded. According to Chapter 19, such major subjects as smartization, recycling and recovery, and transportation infrastructure have not received attention. On the other hand, concerning the case study, field observations, maps, and executive documents, as well as interviews with residents and technical assistants of project installations revealed that the quality of the complex tended to be based on architectural design and the site's quality, as well as the quality of cooling and heating installations. The benchmarks of both systems in such areas as quality of the external shell, use of natural light, passive systems, and use of new technologies were not addressed. Concerning the easiness of cleaning and recycling and recovery, as raised by the DGNB system, a lack of attention in the design stage was noted.

Keywords: Chapter 19 of National Regulations, Evaluation System, Green Buildings, DGNB, Cold and Hot Climates.

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1. INTRODUCTION

According to Article 33 of the National Construction Engineering Organization, the Ministry of Housing and Urban Development is entrusted with monitoring the execution of national building rules and regulations in the design and implementation of all buildings. Accordingly, the Ministry of Housing has published national building regulations in 22 chapters, out of which Chapter 19 pertains to saving energy consumption in buildings. Chapter 19 of National Building Regulations was verified by the Board of Ministers in 1991 and whose implementation was made mandatory across the country. This chapter was revised several times (Bureau for National Building Regulations; Chapter 19 of National Building Regulations (2013)). Since national regulation-related chapters serve as construction standards and the aforementioned chapter sets the benchmarks for energy consumption optimization, and also although the first version saw improvements over the last years, few significant developments have been made in optimizing building energy consumption since then. For this, it is required to provide more in-depth studies in this regard to have a more reliable framework for the better implementation of these benchmarks. International systems can also serve as guides for directing and developing national regulation chapters. Building evaluation systems provide standards in the stages of design, implementation, maintenance, and destruction of buildings, which would evaluate buildings using prescribed criteria (Rovaeean et al. 2014). Evaluation systems such as LEED[2] (U.S.), and BREEAM[3] (England), among others, are key systems that serve as models for other systems (Hassangholinejad, Mofidi Shemirani, and Ghobadian 2020). In this connection, the evaluation system of DGNB, which is sustainable building certification in Germany, is the second generation of building evaluation (i.e., a system developed following LEED and BREEAM and adapted their initial frameworks) (Braune et al. 2019) and its benchmarks are based on Europe's benchmarks. This system relies on the three-pillar model of sustainable development (DGNB system 2018). Since local and regional variables, as well as urban and architectural standards, are critically influential in international evaluation systems and available global systems cannot be applied to Iran's climate, it is required to base our decisions on climatic conditions, regional priorities, and other standards, which are being formulated and implemented across Iran so that a local and sustainable system is developed (Hassangholinejad and Mofidi 2019).

Thus, by selecting the German Building Evaluation System of DGNB, this article aimed to compare its benchmarks with the benchmarks outlined in Chapter 19 to develop green construction in Iran. The reasons for selecting this system, which makes this article distinct from previous studies, is that this subject has been less concerned with in previous research and the past findings have not been repeated. Other reasons include the comprehensiveness of this system, which helps focus the criteria not addressed in other major systems. In the meantime, one can refer to similarities between different areas of German climate and cold areas in Tabriz, as well as the cooperation between the system's management with Iranian associations and the National Construction Engineering Organization, which helps train Iranian engineers.

Comparing the two systems, Chapter 19 cannot cover all of DGNB's components due to its comprehensive nature, as more common areas in the technical quality section could be expected considering the focus of the chapter on technical issues.

Since this study aimed to find common themes and differences between the DGNB system and Chapter 19 of Iran's National Regulation to identify the weak and strong spots of the chapter, using comparative methods can serve as an appropriate solution to meet the goals of the study. To this aim, a review of the past literature led to an accurate investigation of both benchmarks. Later, a comparison of the benchmarks was performed. After finding common themes and differences in the last stage to provide a more applicable evaluation of the benchmarks, which sounded more similar to each other, a checklist was provided and used in a case study in the cold and arid climate of Tabriz.

2. LITERATURE REVIEW

So far, numerous researches have investigated and compared the subject of buildings' sustainability evaluation systems, as released by credible global journals. The majority of comparative research has mainly evaluated two key BREEAM and LEED systems and pertinent derived systems. The Japanese Comprehensive Evaluation System for Building Environmental Efficiency system is relatively recognized. However, fewer studies can be found to have compared and analyzed France's long-standing HQE[4] and Germany's successful DGNB, along with other key systems. The unavailability and French language of the HQE system and the German language and the novelty of the DGNB, on the one hand, and the presence of structural and substantial differences between these two systems with BREEAM and LEED systems, on the other hand, could be the main reasons why the French and German systems are less concerned within the research.

In a study in 2016, Bence Guard posited that previously, a kind of development of "energy design" was focused attention and it was quite difficult to materialize a building with low energy; however, the integrated evaluation of energy design (IEED), including its various approaches, such as integrated delivery, which appeared years later, expedited this process.

Antonio et al. (2019) investigated the LEED, BREEAM, HQE, and DGNB to conclude that the latter was most consistent with the European Union's Sustainability Goals (Antonio Sánchez Cordero et al. 2019).

Mofidi et al. (2018) compared and analyzed five internationally recognized systems, suggesting that the basics and approaches of each system had an effective role in organizing the content structure of the benchmarks; for instance, DGNB, whose evaluation structure is based on the three-pillar principles of sustainable architecture, has a significant portion of its benchmarks concerned with social-economic subjects. Meanwhile, the structures of BREEAM, LEED, and HQE, which fall under the first generation of systems, have structures mainly focused on environmental issues (Mofidi Shemirani, Tahbaz and Mehraban 2019).

2.1. Evaluation Systems

These systems quantify sustainable concepts in the building industry to eventually help formulate regulations and standards for the environmental scoring of buildings. The first building sustainability evaluation system, called BREEAM, was launched in England in 1990 by the Building Research Establishment (BRE). In 1998, the first scoring system version (LEED) was presented as a Green Building Design Regulation by the U.S. Green Building Council (Nik Rawan and Azizi 2017). This was followed by other systems such as GreenStar in Australia, CASBEE in Japan, DGNB in Germany, and HQE in France (Fig. 1).

Most scoring systems aim to produce a comprehensive approach to building efficiency and functions. Meanwhile, some of the systems only take evaluable and easily accessible aspects into account. These systems may simultaneously provide suggestions about how to integrate green elements into designing and administering buildings with flexible criteria. Although the criteria related to sustainable building scoring systems may pursue common goals, their structures are completely different (Zuo and Zhao 2014).

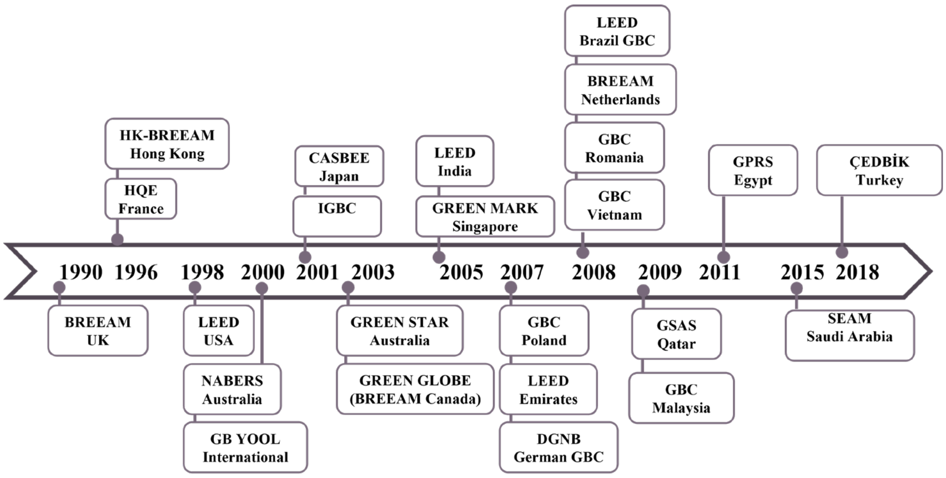

Fig. 1. Timetable of Green Building Scoring System Development

The reason why several different systems have appeared across the world is that evaluation systems are mainly national or international, whereas the concept of sustainability specifically attends to local issues and circumstances. Although nature creates a common sense of life over the earth, local circumstances make this sense completely different in detail (Farzadipour and Ehsani Mehr 2014).

2.2. DGNB Evaluation System

DGNB is a German acronym standing for the German Sustainable Building Council, founded in collaboration with the German Federal Ministry of Transportation, Building and Urban Affairs in 2007. This certification-issuing system was developed based on the three pillars of economic, environmental, and social culture in planning, construction, and utilization of buildings in Germany. This system refers to the Environmental product declaration, developed based on the 14025ISO and 15804EN, and is computed by using the lifecycle evaluation method using quantitative criteria (Braune et al. 2019).

The sustainability concept of the DGNB system relies on the three-pillar model of sustainable development (e.g., environmental, social, and economic). Hence, the benchmarks of this system include environmental, economic, technical, social-cultural-functional, process, and site qualities, which cover all sustainable building components. The first four qualities enjoy equal share and weight in the evaluations and evidence their equal importance. For example, in the [DGNB] system, the evaluation of the building's economic components is important by as much as the environmental and social components (Mofidi

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Shemirani, Tahbaz, and Mehraban 2019).
DGNB has a wider scope of sustainability and is beyond the famous 3-pillar model. This system, which comprehensively covers all fundamental components of sustainable building, consists of the following six subjects, namely, ecological, economic, social-cultural and functional, technological, processes and site components (Fig. 1). This method converts the DGNB system to the only system that gives importance to both the economic component of sustainable building and ecological criteria (DGNB systems 2018).

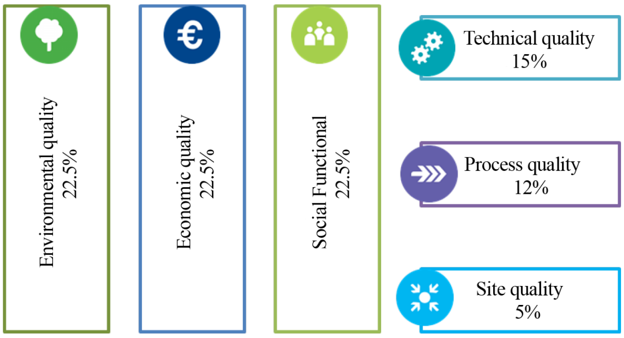

Fig. 2. The main DGNB System Structure
(DGNB System 2018)

2.3. Chapter 19 of Iran's National Regulations

Chapter 19 of the National Building Regulations is one of the guidelines related to the subject of sustainability in buildings, the last edition of which was released in 2020. The main theme of this chapter is energy saving. This chapter aims to provide solutions by providing benchmarks for the design, computation, and implementation of thermal insulation and heating, cooling, ventilation, and water consumption provision systems (Chapter 19 of National Building Regulations, 2020).
In addition to the regulations provided for by Chapter 19, to save energy consumption in the mechanical installation section, it is recommended to use active or inactive systems and equipment, that make use of renewable energy resources such as the sun and geothermal resources, specifically in buildings with built-up areas of over 2000 m^2. Meanwhile, it is highly important to separate controlled spaces from uncontrolled spaces critical in cooling and heating equipment (Chapter 14 of National Building Regulations, 2013). In this connection, the systems controlling space lighting, systems reducing degree or duration of lighting, controlling lighting switch-off, the intensity of space lighting, compound and outside-of-building lighting such as lamps, installing meters and engines, space lighting, among others, can also be utilized (Chapter 13 of National Building Regulations, 2013).

3. METHODS

This study first used a comparative approach. The comparative method is a systematic method for contrasting two or several phenomena by which it explores similarities and differences, with the results leading to defining the problem under study or improving knowledge about it (García Garrido et al. 2012). The main goal of this method is empirical generalization and hypothesis confirmation. Hence, unknown matters can be perceived as known matters. This methodology helps to interpret and explain subjects, produce new knowledge, and highlight the characteristics of known and similar phenomena (Keuschnigg 2018).
According to the stages of this method, evaluation systems and national regulation issues were first studied. Then, having been selected, DGNB and Chapter 19 were meticulously studied. This article aimed to find similarities and differences between Chapter 19 of National Building Regulations and the evaluation system of DGNB so that it can improve the issues in the chapter and identify its weak and strong spots. For this, the benchmarks of the two systems were categorized and compared in a table that helps to determine their overlap or lack of which. After comparing the benchmarks of the system and the mentioned chapter and finding similar and different areas, a checklist of comparable criteria was provided to present a more accurate and applicable evaluation. These characteristics were investigated in one of the key complexes in Tabriz City. This investigation was performed in Tabriz's Aseman Residential Complex via field observations and personal visits in winter and also interviews with residents, experts, and technical assistants of the installations of one of the blocs, as well as via investigating available documents and maps. The manner of evaluation in the case study was as follows: Concerning DGNB benchmarks since this system is based on scoring, the 2018 version guideline was used for the scoring procedure. Here, the sub-items related to technical quality benchmarks were provided and the explanations related to the

items were presented in the checklist table. In the end, a table was provided to summarize and apply the weight coefficients of each benchmark. Concerning the benchmarks of Chapter 19, it was required to observe the minimum values since the benchmarks on the mandatory criteria were provided in the checklist table. Therefore, the section on the benchmarks only addressed the observance of the benchmarks or lack of which.

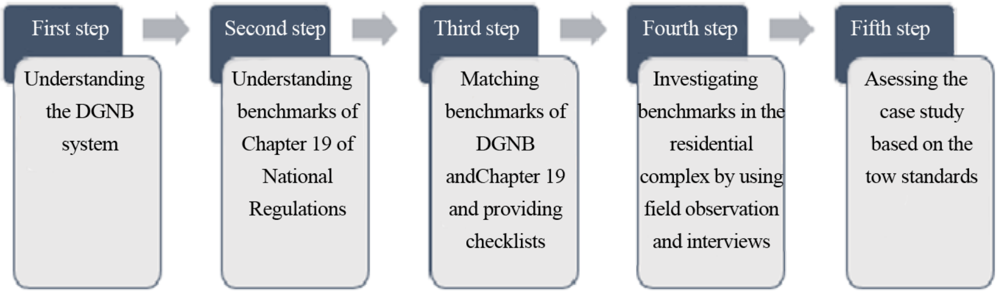

Fig. 3. Study Administration Method

4. VARIABLES AND DATA COLLECTION

This study aimed to find the strong and weak spots of Chapter 19 of National Building Regulations by comparing them with the successful evaluation system of DGNB. To meet this, an understanding of both systems under comparison had to be generally made; thus, following a general review and understanding of the subjects under study, a general comparison had to be made to achieve a general viewpoint of their similarities and differences. This led to the identification of the benchmarks not included in Chapter 19 of National Regulations, those that saw the highest conformity to the national regulations, and those to be attended to in the future.

4.1. General Comparison of DGNB System Benchmarks with Subjects of Chapter 19

This section concerns similar and different areas of the DGNB and Chapter 19 of National Regulations. It is noteworthy that some of the benchmarks in the mentioned system relate to some dimensions not included in the national regulations and require separate standards. No single chapter is expected to cover all the components and dimensions, alone.

The table below compares 37 benchmarks (categorized into six main qualities) both in the intended system and in Chapter 19 of National Regulations. As stated above and noted in Table 1, bio-diversity benchmarks or benchmarks related to site quality and economic quality are beyond the subject under study. Also, some other criteria fall under other categories of national regulations, such as auditory comfort in social and functional qualities and sound insulation in technical quality, which need to be addressed in Chapter 18 on Insulation and Sound Adjustment.

Based on the comparison made, concerning environmental, social-functional, technical, and process qualities, there are benchmarks related to the subject of Chapter 19. These benchmarks fall under the three groups of benchmarks, those that receive acceptable attention, those that receive less attention, and those that need more attention. Meanwhile, the benchmarks that enjoy thematic comparison, but have received no attention, are also determined. Other benchmarks are either not included under the subject of national regulations and need new chapters or are included in other chapters. Thus, because the chapter under study tends to address technical aspects of energy consumption in buildings, it is most thematically compared with technical quality benchmarks.

Table 1. Comparing DGNB System Benchmarks with Chapter 19

			Chapter 19 of National Regulations					
		Benchmark Name	General Regula-tions	External/ Outer Shell	Mechanical Installations	Electrical Installations	Renewable Energy	Group Determi-nation
DGNB Qual-ities	Economic (ECO)	Life Cycle Costs (ECO 1.1)	-	-	-	-	-	-
		Flexibility and Adaptability (ECO 2.1.)	-	-	-	-	-	-
		Commercial Durability (ECO 2.2)	-	-	-	-	-	-

			Chapter 19 of National Regulations					
		Benchmark Name	General Regulations	External/ Outer Shell	Mechanical Installations	Electrical Installations	Renewable Energy	Group Determination
DGNB qualities	Social and Functional (SOC)	Building Life Cycle Evaluation (ENV 1.1)	X	X	-	-	-	-
		Effects of the Local Environment (ENV 1.2)	-	-	-	-	-	-
		Sustainable Resource Extraction (ENV 1.3)	*	-	-	-	*	*
		Drinking Water Demand and Wastewater Amounts (ENV 2.2)	X	-	*	-	-	-
		Land Use (ENV 2.3)	-	-	-	-	-	*
		Biodiversity in the Site (ENV 2.4)	-	-	-	-	-	-
	Social and Functional (SOC)	Thermal Comfort (SOC 1.1)	X	-	-	-	-	-
		Indoor (Inside Building) Air Quality (SOC 1.2)	X	X	-	-	-	-
		Auditory Comfort (Soc 1.3)	+	-	-	-	-	-
		Visual Comfort (Soc 1.4)	*	*	-	*	-	-
		User Control (SOC 1.5)	X	-	*	-	-	-
		Quality of Indoor and Outdoor Spaces (SOC 1.6)	X	-	-	-	-	-
		Safety and Security (SOC 1.7)	+	-	-	-	-	-
		Design for All (SOC 2.1)	+	-	-	-	-	-
	Technical (TEC)	Sound Insulation (TEC1.2)	+	-	-	-	-	-
		Building Covering Quality (TEC1.3)	**	**	-	-	-	**
		Use and Integration of Building Technology (TEC1.4)	*	*	*	*	*	*
		Easiness of Cleaning of Building Components (TEC1.5)	X	X	-	-	-	-
		Easiness of Recovery and Recycling (TEC1.6)	X	X	-	-	-	-
		Controlling Pollution Emission from the Building to the Outside (TEC1.7)	X	X	-	-	-	-
		Transportation Infrastructure (TEC3.1)	X	-	-	-	-	-
	Process (PRO)	Comprehensive Project Summary (PRO1.1)	*	-	-	-	-	*
		Sustainability Components in the Tender Stage (PRO1.4)	-	-	-	-	-	-
		Sustainable Management Documentation (PRO1.5)	X	-	-	-	-	-
		Urban Planning and Design Procedure (PRO1.6)	-	-	-	-	-	-
		Construction Site/Construction Process (PRO2.1)	-	-	-	-	-	-
		Construction Quality Assurance (PRO2.2)	-	-	-	-	-	-

			Chapter 19 of National Regulations					
		Benchmark Name	General Regula-tions	External/ Outer Shell	Mechanical Installations	Electrical Installations	Renewable Energy	Group Determi-nation
DGNB Qualities	Process (PRO)	Systematic Launch (PRO2.3)	X	-	-	-	-	-
		User Relation (PRO2.4)	-	-	-	-	-	-
		Programming According to FM (PRO2.5)	X	-	-	-	-	-
	Site (SIT)	Local Environment (SITE1.1)	-	-	-	-	-	-
		Influence in the Area (SITE1.2)	-	-	-	-	-	-
		Access to Transportation (SITE1.3)	-	-	-	-	-	-
		Access to Welfare Amenities (SITE1.4)	-	-	-	-	-	-

** Receive acceptable attention, * receive little attention and need more attention, + related to other chapters of national regulations, - subject disconformity, X subject conformity and lack of attention

4.2. DGNB Benchmarks Under Study

As stated above, the highest overlap between Chapter 19 of National Regulations and the DGNB system pertained to the technical quality section. In this study, attention was focused on the benchmarks of the technical quality of this system, with other qualities delayed to future research.

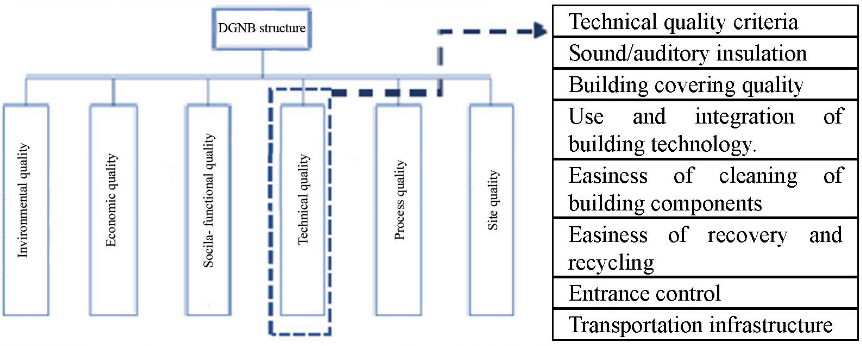

Fig. 4. Benchmarks Taken from the DGNB System

Technical quality, which is the fourth quality in this system, consists of seven benchmarks, each of which involves sub-branches shown above.

4.3. Chapter 19 of National Regulations Benchmarks Under Study

Following the study of Chapter 19, the figure below summarizes the benchmarks of the chapter into five groups. In addition to the four design methods, suggested in Chapter 19, Chapter 4 of the regulations is entitled Mandatory Benchmarks, which involves criteria to be observed in all buildings.

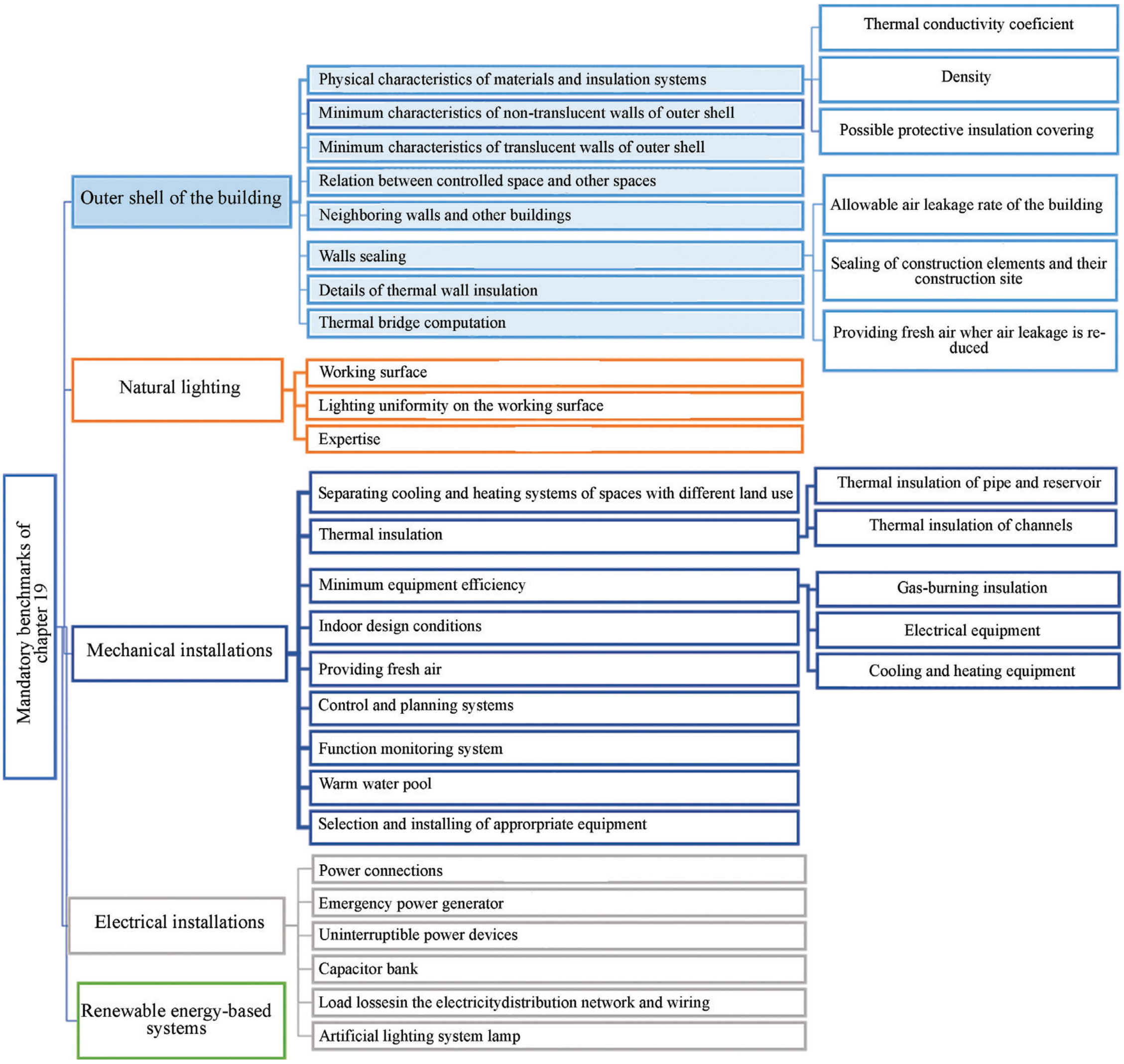

Fig. 5. Benchmarks extracted from Chapter 19 of National Regulations

In sum, apart from deciding on the preferential design method in each building, it should be first ensured whether these benchmarks have been observed. These benchmarks, summarized in Figure 5, are categorized into five groups outer shell, natural lighting, mechanical installations, electrical installations, and renewable energy-based systems. Because electrical equipment benchmarks pertain to electricity-supplying equipment and require their special domains, this study did not investigate them.

4.4. Selection of the Case Study

The residential complex of Aseman Towers in Tabriz, Iran, is currently one of the most outstanding residential complexes across the city, which covers an area of 94000 m^2 in sixteen 18-story towers by considering two stories of parking lot and a basement. This complex was constructed in 1999 and involves 928 residential units, each measuring 112 to 223 m^2 with two and three bedrooms. This complex was constructed by the Maskan Investment Company in 1999 and is located in E'l Goli Bld., Shahid Rajaei Sq., Sina St. Tabriz City. This complex has attracted the attention of numerous research models due to its residents' high-level satisfaction (Babazade Oskouei, Toofan, and Jamali 2020), its quality of construction compared to other residential complexes, valuableness and significance of the design as an outstanding model and the significance of the complex as a residential compound across the country, especially in Eastern Azerbaijan (Maskan Investment Group Company 2018). Other research has investigated different aspects of the complex and the present study has also taken this complex as the case study.

Fig. 6. Plan's Site and the Façade of Tabriz's Aseman Complex

The general specifications of the complex are as follows:

- Structure: Reinforced concrete and waffle roof
- Wall materials: Clay brick and exposed concrete façade
- Windows: Galvanized steel-made windows with colored glass
- Heating system: Central heating system and boiler with fan coil
- Cooling system: Absorption chiller with fan coil distribution

This study selected the Narenjestan Tower and investigated the criteria through field observation and interviews with the residents and technicians of the tower, as well as observing maps and executive documents. Below, Tables 2-10 give checklists of the items obtained from the DGNB System Guidelines and Chapter 19 of National Regulations. In this connection, the case study grouping should first be based on the explanation outlined in Paragraphs 2-2-2-19 on Page 47 of Chapter 19 and also Appendices 3 and 4 of the chapter. In this categorization, the city of Tabriz falls under groups of cities that require much energy and much heating, with the Narenjestan Tower falling under Group One based on its residential land use, built-up area, the number of stories, and the city where it is located.

4.5. Findings

In the following, tables (2-10) provide checklists to investigate the benchmarks obtained from the DGNB system and Chapter 19 on the case study using standards, suggested previously. Because DGNB benchmarks make use of scoring methods for each benchmark, the reason for the scoring has been briefly given to each of the benchmarks observed in the building. Concerning the benchmarks of Chapter 19, however, it should be determined whether the benchmarks have been observed or not. Therefore, the confirmed items met the minimum needs provided for by the benchmark; however, the description section gives explanations about the reason for the rejection of the items not confirmed.

It is noted that the values determined by the DGNB system evaluation guidelines are based on German building-construction standards, developed based on social, climatic, and economic conditions, as well as available materials in that country. Hence, this study determined to use items for which benchmarks are defined by Iran's National Regulations, which are provided by relevant experts based on Iran's national rules and regulations. This would thus help provide an evaluation of those cases based on existing conditions.

First, the items falling under the benchmark of Building Covering Quality (TEC 1.3) are discussed. This benchmark has five sub-sections, the first section of which pertains to sound insulation. Since this subject pertains to Chapter 18 of National Regulations, it is not investigated here. To investigate the quality of building covering, it is first required to determine the shell's material specifications. Using field observations and available documents taken from the Aseman Residential Complex, the outer shell specifications are as follows:

Outer wall: Façade's concrete layer (0.05 m), cement mortar (0.04 m), clay brick (0.028 m), cement mortar (0.04 m), plasterwork (0.02 m), plaster (0.02 m), heat transfer coefficient (0.482 w/km^2), thermal resistance (2.074w/km^2).

Flat rooftop: Asphalt (0.02 m), tar paper layers (0.03 m), cement mortar (0.02 m), reinforced concrete (0.35 m), plasterwork (0.02 m), final plaster (0.01 m), heat transfer coefficient (1.867 km^2/w), thermal resistance (0.536 km^2/w).

The items of this benchmark are scored based on the data and values determined by the system's guidelines and benchmarks.

Table 2: Checklist of the benchmarks obtained from technical quality; building shell quality benchmarks (TEC 1.3)

Benchmarks extracted from Technical Quality; Building Shell Quality Benchmarks				
Description	Score	Observance		
Lack of appropriate thermal insulation on the outer shell consistent with the cold climate	-	×	Shell's Heat Transfer Coefficient	Airtight
Absence of appropriate insulation of outer walls and terrace floors	-	×	Thermal Bridge	
The air ventilation rate is consistent with standards, as indicated by interviews with experts of the Narenjestan Tower installation	10	✓	Air Exchange Rate	
The average scoring (score) was assigned due to using double-glazed steel windows	5	✓	Type of Windows and Doors	
In none of the fronts, solar control measures in summer are in place.	-	×	Sunlight Protection	

Table 3 relates to the benchmarks of use and integration of technology in the building. In this complex, no use of pre-defined passive systems is observed; however, given the appropriate windows-to-wall percentage, some scores can be considered for this section. Concerning cooling and heating installations and access to these installations, suitable designs and computations were considered based on observations and interviews with the technical assistants of the tower's installations. Concerning system performance integration in the building, there were some presence detection facilities for lighting in public corridors and lifting systems.

Table 3. Checklist of the Benchmarks obtained from Technical Quality; Use and Integration of Technology in Building Benchmarks (TEC 1.4)

Benchmarks extracted from Technical Quality; Use and Integration of Technology In Building Benchmarks				
Description	Score	Observance		
Under a cold climate, compressed amounts are suitable, but these complex blocs are singular.	7.5	×	Compression and Arrangement	Passive Systems
The ratio of window heat to the wall is 33%, which is consistent with standards.		✓	Ratio of Window Area	
Due to the appropriate surface of the windows, it is possible to use daylight, which is consistent with standards.		✓	Using Daylight	
Failure to place passive systems for using the sunlight		×	Passive Use of Solar Energy	
Failure to select materials with high thermal mass or thermal storage systems		×	Thermal Storage Mass	
Lack of appropriate insulation on outer walls		×	Standard Insulation	
Proportion of the windows is suitable for cold climates and natural ventilation is desirably possible.		✓	Natural Ventilation	
Absence of passive systems for heating		×	Heating	
Based on the characteristics of the heating system and data obtained from interviews with experts in building installations, the heating range of the steam boiler is over 60°C.	1	✓	Heating System Information	
Based on the characteristics of the cooling system and data obtained from interviews with experts of Narenjestan Tower installations, the cooling range of the system is from 14 to 19°C.	4	✓	Cooling System Information	
Accessibility is good based on interviews by experts of the building installation.	10	✓	Access to Technical Installations	Accessibility
	10	✓	Access to Shafts and Paths	

Benchmarks extracted from Technical Quality; Use and Integration of Technology in Building Benchmarks				
Description	Score	Obser-vance		
Non-installment of a burglar alarm in the building	1 score for compliance with each item, 3 scores	×	Burglar Alarm	Integrated Performance Systems
In public spaces, such as corridors and aisles, presence detection systems are embedded for lighting.		✓	Presence Detection	
Absence of meteorological stations for weather monitoring		×	Meteorological Station	
Non-installation of canopy		×	Sunlight Protection	
Non-installment of canopy		×	Sunlight Protection	
In public spaces, lighting is in place for the detection of people's presence.		✓	Smart Lighting	
Failure to place a smart ventilation system		×	Smart Ventilation	
Failure to place a smart cooling system		×	Smart Cooling	
With elevators		✓	Lifting System	
Failure to use smart gadgets (taps, siphons, etc.) in WCs		×	Health and Hygienic Systems	
Failure to use energies produced from regional renewable resources	-	×	Integration with Regional Energy Infrastructure	
Failure to take measures for renewable energies	-	×	Energy Provision from Renewable Energies	
Failure to use the automation system for integrating building systems	-	×	Technical System Integration	

Concerning the benchmark of easiness of cleaning components, as stated in Table 4, it is possible in the case study to access external glass-made surfaces, except for the glass-made façade section of the elevator quite easily without special equipment. Concerning materials, the type of materials on the façade and the floor need less cleaning.

Table 4. Checklist of the Benchmarks obtained from Technical Quality; Easiness of Cleaning of Building Components Benchmarks (Tec1.5)

Benchmarks extracted from Technical Quality; Easiness of Cleaning of Building Components Benchmarks			
Description	Score	Obser-vance	
Easy access to all surfaces for cleaning except for the glass-made façade of the elevator	5	✓	Access to External Glass Surfaces
Façade materials do not need special cleaning. Floor materials on public corridors involve colors that need less cleaning.	5	✓	Indoor and Outdoor Component Cleaning
In intersecting areas and partially in areas with patterned floor covering	10	✓	Floor Covering Cleaning
Failure to place dirt traps at entrances and the straight entry from the compound to the lobby	-	×	Dirt trap at the Entrance
Absence of radiators, railing connections with fewer barriers to the floor	10	✓	No-Obstacle Plan for Cleaning
Failure to use tools and provide solutions for easiness of surface cleaning	5	×	Planning for Easy Surface Cleaning
Possibility of window recycling	5	×	Materials Recycling and Reuse

Considering the type of materials used in the complex, it is less likely to recycle and reuse the materials and it is only possible to recycle some limited areas such as doors, windows railings, etc.

Table 5. Checklist of the Benchmarks obtained from Technical Quality; Easiness of Recovery and Recycling Benchmarks (TEC1.6)

Benchmarks obtained from Technical Quality; Easiness of Recovery and Recycling Benchmarks			
Description	Score	Obser-vance	
Possibility of Window Recycling	5	×	Materials Recycling and Reuse

The benchmark of the building's exit controls relates to two items sound and lighting. Given existing observations, the scores were assigned to wall and double-glazed thicknesses, façade non-lighting, and type of lights in the complex's compound in consistency with the guidelines.

Table 6. Checklist of the Benchmarks obtained from Technical Quality; Exit Control Benchmarks (TEC1.7)

Benchmarks extracted from Technical Quality; Exit Control			
Description	Score	Obser-vance	
Non-emission of sound from the indoors to the outdoors	10	✓	No Sound Pollution
Most of the artificial light sources in the compound have lighting toward the ground	5	✓	No Lighting Pollution

Concerning the benchmark of transportation infrastructure, such amenities as the use and rental of bicycles and EVs were addressed. According to observations, in the Narenjestan Tower parking lot, specifically in empty spaces between places where cars are parked, there are cycle stands by the number of at least half of the units of the blocs.

Table 7. Checklist of the Benchmarks obtained from Technical Quality; Transportation Infrastructure Benchmarks (TEC 3.1)

Benchmarks obtained from Technical Quality; Transportation Infrastructure Benchmarks			
Description	Score	Obser-vance	
Placement of bicycles by the number of at least half of the units in each bloc in the parking lot	5	✓	Bicycle Parking Lot
Placement of bicycle stands along car parking lots	5	✓	Bicycle Anti-Theft Measures
Absence of bicycle repair facilities	-	×	Facilities for Cycle Repairing and Maintenance
The bicycle parking stand is in the car parking lot of the building in the basement and enjoys lighting	5	✓	Lighting for Bicycle Parking Lot
Non-possibility of renting cars and bicycles	-	×	Possibility of Renting Bicycles and Cars, etc.
Failure to provide equipment (charging, etc.) for EVs	-	×	Equipment and Facilities for EVs

According to the data and the checklists in Tables 2-7, the case study was assigned 110 scores in the technical benchmarks of the DGNB system. In these systems, relevant weight coefficients were assigned based on the importance of each benchmark, as listed in Table 8.

Table 8. Summing of Scores of each Benchmark and Applying Weight Coefficients

Benchmarks	Score Gained	The Weight Coefficient of each Benchmark	Total
Building shell benchmarks (TEC 1.3)	15	4	60
Use and integration of technology in building (TEC 1.4)	35.5	3	106.5
Easiness of cleaning in building components (TEC 1.5)	40	2	80
Easiness of recycling and recovery (TEC 1.6)	5	4	20
Exit control (TEC 1.7)	15	1	15
Transportation infrastructure (TEC 3.1)	15	3	45
Score Total			326.5

As noted by the table above, with the coefficients applied, the total score of the case study is 326.5, being lower than the minimum score of technical quality (450). Items that have received no attention in the building include lack of good insulation, less use of passive systems, less use of smart systems, absence of renewable energy-based systems, non-placement of dirt traps at entrances, absence of measures for easiness of surface cleaning, impossibility of recycling and reuse of materials, absence of amenities for EVs.

The following concerns the mandatory benchmarks of Chapter 19 in the Narenjestan Tower. Concerning mandatory benchmarks of the outer shell, as suggested by Chapter 4, material specifications and executive details were determined.

Table 9. Checklist of Mandatory Benchmarks of Chapter 19 of National Iran Regulations; Building Outer Shell

Benchmarks extracted from Chapter 19; Building's Outer Shell		
Description	Obser-vance	
Minimum benchmarks have been met for using double-glazed windows.	✓	Minimum Specifications of Translucent Walls of Outer Shell
Lack of appropriate insulation in the ceiling and non-observance of the minimum thermal resistance of the walls	×	Minimum Specifications of Non-Translucent Walls of the Outer Shell
The door is only automatically closed at the lobby entrance and opens directly towards uncontrolled spaces of the corridors.	×	Relation of Controlled Spaces with Other Spaces
Based on the type of the complex's design, which takes the form of individual blocs, there are no walls adjoining other buildings.	-	Walls Neighboring Other Buildings
As indicated by the observations, the maps, and documents, no appropriate sealing was seen in the walls due to the failure to use thermal insulation.	×	Wall Sealing
Lack of appropriate insulation consistent with minimum benchmarks based on building grouping	×	Details of Walls' Thermal Insulation
The presence of thermal bridges in the section where the terrace's floor is connected to the wall due to lack of insulation on the terrace's floor	×	Thermal Bridges

Concerning natural lighting, since it is possible for the building to absorb light from all four directions, the enjoyment of natural light is acceptable; however, due to the depth of the plans, some farther spaces in the units enjoy less light than other areas.

Table 10. Checklist of Mandatory Benchmarks of Chapter 19 of Iran National Regulations; Natural Lighting

Benchmarks extracted from Chapter 19; Natural Lighting		
Description	Obser-vance	
Enjoyment of natural light from all directions	✓	Surface Natural Lighting
Failure to use all main spaces such as private living rooms and kitchens farther than the light-absorbent frontage in some of the units	×	Natural Lighting Uniformity on the Surface
Failure to place external canopy	×	Preventing Natural Lighting from Staring

Concerning mechanical installations, for heating, a central powerhouse, a steam boiler with fan coil, and cooling, an absorption chiller with fan coil distribution was used. Based on the observations and existing documents about the type of installations, the minimum efficiency benchmarks were met.

Table 11. Checklist of Mandatory Benchmarks of Chapter 19 of Iran's National Regulations; Mechanical Installations

Benchmarks extracted from Chapter 19; Mechanical Installations		
Description	Obser-vance	
Based on observations and interviews with technical assistants of the Narenjestan Tower installations	✓	Thermal Insulation of Mechanical Installations
The water system is integrated and it is not possible to shut the warm water pipes for each independent unit.	×	Separating Cooling and Heating Systems of Spaces with Different Land Uses
Using equipment with authorized energy classes	✓	Minimum Efficiency of Mechanical Equipment

Benchmarks extracted from Chapter 19; Mechanical Installations		
Description	Observance	
Each cooling and heating terminal at the units can adjust temperature and be switched off.	✓	Control and Planning Systems
Absence of a separate energy consumption monitoring system for each unit	×	Performance Monitoring Systems
	-	Warm Water Pool
Using appropriate taps and equipment in the units and relevant gear in central installations	✓	Selection and Installment of Appropriate Equipment

Concerning the mandatory benchmarks of Chapter 19, the items of material physical specifications and thermal insulation systems, wall sealing, details of walls' thermal insulation, and thermal bridges were not confirmed due to the lack of suitable insulation proportionate to the type of land use and the Tabriz climate. Also, the item of natural lighting starting was not met due to the non-placement of external canopies. The item of separation of cooling and heating systems in spaces was not confirmed either, due to the failure to provide an independent control/interruption system for each unit. Furthermore, it is not also possible to monitor energy consumption for each independent unit. Finally, the lack of renewable energy-based systems had this item not confirmed.

5. DISCUSSION AND ANALYSIS

The following explains in detail the benchmarks investigated in the case study. Concerning the findings, the two groups of the benchmarks, compared with regards to both subjects and those that just fall under the DGNB system, will be discussed.

5.1. Benchmarks Shared by DGNB System[3] and Chapter 19 of National Regulations

Concerning the technical quality benchmarks of the DGNB system and the mandatory benchmarks of Chapter 19, insulation and thermal bridges in the benchmark of outer shell quality are among the issues that do not meet the expectations, as set by the two benchmarks. As stated by the chapter, to determine the minimum specifications, the wall without thermal insulation falls under homogenous insulated walls. As stated by the benchmark of the heat transfer coefficient in the chapter, the standard heat transfer coefficient values (Tables 1-6-19 and 2-6-19) of the outer shell with the homogenous insulation and the flat rooftop were maximum 0.440 (km^2/w) and maximum 0.410 (km^2/w). According to the data obtained, the outer shell material layers of the building held higher heat transfer coefficients and thus failed to observe the allowable limits.

As stated by the mandatory benchmarks of Chapter 19 (Table 1-4-19), the thermal resistance values of the wall and the rooftop were 0.5 (km^2/w) and 0.7 (km^2/w), respectively, with the Aseman complex exhibiting a value of 2.074 (km^2/w) for the wall and 0.536 (km^2/w) for the rooftop, respectively. As seen, the [thermal resistance] value of the rooftop was lower than the minimum rate.

Concerning the walls, since the case under study falls under Group One, this value is seen to be much lower though it may considerably go higher if one of the design methods is used. In this connection, due to the lack of appropriate insulation, it is clear to see thermal bridges on the sections where terrace floors and ceilings get connected to the walls. The windows of this complex were galvanized steel-made double-pane, which enjoyed good airtight quality. These windows meet the minimum allowable quality as set by benchmarks 2-4-19 and Chapter 19 appendix.

On the other hand, the benchmarks of using passive systems, smartization, easiness of recovery and recycling, as well as transportation infrastructure received less attention, which caused them to receive low technical quality scores.

Concerning the benchmarks of using passive systems, inattention to the needs of Tabriz's cold climate to compressed and dense volumes, failure to use passive solar energy systems, and also failure to use thermal storage masses and standard insulations were among the benchmarks that did not receive attention. Meanwhile, these items did not meet minimum Chapter 19 benchmarks. As given by Table 1-5-19 (Chapter 19), for Group One buildings, wall and ceiling insulation must meet the minimum thermal resistance of 2.1 (km^2/w) and 2.3 (km^2/w), respectively, with the respective values of the case study being 2.07 and 0.536 (km^2/w) for the wall and the ceiling, respectively. Since renewable energies in this complex were not used and excess energy was not produced in this way, no integration with the regional energy infrastructure was possible.

Considering the observance of the appropriate window-to-wall ratio, the degree of using daylight and natural ventilation can meet expectations. However, the spaces, which are farther from the windows, require artificial lighting at different hours of the day, and this was evident when the authors visited the Narenjestan site at different hours of the day.

The heating and cooling systems in the complex received the minimum score since high-quality central heating systems were used in the complex. Also, based on Tables 6-4-19 and 7-4-19, the minimum efficiency of the cooling and heating installations was met, as indicated by Chapter 19. This is indicative of the fact that installations received much attention in the complex.

The smartization, control, and planning of cooling and heating systems also required much attention, though they had received little attention. This factor, i.e., smartization, control, and planning were just performed in some basic elements such as using elevators or presence-detection systems for lighting in corridors. This was highlighted when the authors visited a vacant unit in the tower in winter when the unit's temperature had been tangibly warm despite the fan coils being switched off, which was due to failure to control and shut off the warm water tap leading to the units. On the other hand, the passing of these pipes from the corridors causes these spaces to become uncontrolled spaces while being tangibly warmer than outdoors. This indicates a significant reduction in the temperature between controlled and uncontrolled spaces, which also reduces thermal losses through the walls between these two spaces.

5.2. Benchmarks Considered by the DGNB System

Concerning the subject of easiness of cleaning, discussed in the DGNB system benchmarks, access to the outer surface of the glass was possible without equipment based on the type of the façade, as equipment was only required for cleaning the glass façade of the elevator. This was performed by planning how to manage each of the towers at certain intervals. However, using dirt traps at entrances was a simple issue that could be provided using simple measures in the design process, though this was not embedded in the complex. This issue is differently prioritized in benchmarks because it does not need special costs or technology. It should be borne in mind the issue of cleaning may seem a simple and insignificant issue at first; however, cleaning public spaces in large complexes such as Tabriz's Aseman Towers can consume much water and energy, which is critical due to the current water situation in the country.

The next major issue, which has received no attention in the benchmarks, is that of recycling the materials used in the building. Because the material production sector accounts for a considerable part of energy consumption in buildings, and many materials are produced from natural and mineral resources and this can affect the lifecycle of buildings, which is a major issue in developed societies, it is critical to pay attention to the minimum requirements of building materials, as detailed by Chapter 19.

Concerning the non-emission of light pollution to the peripheral environment, which has not received attention by Chapter 19, the appropriate outside-the-building light should not be directed at the sky, as suggested by the DGNB standard, since this may cause light pollution for birds at night. It is noteworthy that the emission of sound and light pollution not only leave much effect on daily human life but also negatively affects animals and birds in the urban environment. For this, this issue is critical concerning the protection of all animal habitats in and out of the city.

In the Aseman Residential Complex compound, there were two types of light, one of which was illumination directed at the ground, which was deemed appropriate based on the system's standards. The second type was spherical light spreading illumination in all directions, though not confirmed due to causing light pollution towards the sky. In the meantime, there is no inappropriate light emission from the building to the environment due to the lack of lighting on the façade of this complex.

In sum, the issue of transportation infrastructure is the last benchmark raised under the category of the technical quality of the DGNB system.

Concerning this benchmark, there are bicycle stands, along with car parking lots, by almost half of the Narenjestan Tower units, in the parking area and the vacant spaces between the cars and next to the storehouses. However, there are no amenities to use EVs or to rent bicycles and cars, which indicates the lack of culture-building in our country.

As stated above, the scores the Aseman Complex received were lower than the minimum scores required. This may indicate that the priorities in constructing buildings in Iran, even in famous buildings, still do not address energy as a key issue; therefore, this building, too, has failed to focus on the issue of energy in the section of construction quality, installations, and also amenities. This may indicate that the issue of energy is not still seriously addressed in large-scale projects, and there is thus a need to focus on this issue.

6. CONCLUSION

Over the past years, Chapter 19 was regarded as the building energy consumption optimization standard. Hence, by selecting the German Building Evaluation System of DGNB , this article aimed to compare its benchmarks with those outlined in Chapter 19 and to identify similarities and differences between the two [systems], which would develop national regulations and achieve a local building evaluation system. The DGNB system is developed based on German standards, and as reported previously, even larger international system versions cannot meet the conditions, climates, and cultures of other countries. This can be viewed as the first literature review result; for this, this study aimed to find the basics and a more appropriate direction toward meeting standards and green construction goals. The most important difference between Iran's national regulations and the

DGNB system is the attention of the latter system to the lifecycle of the building from the stage of design to the stage of destruction. Iran's national regulations are set up based on the stage of construction and thus fail to focus on existing circumstances and building innovation, which is a weak spot of these regulations, apart from humidity and visual comfort. Here, in the chapter under study, walls' insulation is focused and, unlike other systems, it has failed to address passive energy strategies in architecture, technology, and using renewable energies in an applied manner. Also, national construction regulations have yet to produce a series of rules on growing desertification in Iran and the water crisis in the country, while ignoring such guidelines as using water, compound irrigation, and modern methods of water consumption saving.

The general review of the benchmarks under study and comparison of them with Chapter 19 regulations revealed that out of the six qualities in the system under study, two technical and social-functional qualities were found to conform to the subjects taken up by the chapter, with the rest of the qualities either not generally discussed in national regulations or discussed in other discussions. In general, the highest conformity to the technical quality was noted in the chapter, which made this study focus on this quality. Concerning the technical quality, which saw the highest overlap with Chapter 19 of National Regulations, such benchmarks as sound insulation and building covering quality were focused under the benchmark of the building shell, noting an acceptable and appropriate overlap. However, neither the benchmarks of easiness of cleaning, easiness of recovery and recycling, exit control of buildings, as well as transportation infrastructure were focused under the category of national regulations.

The social quality, which involves eight benchmarks, cannot be investigated under Chapter 19 since the sound benchmark pertains to Chapter 18 of National Regulations, where the issue is discussed in detail. However, thermal comfort and visual comfort were taken up by some sections of the chapter, which are expected to be discussed in detail. Also, major benchmarks such as user control, which pertains to smartization subjects, indoor and outdoor air quality, security, and design were among the benchmarks of this quality, which did not receive attention under the national regulations chapter.

As stated, Chapter 19 appears to have focused on technical quality more than other sections, and future investigations are recommended to also pay attention to such benchmarks as smartization, easiness of recycling, indoor and outdoor air quality, etc. For this, considering the classification of national regulation subjects, there is a need for defining new subjects for such major qualities as site processes, and environmental and economic issues, not to mention others.

A review of Tabriz's Aseman Residential Complex using field observations and executive documents, as well s interviews with residents and technical assistants of the project installations determined that the project had focused less on energy consumption, though acceptable quality was noted in the installation and structure sections and welfare amenities. Also, window sections and cooling/heating installations saw acceptable quality. This caused the complex to not gain enough scores but to see many of its primary benchmarks of Chapter 19 not met. Because this complex has been one of the main outstanding complexes in the country and the number of buildings with similar conditions is on the rise, some benchmarks can be developed to reconstruct and optimize these buildings under existing conditions.

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The authors state that they have directly participated in the stages of conducting research and writing the article.

ENDNOTE

1. Deutsche Gesellschaft für Nachhaltiges Bauen
2. Leadership in Energy and Environmental Design
3. Building Research Establishment’s Evaluation Method
4. Haute Qualite Environmentale

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