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Review paper

CONTRIBUTION OF BUILDING MATERIALS TO LEED, BREEAM, AND DGNB CERTIFICATION

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Abstract

The construction industry plays an important role in satisfying the needs of society, enhancing the quality of life, and contributing to the economic growth of a country. It has been widely criticized for significantly contributing to carbon emissions, environmental degradation, generating a large amount of construction and demolition waste and global warming due to the use of a significant portion of natural resources and energy consumption. As an indispensable need, green building rating systems (GBRSs) have been launched to optimize the consumption of natural resources and control pollution. BREEAM (Building Research Establishment Environmental Assessment Method) was the first to appear among them, and then others followed. Today we can single out GBRSs, which is widely adopted internationally, or play a dominant role at the regional and national level in Europe, such as HQE (Haute Qualité Environnementale or High Environmental Quality), DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen, or the German Sustainable Building Council) and LEED (Leadership in Energy and Environmental Design). The assessment of building materials is an important component of the GBRSs. In order to better understand their impact on the overall certification outcome, it is necessary to analyze the weighting factors and the share of points assigned to material-related criteria within the different certification frameworks. Although all major GBRSs recognize the importance of building materials, the extent to which they contribute to the final certification score varies significantly and is not so easy to define. This paper analyzes the contribution of materials to the overall GBRSs rating, choosing LEED, BREEAM and DGNB as the most widely used and widespread certificates in Europe. Based on the obtained results, we can conclude that DGNB v2023 gives the greatest importance to the choice and performance of building materials, while BREEAM v7 and LEED v5 place a strong emphasis on reducing embodied carbon, but with a smaller overall share in the final rating.

Key words: *Green building rating systems (GBRSs), BREEAM, LEED, DGNB, building materials*

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1. INTRODUCTION

The construction industry plays an important role in satisfying the needs of society, enhancing the quality of life, and contributing to the economic growth of a country [1]. At the same time, it has been widely criticized for significantly contributing to carbon emissions, environmental degradation, generating a large amount of construction and demolition waste and global warming due to the use of a large portion of natural resources and energy consumption [1].

Recognizing the importance of sustainable building practices, the "green approach" and "environmental sustainability" have been introduced for many years. Despite this, the construction industry is still the main consumer of energy according to official statistics. One reason for this could be the passive attitude of construction professionals towards the adoption of sustainable solutions. Faced with rising energy costs, energy shortages, and growing environmental concerns, the demand for sustainable buildings with minimal environmental impact has recently grown even more significantly [1].

As a logical consequence of that, governments and numerous organizations have launched green building rating systems (GBRSs) to minimize/optimize the consumption of natural resources and control pollution. We can consider GBRSs as a new building philosophy, encouraging the use of more environmentally friendly materials, the implementation of techniques to save resources and reduce waste consumption, and the improvement of indoor environmental quality [2]. Or we can consider it as a tool for measuring the environmental performance of buildings [3] that can assess the sustainability of buildings throughout their life cycle that enables the transition towards a sustainable built environment, from an environmental, social and economic perspective [4]. Buildings certified under these rating systems consume less energy and contribute to the overall reputation and value of the property [1]. Today, there are a large number of GBRSs around the world.

The paper shows the contribution of building materials in the certification process through the allocation of weights or points.

2. GREEN BUILDING RATING SYSTEMS (GBRSS)

The first real attempt to "establish comprehensive means of simultaneously assessing abroad range of environmental considerations in buildings" was the Building Research Establishment Environmental Assessment Method (BREEAM). It is the first commercially available tool for assessing the environmental impact of buildings, based on specific target values for various criteria, and was established in 1990 in the United Kingdom. Since then, many different tools have been launched around the world, Figure 1 [3]. GBRSs also called ''Whole building assessment frameworks or systems"- are used to assess building performance based on standard quantitative and qualitative basis for the whole building or specific phases of its life cycle [5].

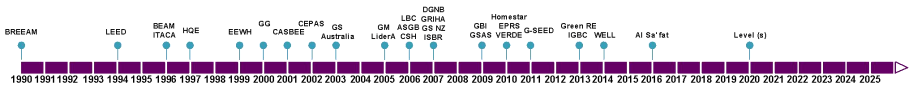


Figure 1. Timeline of GBRSs [3]

The principle behind these tools (Figure 1) includes environmental categories divided into credits, each addressing an issue and assigning a weighting of points that indicates the perceived level of sustainable performance of the building and, in summary, determining its corresponding certification level [5]. We can say that they are a multi-criteria evaluation tool based on multidimensional targets and that they are divided into the following four levels: categories, criteria, sub-criteria, and indicator levels [6]. All of these systems are not only applicable at the local level, but can also be applied internationally [7]. Each system includes a certain number of schemes that are chosen depending on the scope covered by the certification or the stage in which the facility is located.

After BREEAM, the most used GBRSs in Europe are HQE (*Haute Qualité Environnementale*) developed in France in 1997, LEED (*Leadership in Energy and Environmental Design*) developed in US in 1998 and DGNB (*Deutsche Gesellschaft für Nachhaltiges Bauen*) developed in Germany in 2007. These systems are widely adopted internationally or play a dominant role at regional and national levels in Europe [7][8].

For the analysis in this paper, 3 systems with their latest versions and a certain scheme were chosen: LEED v5 - Building Design and Construction, BREEAM v7 - New Construction and DGNB v2023 - System for New Construction.

2.1. BREEAM

This system considers and analyses ten different macro-areas and each is then divided into indicators, which include different credits reaching the maximum possible score depending on the purpose of the building. The maximum score is 100% and an additional 1% to 10% can be added to the final score as an “innovation credit”. When calculating the rank, the credit weighting factor is also taken into account. Based on the final score achieved, it is possible to earn one of the following rating levels: Unclassified (< 30 points), Pass (≥ 30 points), Good (≥ 45 points), Very Good (≥ 55 points), Excellent (≥ 70 points) and Outstanding (≥ 85 points), Figure 2 [9][10][11].

2.2. LEED

LEED is a system that requires certain prerequisites which needed to qualify for the certification. The protocol is divided into nine macro-areas that address key aspects of green buildings. These areas are the same for all the project types and are made up of credits. Points can be awarded for meeting criteria, which are grouped into credit categories. The maximum number of achievable points is 100 but 10 extra points can be obtained in the “Innovation” and “Regional priority” categories [9]. LEED often offers more pathways or options to meet certain credit criteria, so that the design can be flexible and adjusted to local conditions [11]. The final ranking is obtained by simply adding up the points assigned to certain categories. Based on the total number of building points, new construction can be classified into four groups: Certified (40–49 points), Silver (50–59 points), Gold (60–79 points), and Platinum (80+ points), Figure 2 [12].

2.3. DGNB

DGNB, in contrast to BREEAM and LEED, is more in line with the triple bottom line approach, addressing the social, economic, and environmental dimensions in a more balanced manner [8]. DGNB is organized into six categories according to six quality area [13]. DGNB is also the only method aligned to United Nations' Sustainable Development Goals (UN SDG's) and to Level(s), a European Union's (EU) voluntary reporting framework created to improve buildings sustainability, in line with the EU's Circular Economy Action Plan [8]. The number of points achieved in each topic is weighted differently to give the overall score. The final building grade (bronze, silver, gold, platinum, Figure 2) is awarded based on the total performance index and minimum performance index. The total performance index is calculated using all six topics, while the minimum performance index must be achieved in the three main topics (environment, economy and socio-cultural quality) to ensure a certain level of quality [14].

BREEAM rating		% score
Outstanding	★★★★★★	≥85
Excellent	★★★★★☆	≥70
Very good	★★★★☆☆	≥55
Good	★★★☆☆☆	≥45
Pass	★★☆☆☆☆	≥25
Unclassified	★☆☆☆☆☆	<25



	DGNB Platinum	DGNB Gold	DGNB Silver	DGNB Bronze*
Total performance index	80% and higher	65% and higher	50% and higher	35% and higher
Minimum performance index	65%	50%	35%	-- %

Figure 2. Rating levels of GBRSs [11][12][13]

LEED, BREEAM, and DGBN all award credits, points, or percentages when the designer satisfies designated levels of performance for each indicator. Nevertheless, LEED, BREEAM, and DGBN differ in the weight they award specific indicators and in the choice of relevant indicators in each category, which means that these methods view the importance of sustainability areas differently [8]. Additionally, DGNB was chosen for being a system that intends to assess the whole building's life cycle, giving more balanced weights to the environmental, social, and economic dimensions, thus closing the gap left by LEED and BREEAM regarding this matter [8].

In BREEAM, the final score is factored by a given coefficient, whereas in LEED, credits are simply added to the final score. DGNB attributes different coefficients to each of the indicators within the categories (referred to as "share") that are further adjusted with an additional weighting factor [8].

3. BUILDING MATERIALS IN GBRSS

All GBRSs schemes are voluntary, for now. As stated, these systems measure the performance of green buildings by assigning credits and weights to environmental topics, sorted into appropriate categories which comprise a set of indicators to evaluate buildings throughout their life cycle.

We can see how important materials are from the base, a careful design process and a comprehensive material selection method, rather than an elevated investment in technology, may be enough to achieve desired environmental goals at a lower cost [2].

Analyzing the systems, we can observe that energy, water and materials are the most common categories analyzed by rating systems, followed by location and the qualities of the indoor and outdoor environment [15]. Although the tools appear to cover the same phases of the building life cycle, they may cover the phases differently.

3.1. Sertifications of building materials

The choice of materials, in addition to directly affecting energy consumption through production, installation and use, also affects the energy consumption of the entire building and the overall rating of the building in the GBRSs.

For this reason, it is very important to know all this information when choosing and applying materials in buildings. The best and easiest way is the existence of certain tools, documents, standards and etc. that would unify all this data. At GBRSs, when assessing the impact of materials on the environment and the level of certification, we use some of the following:

1) **Life Cycle Assessment (LCA)** - compilation and evaluation of the inputs, outputs and potential environmental impacts of a product or system throughout its life cycle [5].
2) **Environmental Product Declarations (EPDs)** - provides objective, transparent, and third-party verified information about the environmental performance of a product or service throughout its life cycle [16].
3) **Responsible Sourcing Certification** - verification process that proves a company's products and materials are obtained in an ethical, sustainable, and socially responsible manner [17].
4) **Material Health Declarations (HPD)** - standardized technical document that transparently discloses the chemical ingredients in a product and their associated health impacts [18].

Here are only some of the documents that include the most important data on the materials used and the aspects of impact on the environment, energy consumption and human health.

3.2. Importance of materials in certification systems

In the following analysis “credit” means each issue taken into account in each macro area and characterized by a certain amount of points; “weight” stands for the importance given to each credit; “score” represents the sum of the total credit points, which have been previously multiplied for their specific weights. As mentioned, each

tool is characterized by credits achievable on the basis of the building characteristics in specific areas and each rating system allows to obtain a building labelling, according to the reached total score, Figure 2. Despite their extensive use and proven benefits, GBRSs exhibit significant methodological differences that complicate direct and objective comparisons [19].

The assessment of construction materials constitutes an important component of GBRSs. To better understand their influence on the overall certification outcome, it is necessary to analyze the weighting factors and the proportion of points allocated to material-related criteria within different certification frameworks. Although all major GBRSs recognize the importance of construction materials, the extent to which they contribute to the final certification score varies considerably and it is not so simple to define. The following section examines the weighting of material-related criteria and their contribution to the overall assessment in LEED, BREEAM, and DGNB certification systems.

In all three choosen systems materials are not rated in just one „simple“ category, but are distributed across several areas — but there is one dominant „main“ category.

BREEAM- The main category in which the material is evaluated is Materials (Mat). Materials are primarily assessed through LCA analysis of the building; responsible procurement (sourcing); EPD declarations; lifetime of the material/durability. Also, material related with Waste (Wst) and Innovation (Inn) [11]. In BREEAM, materials are not evaluated with a single number of points, but through multiple credits (Table 1). In order to obtain points, the project is compared with a reference object and points are determined based on the reduction of impact. The credits achieved are then multiplied by the weighting factor of the category. It contributes about ~ 15 -21 % of the total score (depending on the scheme), Table 2 [11].

LEED - The main category in which the material is evaluated is Materials and Resources (MR). Through it we observe the following: choice of building materials; EPD (Type III); LCA; recycled and regional materials; material composition (eg. cement, steel, concrete). The impact of materials is also felt across the areas of energy and atmosphere (EA) and innovation (IN). In LEED there are points that simply add up. Similar like in BREEAM, the project is compared with a reference object and points are determined based on the reduction of impact. It contributes max 18 points out of a total of 110 (in category Material) or ~ 16%. The distribution of points by items for material in the New Construction is given in Table 1 [12].

DGBN - There is no single category in these GBRSs for materials, but rather it is viewed through several of them, but the one that most encompasses this topic of materials is Environmental Quality. It evaluates: GWP (CO_2 emissions); LCA analysis (EN 15978); consumption of primary resources; recycling potential; the overall impact of the structure (including concrete and cement). There are no fixed material points, materials influence through several criteria and are evaluated through the degree of fulfillment. Each criterion that includes DGNB in the field of materials carries a certain weight (Table 1). The total contribution is calculated as Σ (weight × percent filled). It contributes around 22–25% of the total grade in the area in the area closest to the materials (Environmental Quality), depending on the chosen scheme [13].

For easier mutual comparison of systems, the number of final points or weights has been reduced to percentages, i.e. it is normalized. Table 1 gives the points and weighting factors for BREEAM, points for LEED in the material category, while for DGNB the percentage contribution of materials in various categories.

Table 1- Schedule of points, weighting factors and participation of materials in the selected GBRSs [11][12][13]

BREEAM			**LEED**		**DGNB**	
Issues	Points	Weight (%)	Credit	Points	Criterion	Contribution %
Mat 01 (LCA)	≤7-10	15,5-21,0	**MRc1** (Building and Mat. Reuse)	≤3	**ENV1.1** – Climate action and energy (LCA)	22,5
Mat 02 (EPD)	≤1		**MRc2** (Reduce Emb. Carbon)	≤6	**ENV1.2** – Local environmental impact	
Mat 03 (Resp. Sourc.)	≤4-5		**MRc3** (Low-emitting materials)	≤2	**ENV1.3** – Responsible resource extraction	
Mat 04 (Durability and resilience)	≤1		**MRc4** (Build. Product Selection and Procurement)	≤5	**TEC1.6** – Circular construction (Design for disassembly and recyclability)	2-4
Mat 05 (Efficien.)	≤1		**MRc5** (Demolition Waste)	≤2		

Table 2 gives the contribution of materials in certificates expressed in % and normalized for easier comparison. The values shown are estimated directly through credits and weighting factors that are assigned through the material category (BREEAM, LEED) or the category closest to the materials (DGNB), as well as an assessment that takes into account other categories that the materials indirectly affect (Figure 3).

Table 2- Contribution of materials in the final rate of selected GBRSs [11][12][13]

System	Version	Maximum contribution of the material to the overall grade	Estimated total impact and out-of-category material
BREEAM	Version 7	~15,5-21%	20-30%
LEED	Version 5	~16,4%	20-25%
DGNB	2023	~22-25%	25-30%

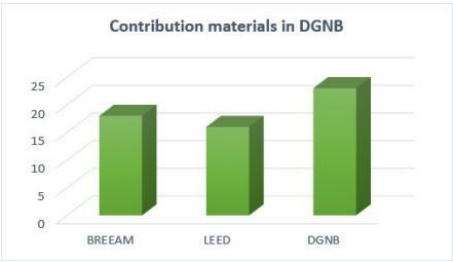


Figure 3. Contribution of materials in the final rate of selected GBRSs

4. DICSUSION

Understanding the complexity of the problem of identifying and assessing the environmental characteristics of building materials requires attention to the different aspects from which this problem could be analyzed. Consequently, it is necessary to take many things into consideration such as, among others, the capacity of environmental resources, the various environmental impacts of materials, energy consumption, life cycle assessment of materials and buildings, etc.

The assessment of material contribution within certification systems is complex due to differences in methodologies, data requirements, and evaluation frameworks. One of the main challenges is the availability and quality of data.

Another difficulty lies in the inconsistent valuation of the same materials across systems. LEED uses a threshold-based point system, BREEAM applies weighted credits, while DGNB uses percentage-based scoring with multiple interconnected criteria. As a result, identical materials can have significantly different impacts on the final certification score depending on the system. Additionally, regional differences in supply chains complicate the assessment, as materials with similar technical properties may have different environmental impacts due to transportation distances and local production conditions. Likewise, the interpretation of LCA results is challenging because different databases and software tools can produce varying outcomes for the same material, making consistent and comparable evaluation difficult across projects and certification schemes. To reduce transport-related emissions, GBRSs emphasized the adoption of local materials for buildings [20].

The most common materials highlighted in the GBRSs are concrete, cement, steel, aggregates and timber. For example, the adoption of Supplementary Cementitious Materials (SCMs) for cement replacement is common in the GBRSs, where points are allocated based on the percentage of replacement [20]. Other materials should be included here, but the availability of SCM should also be taken into account. Also, timber materials are highly emphasized across, and they valued timber sourcing from certified sustainable parties, which require that the timber be legally harvested. Otherwise, the adoption of uncertified wood in buildings may have a negative effect on carbon emissions reduction, promoting forest restoration and biodiversity [20]. All of this shows that caution and care should be taken, as certain green materials cen lead to longer transportation distances and increase carbon emissions over the life cycle of a building.

Also, in the GBRSs, the treatment of carbon throughout the life cycle remains uneven, with operational carbon generally given greater emphasis than carbon associated with material production, transport and end-of-life phases. However, the embodied carbon associated with building materials is becoming increasingly significant. This shift highlights the need for integrated strategies that address both operational and embodied carbon throughout the life cycle of a building [20]. Of the systems analyzed, the DGNB comes closest to the idea of covering the entire life cycle of a material.

Based on the results obtained in Tables 1 and 2 and Figure 2, we can conclude that DGNB v2023 gives the greatest importance to the choice and performance of building

materials, while BREEAM v7 and LEED v5 place a strong emphasis on reducing embodied carbon, but with a smaller overall share in the final rating.

5. CONCLUSION

All three selected systems BREEAM, LEED and DGNB apply the LCA approach, but with different valuation methods and weighting factors, leading to different effects of the same materials on the final assessment. In the modern versions of these systems, the circular economy, the reuse of materials and the reduction of the overall ecological footprint, especially through the reduction of incorporated carbon, are becoming increasingly important, especially in the latest version. The focus is on the reduction of embodied and operational carbon, but also on broader aspects such as resource consumption, the possibility of recycling and the impact on human health and the environment.

In BREEAM and LEED, there is a defined category for materials and it is much easier to define the contribution of materials to the overall ranking, and there is also a smaller contribution of materials through other categories. In DGNB, it is not easy to define materials because there is no specific category, but rather it is assessed based on the category that is most closely related to which the material has the greatest impact. Based on the analysis, it was found that materials have the greatest contribution in DGNB and we can say that this system promotes the transition to a circular economy and life cycle thinking the most.

We can certainly say that the contribution of the material and, therefore, the importance of choosing an adequate material during the certification of facilities is extremely important. The recommendation would be to try to find some common framework in order to make the certification simpler, more acceptable by users, at least in the domain of documents that are used as bases.

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