EVALUATION OF SOIL STABILIZERS THROUGH BUILDING BIOLOGY

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Abstract

Due to the continuing increase of building-related illnesses, material considerations in architectural design gained in importance over the last decade. In this respect, the Institute of Building Biology + Sustainability (IBN) performs material evaluations and publishes the results. According to the Material Evaluation Tables prepared by IBN, earthen building material is a valuable alternative to commonly used artificial materials due to its positive effects on human and environmental health. However, the continuing usage of synthetic ingredients for modern soil stabilization methods results in the loss of valuable natural characteristics of earthen building materials. The reason to prepare this study is the necessity to prove that earthen building material should stay “true to its origin” by utilizing natural ingredients for stabilization. This study shows how increasing the mechanical properties of earthen building material’s without adding chemical agents effects human and environmental health positively. Thus, based on IBN’s material values a new method was developed in 2019 for the evaluation of building materials, which should be used in the early design phase of architectural projects. For the present study this new method is applied on an earthen building material sample from ancient Daskyleion to evaluate the natural soil stabilizer and to compare it with a synthetic substitute. As a result, this study underlines the fact that valuable natural earthen building material characteristics can only be achieved by utilizing natural soil stabilizers.

Keywords: Soil Stabilizer, Building Biology, Material Evaluation

1 Introduction

The increase in building-related illnesses has made material considerations in architectural design increasingly important over the last decade. In 2015, a study by Yıldız and Sezer evaluated the results of 46 studies related to the relationship between building materials and human health. The authors’ conclusion emphasizes the adverse effects of materials on residents’ health. A list of illnesses caused by pollutants derived from harmful materials was provided, including chronic lung disease, cancer, blood and bone marrow disorders, respiratory illnesses, infections, allergies, and psychological disorders [1]. In this regard, the Institute of Building Biology + Sustainability (IBN), which primarily focuses on human and environmental health issues related to construction, conducts material evaluations and publishes the results. Indoor air pollution and health problems associated with buildings can be attributed to many factors, according to IBN. However, the root of the problem pertains to the excessive consumption of artificial building materials [2]. Compared to artificial building materials, earthen building materials are highly beneficial to human health and the environment, as highlighted by the Materials Evaluation Tables prepared by the IBN. In the material evaluation process, the IBN describes 15 assessment criteria that lead to a score range from 0 to 3, indicating the degree of ecological and health protection offered by a building material. A number of factors were taken into account during the assessment process, including natural building materials, thermal properties, moisture behaviour, water vapor diffusion, toxins, odours, electrobiology, radioactivity, environmental impact, energy use, fire behaviour, airborne sound insulation, impact sound insulation, long-term sustainability, affordability. The IBN's material evaluation results indicate that earthen building materials are most compatible with both human and environmental health. Clay products achieved a score of 2.6, the highest among the building materials analysed in the study. IBN's research indicates that soil constitutes an indispensable building material for the protection of human health and the environment [3, 4, 5].

However, the continuing usage of synthetic ingredients for modern soil stabilization methods results in the loss of valuable natural characteristics of earthen building materials. Consequently, this study was developed in order to demonstrate that earthen building materials should remain true to their origins by using natural ingredients for stabilization.

2 Soil stabilization

A highly variable climate and topographic structure can result in different types of bedrock formations, which results in a diverse range of soil types. Among these, soils with cohesive properties should be preferred as building materials. In the absence of such a resource, the soil available should be improved and stabilized and used as a building material once it evolves into one. Stabilization and improvement are procedures used to enhance the quality of the soil to make it suitable for use in structures and to make it stable [6]. A summary of experimental stabilization studies aimed at strengthening the compressive strength and water resistance of earthen construction materials was published by the author in 2019. A review of past experiments carried out from the 1960s to today aimed at optimizing the properties of soil by stabilizing earthen construction materials has found that a general use of synthetic additives causes the soil material to lose some of its valuable properties that are also highly valued by IBN [4].

Interestingly, natural ingredients from ancient techniques typically do not figure into soil stabilization methods. In Anatolia, earthen building materials have been used since ancient times. Earthen material production and application techniques differed across time and place in Anatolia, owing to the variety of soil types and local stabilization processes. In 2019 the author of the present study gathered and evaluated micro-level research results of the earthen building materials of ancient settlements of Turkey. Even though the tradition of building with earth dates back to the Aceramic Neolithic Period in Anatolia, material research done on a micro-level has been identified only for eight ancient settlements, including Aktopraklık, Güvercinkayası, Aşıklıhöyük, Arslantepe Mound, Çatalhöyük, Barcın Höyük, Ulucak Höyük and Yumuktepe. Additionally, soil samples taken from the ancient settlements of Küllüoba and Daskyleion were examined on a micro level and were incorporated into a table for

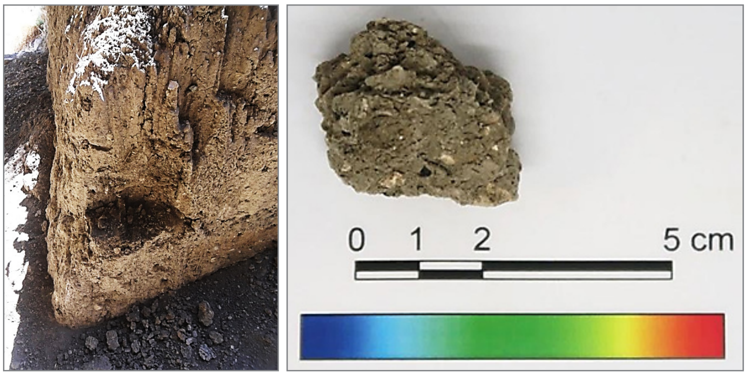

Figure 3.1. In-situ picture and image of sample no. 24 (Kurtul Vacek,2019) [4, 8].

documentation and evaluation of improvement and stabilization methods. Among the soil building samples examined in the study mentioned above, samples taken from the fortification wall of Daskyleion turned out to be particularly interesting in terms of mechanical-physical properties and material ingredients [4].

Based on IBN's criterias, a new method for evaluating building materials was developed in 2019 by the author, which is intended to be used in the early stages of architectural design. For the present study, this new method is applied to a sample of earthen building material from ancient Daskyleion to evaluate the natural soil stabilizer and to compare it with a synthetic substitute.

3 Material evaluation

After analyzing a number of international evaluation methods and incorporating IBN's material assessments, a new method for evaluating the effect of building materials on human health and the environment has been developed [4]. Since the choice of the right material at the beginning of each new project will have a significant impact on the air quality and the health of the users, and hence is of the utmost importance. Therefore, a comprehensive evaluation system, which includes the total score for each material type provided by IBN, is considered indispensable in order to prevent serious adverse consequences.

The Daskyleion sample no. 24, dated BC 530, is used as a case study for explaining this method. The experimental results[1] indicate that the additive in sample no.24, which was determined as the strongest example, is flax tow. As sample no.24 has the greatest compressive strength of 1.7 N/mm², the suitability of flax tow for the improvement-stabilization technique appears to be confirmed. This might explain why flax tow was used in ancient fortification walls [4, 8]. Interestingly, flax fibre has been found to be an important composite material component in recent academic studies. For example, Garkhail et al. (2000) developed a composite composition using flax fibres and propylene (PP). The composite samples were tested for hardness, tensile strength, and Charpy impact. Based on the

1 To determine the content and properties of the soil material samples taken from archaeological areas, visual analysis, simple chemistry analysis, soluble salt, protein, oil and organic matter determinations, physical-mechanical property tests, thin section, XRD-XRF analyses were carried out in the laboratory [4].

results obtained from the experiments, they concluded that composites reinforced by natural fibre are suitable for low-cost engineering applications. Researches state that flax fibre can compete with glass fibre, especially when high hardness per mm^2 is desired [7]. In terms of the IBN's Building Materials Table, glass wool should be rated with 1.2 points, while linen receives 2.3 points and has a higher value in terms of ecological and health protection [4].

The issue of which additive should be used as part of the stabilization process is a decision that must be made at the beginning of the project. In a hypothetical scenario, the selection process consists of two options (see table 3.1), and different assessment factors will be considered. In light of the points IBN has made about the choices, bring 15 assessments directly to the evaluation process that provide an impersonal identity focused on ecological and health protection.

This section examines the steps taken for the new proposed material evaluation method.

NO.	CHOICES	SCORE
1	Flax Tow	2.3
2	Glass Fibre	1.2

Table 3.1 Selected additive for soil stabilization.

CRITERIA	1	2	3	4	5
BENEFIT	NONE	LOW	BENEFIT	MUCH	THE MOST
Hardness per mm^2				1-2	
N. for Plaster	2				1
N. for Finishing Material	2				1
Building Biology Material Score		2			1
Cost			2		1

Table 3.2 Criteria-benefit (note: N. stands for necessity).

ASSESSMENT	IMPORTANCE %		IMPORTANCE RATIO
Hardness per mm^2	35	15	0,15
N. for Plaster		10	0,1
N. for Finishing Material		10	0,1
Building Biology Material Score	50		0,5
Cost	15		0,15
TOTAL	100		1

Table 3.3 Assessment criteria for evaluation of the earthen wall with additives.

ASSESSMENT AND IMPORTANCE RATIO	CHOICES			
	1. FLAX TOW		2. GLASS FIBER	
Hardness per mm² x 0,15	4	0.6	4	0.6
N. for Plaster x 0,1	5	0.5	1	0.1
N. for Finishing Material x 0,1	5	0.5	1	0.1
Building Biology Material Score x 0,5	5	2.5	2	1
Total Usage Value	4.1		1.8	
Cost x 0,15	5	0.75	3	0.45
TOTAL	4.85		2.25	

Table 3.4 Comparison.

As a result of the assessment criteria, the analysis of criteria-benefit, importance ratios, and at the end of this comparison, flax tow got selected with a rating of 4.85.

4 Conclusion

Based on the data contained within the Material Assessment Table prepared by IBN, the soil, which is considered to be the most appropriate material in terms of health and environment, requires improvement and stabilization methods to achieve the quality of a building material. The results of this study suggest that ancient soil recipes might replace the synthetic modern additives usually considered in academic studies for stabilizing soils.

A new method suggests inserting the numeric value that IBN's 15 assessments reveal in the evaluation process. The new method has been used to compare flax tow with glass fiber for soil stabilization. Through the comparison, the conclusion of this study highlights the fact that valuable natural characteristics of earthen building materials can only be achieved by using natural soil stabilizers.

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