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A New System Proposal about Certification of Engineering Properties of Buildings

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***Abstract*— In this study, it is aimed to introduce a new certification system which certificates and investigates that the building is stable, peaceful, comfortable, harmonious, healthy, and compatible or not with the user identity and intended purpose. The proposed new system is the name of the Bioharmological Conformity Assessment. Its short name is BCA. The proposed system has been applied in a regional boarding school in Elazig-Turkey. At the end of the study very interesting results were obtained. In study, a regional boarding school building in Elazig was examined in the scope of BCA according to 14 basic criteria of Planning, Project Design and Application (PPA). BCA Certificate Class of the examined building was determined as "Should be Improved (A)" and deficiency-inadequacy level was determined as 52%. Mechanical system (84%), practice according to the technique (83%), Lighting (67%), building installations (65%), furnishing and configuration (58%) and selection of appropriate materials (56%) were determined as the highest and most significant deficiency-inadequacy criteria among the 14 criteria of the middle school in question. Therefore, it was concluded that the current physical characteristics of the school building in question is not appropriate for user identity and intended purpose, would have negative effect on education and training as well as negative effects on the biological, physiological and psychological development of the students.**

***Keywords*— bioharmology, planning, project design, user identity, intended purpose, educational buildings.**

I. Introduction

Buildings are one of the oldest spatial elements of humanity and are constructed and/or artificial environments that are made using various materials and methods designed in the local environment. Hence, no matter what the reasons for constructing or designing a building are, they should be designed in compliance with the identity and needs of their users while also conforming to its users in a well-balanced manner. This designed or constructed building can be a pool, greenhouse, school, hospital or residence. These structures that are designed to be underground, over ground or in the water should have various specific properties. Because plants, animals and humans have very different needs regarding activities such as reproduction, growth, resting, sleeping, working and eating. Because, living things meet their working, feeding, sleeping and resting needs in these built environments in addition to socializing, protecting and sheltering.

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Hence, it is expected from a structure that it protects its user especially from unfavorable situations that can occur both at the inner and outer environments while providing a secure, peaceful, harmonized, balanced and comfortable environment and opportunities. Physical, chemical, mechanical, biological, rheological, ergonomic and anthropometric properties are among the primary factors that have negative effects on the user in a building. Even though these factors vary from building to building, the effect level can change according to many factors such as the location of the building, the environment, climate conditions, user identity, age of the building and the rheological properties of materials used in the construction of the building.

Buildings live with their users. In addition, buildings can get sick just like living things. "Comfort conditions are met" if the building and the living things are in harmony and well balanced. It can especially be said that the human body has become one with an object if he/she is not affected adversely from the objects that surround him/her. Hence, bioharmological process meaning balanced and user friendly design and construction should be started by selecting and using quality material that is in accordance with user identity and usage purpose.

Variety is rapidly increasing in today's construction materials in comparison with the past. There is a significant increase in the use of inorganic materials. It has been realized that most of the widely used construction materials are cancerogenic, however this has not yet been proven scientifically. On the other hand, there is also a decrease in the use of organic materials in residences and an increase in the use of artificial construction materials. This development has led to the increase of factors that have adverse effects on human health and thus the disruption of the balance and harmony in structures [1-4, 6, 8-15].

The following factors given below should be taken into consideration in order to attain the desired success in construction design that is in accordance with the user, meaning a bioharmological design. These are;

- Minimizing the amount of materials used in construction,
- Reusability of the material or structure,
- Transformability in accordance with varying conditions,
- Being hygienic and not producing any bacteria,
- Safety for humans and other living beings,
- Providing energy savings thus having no need for fossil sources as materials or for heating of the structure,
- Being in accordance with local or regional conditions [7].

According to the theoretical principles of bioharmology, the design and construction of buildings that are harmonious, comfortable, healthy and balanced should be carried out according to the basic properties given below. These are;

- The strength and resistance against ecological and seismological events,
- The materials should conserve their rheological, physical and agelessness properties,
- Accordance with psychological and sociological needs,
- Meeting biological and physiological demands,
- Being in accordance with the anthropometric properties of the user,
- Sensitivity to epidemiological and sanitation formations,
- Preserving its serviceability and functionality when faced with changing demands [1, 5, 7].

There are many methods regarding the evaluation, certification and/or sustainability of structures. That is, the evaluation of the environmental performances and energy efficiencies of buildings is becoming more important with the increase of awareness and sustainable approach in architectural and structural design. To this end, many certification systems and/or methods such as "LEED", "BREEAM", "CASBEE" and "GREENSTAR" have been developed to evaluate the performance of buildings following their design and to certify them as well as to monitor their performance over a long period of time and determine the success levels in reaching the goals that have been set previously regarding sustainability. Even though there are various differences among current systems, technical features such as having clever systems, waste management, less energy consuming systems with an environmental awareness have come to the forefront [16].

In bioharmology, buildings are examined and certified in two basic stages according to their engineering and architectural properties. This study focuses on the examination and certification of buildings according to their engineering properties. The name of the suggested system is Bioharmological Conformity Assessment (BCA). In addition to having similarities with the aforementioned certification programs, it can be stated that BCA has significant differences with regards to its perspective on the subject and its evaluation of the building as a whole (building age-fatigue performance relationship). For instance, important results can be drawn from the positive and negative (deficiency-insufficiency) properties of the architectural and engineering features of the building. This study has been supported by a sample application in order to ensure that the system suggested is understood better and that the positive aspects of the system in comparison with other systems are realized. The study is important since it will shed light on those who work actively in the sector due to its content and different perspective. It is thought that the study will be beneficial for those who work actively in the planning, project and application works of structures. On the other hand, the study will also contribute to the general comparison and evaluation processes regarding the results of surveys and/or experimental studies.

II. Methods and Principles

First, the paradigm of this study is a regional boarding school in the province of Elazig. The method used is PPA criteria and investigation method based on technical observation. Official permissions were received for these studies and the investigations based on technical observations were completed in two different periods; winter conditions (November-December 2012: Hours 09:00-16:00) and summer conditions (April-May: Hours 11:00-15:00).

The current situation of the school was examined with 530 questions those are covering PPA characteristics. The data obtained during examinations were recorded on the related forms, mathematically calculated and interpreted on the final results comparing with BCA data.

The educational building that was examined was served as multi-purpose lycée status (high school) in the school year of 2000-2001 then transformed to a full-time regional boarding school. The school has 24 classrooms and 36 teachers, 12 administrative personnel for 340 students in the school year of 2012-2013. In addition, housing space of the physical building and facilities are approximately 10000 m^2. A garden area of 5000 m^2 is available also.

A preliminary technical examination was performed according to PPA and studies were implemented to inform the school supervisors. The preliminary technical examination is a study about the matter if the building is worth to a comprehensive examination. Then, a team of specialists was formed to determine the reflection of 530 questions in the scope of 14 criteria given in Table 2 on building – construction. Subsequently, the answers those are given like "Suitable-Sufficient (+)", "Not Suitable- Insufficient (-)" or "Not Examined- No Data Available (±)" recorded for each question.

Budbox graph shown in Figure 1 is plotted with the relation between the age of the building (years) and fatigue performance (%). In Budbox, the relation between the age of the building and fatigue performance was developed using Matlab program with "e^t"logic with a special equation. The age of the building based on BA=100 / (e-1) x (e^t-1), wear performance based on WP=100-BA equations. This equation shows the decrement relation of fatigue performance in a building continuously aging during lifetime. That is, in Budbox approach, it is accepted that as the age of the building increases, there is a general decrease in the wear, tear and depletion performance of the construction components of the building. On the other hand, there are differences between general wear performance, the reflection level to the spatial characteristics (%) and the fatigue performance level perceived by the user. These differences could be observed all together in Budbox [1, 16] .

The dilemmas encountered during answering step resolved by comparison with the BCALS values [12] published in Turkish Standards and the 591. Issue of the Turkish Standards Periodical. The answers "Suitable-Sufficient (+)" were

summed and valuation point (VP) of the criterion was calculated.

The results in Table 4 were calculated using operation steps and special formulas. A time management chart for the buildings studied at first and a current situation chart where they obtained data were recorded were prepared for this purpose.

Calculated with the formula [16] :

VP= ((9/Criterion Question Number) x "Suitable-Sufficient (+)" Number (1)

The numerical value found is written on the part in Table 3. The VP points of the other criteria are calculated with this logic and written in related spaces. Then BCA_{PPA} values of the PPA step is calculated.

Calculated with the formula [16] :

BCA_{PPA}= (100/105) x IC x WP x VP (2)

Where;

105= PPA Importance Coefficients Count (Table 2)

IC= Importance Coefficient

(According to the criterion examined, → from Table 1)

FP = Fatigue Performance

(According to the Age of Building, → from Figure 1)

VP = Valuation Point.

The BCA_{PPA} related with "User Identity" and "Intended Purpose" criteria in the extent of PPA were calculated like, for example;

User Identity Criterion [16] :

BA= Building Age 15 = 0.93 … (from Figure 1)

IC= User Identity = 14 … (from Table 1)

VP = Valuation Point = 35 from investigation question 13 "Suitable- Sufficient (+)"

VP= (9/35) x 13 = 3,34

BCA_{PPA}= ((100/105) x BA x IC x VP)

BCA_{PPA} = ((100/105) x 14 x 0,93 x 3,34) = 41,45

The BCA_{CDIP} (Criterion Deficiency Inadequacy-Percentage) related with "User Identity" and "Intended Purpose" criteria in the extent of PPA were also calculated like this:

BCA_{CDIP} = Deficiency Inadequacy Number Determined/ (TQE-UQ) x 100 (3)

TQE=Total Queries Examined

UQ =Unexamined Queries

User Identity Criterion:

TQE=Total Queries Examined = 35 … (from Table 4)

UQ = Unexamined Queries = 8 … (from Table 4)

DIQ = Deficiency Inadequacy Queries

DIQ = 14 "Not Suitable-Insufficient (-)" from 35 queries.

BCA_{CDIP} = (DIQ/TQE-UQ)) x 100

BCA_{CDIP} = (14/ (35-8)) x 100= 51,85= ~52

The criteria in the extent of PPA were calculated according to the above example and the results obtained were shown in Table 3. BCA Certificate class of the building was determined by comparing the results in Table 3 with the data in Table 2. The general PPA assessment of the schools was shown in Table 4.

Figure 1. Fatigue performance of the buildings according to age (Budbox) [1, 16]

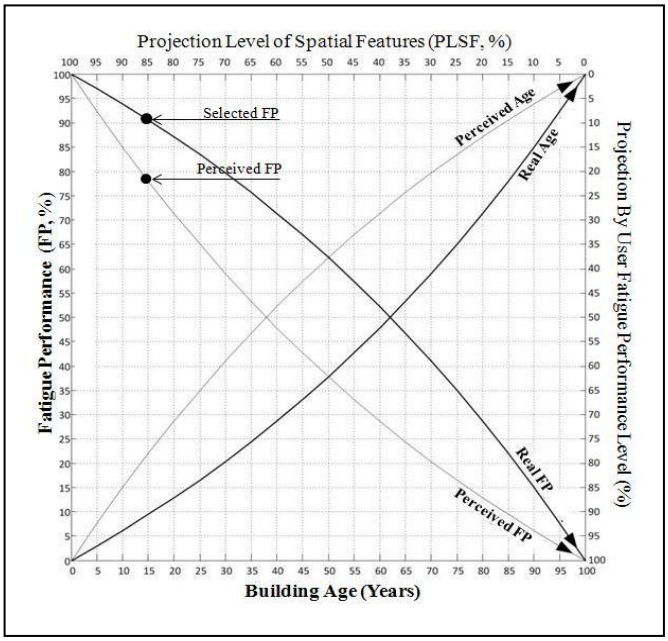

TABLE I. EVALUATION CRITERIA AND ENGINEERING PROPERTIES OF BUILDINGS [1, 16]

Criterion Examined	IC	Criterion Explanation	Criterion Query
User Identity	14	Who, Age, Handicapped, Sex, …	35
Intended Purpose	13	House, Hospital, School, Office, Greenhouse, Livestock Farming, Shopping Center, …	50
Physical Properties of Place	12	Area, Volume, Depth, Direction, …	50
Structural Elements	11	Foundation, Column, Curtain Wall, Beam, …	60
Complementary Elements	10	Wall, Flooring, Window, Stairs, Ceiling, …	55
Appropriate Material Selection	9	Masonry, Wood, Composite, Paint, …	40
Practice According to the Technique	8	Standard, Detail, Qualified Labor Use, …	35
Environment and Ecology	7	Landscape, Land and Soil Structure, Heat, Rain, Wind, …	55
Seismology	6	Earthquake, Statics, Stress, Earthquake Response of the Building, …	35
Mechanical System	5	Elevator, Heating, Ventilation, Alternative Energy Use, …	30
Building Installations	4	Waste Treatment, Waterworks and Efficiency, Electric Wiring, …	40
Furnishing and Configuration	3	Embedded Elements, Essential Furniture and Accessories…	15
Lighting	2	Natural, Direct, Effects, …	15
Accessories	1	Faucets, Power Plugs, Door-Window Handles, ...	15
IC: Importance Coefficient		Total	530

TABLE II. BCA CERTIFICA CLASS TABLE [1, 16]

Certificate Ratings	Symbol	Certification Class	Explanation
751-900	A^{+++}	Gold	"Gold" Certified Bioharmological Building
601-750	A^{++}	Silver	"Silver" Certified Bioharmological Building
451-600	A^{+}	Bronze	"Bronze" Certified Bioharmological Building
301-450	A	Should be Improved	
000-300	A^{-}	Unsuitable	

II. Finding and Discussion

Before general engineering properties and current situation of the building revealed by planning, project design and application according to BCA on the basis of user identity and intended purpose are shown on Table 3 and a general PPA assessment shown in Table 4.

As shown in Table 3, the educational building cannot get the points necessary to obtain BCA certificate. In Table 4, PPA Mean Deficiency-Inadequacy Percentage is 53% according to examination criteria of the schools. With respect to PPA, the smaller this value is, the bioharmological characteristics of the building are better. However, this value is rather high.

In the buildings suitable for the user identity and intended purpose, average deficiency-inadequacy should be maximum 25%. Since maintenance, repair and improvement costs are equivalent of 50% of the total cost of the buildings with mean deficiency- inadequacy value higher than 50%, restoration and reinforcement is not considered as a rational solution [16]. According to this general assessment, it is suggested that the educational building examined is not a bioharmological edifice regarding PPA and engineering characteristics.

TABLE III. DETERMINATION OF BCA CERTIFICATION CLASS [16]

Criterion Examined	IC	FP	VP	BCA
User Identity	14	0,93	3,34	41,45
Intended Purpose	13	0,93	3,15	36,27
Physical Properties of Place	12	0,93	3,96	42,09
Structural Elements	11	0,93	3,60	35,07
Complementary Elements	10	0,93	4,09	36,23
Appropriate Material Selection	9	0,93	3,83	30,49
Practice According to the Technique	8	0,93	0,77	5,47
Environment and Ecology	7	0,93	4,58	28,41
Seismology	6	0,93	5,40	28,69
Mechanical System	5	0,93	1,20	5,31
Building Installations	4	0,93	2,70	9,56
Furnishing and Configuration	3	0,93	3,00	7,97
Lighting	2	0,93	3,00	5,31
Accessories	1	0,93	4,20	3,72
Total Score				316,06
BCA Certification Class				Should be Improved (A)

IC	Importance Coefficient	*FP*	Fatigue Performance
VP	Valuation Point	*BCA*	Bio. Conformity Assessment

TABLE IV. OVERALL ASSESSMENT OF THE BUILDING [16]

Criterion Examined	QNQ	DINQ	NQA	CDIP(%)	RPDIP
User Identity	35	14	8	52	7
Intended Purpose	50	24	2	50	8
Physical Properties of Place	50	11	17	33	12
Structural Elements	60	12	24	33	12
Complementary Elements	55	20	10	44	9
Appropriate Material Selection	40	22	1	56	6
Practice According to the Technique	35	23	9	83	2
Environment and Ecology	55	21	6	43	11
Seismology	35	5	9	19	14
Mechanical System	30	21	5	84	1
Building Installations	40	22	6	65	4
Furnishing and Configuration	15	7	3	58	5
Lighting	15	10	0	67	3
Accessories	15	8	0	44	9
Criterion Examined	530	220	100		
PPA Mean Deficiency-Inadequacy Percentage					52

QNQ	Queried Number of Questions
DINQ	Deficiency Identified Number Query
NQA	Number of Queries that cannot be Analyzed
CDIP	Criterion Deficiency- Inadequacy Percentage
RPDIP	Ranking Percentage of Deficiency-Inadequacy Percentage

III. Conclusion and Suggestions

The main purpose of this article is to introduce a new certification system of the BCA. The implementation of this system is also very easy. Because of the engineering properties of the buildings examines under the 14 basic criteria. The new system proposal and its results are very clear, practical and easier to understand. This situation can be understood by examining the tables above. In addition, this new certification system can determine the deficiencies and inadequacies of the buildings.

Certification is carried out by a specialized team of experts. The BCA group consists of bioharmology expert, architects, and engineers (civil engineer, environmental engineer, mechanical engineer, electrical and electronic engineer, and geological engineer).

There are many systems for certification of buildings in developed and industrialized countries. For example, LEED, BREEAM, CASBEE and GREENSTAR, etc. Therefore, in this article, there has not been comparison of systems. Comparison of the existing systems should be addressed in other studies.

The pupils educated in the school under study are in the age group of 7-15. That is, user identity is just children those are not capable of improving, organizing or restoring environmental conditions. On the other hand, children of this age group are more susceptible to the environmental pollution comparing with grown-ups. Besides, these schools are the places where children spend most of their outdoor times.

The unfavorable environmental conditions in the school may affect the learning and performance of the pupils and

cause momentary or lifelong negative consequences for the pupils and society. Therefore, physical environment is an important part of the effective learning and teaching process. Besides, these schools which provide board and lodging together with education and training activities should have bioharmological characteristics. This matter is guaranteed in the 56th Article of the Constitution of the Turkish Republic. There is a definitive provision like: *"Every individual have a right to live in a healthy and balanced environment. It is the duty of the government and the citizens to improve and protect environmental health and prevent environmental pollution."* From this point of view, it is both a humane and constitutional obligation to design and construct the educational buildings according to the theoretical fundamentals of bioharmology.

According to the data in Table 3, the BCA Certificate Class of the building was found as "Should be Improved (A)". According the data in Table 4, Deficiency-Inadequacy value of the building is 53%. Besides, the most important first five criteria according to deficiency-inadequacy percentage grading sequence are like; 1. Mechanical System (84%), 2. Practice According to the Technique (83%), 3. Lighting (67%), 4. Building Installations (58%) and 5. Furnishing and Configuration (56%). In addition, the fatigue performance value of the 15 year old building perceived by the user on the basis of Budbox chart shown in Figure 1 is 78%.

According to these results, continuing the training and education in this building may create some concerns about negative effects on the effective and efficient training and education as well as comfort conditions and user satisfaction. Therefore, since the current physical characteristics of the school in question is not suitable for user identity and intended purpose, it is more likely to have negative effects on training and education as well as biological, physiological and psychological development of the pupils.

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About Author:

Bioharmology is the science of a new universal science. Bioharmology is studying the conditions required for stable, peaceful, comfortable, harmonious, healthy, compatible, secure building design and the physical, chemical, mechanical and rheological properties of the materials those are forming the building. Besides, emphasizes the faults arising from building design, selection of inadequate construction material and application and the effects on the users and attempts to suggest rational solutions. Therefore, BCA study could inform that if the current and the future architectural and engineering characteristics of the building will be suitable for the user identity and intended purpose.