The Research on the Utilization of Green Building Ecological Index Group in Campus Environment – Taking of Elementary Schools at Houli District, Taichung City as Example

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Abstract

The elementary school is the most basic educational site, and the spatial characteristics of school building have relative large area of outdoor space. If the ecological education can be promoted from the campus, it will not be able to improve the overall environmental ecology, but also able to root the ecological education from the lowest base. The paper research takes the field survey at the elementary school and analysis the relevant affecting factors. It hopes to provide appropriate reference contribution to planner or government in the future.

Key words: Green Building, Ecological Index Group, Elementary School Campus, Ecological Quality, Sustainable Campus

1. Introduction

Due to the over-exploitation to Earth and dramatic increase in energy consumption that cause the concentration of CO_2 increased year by year, and result the environmental imbalance phenomena of Earth warming, abnormal climate, ozone depletion, forests gradually disappeared and debris flow etc. [1]. Taiwan government incorporated the「Green Building」into「Urban-Rural Sustainable Development Policy」as the implementation priority in the year of 1996, and fully promotes the green building policy, in March 2004.

Facing the crisis of Earth environment, the promotion and education of sustainable development are the foundations for resolving the problem [3]. The school ecology is the most important part in the urban-rural ecological environment, school has large area space, if it can be converted into the quality ecological environment that will be great help to the urban-rural ecological green network, ecological conservation and even the national ecological education [2,7].

This article takes the campus of five elementary schools located in Houli District, aims at the Ecological Index Group, most closely to the campus outdoor space including biodiversity, greenery, Soil Water Content 3 indexes to perform assessment and research. It is expected to enhance the environmental quality of elementary school campus in that district and city, and provide the basic analysis data for the reference of follow-on researchers and planning units.

2. *Literature*

The trend of thought for green building started at the two times of energy crisis in 1970s, due to the panic

from the oil crisis, the energy-saving design was raised in the construction industry. In recent decade, under the environmental crisis of Earth warming and climate abnormal change, the earth environmental design and green building concept of life cycle assessment, CO2 reduction, biodiversity design have been further developed [4]. The green building is the concept of pursuing the environment sustainable design, it is called as ecology building Japan; European countries call as「Ecological Building」and「Sustainable Building」, United States, Canada also call as「Green Building」, it is the general call of ecology, environmental protection, sustainable, ecology building [5,6].

In the year of 1990, British Building Research Establishment (BRE) brought the first assessment system for green building i.e. BREEAM which affected the follow-on assessment method e.g. LEED of United States in the year of 1996, GBTool of Canada in the year of 1998 etc. Taiwan established the green building evaluation system of EEWH in the year of 1999 which is the 4th green building assessment system in the world [5]. Up to the year of 2011, there are 26 countries formerly owned the green building assessment system in the world shown as Fig. 1, there are 89 countries already established or under preparation for organizing the green building related associations.

Fig. 1. Countries with Assessment System [5]

In Taiwan, it formulated green building assessment manual in 1999, and it has been revised for many times until 2012 to establish EEWH (Ecology, Energy Saving, Waste Reduction & Health) assessment indexes. The index of WWEH includes 1. Ecology: biodiversity, greenery, soil water content three indexes2. Energy Saving: the daily energy saving index, 3. Waste Reduction: waste reduction and CO_2 reduction 4. Health: indoor environment, water resource, improvement of sewage waste, totally there are 9 indexes [5].

3. Research Method

This research is assessed in accordance with the ecological assessment items and standards stated in the「Green Building Assessment Manual」issued by Taiwan Construction & Planning Agency, take the biodiversity, greenery and soil water content index.

3.1 Assessment Mode of Biodiversity Index

The biodiversity index is the base of biological habitat and biological exchange, the base scale shall be over 1 hectare and then be applicable to assess by this index. According to biodiversity index BD, its value shall be greater than the baseline value of biodiversity index BDc, and the score of biodiversity index system RS1 shall comply with $0.0 \leqq RS1 \leqq 9.0$, its relative formula is as follows Eq.1~2:

$$BD = \sum_{i}^{n} Xi \quad , i = 1,2,3\ldots,23 \quad \cdots\cdots\cdots\cdots \quad (1)$$

$$RS1 = 18.75 \times \frac{BD - BD_c}{BD_c} + 1.5 \quad , 0 \leq RS1 \leq 9 \quad \cdots \quad (2)$$

BD：Biodiversity Index Calculation Value

Xi ：Sub-score, i=1，2，3 ……，23

RS1：Biodiversity Index System Score, $0.0 \leqq RS1 \leqq 9.0$

BDc：Baseline Value of Biodiversity Index

3.2 Assessment Mode of Greenery Index

The greenery index takes the plant photosynthesis as the assessment baseline, configure the 40 years of CO2 fixed volume as the conversion baseline of greening benefit, the calculation value of greenery index TCO2 is calculated from the total CO2 fixed volume of all plants in the base, the system score of its greenery index RS2 i.e. converted from its index calculation value TCO2 and greenery index baseline value TCO2c, the score of greenery system RS2 shall comply with the limit of $0.0 \leqq RS2 \leqq 9.0$, its relative calculation formula is as follows Eq.3~5:

$$TCO_2 = (\sum_{i=1}^{n} (Gi \times Ai)) \times \alpha \quad \cdots\cdots\cdots\cdots\cdots\cdots (3)$$

$$A' = (A_0 - A_p) \times (1 - r) \quad , A' \geq 0.15 \times A_0 \quad \cdots (4)$$

$$RS2 = 6.81 \times \left(\frac{TCO_2 - TCO_{2c}}{TCO_{2c}} \right) + 1.5 \quad , 0 \leq RS2 \leq 9 \quad \cdots (5)$$

Gi：Unit Area of Certain Planting Species CO_2 Fixed

Volume (kg/m^2)
Ai：Planting Area Baseline
A'：Minimum Green Area (m^2)
α：Ecological Greening Correction coefficient
A_o：Base Area (m^2) i.e.「School Land Area」of this research.
A_p： Unable to greening area (m^2)
r：Legal Floor Area Ratio

3.3 Assessment Mode of Soil Water Content

The assessment of soil water content index is categorized into the common soil water content design and special soil water content design two items, the calculation value of soil water content λ is the relative ratio between the nature land soil water content prior to development Q_0 and the land soil water content after development Q', base λ c is the baseline of land soil water index. The larger λ value indicates that the performance of soil water content is better, otherwise the worse. When its value is 1.0, it indicates that the land development activities have no damage to the function of soil water content of the original nature bare land. The system score of soil water content RS3, conversion from the design value of soil water content λ and baseline value λc, its system score must have the limit of $0.0 \leqq RS3 \leqq 9.0$, its relative calculation formula is as follows Eq.6~8:

$$\lambda = \sum_{i=1}^{n} Q_i / A_o \cdot f \cdot t \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (6)$$

$$\lambda_c = 0.5 \times (1.0 - r) \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (7)$$

$$RS3 = 4 \times \left(\frac{\lambda - \lambda_c}{\lambda_c} \right) + 1.5 \quad , 0 \leq RS3 \leq 9 \quad \cdots\cdots \quad (8)$$

$RS3$：System Score of Soil Water Content Index
λ ：Calculation Value of Soil Water Content Index
λc：Baseline Value of Soil Water Content Index
Qi：Soil Water Content Volume of Various Kind of Soil Water Content Design (m^3)
A_o：Total Base Area (m^3)
r：Legal Floor Area Ratio
f：Base Final Infiltration Rate (m/s)
t：Maximum Rain Delay (s)

4. Case Survey Results & Analysis

The basic data of this research scope are shown as Table 1, the Houli elementary school has the highest floor are ratio, up to 33.5%, the floor area ratio of other four schools are very similar, all less than 15%.

Table1 List of Basic Data of Elementary Schools in Houli District

School Name	School LandAream2	Building Area m2	Floor Area Ratio %	Numbers of Students	Density of Student m2 /person	Built Year of School
Tai'an	22402	2408.825	10.75	167	134.1	1946
Hoili	19374.92	6490.28	33.50	707	27.4	1946
Neipu	30812	3414.8	11.08	1484	20.8	1904
Qixing	11592	1562	13.47	279	41.5	1958
Yuhing	12912	1622.89	12.57	262	49.3	1964

4.1 Status Analysis of Biodiversity Index

The biodiversity index assessment result of relative survey data are shown as Table 2 i.e., the calculation results of biodiversity index assessment studied by this article. From the Table 2, only the ratio of biodiversity index (BD/BDc) of Tai'an elementary school was 1.12 since its relative smaller floor area ratio and larger green area, it indicates that the biodiversity part shall be further enhanced.

4.2 Status Analysis of Greenery Index

As summarize from the data of each elementary school in Houli District, the calculation results of greenery index are shown as Table 3. From the Table 3 got the greenery and greening baseline value (TCO_2/ TCO_2c) of 5 elementary schools are all greater than 1, it meet the baseline. It indicates that the greenery implementation status of elementary schools in Houli District is quite well.

Table 2 Calculation Results of Biodiversity Index Assessment

Primary Category	Minor Category	Design Item	Tai'an Elementary School	Hoili Elementary School	Neipu Elementary School	Qixing Elementary School	Yuhing Elementaryy School
	Total (BD)		56	43.3	15.6	18.3	21.9
	Baseline Vale (BDc)		50	50	50	50	50
	BD/BDc		1.12	0.87	0.31	0.37	0.44
	Qualification Rate				20%		

able 3 Statistical Table of Greenery

School Name	School Land Area m2	Sports Field m2	TCO2	TCO2c	TCO2/ TCO2c	Qualification Rate	System Score RS2
Tai'an	22402	3,084	5,256,643	3,622,125	1.45	100%	4.57
Hoili	19375	3,240	5,120,505	3,025,313	1.69		6.22
Neipu	30812	10,451	5,928,899	3,817,688	1.55		5.27
Qixing	11592	3,428	3,233,848	1,530,750	2.11		9
Yuhing	12912	3,193	4,796,559	1,822,378	2.63		9

4.3 Status Analysis of Soil Water Content

The soil water content are shown as Table4. From Table 4, the index value and soil water content baseline value (λ / λ c) is greater than 1 for Tai'an & Hoili elementary schools and Neipu, Qixing & Yuhing elementary schools are all lower than 1. It did not meet the baseline due to the insufficient green area, the main water conservation of soil water content mainly comes from the green area.

Table 4 Statistical Table of Soil Water Content Index

School Name	School Land Area m2	Green Area m2	λ	λ c	λ / λ c	Qualification Rate	System Score RS3
Tai'an	22402	13,984	0.64	0.5	1.28	40%	2.64
Hoili	19375	8,645	0.5		1		1.5
Neipu	30812	4,189	0.48		0.96		1.33
Qixing	11592	2,580	0.23		0.47		0
Yuhing	12912	3,227	0.34		0.67		0.19
Ecological Index Group Total Score		27	10.96	7.72	6.6	9	9.19

5. Conclusion & Recommendation

The qualification rate of greenery is up to 100%, biodiversity and soil water content are 20% and 40% respectively, consolidate the reasons as follows:

1. Poor planning for the bio-friendly environment, the pavement common uses excess of asphalt or concrete, causes the poor hydrophilic property of land.
2. The green area is the important role of campus ecological environment, only with sufficient green area plus the complete biological environment and perfect lawn or using pavement with good permeability will then be able to achieve the 「 qualitative 」 and 「 quantitative 」 baseline of greening.
3. The water biological habitat is the richest place for biological gathering and exchange. The sports field is the mandatory facility for elementary school, excessively high proportion will cause the green area relatively reduced, and how to give balance for both will be very important issue while planning the campus.
4. Increase the species of trees in campus, species diversification, it will then have variety of creatures inhabit, breed, change the cement revetment and pool bottom to the masonry revetment with more ecological and natural soil as the pool bottom to create the ecological waters space for providing habitat.

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