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The Fuzzing Evaluation on Environmental Harmonization of the Rural Building Materials

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Abstract

The rural dwelling house is not only an important component of housing construction in China, but also significant of promotion of the construction socialism new countryside. With the rapid development of urbanization of rural China, the level of urbanization in China will be close to 60% excepted by 2020, which undoubtedly bring to the rural building industry an unprecedented opportunity for development. The main problem which rural building materials faced is lack of the product performance certification. According to characteristic of customers and tendency of building material industry, the rural building materials should possess the harmonization, except basic quality performance. This paper analyzed the factors which influence on the environmental harmonization and established a fuzzing evaluation model, based on life cycle assessment. Through validation of environmental harmonization of ceramic, fuzzing evaluation method was effective and feasible to assess the rural building material environment harmonization.

Keywords: Rrural building material, Eenvironment harmonization, Fuzzing evaluation

1. Factors of Village Building Materials Life Cycle Assessment

It is a paramount important issue to evaluate the material environmental harmonization in the research on material. At present, LAC is usually adopted and accepted.

1.1 The life cycle assessment

LCA is the method for understanding environmental impacts of a product quantitatively through its life cycle. LAC originated from environmental characteristics of the analysis of resource consumption and release between different beverage containers in Coca-Cola 1969. It was firstly advanced on the international symposium on life cycle assessment held by the international society of environmental toxicology and chemistry. It has been widely used as the analysis and decision-making tool of production environment. Life cycle assessment is a "cradle-to-grave" approach for assessing industrial systems. "Cradle-to-grave" begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. LCA enables the estimation of the cumulative environmental impacts resulting from all stages in the product life cycle, often including impacts not considered in more traditional analyses (e.g., raw material extraction, material transportation, ultimate product disposal, etc). By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection (Wei, 2007). For building materials, LAC is a analyzed and expressed process which the various stages of life cycle environmental load is broken down into the usage of energy resources, the pollution of air, water and soil ,effect of global warming and emission of castoff. It lays heavy emphasis on determination of the environment evaluation factors.

1.2 Evaluation factors of the Rural Material Environmental Harmonization

The primary issue of evaluation of rural building material environmental harmonization is to determine the evaluation factor. The evaluation system which is composed by evaluation factors can entirely reflect the characteristic of material in the fully life course and guide or improve on environmental harmonization. According to life cycle theory, the environment harmonization of rural building materials should cover all stages of the life cycle, which include pre-process used non-renewable resources, materials manufacture process released gas, waste and noise and consumption process recycled and reused waste products. Moreover based on characteristic of rural customer, economic factor is brought into the evaluation system. The definition of economic factor is the full cost which happed in the material life cycle (Chen, 2008). According to results of LAC researches, this paper showed that evaluation factors of environmental harmonization include resource consumption factor, energy consumption factor, environmental emission factors and economic factors, base on the , combined with Chinese's rural building materials production and consumption in the course of the specific environmental behavior.

1.2.1 The resource consumption factor

The resource consumption factor is used to evaluate the resource consumption in the whole life cycle. In general speaking, building materials derived from mineral raw materials or biological materials, such as resource consumption factor of glazed tiles can be defined as clay, pyrophyllite, kaolin and water.

1.2.2 The energy consumption factor

The Energy consumption factor is mainly used to evaluate one-time energy consumption of building materials in the whole life cycle. One-time energy consumption is primary coal in the production process, and the consumption in the transport process is gasoline, diesel and so on.

1.2.3 The environmental emission factor

The environmental emission factor is used to evaluate impact of various castoff, which released in the whole life cycle on the ecosystem. The prominent feature of environmental emission factor is throughout the all aspects of the life cycle, began with mining terminated in exhausting (Mary, 1993). According to the discrepancy in impact on environment, the environmental emission factor can be divided into four groups: the first category is air pollution, the second category is water pollution, the third category is solid castoff, and the fourth category is the noise and others. As an example, environmental emission factors of ceramics industry is listed in table

1.2.4 The economic consumption factor

The economic consumption factor is used to measure the cost which consumers must pay for using the materials in life cycle. The economic consumption factor is codetermined by the materials cost and useful life. The cost occurred during consumption process included materials price, maintenance cost and retired cost. For example, the purchase price of ground material is 100 Yuan /m^2, maintenance costs is 10yuan/year and useful life is five years, the economic consumption of materials can be defined as 30 Yuan / year. The consumers of rural building material characterized by a significant low level of purchasing power expected cheap production. At present, the higher price is the main obstacle which the material with better environmental harmonization faced in process of extension of rural market. If the building materials cost per unit year can effectively be reduced brought useful life and maintenance cost into economic analysis, the types of materials can be considered in the villages, and vice versa.

2. Evaluation Method of Environmental Harmonization of the Rural Building Materials

The evaluation system of environmental harmonization of the rural building materials includes various factors, such as resource consumption, energy consumption and basic characteristic of material. And each factor includes kinds of elements, such as non-renewable resource consumption (Jeroen, 2002 and Kohler 2002). Fuzzying evaluation method is adopted to assess environmental harmonization of the rural building materials. Fuzzing evaluation utilizes membership function to describe and assess the limits of the rating level, and puts different weight to single factor according to the effect on whole influence. The advantage of this method is the determination of the weight more objective and conversion materials life cycle assessment from qualitative to quantitative.

2.1 Membership function

The membership function is the basis of fuzzy control applications. It is one of the keys to correct structure the membership function in of fuzzy control. According to the characteristics of building material factors, the relationship between membership function is followed:

$$u_i = \begin{cases} (x_{i+1} - x)/(x_{i+1} - x_i) & (x_i < x < x_{i+1}) \\ 1 & (x = x_i) \\ 0 & (x < x_i \ or \ x > x_{i+1}) \end{cases}$$

μ_i – membership

x – Value of factor

x_i, x_{i+1} – Adjacent values of the indicators

2.2 Evaluation criteria

According to life cycle theory and characteristics of rural building materials, the evaluation criteria should be reasonable to distinguish resource consumption, energy consumption, waste emission and economic consumption between the different materials. This paper selected five types of indicators to represent environmental coordination. The meanings of various indicators are shown in table 2.

2.3 Weight coefficient vector

Due to the discrepant importance of various factors, the evaluated factor should be given a corresponding weight v_i. The weight coefficient vector is expressed as followed:

$$N = \left(w_1, w_2, \ldots, w_m\right)$$

$$w_i = \frac{\left(c_i / s_i\right)}{\sum\left(c_i / s_i\right)}$$

c_i – Value of i evaluated factor

s_i – Average value of i evaluated factor

2.4 The steps of fuzzing evaluation

1). Establish the evaluation factors set

$$U = \{u_1, u_2, \cdots, u_n\}$$

2). Establish the evaluation set

$$V = \{v_1, v_2, \cdots, v_n\}$$

3). Establish fuzzing relationship matrix

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

4). Establish the weight coefficient vector

$$N = \left(w_1, w_2, \ldots, w_m\right)$$

5). Calculate fuzzing comprehensive evaluation matrix calculated

$$B = N \cdot R = \left(b_1, b_2, \cdots, b_m\right)$$

6). Determine evaluation level

$$b_j = \mathop{\vee}_{i=1}^{n} (a_i \wedge r_{ij}), j = (1, 2, \cdots, m)$$

$$b_j = \max\{\min(a_1, r_{1j}), \min(a_2, r_{2j}), \cdots, \min(a_n, r_{nj})\}, j = (1,2,\cdots,m)$$

In fuzzying evaluation matrix, the grade level is determined by the maximum value.

3. The Application of Fuzzing Evaluation in the Rural Building Material Environmental Harmonization

Research targets are two tiles XA and XB which product separately in A and B companies. Type of tile is VWH002NP, and size is 250mm×330mm×8.3mm, functional units is 1m2. The purchase price in March 2009 is separately 48Yuan / m2 and 79Yuan/ m2, without maintenance cost in useful life. The data of environmental harmonization are listed in table 3 and 4. The evaluation criteria of VWH002NP tile is refer to product and emission criteria of enterprise and industry. The detail data are list in table3.

Comprehensive evaluation matrix of x_A is: B= (0, 0.044, 0.455, 0.094, and 0).The largest vector-value is 0.455, the environmental harmonization degree isⅢ. Comprehensive evaluation matrix of x_B is: B= (0, 0.1713, 0.1307, 0, and 0).The largest vector-value is 0.1713, the environmental harmonization degree isⅡ.

4. Conclusions

The factors impacted on environment exist in each stage in material cycle life, and is different to quantitative analysis the factor. So fuzzing evaluation is a more scientific and appreciative method to assess the environmental harmonization of rural building material.

In this paper, the design of evaluation system not only considered various types of evaluation of resource consumption and waste emission factors, but also included economic performance based on the characteristics of rural consumer groups. It highlighted the problem which should be faced in promotion process of rural building material and the quantitative result responded the practice preferably. The fuzzing evaluation is valid and practicable that is confirmed by the application of title environmental harmonization assessment. As the result of sample size and time limitations, the evaluation factors designed in this paper is not entirely suit for rural building material, it is necessary to adjust and amend.

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Table 1. The emission factors of ceramics industry in cycle life

category	emission factors	cycle life				
		Mining of raw materials	Transport of raw materials	process of production	Transport of production	Use and waste
air pollution	CO_2	√	√	√	√	
	SO_2	√	√	√	√	
	NO_X	√	√	√	√	
	CO	√		√		
	Dust	√		√		
	Powder			√		
	Hydrocarbons	√		√		
water pollution	Suspended solids			√		
	Lead			√		
	Cadmium			√		
	COD_{cr}			√		
	Fluorid			√		
solid castoff	Slag			√		
	Industrial castoff			√		√
Others	Noise			√		

Table 2. The meanings of various indicators

Evaluation criteria	I	II	III	IV	VI
Resource consumption	Less affected	Small affected	Certain influence	Great affected	Greater affected
Energy consumption	Less affected	Small affected	Certain influence	Great affected	Greater affected
waste emission	Less affected	Small affected	Certain influence	Great affected	Greater affected
economic consumption	Less affected	Small affected	Certain influence	Great affected	Greater affected

Table 3. Input data of two tiles

Input(kg)	Clay	Pyrophyllite	Kaolin	Feldspar	Water	Diesel	Coal
X_A	10.15	5.40	2.79	0.99	580	3.79	2.89
X_B	9.5	6.35	2.54	0.79	530	3.96	2.79

Table 4. Output data of two tiles

Input (kg)	CO_2	SO_2	NO_X	CO	Dust	Powder	Hydrocarbons
X_A	17.98	0.89	0.225	0.026	0.83	0.88	0.007
X_B	17.23	0.69	0.19	0.019	0.69	0.76	0.055
Output (g)	Lead	Cadmium	COD_{cr}	Fluoride	Slag	Suspended solids	Industry castoff
X_A	0.143	0.078	88.15	6.13	5.8	908	30.99
X_B	0.129	0.059	85.13	5.73	3.5	897	29.08

Table 5. Evaluation criteria

Evaluation	I	II	III	V	VI
Clay	5	7.3	9.60	11.9	14.2
Pyrophyllite	2.5	2	4.50	6.5	8.5
Kaolin	0.88	1.76	2.64	3.53	4.4
Feldspar	0.3	0.6	0.89	1.2	1.5
Water	300	400	550.00	650	800
Diesel	1.3	2.6	3.57	5.2	6.5
Coal	1.5	2	2.50	3	3.5
CO_2	5	11	16.64	21	26
SO_2	0.22	0.44	0.68	0.88	1.02
NO_X	0.04	0.08	0.13	0.2	0.28
CO	0.007	0.014	0.02	0.03	0.04
Dust	0.25	0.5	0.71	0.9	1.15
Powder	0.2	0.4	0.78	0.8	1.1
Hydrocarbons	0.002	0.004	0.01	0.008	0.01
Lead	0.04	0.08	0.13	0.16	0.2
Cadmium	0.022	0.044	0.07	0.088	0.11
COD_{cr}	28	56	84.15	112	140
Fluoride	1.87	3.74	5.61	7.48	9.35
Slag	1.4	2.8	4.40	6.4	7.8
Suspended solids	297	594	891.00	1188	1485
Industry castoff	9.59	19.18	28.77	38.38	47.95
Price	22	44	66	88	110