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Investigation and analyze the methods of the life cycle assessment for High-Rise Construction in Tehran

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ABSTRACT: In today's world, life cycle assessment is recognized as one of the complete methods for evaluating buildings' environmental evaluation. This study aimed to select the best way to assess the life cycle of high-rise construction with full coverage of environmental impact classification. In this study, seven important categories of environmental impacts were analyzed in eight widely used life cycle assessment methods using SPSS software, and finally, the ReCiPe method was selected as the most appropriate method. This method has then been studied for 16 high-consumption materials in a high-rise residential construction model in the construction phase in Tehran. Conclusion In this study, after comparing the midpoint and endpoint approaches using the ReCiPe method, the midpoint results are comprehensive while the endpoint results are brief. However, the endpoint approach provides more information on the environmental damage that should be considered to use a midpoint supplement. This study's findings can help project designers and builders before the construction of high-rise residential projects by estimating the environmental impact at the level of two approaches in selecting environmentally friendly materials. It should be noted that any misuse of these two approaches may affect the evaluation results and lead to misleading findings.

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1- Introduction

Life cycle assessment is a basic tool for describing environmental risks in different stages of a product's life cycle [1]. This tool is an important resource in management strategy and decision-making, which is designed to improve environmental practices and implement adjustments or technological changes in the organization [2]. The construction industry is one of the most important sectors of economic development in any country and has significant effects on the environment. According to the statistics of the United Nations Environment Program, the construction, and operation of buildings allocated to account for 40% of energy consumption, 38% of greenhouse gas emissions, 40% of raw material use, 30% of waste production, and 16% of water withdrawal in the world [3]. Construction and the discussion of energy consumption optimization due to the reduction of energy reserves on the one hand and the importance of the environment and sustainable development and the essential role of building materials on the other hand, remind the necessity of thinking in advance about constructions [4].

Previous studies in the field of construction industry showed that the appropriate and practical method to evaluate the effects of the life cycle of the building is still not well known. It should be noted that by examining the background of previous researches are chosen seven widely used classifications of environmental impacts, including climate change, acidification, biotoxicity, carcinogenesis, eutrophication, ozone depletion, and reduction of energy resources for consideration in this study. These impacts were subjected to regression analysis using SPSS software. In this study, 16 commonly used construction materials in a residential project in the construction phase have been investigated using SimaPro commercial software as a tool for environmental impact analysis.

The main purpose of this research is to compare common life cycle assessment methods choose the best method and examine it in terms of environmental impacts. In this research, the differences between the midpoint and endpoint approaches in the ReCiPe method were investigated in a case study of high-rise construction in the Tehran metropolis. Based on these results, suggestions about when to extract the endpoint approach and how to interpret the different results from the two approaches have been bandied. Today, due to the increase in the speed of construction in response to the needs of the growing population, the negative effects of these projects have increased in terms of energy consumption, environmental pollution, and construction waste. But so far, no research has been done in a comprehensive and documented way to evaluate different life cycle methods to examine the environmental impacts of consumer materials and to choose the best life cycle assessment method in the construction industry in Iran.

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2- Methodology

2- 1- Steps of the research method

-Compilation of reports, preparation of project information based on field visits interviews and observation

- Interview with professors and experts in the field of life cycle and building assessment

- Examining the most widely used methods of evaluating life cycle impacts based on authoritative articles related to the subject

- Comparison of the most widely used life cycle assessment methods using the Pearson regression analysis method

2- 2- Introduction of life cycle environmental impact assessment methods

According to the review of previous studies, eight widely used life cycle impact assessment methods including CML[1]- Eco-indicator 95- EDIP[2]- EPD[3]- IMPACT-ReCipe-TRACI[4]- Eco-indicator 99 were compared in this study.

2- 3- Regression analysis

The difficulty of comparing life cycle impact assessment methods lies in the complexity of life cycle impact assessment at different levels such as characterization, normalization, and weighting. Characterization as the most important step in environmental life cycle assessment should be considered, on the other hand, normalization and weighting are relatively subjective factors and have been omitted in this comparison.

The data are compared according to equation (1):

$$r = \frac{\Sigma\left(X - \bar{X}\right)\left(Y - \bar{Y}\right)}{\sqrt{\left(X - \bar{X}\right)\left(Y - \bar{Y}\right)}} \quad (1)$$

In this equation, x and y show the array of characteristic factors in two methods of life cycle impact assessment. represents the mean of x and represents the mean of y. To calculate the significance, the T-test has been used according to equation (2). The T-test equation is obtained with N-2 degrees of freedom (the significance level is set at 0.05), where (N) represents the even number of characteristic factors in the method. Life cycle impact assessment is:

$$t = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}} \quad (2)$$

3- Results and Discussion

Among the methods analyzed above, the ReCiPe method was chosen. The environmental performance for 16 materials consumption mentioned in this project were compared in two

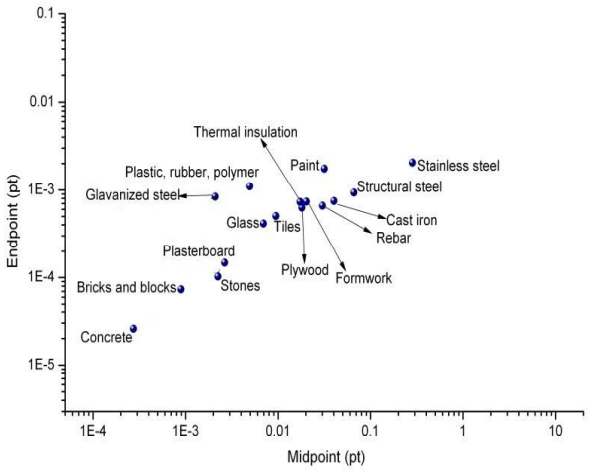

Fig. 1. Comparison of the total environmental performance of the selected materials based on normalization results (functional unit: 1 kg)

midpoints and endpoint in this method (Figure 1). The results showed that these two performances are linearly correlated.

The results showed that, the middle point agrees with the endpoint, but there is no obvious relationship between the results of the middle and end points in terms of ranking the categories of impacts.

In the ReCiPe method, the weighting factors are determined using the same method as the CML[2] method. In this method, weighting is not provided at the level of effect categories but only defined for damage categories at the end point. The end point approach has defined weighting factors in terms of time perspective (short term, medium term, long-term). In this research, mid-term weighting factors have been used at the end point due to the cross-sectional nature of the project.

4- Conclusions

The conclusions of this study showed:

- Correlation coefficients are consistent between the eight methods selected to categorize climate change, acidification, energy reduction, and ozone depletion.
- There is disagreement in life cycle impact assessment methods in many aspects, such as disagreements in categories, incompatible units, differences in characterization factors, etc.
- The midpoint point is able to provide analysis for a range of impact categories despite the difficult interpretation of the results, but the endpoint point includes damage assessment and adds more uncertainty to the results.
- In ReCiPe, two approaches, the middle point and the end point, can lead to different interpretations.
- This method could be helping for project designers to identify the environmental impacts of the

1 Centre of Environmental Science(CML), Leiden University in 2001
2 Environmental Design of Industrials product 2003
3 Environmental Product Declaration 2008
4 Tools for the Reduction and Assessment of Chemical Impacts

building life cycle by interpreting the results of the two methods before implementing the project and providing the results to the builder to choose environmentally friendly materials in the direction of developing sustainable buildings.

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