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Environmental and Economic Impact Assessment of Flooring Materials Using Life Cycle Assessment

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Abstract— In India, various materials are used in the midst of advancement which encounters particular manufacturing and transporting process, which may ominously impact nature. Choosing anenvironmental friendly material will reduce the unfriendly environmental effect caused by building material. Nevertheless, for the right decision of a sustainable flooring material it must be balanced against the money related execution as well. This examination analysedthree flooring materials (ceramic tile, composite marble and linoleum flooring) on their environmental and economic effect. The environmental impact analysis was done using the Building for Environmental and Economic Sustainability (BEES) software The Life cycle cost of the materials were resolved reliant on Indian setting. . The result obtained were then analyzed using the VIKOR method to develop a common score for the assurance of a best sustainable material.

Keywords— Life cycle assessment, Life cycle cost Assessment, VIKOR, Sustainability

I.INTRODUCTION

These days the effect brought about by human exercises on nature is expanding radically and various environmental issues have developed at nearby, territorial and worldwide dimensions. As indicated by environmental performance index (epi) 2018, created by yale university and columbia university in a joint effort with the world economic forum and the joint research center of the european commission, india has been positioned 177 among 180 nations. Development industry comprises of different building materials which experience diverse manufacturing and transportation process. This may result in the arrival of outflow of different ozone depleting substances and other unsafe gases into the air, soil, and water, which may prompt a global warming, eutrophication, acidification, and different other ecological effects. Subsequently, there comes a requirement for the evaluation of natural soundness of items. Life cycle appraisal (lca) is turning into an undeniably significant strategy for making item related natural evaluations in india. Flooring materials is a significant component of a structure. It spread about half of the structure surface. In any case, while picking a flooring material its environmental effect can't be considered as the only choice criteria. Determination of a material relies upon economic factor moreover. There comes the need to coordinate the life cycle cost with life cycle evaluation. In this paper, study of life cycle assessment and life cycle cost assessment of threeflooring materials (composite marble, linoleum flooring and ceramic tiles) is done to analyze the environmental end economic effects. Thebuilding for environmental and economic sustainability (bees) and vikor(visekriterijumskaoptimizacija i kom-promisnoresenje) that implies: multicriteria optimization and compromise solu-tion approach of multi attribute decision making(mcdm) where utilized in this examination.

II.DEFINITIONS

A. Life cycle assessment

LCA is a tool for systematically analyzing the environmental performance of products or processes over their entire life cycle, including raw material extraction, manufacturing, use, and end of- life disposal and recycling. Therefore, LCA is considered a "cradle to grave" approach for the evaluation of environmental impacts (Cabeza et al. 2014). Similarly, Joshi (1999) reported that the major share of the environmental impacts did not occur in the use, maintenance, and repair of the product itself, but occurred in the production, transportation, and disposal stages. The LCA studies areconducted in conformance with the ISO 14040 (ISO 2006) standards, which provide the minimum requirements for performing such studies (Weidema 2014).

B. Life Cycle Cost Assessment

LCC is an assessment of all costs associated with the life cycle of a product that is directly covered by any one or more of the factors involved in the product life cycle (Hunkeler and Rebitzer 2005). The objective of the LCC analysis is to choose the most cost effective approach from a series of alternatives to achieve the lowest long-term cost of ownership (Shil and Parvez 2007). The LCC analysis can be performed on large and small buildings or on isolated building systems. Many building owners apply the principles of life cycle cost analysis in decisions made regarding the construction or improvements to a facility (Cabeza et al. 2014). The LCC analysis helps to select products or processes based on their total life cycle costs rather than the initial purchasing cost ciated with the life cycle of a product that is directly covered by any one or more of the factors involved in the product life cycle (Hunkeler and Rebitzer 2005).

III. COMPUTATION OF ENVIRONEMNTAL IMPACT SCORE

So as to figure the environmental impact score of different flooring alternatives, the BEES model were utilized. The BEES model uses the LCA approach to discover the environmental effect of flooring materials dependent on ISO 14040 arrangement of standards. The LCA is a support to-grave way to deal with discover the absolute environmental effect brought about by different flooring materials.The data from SimaPro LCA database and United States Life Cycle Inventory Database were used in the BEES for the investigation of different flooring materials used in this examination.

IV. INPUT FOR ENVIRONMENTAL IMPACT CALCULATONS

Data is collected from information acquired through survey. A specialist survey was conducted through email to get the weight out of 100 for each environmental impact considered for the examination. An aggregate of 26 replays was obtained from specialists having background of around 3 to 20 years. Among all the environmental effect factors global warming, fossil fuel depletion, and human health scores the greatest.

TABLE 1
INPUT BASED ON SURVEY RESULT

Impact factors	Average Weightage
Global warming	25
Acidification	5.5
Eutrophication	5
Fossil Fuel Depletion	13
Indoor Air Quality	9
Habitat Alteration	6
Water Intake	2
Criteria Air Pollutants	3
Smog	2
Eco Toxicity	4
Ozone Depletion	6.1
Human Health	19.4
Sum	100

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V. OUTPUT FOR ENVIRONMENTAL IMPACT CALCULATONS

From the environmental impact result from examination utilizing BEES it is discovered that the composite marble have the greatest global warming capability of about 4141g CO_2 and Vinyl arrangement tile contribute the least of about 1042g CO_2. Composite marble transmits a lot of carbon dioxide and methane, which is a fundamental wellspring of expanding a worldwide temperature alteration. Since linoleumflooring is produced utilizing natural materials the impact caused to environment is less.Similar way the environmental effect brought about by each flooring materials are determined. Fig 1. below shows the global warming potential of composite marble, linoleum flooring as ceramic tile. It is expressed in gram carbon dioxide equivalent.
The equation used in BEES to calculate the impact result is as follows:
$IAjk = \sum_{i=1}^{n} Iij$ * IAfactor$_i$ (Lippiat, 2017)
Where,

N = NUMBER OF INVENTORY FLOWS IN IMPACT CATEGORY K

IIJ = INVENTORY FLOW QUANTITY FOR ALTERNATIVE J WITH RESPECT TO INVENTORY FLOW I,

IAFACTORI = IMPACT ASSESSMENT CHARACTERIZATION FACTOR FOR INVENTORY FLOW I.

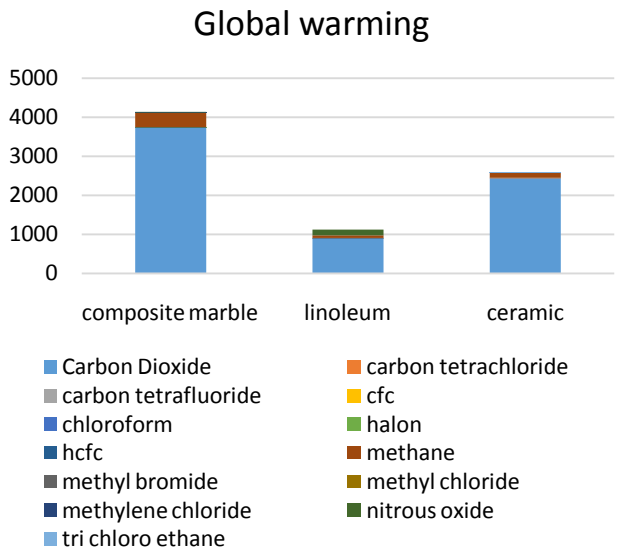
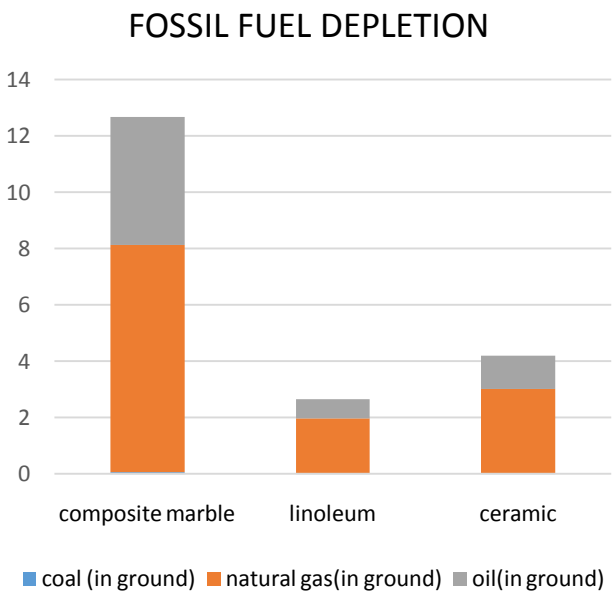


Fig 2. Shows the graph of fossil fuel depletion of composite marble, linoleum flooring and ceramic tile. Its unit is mj/ft^2. From the graph it is clear that the consumption of fossil fuel by composite marble is higher, next comes the ceramic tiles and least is the linoleum flooring. In a similar manner, the impact caused by each environmental impact factors obtained.



2. NORMALIZING IMPACT VALUES

The impact regards gained from bees is in different units for instance global warming potential in co_2 proportionate, fossil fuel depletion in mj, etc. So for getting a common score situating for each environmental effect these impact are to be changed over into normalized score. The normalized score is resolved using the us normalization factor (table 2), since it is the internationally recognized normalized values. The calculation used to determine the normalized score is given underneath:

$\boldsymbol{NSi = \frac{IAjk}{NFi}}$, (lippiat,2017)

Where,

Ns_i = normalized score of impact category i

Ia_{jk} = environmental impact result for impact category i

Nf_i = normalization factor for impact category i

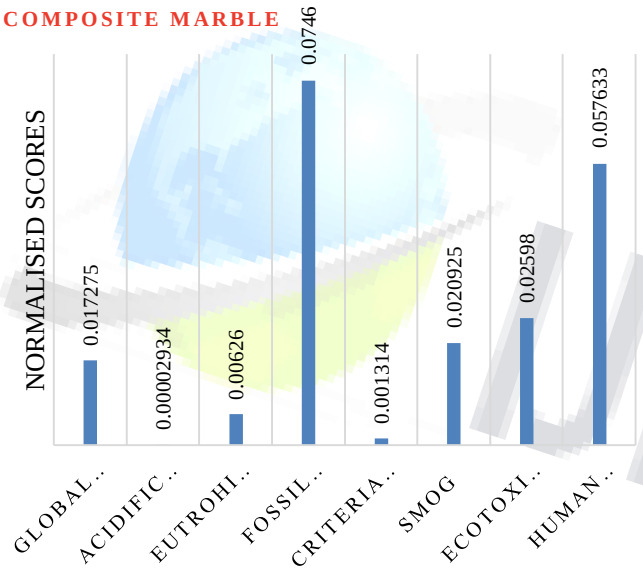
TABLE 2

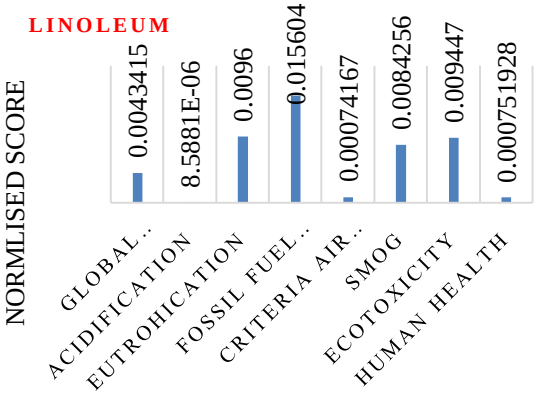
US INVENTORY DATA

Impact catogory	**Normalization factor**	**Unit**
Global warming	2.41E+4	kg CO_2 equivalent
Acidification	7.8E+5	milligrams H+ equivalents
Eutrophication	19 214.20	g N equivalents
Fossil Fuel Depletion	35 309.00	MJ surplus energy
Criteria Air	19 200	microDALYs

Pollutants		
Smog	151 500.03	g NOX equivalents
Ecological Toxicity	81 646.72	g 2,4-D equivalents
Ozone Depletion	340.19	g CFC-11 equivalents
Human Health	274 557 555.37	g C_7H_8 equivalents

THE FOLLOWING GRAPH SHOWS THE NORMALIZED SCORE FOR COMPOSITE MARBLE, LINOLEUM FLOORING AND CERAMIC TILES.





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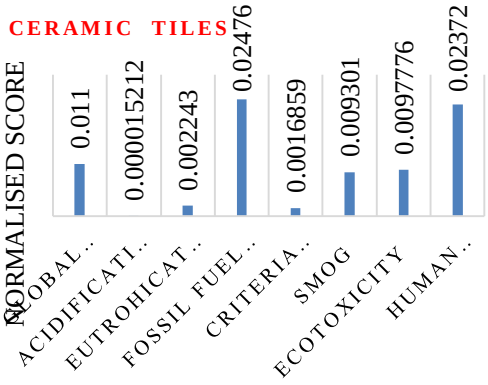
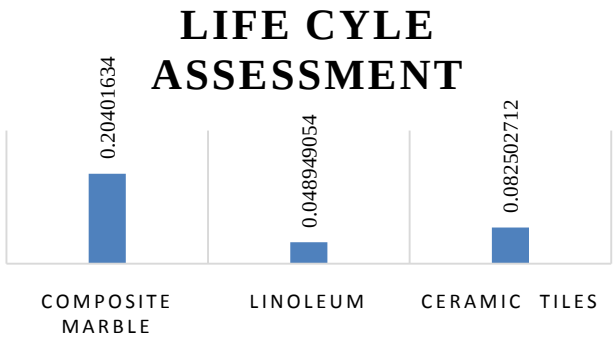


Table below shows the overall normalized score obtained for the three flooring materials and it shows that linoleum scores the least (0.048949054) which means it is the best material based on environmental sustainability.



V. COMPUTATION OF ECONOMIC IMPACT

The life cycle cost amid the use phase of the material is determined utilizing the lifecycle cost examination. For LCC figuring, the discount rate is taken as 6.25%, which is the discount rate in India. The yearly maintenance cost is thought to be 3% of initial cost and the life cycle cost is determined for per ft^2 of flooring material. For instance, the LCC calculation of composite marble, the initial expense is assessed to be Rs.185/ft^2 (Purchase cost + Installation cost), where purchase cost is Rs.150/ft^2 and installation cost is Rs.35/ft^2 . Concerning it is a flooring material, it is assumed thatmaintenance would be done once at 5 year interval. The present value is given by PV = F × SPV, where F is the future value and SPV = $(1+d)^{-n}$ is the single present value at time t, with the discount rate of d.Table 1 follows the estimation for the maintenance and replacement costs for composite marble. The regard Rs.14.9182 is the PV of the re-pair/bolster cost picked at ordinary intervals of the examination time apportioning at a discont rate of 6.25% and 3% fix rate. Since the life span of composite is 75yrs, which is more than the examination time assignment, no exchange is considered for composite marble.

TABLE 3
REPLACEMENT AND MAINTENANCE COST FOR COMPOSITE MARBLE

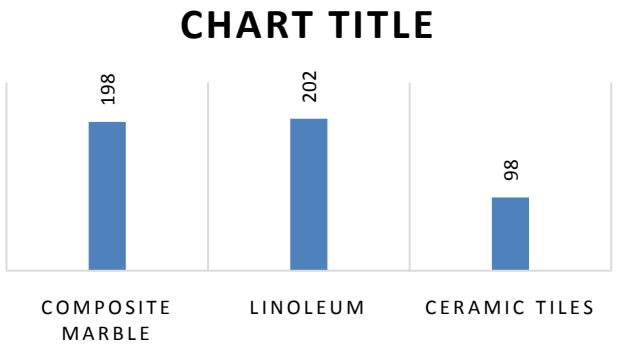
Maintenance cycle(yrs)	Discount factor	Present value(Rs./ ft^2)	Replacement year
5	0.7385	4.0987	-
10	0.5454	3.0270	-
15	0.4028	2.2355	-

20	0.2975	1.6511	-
25	0.2197	1.2194	-
30	0.1622	0.900	-
35	0.1198	0.6649	-
40	0.0885	0.4911	-
45	0.0653	0.3624	-
50	0.0483	0.2687	-
TOTAL		14.9182	

The LCC is given by

Total life cycle cost = $I_C + M_{PV} + REPL_{PV} + R_{PV}$

Where, Ic = beginning establishment cost; Mpv = present estimation of the upkeep cost; $Repl_{pv}$ = present estimation of the substitution cost; and R_{pv}= PV of the leftover esteem. The estimation of LCC can accordingly be determined as LCC = (185 + 14.9182 +1.978), where Rs.1.9878 is the rescue estimation of composite material. So the absolute LCC of composite marble is determined to be Rs.198/ft^2 . Also the LCC of all the other three flooring materials are for multi year consider period. The diagram 2 demonstrates the calculated life cycle cost of all the ground surface materials.



VI. DEVELOPING OVERALL PERFORMANCE SCORE

Choosing an appropriate flooring material dependent on one criteria is can't be considered as a legitimate strategy. So a joined exhibition score must be created considering both ecological end monetary effect. For this VIKOR technique is utilized, which is a multi-criteria decision method (MCDM) or multi-criteria choice investigation strategy. The steps associated with VIKOR technique is given beneath. Table 4. gives the outcome for consolidated execution score computation.

Step 1: Establish the decision matrix

Step 2: Determine the normalized decision matrix.

Step 3: Determine the ideal and negative ideal solutions

Step 4: Calculate the utility measure (Si) and the regret measure (Ri).

Step 5: Calculate the VIKOR index (Qi)

Step 6: The alternative solution with the highest VIKOR index is the best solution.

TABLE 4

RANKING OF FLOORING MATERIALS

	S_i	R_i	Q_i	RANK
Composite marble	0.126659	0.047843	0.000	3
Linoleum	0.142767	0.738498	0.851	1
Ceramic	1.607484	0.544095	0.770	2

VII. CONCLUSIONS

The LCA and LCC examinations are two main approaches to manage measure the environmental and economic effect of materials. MADM is a methodology for investigating decisions with characteristics in unbalanced units. This examination used the NIST's BEES model to break down the environmental effect and cost dependent on Indian setting. It is discovered that among the chose flooring materials linoleum tile flooring is the best arrangement while considering both environmental and economic effect. This implies when adjusting natural against monetary execution linoleum flooring is the best materials than others. Additionally the outcomes demonstrates that Composite marble is the most minimal scoring material dependent on environmental and financial effect. The use of this strategy improved the predisposition in picking the best flooring material that is only founded on environmental and economic impact.

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IX. REFERENCES

[1] Athawale, V. M., and S. Chakraborty. 2012. “Material selection using multi- criteria decision-making methods: A comparative study.” Proc. Inst. Mech. Eng. Part L: J. Mater. Des. Appl., 226 (4), 266–285.
[2] Azar, F. S. 2000. Multiattribute decision-making: Use of three scoring methods to compare the performance of imaging techniques for breast cancer detection. Technical Rep. No. MS-CIS-00-10. Philadelphia: Univ. of Pennsylvania
[3] Cabeza, L. F., L. Rinc ´on, V. Vilarino, G. Pérez, and A. Castell. 2014. ˜ “Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review.” Renewable Sustainable Energy Rev. 29: 394–416.
[4] Hunkeler, D., and G. Rebitzer. 2005. “The future of life cycle assessment.” Int. J. Life Cycle Assess. 10 (5): 305–308.
[5] Lippiatt, B. C. 2000. Building for environmental and economic sustainability technical manual and user guide. Washington, DC: U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics.
[6] Lippiatt, B. C. 2017. BEES 3.0 building for environmental and economic sustainability: Technical manual and user guide. NIST Interagency/ Internal Rep. (NISTIR)-6916. Gaithersburg, MD: NIST.
[7] Makutėnienė, D., O. R. Šostak, and A. Maceika. 2016. “Decision support system for roof installation.” Stud. Inf. Control 25 (2): 164
[8] Pérez-Lombard, L., J. Ortiz, and C. Pout. 2008. “A review of buildings energy consumption information.” Energy Build. 40 (3): 394–398
[9] Senitková, I., and P. Bednárová. 2015. “Life cycle assessment.” JP J. Heat Mass Transf. 11 (1): 29.
[10] Shil, N. C., and M. Parvez. 2007. “Life cycle costing: An alternative selection tool.” J. Bus. Res. 9: 49–68.
[11] Sim, J., J. Sim, and C. Park. 2016. “The air emission assessment of a South Korean apartment building’s life cycle, along with environmental impact.” Build. Environ. 95: 104–115.
[12] Weidema, B. 2014. “Has ISO 14040/44 failed its role as a standard for life cycle assessment?” J. Ind. Ecol. 18 (3): 324–326.