Optimizing Material Solutions according to LEED Accreditation System

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Urbanization and growth in population have led to an increase in impervious surfaces, which results in an Increasing project complexity made the construction tradeoffs (time-cost, time-cost-quality etc…) highly convoluted. With addition of the sustainability aspect in construction and the Leadership in Energy and Environment Design (LEED) certification system as a sustainable measure, more tradeoffs have been added to the overall project success criteria. LEED is a credit based system where sustainability criteria for a building is formulated as points under the different credit sections. The total number of points earned by a building places it under different certification levels (certified, silver, gold, platinum). However, it was debated that sustainability applications weren't cost effective as it required intense pre planning and budgeting before the start of project. According to literature, some owners have a misplaced belief that using sustainable materials would have a negative impact on their revenue due to increasing costs which was contrasted by researchers who suggested cost savings could be achieved using sustainable materials and processes. Sustainability along with other tradeoff constraints (time, cost, quality etc…), have metamorphosed the project's complexity by increasing the number of tradeoffs leading to difficulty in their prioritization by stakeholders. Therefore, this research directly addresses the problem faced by the owners and design-builders among other stakeholders in solving the tradeoff between the time, cost and sustainability (MR category) in construction projects. This research is focused on the tradeoff between Time, Cost, and the sustainability criteria for the Material & Resources credits (section of the LEED checklist). The research aims to solve multiple objectives: (1) Maximize credits, (2) Minimize cost and (3) Minimize time.

The tradeoff mentioned in the research objective was formulated as a multi-objective optimization problem which was coded using Python 3.5 programming platform. Testing the model code (in Python) started with running a preliminary dataset through an exhaustive search and finding the optimal solution based on user entered relative importance factors (RIFs) for time, cost and sustainability (LEED MR). Exhaustive search being highly inefficient for higher number of combinations, evolutionary genetic algorithms (GAs) were introduced to significantly increase the optimization model's efficiency and reduce the computational time. The preliminary dataset was retested/re-run using the GA model for internal validation of the model. Finally, a "real world project" case study was introduced to externally validate the GA optimization model. The preliminary study showed the model to be coherent with attainment of minimum cost and time, and maximum credits goals, among all possible combinations (per predefined RIFs). The validation study applied the GA, while also considering the user input as RIFs to test the ability of solving for a tradeoff optimal/near-optimal solutions. Results show that the optimal solution depends on: (1) RIFs entered by the user, (2) Number of runs for the genetic algorithm code, (3) The initial size of the population (containing a set of combinations). The computational time increases with the number of runs and with the increased population size. Hence the user needs to decide the level of optimality required and its tradeoff with the computational time required. The computational time would increase exponentially as the size of dataset increases. It is expected that the solution would be the most optimal if the GA is left to run for a sufficient time (large number of runs like a 1000 iterations).

The model has been found to work efficiently with changing RIFs to yield optimal solutions which can minimize a project's cost and time, while maximizing the earned credits. This optimization model is beneficial to different stakeholders in the construction industry. It can reduce the workload of LEED consultants exponentially, by providing them with material options to be used, based on the importance factors provided by the owners. Similarly, Design-Builders can use it to optimize the owner's budget while attaining the maximum credits for the LEED certification and reducing the risk of their schedules. The optimization model developed in this research is proven to be highly successful in the preliminary study, which created a premise for validation using a case study. The success from the validation study shows that the model not only works at the theoretical level, but also at a practical level and has the potential of getting embedded in a software package for industry use. The dynamic and user friendly nature of coding helps in working with diverse datasets and inexperienced users, respectively. Finally, the optimization model considers user-defined priorities which can provide them with easy and customized efficient solutions to various tradeoffs.

Keywords: Optimization, Multi-objective optimization, Sustainability, LEED, Tradeoffs