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Measuring the Embodied Energy of Construction Materials and Their Associated Cost Through Building Information Modelling

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Abstract : Energy assessment is an evidently significant factor when evaluating the sustainability of structures especially at the early design stage. Today design practices revolve around the selection of material that reduces the operational energy and yet meets their displinary need. Operational energy represents a substantial part of the building lifecycle energy usage but the fact remains that embodied energy is an important aspect unaccounted for in the carbon footprint. At the moment, little or no consideration is given to embodied energy mainly due to the complexity of calculation and the various factors involved. The equipment used, the fuel needed, and electricity required for each material vary with location and thus the embodied energy will differ for each project. Moreover, the method and the technique used in manufacturing, transporting and putting in place will have a significant influence on the materials' embodied energy. This anomaly has made it difficult to calculate or even bench mark the usage of such energies. This paper presents a model aimed at helping designers select the construction materials based on their embodied energy. Moreover, this paper presents a systematic approach that uses an efficient method of calculation and ultimately provides new insight into construction material selection. The model is developed in a BIM environment targeting the quantification of embodied energy for construction materials through the three main stages of their life: manufacturing, transportation and placement. The model contains three major databases each of which contains a set of the most commonly used construction materials. The first dataset holds information about the energy required to manufacture any type of materials, the second includes information about the energy required for transporting the materials while the third stores information about the energy required by tools and cranes needed to place an item in its intended location. The model provides designers with sets of all available construction materials and their associated embodied energies to use for the selection during the design process. Through geospatial data and dimensional material analysis, the model will also be able to automatically calculate the distance between the factories and the construction site. To remain within the sustainability criteria set by LEED, a final database is created and used to calculate the overall construction cost based on R.M.S. means cost data and then automatically recalculate the costs for any modifications. Design criteria including both operational and embodied energies will cause designers to revaluate the current material selection for cost, energy, and most importantly sustainability.

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