Towards nearly zero carbon communities: the impact of construction materials on environmental performance of educational building

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1. Introduction – Building sector plays an important role in a moving towards sustainable development goals. Even there are numerous studies conducting on life cycle of buildings, most of them was focused on the operation phase because it consumed energy about 80-90% of total building's life cycle energy demand [1]. However, the performances regarding construction stage should take into consideration as the amount of material used for building construction will proportionally affect the level of building's total embodied energy and carbon and different types of building material will result in different amount of energy demand in operation phase as well [2-3]. This study, therefore, was aimed at identifying the amount of embodied carbon emissions in construction materials of educational building located in Bangkok and to propose the way for minimizing carbon emissions throughout building service life (BSL) of 50 years. The findings of this study will be useful for building owner or decision maker in designing a sustainable building based on low carbon approach.

2. Material and Methods - Four buildings (3 mix-used office and 1 dormitory) of Chulalongkorn University were selected as case studies and a square meter of floor area was used as a functional unit to quantify building's performances. According to bill of quantities, building construction materials classified into 4 groups of structural materials (SM), decoration materials (DM), materials supplied for heat, ventilation and air condition (HVAC) system, and for sanitary and fire protection (SFP) work were calculated in kg/m^2. Due to a lack of available data in Thailand, the BEES (Building for Environmental and Economic Sustainability) database was used to determine the carbon emissions.

3. Results and Discussion - For each case study, the value of mass intensity was in a range of 1,595 – 1,699 kg/m^2. A group of concrete materials for sole plate, foundation, structure and precast accounted for 80% of the total material mass of building followed by sawnwood, a group of cement, aggregate, and a group of steel. On weighted average, the intensities of embodied carbon in construction materials of educational building in this study was 347 $kgCO_2e/m^2$. about one-fourth of such intensity was associated with decoration materials while a category of structural materials was employed for embodied carbon emission for more than 70%. Because more than half of total energy was consumed for cooling system, thus different kinds of external wall insulation were examined to identify the best solution for optimizing energy-related emissions throughout building service life. The results revealed that the best option was cellulose as it could reduce about 23 tCO2e/year. Such number can be used to compensate for the amount of embodied carbon increased in building due to the increase of material (insulation) consumed, the payback period of carbon offset was 1.4 years for every 10 years of insulation replacement.

4. Conclusions - The results illustrated that either intensities of materials mass or embodied carbon contributed the highest share to structural material followed by decoration materials. A loft design building which polished with neither ceramic tile nor paint was recommended as it could reduce about 5% of embodied carbon intensity based on this study. Fly-ash or blast furnace slag are encouraged to substitute instead of using a virgin concrete as well. For improving existing building, HVAC system needs to be focused on as it consumed a large amount of energy during operation phase and cellulose was recommended for external wall insulation. The increased embodied carbon of insulation can be compensated with the reduced energy-related emission.

5. References

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