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Evaluation of Carbon Dioxide Emissions for Concrete Works in Constructions of Standard and Conservative-Style Houses

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ABSTRACT

This paper presents the evaluation results of carbon dioxide emissions for concrete works in constructions of residences in Thailand. The drawings of standard and conservative-style houses provided by Department of Public Works and Town & Planning were used in this study. The value of carbon footprint of ready-mixed concrete given by the Thailand Greenhouse Gas Management Organization was used in the evaluation. The evaluation results show that the average values of the CO_2eq emissions per 1 m^2 of usable area for standard and conservative-style houses are 79.75 and 75.77 kg/m^2, respectively. Moreover, the amount of CO_2eq emissions increased with increasing the usable area of house.

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INTRODUCTION

Typically, the main structures of building are constructed using concrete, which is a composite material composed of coarse granular material, aggregate particles and Portland cement. However, the Portland cement industries cause the environment pollutions in their processes. Examples of pollutions are greenhouse gases, dusts, noises and vibrations.

Generally, the environmental impacts are evaluated using the carbon footprint method, defined as a methodology to estimate the total emission of green-house gases (GHG) in carbon dioxide equivalents (CO_2eq) from a product across its life cycle from the production of raw material used in its manufacture to disposal of the finished product, excluding in-use emissions (Carbon Trust 2007). There have been several sources providing the values of emissions in carbon equivalent from some products (e.g. Thailand Greenhouse Gas Management Organization 2014, Carbon Footprint Ltd 2014, Ecometrica 2014)

The Thailand Greenhouse Gas Management Organization (2014) provides the average emissions of CO_2eq from using the ready-mixed concrete with the compressive strength values of 240 and 280 kg/cm^2 across life cycle are 260 and 272 kgCO_2eq/m^3, respectively. In Thailand and other developing countries, several construction projects of infrastructures and residences have been conducted and need large volume of Portland cement in the form of concrete components.

Thus, this study was aimed at evaluating the average emissions of CO_2eq from using ready-mixed concrete in construction of residences in Thailand. The CO_2eq emissions for concrete works were evaluated from the construction drawings of standard and conservative-style houses, provided by Department of Public Works and Town & Planning, Thailand. The evaluation results of both types of house are presented and compared.

2. Construction Drawings Provided by Department of Public Works and Town & Planning, Thailand:

The policy of service construction drawings of residence in Thailand was promoted by the Royal Thai Government in 2004. Thai people can used these drawings to obtain house construction licenses. The Department of Public Works and Town & Planning (2004) was the agency responsible for designing and preparing construction drawings, including 30 types of drawings for low cost houses, standard houses, conservative-style houses and commercial buildings. Tables 1 and 2 show the values of usable area for both standard and conservative-style houses, which were selected in evaluation of CO_2eq emissions for concrete works in this study.

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Table 1: Usable area for standard houses.

House type	No. of stories	Usable area (m^2)
Type 1	1	77
Type 2	1	113
Type 3	2	126
Type 4	2	180
Type 5	2	169
Type 6	2	240
Type 7	2	241
Type 8	2	363

Table 2: Usable area for conservative-style houses.

House type	No. of stories	Usable area (m^2)
Northern Type	2	77
Central Type	2	113
Northeastern Type	2	126
Southern Type	2	180

3.Evaluation of CO_2 Equivalent Emission from Concrete Works in Constructions of Standard and Conservative-Style Houses:

To evaluate the CO_2eq emission from concrete works in construction, the quantity of concrete for each type of house was first estimated. In this study, the concrete works, including lean concrete, structure concrete, and precast concrete slab, were calculated from the drawing of standard and conservative-style houses provided by the Department of Public Works and Town & Planning (2004). Tables 3 and 4 show the quantity of concrete works of standard and conservative-style houses.

Table 3: Quantity of concrete works for standard houses.

House type	Quantity of concrete works (m^3)
Type 1	20.95
Type 2	39.00
Type 3	39.30
Type 4	57.10
Type 5	48.40
Type 6	60.60
Type 7	87.00
Type 8	111.80

Table 4: Quantity of concrete works for conservative-style houses.

House type	Quantity of concrete works (m^3)
Northern Type	88.20
Central Type	97.00
Northeastern Type	74.00
Southern Type	75.00

It was assumed in this study that the concrete with the ultimate compressive strength of 240 kg/cm^2 was solely allowed in construction of main structure components. According to the Thailand Greenhouse Gas Management Organization (2014), the average value of CO_2eq emissions from the use of ready-mixed concrete with compressive strength of 240 kg/cm^2 across life cycle is approximately 260 $kgCO_2eq/m^3$. From the quantities of concrete works for standard and conservative-style houses given in Tables 3 and 4 respectively, the values of CO_2eq emissions and CO_2eq emissions per 1 m^2 of usable area for each type of house can be calculated as shown in Tables 5 to 6 and Figures 1 to 4. The average values of the CO_2eq emissions per 1 m^2 of usable area for standard and conservative-style houses are 79.75 and 75.77 kg/m^2, respectively. Figure 5 shows the plot between the amount of CO_2eq emissions and the usable area. It can be noticed that the amount of CO_2eq emissions increased with increasing the usable area. The results also show that the value of CO_2eq emissions (kg) is approximately 80 times usable area of house (m^2).

Since the environmental issue has been raised as a serious topic, the agencies responsible for constructions must promote the policies supporting a modern building design with the use of environment-friendly materials. Moreover, there have been several researchers studying on the engineering properties of concrete, in which some part of Portland cement was replaced by industrial and agricultural wastes, such as fly ash (e.g. Malhotra 2002, Li 2004) and rice husk ash (e.g. Nehdi et al. 2003, Bui et al. 2005). Thus, these types of concrete should be introduced and applied in the construction projects.

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Table 5: Emission of CO_2eq from using ready-mixed concrete in construction of standard houses.

House type	CO_2eq (kg)	CO_2eq /1 m^2 of usable area (kg/m^2)
Type 1	5,447	70.74
Type 2	10,140	89.45
Type 3	10,218	81.10
Type 4	14,846	82.48
Type 5	12,584	74.46
Type 6	15,756	65.65
Type 7	22,620	94.08
Type 8	29,068	80.08
	Average	79.75

Table 6: Emission of CO_2eq from using ready-mixed concrete in construction of conservative-style houses.

House type	CO_2eq (kg)	CO_2eq /1 m^2 of usable area (kg/m^2)
Northern Type	22932	68.89
Central Type	25220	74.53
Northeastern Type	19240	79.50
Southern Type	19500	80.15
	Average	75.77

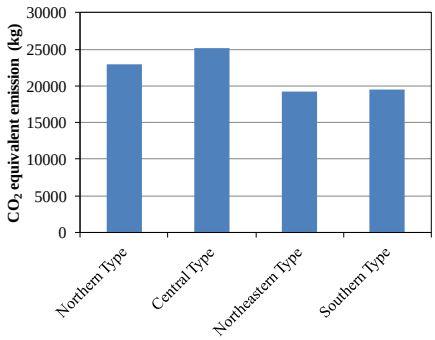

Fig. 2: Emission of CO_2eq from using concrete in construction of conservative-style houses.

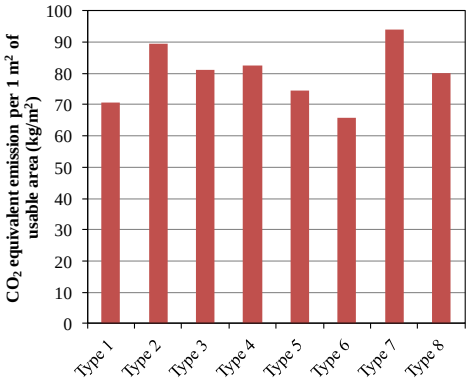

Fig. 3: CO_2eq emission per 1 m^2 of usable area from using concrete in construction of standard houses.

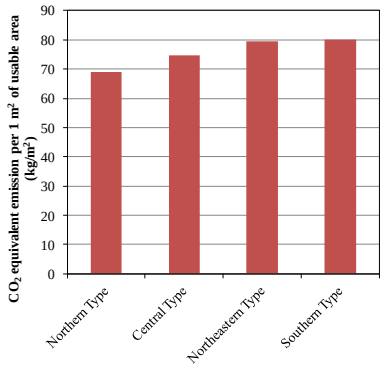

Fig. 4: CO_2eq emission per 1 m^2 of usable area from using concrete in construction of conservative-style houses.

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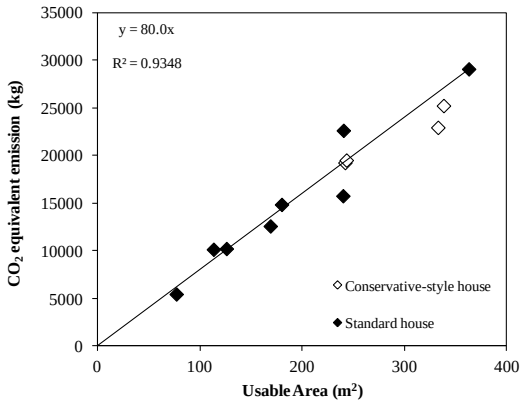

Fig. 5: Relationship between amounts of CO_2eq emission from using concrete and usable area of house.

Conclusions:

The average values of CO_2eq emission from using Portland cement to produce concrete components of standard and conservative-style houses in Thailand were evaluated using the value of carbon footprint of ready-mixed concrete provided by the Thailand Greenhouse Gas Management Organization. The evaluation results show that the average values of the CO_2eq emissions per 1 m^2 of usable area for standard and conservative-style houses are 79.75 and 75.77 kg/m^2, respectively. Moreover, the amount of CO_2eq emissions increased with increasing the usable area.

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