Clarification of actual building envelope and equipment design specifications using energy conservation standard application data

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1. Introduction

To realize carbon neutrality by 2050, further energy conservation in homes and buildings is necessary, and to achieve this energy conservation, it is important to accurately identify the actual status of conservation and take more effective measures. However, for non-residential buildings in particular, there are few past surveys on the actual status of building envelope and equipment design specifications for each building use type and scale, making it difficult to study effective measures based on the characteristics of use type, etc.

To solve this problem, NILIM has been collecting input/output data of a program (Web program) for determining compliance with energy conservation standards with the permission of the program's users, in an attempt to clarify the actual status of design specifications for non-housing buildings.[1] This report covers a summary of the results of an analysis conducted on newly constructed office buildings (1,731 in total) of application data of the FY 2018 energy conservation standard (14,802 in total).[2]

2. Grouping using energy conservation standard evaluation indicators

Figure 1 shows the distribution of the results of primary energy consumption performance

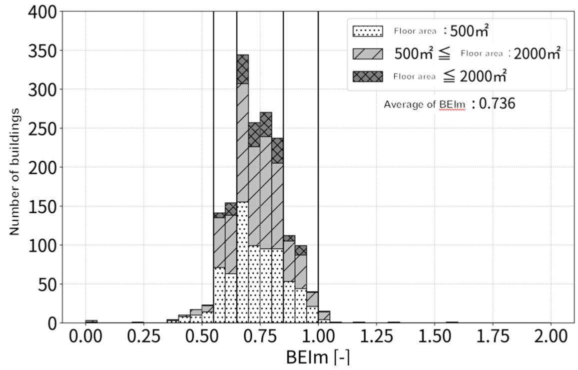

Figure 1: Distribution of BEIm (new office buildings)

evaluation (BEIm) by the model building method (simplified evaluation route). BEIm is a value obtained by dividing the design primary energy consumption (energy consumption calculated based on design specifications) by the reference primary energy consumption, and if BEIm is less than 1, the building is in compliance with the standard. Figure 1 shows that there is a large change in the number of cases after BEIm = 0.55, 0.65, and 0.85. Therefore, based on BEIm, an analysis was performed by dividing the results into the five groups (Group I, II, III, IV, and V) shown in Figure 1. Since the trend for Group I varies greatly depending on the presence of photovoltaic power generation equipment, the properties in Group I without photovoltaic power generation equipment (35 in total) were extracted as Group I-npv and are shown separately from the

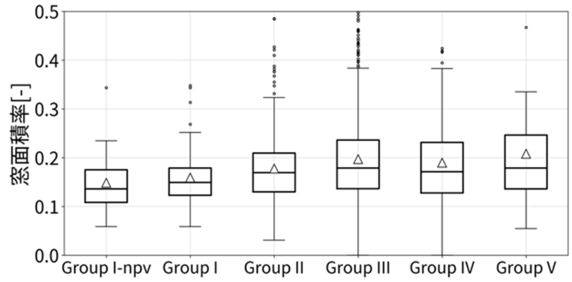

Figure 2: Window area ratio

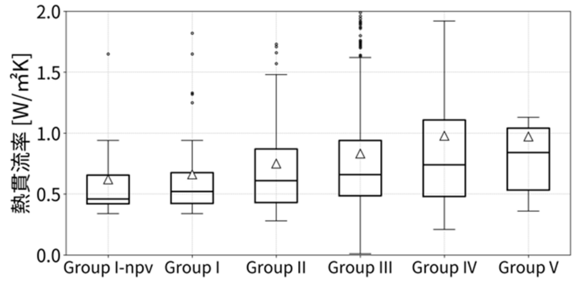

Figure 3: Thermal transmittance of exterior wall

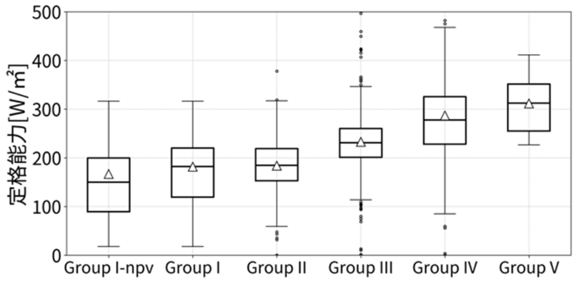

Figure 4: Rated capacities of air-conditioning (cooling/heating) equipment

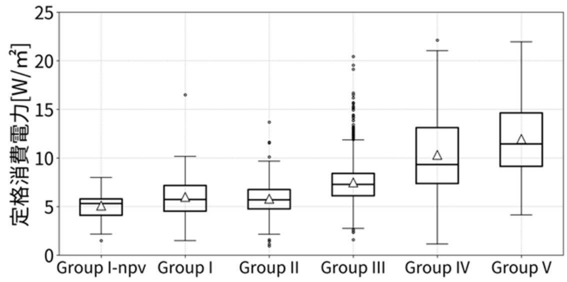

Figure 5: Rated power consumption of lighting fixtures

Group name	Envelope						Air-conditioning				Lighting	PV panel power generation capacity [W/m^2]
	Exterior wall ratio [-]	Coef. of heat transmission of wall [W/m^{2}K]	Coef. of heat transmission of roof [W/m^{2}K]	Window area ratio [-]	Coef. of heat transmission of window [W/m^{2}K]	Solar heat gain coef. of window [-]	Rated capacity of heat source [W/m^2]		Rated efficient of heat source [-]		Power consumption [W/m^2]	
							Cooling	Heating	Cooling	Heating		
Group I-npv	0.75	0.45	0.40	0.15	4.5	0.50	150	180	1.5	1.7	5	Not installed
Group I		0.50	0.40	0.16			180	210	1.4	1.6	6	12
Group II		0.60	0.45	0.17								2
Group III		0.65		0.20			230	260	1.3	1.4	8	Not installed
Group IV		0.75	0.50				290	320	1.2	1.3	11	Not installed
Group V		0.85					320	350	1.1	1.2	13	Not installed

Table 1: Standard building envelope and equipment facility design specifications (new office buildings)

overall results of Group I.

3. Analysis of building envelope design specifications

As an example of analysis of building envelope specifications by group, the window area ratio (window area divided by building envelope area) and thermal transmittance through exterior walls (unit: W/m^{2}K; the smaller the value, the higher the insulation performance). Figure 2 and Figure 3 show the results (△ in the figures indicates the average). Regarding the window area ratios in Figure 2, while there is no large difference among the groups, groups with smaller BEIm tend to show slightly smaller window area ratios. The mean is 0.159 for Group I, 0.176 for Group II, and 0.191 for all groups. The thermal transmittance of exterior walls (Figure 3) varies among groups, with Group I having a median of 0.52 W/m^{2}K, Group II 0.61 W/m^{2}K, Group III 0.66 W/m^{2}K, Group IV 0.74 W/m^{2}K, and Group V 0.84 W/m^{2}K.

4. Analysis of equipment design specifications

As examples of analysis of equipment specifications by group, Figure 4 and Figure 5 show the results of analysis of rated capacity per floor area of air-conditioning (cooling/heating) equipment and power consumption per floor area of lighting fixtures. The average of the rated capacity of cooling/heating equipment (Figure 4) is almost the same in Group I and II, with a value of about 182 W/m^2, increasing to 232.6 W/m^2 for Group III, 286.8 W/m^2 for Group IV, and 311.6 W/m^2 for Group V, in this order. The average of rated power consumption of lighting fixtures (Figure 5) is about the same in Group I and II with a value of about 5.9 W/m^2, followed by 7.48 W/m^2 for Group III, 10.30 W/m^2 for Group IV, and 11.94 W/m^2 for Group V.

5. Standard design specifications by group

Based on the findings from the data analysis, Table 1 shows the results of identifying standard design specifications for each group. By utilizing the application data of energy conservation standards, the standard design specifications for Japan as a whole, which were previously unknown, were shown quantitatively.

6. Summary

Currently, there are discussions on strengthening energy conservation standards to realize a decarbonized society. Utilization of the results from this report will clarify what needs to be done, for example, to improve the thermal transmittance of exterior walls from 0.75 W/m^{2}K to 0.60 W/m^{2}K or reduce the power consumption of lighting from 11 W/m^2 to 6 W/m^2, to improve from the Group IV level to the Group II level. The results are expected to be useful for central and local governments in formulating subsidy programs, design guidelines, etc., and for architects and designers in setting design goals.

☞ For more information:
1) Technical Notes of NILIM No.1107 and No.1143
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1107.htm
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1143.htm
2) Masato Miyata, Susumu Hirakawa: Analysis on building envelope and building service equipment design specification using the input and output data from the calculation program to confirm compliance with building energy code (part 1): Identification of the design specification for newly built offices in Japan according to the evaluation result of the building energy code, Japan Architectural Review (Translated Paper), pp.1–12, 2022.4, https://doi.org/10.1002/2475-8876.12265