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Evaluating the effectiveness of improved workmanship quality on the airtightness of Dutch detached houses

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Abstract

Increasing the airtightness of buildings can contribute in coming to energy neutral buildings. This paper evaluates two possible measures: modest technical improvements and coaching of construction teams. Beforehand, the specific leakage rate of 44 detached houses was measured using a blower door test and by means of statistics, the most pressing problems were determined. An educational session was developed to explain construction workers the relevance of and their own influence on building airtight houses. The effectiveness of the technical improvements and the education was assessed by evaluating 14 new houses. This evaluation showed a significantly improved airtightness.

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Keywords: airtight houses, air permeability, blower door test, education, workmanship quality

1. Introduction

Achieving energy neutral buildings is an ambition expressed in the legislation of many countries, especially European. The positive effects of insulation and energy efficient heating systems on the energy performance of a building are compromised when, during the heating season, a house leaks heated air and cold air enters. Therefore, increasing the airtightness of buildings can contribute to accomplishing energy neutral buildings and comfort, next to increasing occasionally air quality, sound insulation, fire resistance and humidity control [1]. Scholars [2–5] conclude

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estimations ex ante on the airtightness of houses are not straightforward, but often depend on the quality of workmanship and the applied design. Other researchers also stated that attention to detail and enhancing supervision in order to improve the quality of workmanship, helps in achieving a better airtightness in buildings [6]. Laverge et al. [4] compared the air leakage between dwellings built with standard workmanship and dwellings built with extra attention for airtightness. They found significant differences between these two groups. Kalamees [5] determined typical air leakage locations and concluded that quality of workmanship and supervision has a significant effect on the airtightness. Sinnot and Dyer [7] concluded that "the results clearly demonstrate that good design, detailing, specification of materials and construction practice are of fundamental importance when constructing new houses". All these studies were not aimed at exploring the effects of workmanship, but finally had to conclude that workmanship affected air leakage. Therefore, the aim of this research is to assess the effects of workmanship quality on the air leakage rate in newly built detached houses, by determining the effects of improving the quality of workmanship of construction workers on the air leakage in buildings.

Nomenclature

BD-test	Blower door test	
n_{50}	Air change rate at 50 Pa	h^{-1}
NrPA	Number of problem areas per building	-
q_{50}	Air permeability across the building envelope area at 50 Pa	$m^3/s{\cdot}m^2$
TL	TotalLeakage per building	-
w_{10}	Specific leakage rate across the usable building floor area at 10 Pa	$dm^3/s{\cdot}m^2$

2. Research method

Dutch legislation uses the specific leakage rate w_{10}, hence this value was used in this research, instead of the more commonly internationally used air permeability (q_{50}) or air change rate (n_{50}). The w_{10} is the volume of air flow per second per square meter floor area at a differential pressure of 10 Pa, that occurs at seams between components in a building envelope [1]. To determine the current airtightness of houses without any intervention, the w_{10} of a first set houses was measured, using a blower door test (BD-test) according to the Dutch norm NEN 2686, [8] and the European norm ISO 9972, [9]. Observations were made for areas that negatively affect the airtightness, which are called problem areas. For each building the total number of problem areas (NrPA) was determined. The severity of these problem areas was defined by TotalLeakage (TL) [6] and adapted to fit this research. To compute the TL, each found problem area is scored on a scale from 1 to 4. A score of 1 indicates the leak is small and not severe. A score of 4 indicates a large and severe leak. The TL is the sum of all these scores for one building.

The results from the baseline measurements were analyzed using statistical methods to determine where improvements were possible to reduce the air leakage rate. This included the compilation of the most severe problem areas by 1) considering how often they occur, 2) the severity based on the TL and 3) partial impacts of problem areas on the total air leakage. The quality of workmanship in the evaluated buildings was assessed by comparing the w_{10}, NrPA and TL per building crew. Based on these analyses, an improvement strategy was developed and applied to reduce the air leakage rate in newly built houses. By measuring the specific leakage rate, NrPA and TL of the new buildings and by comparing them to the baseline results, the effectiveness of the improvement strategy was assessed.

3. Baseline measurement results and defining problem areas

The current specific leakage rate (w_{10}) was measured in 44 newly built detached houses to assess the baseline of the current air leakage rate of the houses built by different construction teams of one contractor. All measurements were performed by two operators using the same method. The average measured w_{10} in 44 houses was 0.678 $dm^3/s{\cdot}m^2$ with a standard deviation (SD) of 0.296. The average NrPA was 9.6 (SD = 3.7) and the average TL was 19.2 (SD = 7.5). Translating the w_{10} into the internationally used q_{50} and n_{50}, the average q_{50} was 2.868 $m^3/s{\cdot}m^2$ (SD = 1.215) and the average n_{50} was 2.653 h^{-1} (SD = 1.137).