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Implementation of the German Passivhaus Concept in the Southern Hemisphere

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Abstract

The first passive house (PH) was built in 1991, in Germany, by the Passive House Institute (PHI) of Darmstadt. In the next ten years several design solutions have been developed, which proved to be useful for the German climate. Later on, these solutions spread in Western and Central Europe and since 2007 in Southeastern Europe, including Romania. This paper focuses on the implementation of the German Passivhaus concept in Southern Hemisphere. Two groups of locations of similar latitudes have been considered. One group consists of cities placed on all Southern Hemisphere Continents, except Antarctica. The other group consists of European towns. The climate of the two groups of locations has been compared. A prototype passive building has been hypothetically placed in these geographical locations and its energy performance was estimated by using the Passive House Planning Package (PHPP). The Passivhaus concept fits well for Tasmania, New Zealand and the Southern part of South America.

Rezumat

Prima casa pasiva (PH) a fost construita in 1991 in Germania, de catre Institutul Casei Pasive (PHI) din Darmstadt. In anii urmatori cateva solutii de proiectare au fost dezvoltate, care s-au dovedit a fi utile in climatul german. Mai tarziu aceste solutii s-au raspandit in Europa de Vest si Centrala si din 2007 in Europa de Sud-Est, inclusiv in Romania. Acest articol se concentreaza pe implementarea conceptului german de casa pasiva (Passivhaus) in emisfera sudica. Doua grupuri de locatii de latitudini similare au fost alese. Un grup consta in orase situate pe toate continentele emisferei sudice, cu exceptia Antarcticei. Celalalt grup consta in orase europene. Climatul celor doua grupuri de locatii a fost comparat. O cladire pasiva prototip a fost plasata ipotetic in aceste locatii geografice si performanta ei energetica a fost estimata folosind PHPP (Passive House Planning Package). Conceptul Passivhaus se potriveste bine pentru Tasmania, Noua Zeelanda si partea sudica a Americii de Sud.

Keywords: passive house; heating demand; Southern Hemisphere

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1. Introduction

After the 1970s and 1980s oil crises, the need of low-energy houses becomes more and more obvious. To accomplish this goal, superinsulation, appropriate orientation, good dimensioning of the windows, airtightness, were well known as essential factors and were applied by physicist William Shurcliff [1] and others for houses built in the cold climate of Northern USA and Canada. As described by Professor Bo Adamson (University of Lund, Sweden) in [2] and [3], he also carried out, in those years, similar studies and simulations for houses to be built in cold climates of Northern Europe and China.

Later on, in the same context applied to Germany - in the milder climate of Central Europe, the physicist Wolfgang Feist has observed, intrigued, the building industry results: from one point, the thermal insulation increase contribution seemed to be insignificant in the decrease of heating energy demand. He clarified this aspect in 1988, during a research stay (in the field of building construction) at the Lund University, Sweden. Based on cited previous knowledge, he and Professor Bo Adamson, managed to co-fundament the Passivhaus concept. It states that increased thermal insulation is recommended to be accompanied by all other known building solutions (airtightness, thermal bridge free, low-e three pane glass windows, heat recovery mechanical ventilation) to profit from free internal and solar gains. Computer simulations are used to verify the design data, to prevent the existence of an active heating (central heating boiler) system. Heat is distributed by the mechanical ventilated fresh air without being recirculated.

The forenamed Passivhaus concept defines "Passive Houses" (PH) as buildings which, in the Central European climate, have a small heating energy requirement [4]. The theoretical proof for the feasibility of such houses was furnished, in the thesis "Passive Houses in Central Europe", through computerized simulations of the energy balance of buildings [5]. The first Passive House was planned and built in 1991 in Darmstadt Kranichstein [4].

Apart from the recommended building solutions briefly cited above, the concept comprises evaluation criteria for the certification of a Passive House: Specific Space Heat Demand max. 15 kWh/(m^2y), Pressurization Test Result n_{50} max. 0.6 h^{-1}, Entire Specific Primary Energy Demand max. 120 kWh/(m^2y) incl. domestic electricity [6] all considered as values necessary to be met in the frame of the Passive House standard [7].

A third aspect of the concept is the use of a powerful design tool: the Passive House Planning Package (PHPP) [6]. It permits, based on design data, to anticipate the energetic performances of a Passive House by comparing them to standard values.

One of the most important factor in promotion and wide spread of Passive House concept was CEPHEUS Project [8]. In this Project about 250 housing units, located in five Central European countries, were evaluated through systematic measurement programs in order to observe the fulfillment of the Passive House standard. It was realized a very good match between Passive House Planning Package [6] calculated results and measurement results.

Because of such a Passive House success, in 2005 emerged the Passive-On European Project [9]. It has looked to see what elements of the Passive House standard could be used and what new elements are needed in promoting the spread of PH design in southern Europe.

The Passive House concept was largely adopted in USA where PHIUS, Passive House Institute of United States, promotes passive houses with its own planning tools.
In Fig.1 it is presented the map with Certified Passive House buildings all over the world [10].

Figure 1. Certified passive house buildings on record with the Passive House Institute (as of June 2012) [10].

As can be seen, the Passive House Institute Darmstadt certified only one passive building in the Southern Hemisphere until June 2012. According to [11], this Passive House is built in Glendowie, Auckland, New Zealand. It is a residential, single family home. At the same time, only Europe counted 1023 units of certified Passive Houses, as Fig. 1 shows. The Passive House is obviously less represented in the Southern Hemisphere.

It is to note that the Southern Hemisphere encloses a bigger water body than the Northern Hemisphere. This may lead to a winter with higher temperatures than in the Northern Hemisphere. This may be accompanied by a smaller yearly specific heating demand than in Northern Hemisphere, which can reduces the appropriateness of the Passive House concept in the Southern Hemisphere. The aim of this study is to evaluate the feasibility of Passive House in that southern space. A similar study has been not accomplished by our knowledge.

2. Method

We transposed in a lot of cities from Southern Hemisphere an office building, the Amvic-Bragadiru building, a Passive House already built, in order to provide information about the thermal performance for each of the chosen location.

2.1. Amvic Passive Building Presentation

The construction year for the four floor Amvic office building is 2009 [14], [12]. The gross floor area is 2085.9 m^2, the main façade has south-east orientation. The building is located in Bragadiru, a small town south of Bucharest, Romania. On the north-west side of the Amvic office building is situated the Amvic neopor and styropor factory. On the north-east side is situated a garage. The constructive system and building elements are presented in [13].

Ground floor, first, second and third floor have function of office and the top floor represent a living area. So the office is the main Amvic building function, therefore in PHPP computation the building is assimilated with a complete nonresidential building.
Detailed description of the building and its systems can be studied in [14], [15], [16].

2.2. South Hemisphere Localities

A lot of cities from all Southern Hemisphere continents have been chosen with final purpose to analyze the feasibility of the Passive House concept in their locations.

Table 1: The geographical coordinates of localities selected from the South Hemisphere, the corresponding latitude European localities and the resulted annual specific heating demands.

South Hemisphere Towns	South Latitude	Specific heating demand	European Towns	North Latitude	Specific heating demand
Grahamstown (South Africa)	33.31	0.00			
Santiago (South America)	33.47	0.16			
Cape Town (South Africa)	33.92	0.00			
Mildure (Australia)	34.21	0.20			
Buenos Aires (South America)	34.60	0.33			
Adelaide (Australia)	34.93	0.22			
Wagga Wagga (Australia)	35.11	0.11			
Canberra (Australia)	35.30	0.88	Heraklion (Crete)	35.34	0.63
Albury (Australia)	36.08	0.29	Victoria (Malta)	36.04	0.27
Shepparton (Australia)	36.38	0.28	Gytheio (Greece)	36.76	1.85
Bendigo (Australia)	36.76	1.83			
Auckland (New Zealand)	36.84	0.17	Molaoi (Greece)	36.81	1.01
Naracoorte (Australia)	36.95	0.44			
Stawell (Australia)	37.06	0.79	Kalamata (Greece)	37.08	5.17
Eden (Australia)	37.06	0.65			
Ballarat (Australia)	37.56	0.90			
Melbourne (Australia)	37.81	0.32	Tripolis (Greece)	37.51	4.76
Mount Gambier (Australia)	37.83	0.55			
Frankston (Australia)	38.13	0.36	Palermo (Italy)	38.12	0.01
Geelong (Australia)	38.15	0.48			
Portland (Australia)	38.35	0.64	Lisboa (Portugal)	38.73	0.10
Wellington (New Zealand)	41.28	0.57			
Launceston (Tasmania, Australia)	41.44	1.21	Lleida (Spain)	41.61	1.03
Hobart (Tasmania, Australia)	42.88	2.69			
Christchurch (New Zealand)	43.53	1.04	Marseille (France)	43.30	1.07
Comodoro Rivadevia (South America)	45.87	5.59	Venezia (Italy)	45.44	3.47
Bluff (New Zealand)	46.60	2.45	Payerne (Swiss)	46.82	8.46
Rio Gallegos (South America)	51.62	9.30	Harzgerode (Germany)	51.64	11.66
Punta Arenas (South America)	53.15	11.53	Hamburg (Germany)	53.55	8.83
Ushuaia (South America)	54.80	13.60	Husum (Germany)	54.48	9.31

2.3. PHPP Simulation

As mentioned above, we used PHPP (Passive House Planning Package) [6] in order to obtain information about the thermal performance of Amvic building transported in all the localities from the Table 1.

PHPP (Passive House Planning Package) [6] is an MS Excel program. The software was developed by PHI (Passivhaus Institut) Darmstadt from 1998 as a specialized tool for steady-state Passive House analysis. Mainly created for residential passive building design, the program can also be used in the design of non-residential passive buildings. As it was conceived from the beginning, the program disposes of a relatively large library of climate data. If the passive building, to be analyzed, is situated in a region for which no data are provided, climate data specific to the building location can be used from other sources. For the majority of localities in Table 1 the climate data are not provided by PHPP. We used instead the SoDa-IS database [17], containing values of meteorological and radiometric parameters averaged over the period of 15 years (1990-2004). The specific format of SoDa-IS climate data was processed to obtain the data that matched for PHPP. Then, the resulted from PHPP annual specific heating demands were filled in Table 1 and represented in Figure 2.

2. Results and discussion

Fig. 2 shows the specific heating demand variation with latitude for cities listed in Table1.

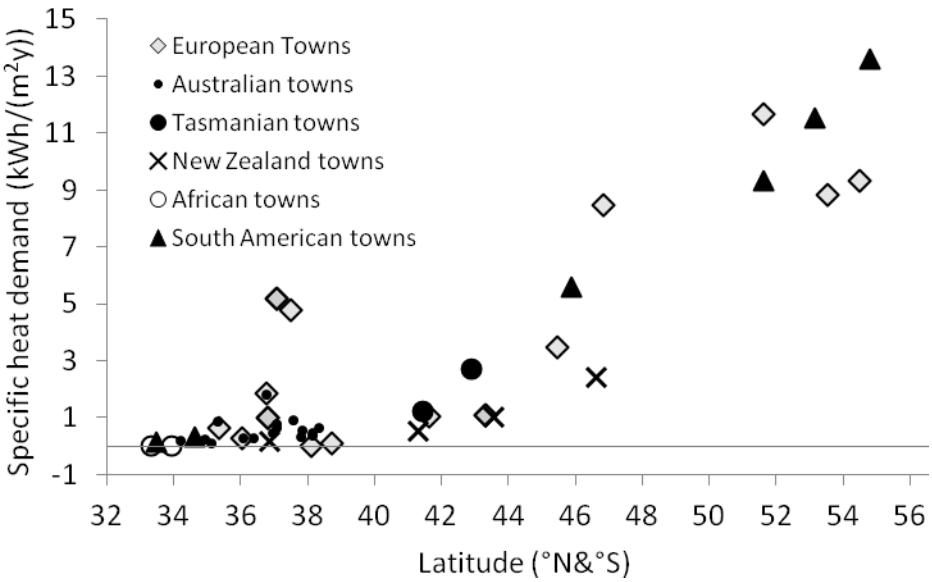

Figure 2. The specific heat demand for localities in Table 1.

It is observed that for less than 40 degrees of latitude in the Southern Hemisphere the heating is almost unnecessary. For above 40 degrees, the specific heat demand has an aspect of linear increase with latitude for the both Hemispheres.

Detailing, we can also observe that the specific heating demands for New Zealand towns are smaller than for any other towns situated at corresponding latitudes, for the Southern Hemisphere localities with latitudes above 40 degrees.

Above 41 degrees of latitude North and South the specific heating demand variation with latitude has an approximately linear aspect. We can say that, at similar latitudes, the specific heating demands for some Southern Hemisphere towns are bigger than the mean specific heating demands for the European towns with two exceptions: Bluff (New Zealand, 46.60 degrees South) compared to Payerne (Swiss, 46.82 degrees North) and Rio Gallegos (Argentina, 51.62 degree South) compared to Harzgerode (Germany, 51.64 degree North). In both cases, the European localities are at high altitude: 400 – 450 m; meantime the two Southern Hemisphere localities are near to the sea level altitude: 16 - 35 m.

Both localities in South America represented in Figure 2 at the greatest latitudes: Puntas Arenas (53.15 degrees South) and Ushuaia (54.80 degrees South) exhibit greater specific heating demands than Hamburg and respectively Husum, both from Germany, due to the specificity of the Southern hemisphere climate. This may be explained by the cold vicinity of the Antarctic continent and cold Pacific currents that prevails whereas the Central Europe localities benefit from the mild warm Gulf Stream.

All these lead to the conclusion that the Southern Hemisphere is suited for application of the Passive House concept, especially for latitudes above 40 degrees. In particular the concept may be applicable in Tasmania, New Zealand and the Southern part of South America.

2. Conclusions

Considering an Amvic building, for all chosen cities, with latitudes between 33 and 57 degrees North or South, we obtain a specific heating demand between 0 and 14 kWh/(m^2y). First, all studied localities meet the Passive House evaluation criteria for specific heat demand (< 15 kWh/(m^2y)).

Heating is almost unnecessary for latitudes under 40 degrees in the Southern Hemisphere. Above 40 degrees of latitude the specific heating demand has an increase with linear aspect for both Hemispheres.

All these lead to the conclusion that the Southern Hemisphere is suited for application of the Passive House concept, especially for latitudes above 40 degrees.

Tasmania, New Zealand and the Southern part of South America are particularly appropriate for Passive House concept implementation.

A building must designed from the very beginning by taking into account the local climatologic data.

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