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PASSIVE HOUSES, AS POSSIBLE ANSWERS OF ENVIRONMENTAL DIRECTED BUILDING FOR THE CHALLENGE OF CLIMATE CHANGE

Abstract

Climate change is a phenomenon affecting the entire Earth requiring new technological solutions, greener thinking and conscious actions in more and more areas. Passive houses meet the basic requirements of sustainability and through their particular features actively contribute to the continuously expanding range of efficient climate responses. The conversion of the existing special military assets by the methods of the passive house technology contains new, untapped opportunities and unexplored areas. The special equipment applied in the performance of military duties can be made more efficient and – concerning its functions – more expandable. The goal of the authors of this article is to present the passive house technology and to provide a broad overview of the application possibilities open to the Hungarian Defence Forces.

Keywords: *global climate change, passive house technology, Hungarian Defence Forces, sustainable growth, military duties*

INTRODUCTION

The problems caused by climate change are being perceived every day at a global level as well as under local circumstances.

The more frequently occurring extremities of the weather, shifting seasons, severe thunderstorms, rains, and huge snow volumes falling abruptly all urge mankind to create a sustainable world for future generations that would significantly protect the environment.

The increasingly noticeable changes of these days could be mitigated mostly by complying with the basic principles of sustainable growth.

The most critical areas are the harmful emissions of traffic and the energy hunger of buildings. Numerous feats of engineering, attempts and methods try to act against them and to impede wastage.

The passive house construction technology that appeared in Hungary only in 2005 (but it appeared in international architecture earlier) is a successful area that can satisfy future architecture striving for energy efficiency and awareness to the maximum extent.

The construction method can equally be applied for public institutions, private buildings, offices or apartment houses and for the renovation of newly built or old buildings, respectively.

The technology has not yet reached its days of glory but "green" buildings are spreading and their number shows an increasing trend all over the world.

GENERAL FEATURES OF PASSIVE HOUSES

Dr. Wolfgang Feist and Prof. Bo Adamson created the concept of the Passive House („Passivhaus"). Although the number of such houses is very small in Hungary their number in Europe is close to 32,000.

The technology is characterised by the consideration of ecological criteria, the observance of social aspects and pursuit of sustainability. The combination of these three areas can handle and solve numerous ecological problems at the level of architecture.

The construction of the first classified passive house in Hungary started in Szada in 2008 which was followed by a number of projects. In 2011 a row of passive houses was handed over to the owners in Dunakeszi with a demonstrable operating cost of only 6-7 thousand forints per month. The 3-layer windows with krypton gas filling, the use of solar energy (in winter also), the orientation, thermal panelling and heat recovery ventilation complement the basic concept of the house in the spirit of economy.

1. Figure. Passive house [1]

Besides apartment blocks some office buildings increased the number of these types of buildings. Probably the most famous of them – at least in Hungary – is the office building erected by the side of the Köröshegy Viaduct (Fig. 2). A common feature of passive houses is the significant energy saving made possible.

The classification of the buildings and the plans is a key question which is currently voluntary and not supported. Concerning the VAT rate of renewable energy there is only one reference made to it in Act CXXVII of 2007. Section (2) lays down that the tax rate for products and services listed in Annex 3 is *5 per cent* of the tax base. District heating is covered by this including the heat supply based on an *energy resource that is qualified as a renewable energy resource* according to the act on electricity.

2. Figure. Office building constructed in passive house style [2]

And the range of allowances related to renewable energy ends here.

The deficit target indices and goals of the current year always surpass green thinking and the spreading of the environment friendly architectural style.

Nevertheless environment friendly passive houses could make considerable achievements in the continuous struggle against climate change. It is relevant that future legislators take into account as well as encourage and support the generations of architects growing up and citizens to design and execute such buildings extensively.

INTRODUCTION OF THE PASSIVE HOUSE TECHNOLOGY

Passive houses are designed in a complex way where a number of factors must be taken into account. These houses are typically zero or energy-plus buildings but numerous criteria must be met simultaneously to achieve that. The keyword is energy efficiency and the application of renewable resources as well as the endeavour to obtain a compact building shape. During their lifecycle passive houses distinguish themselves in reducing carbon dioxide emission also.

The widely known definition of the zero energy building is: energy requirement minus energy generation ≤ 0. Solutions are required which serve the demands of customers in accordance with the following requirements:

- minimisation of the heat loss of the building,
- maximisation of the heat gain of the building,
- taking into account and utilisation of the energy of internal heat resources,
- developing an optimal energy balance (by taking into account orientation, building volume, floor plan alternatives and building engineering solutions).

Sizing procedure

Criteria of passive houses:

- Heating energy requirement <= 15 kWh / (m^2 x year)
- Air tightness <= 0.6 h^{-1}
  (for a pressure difference of 50 Pa)
- Primary energy requirement <= 120 kWh / (m^2 x year)

Recommended criteria:

- Heating load <= 10 Watt/m2
- Becoming overheated in the summer above 25 degrees Celsius <= 10% [3]

An optimal tool of this is the so-called PHPP calculation (Passive House Planning Package[1]) developed by 'Passivhaus Institut' and which appears in a multi-step form during the design (planning) work. Different energy characteristics can be tested with the PHPP.

„The essential condition of obtaining the classification of the Passivhaus Institut of Darmstadt is that the total specific annual primary energy demand is maximum 120 kWh/m^2/year, the n50 air tightness pressure test value is maximum 0.6 1/h, the frequency of overheating is maximum 10%, the specific heating demand is not more than 15 kWh/m^2/year, or the specific heating load does not exceed the value of 10 W/m^2." [4]

In addition the following factors should be taken into account during the design work:

Compact building shape

It is important that the so-called *surface cooling down* associated with the given building volume is as small as possible. In the majority of the cases buildings are designed so that the proportion of frontal glass panes does not exceed 40%. The requirement imposed on doors and windows is that their *U-value*[2] must not exceed 0.85 W/m^2K when installed; in case of other surfaces U <= 0.15 W/m^2K. In order to achieve that in practice a wall structure of min. 55-65 cm thickness furnished with approx. 25-30 cm thick thermal insulation is required. This results in a super-insulated space.

The appropriate *orientation* of the prospective building structure is also relevant which is determined by the aspect of the piece of ground and the consideration of the rules on ground coverage.

The orientation of large glass surfaces is recommended to be south-east or south-west; a smaller part of them may face east or west but north-facing glass surfaces should be minimised (5%). Buildings with suitable orientation provide positive experience both externally and aesthetically.

Various buildings should protect from cold in winter and heat in summer. Diverse *blinds* should be used against heat and overheating. Particularly sunlit sides can be cooled by mounting panelled external blinds.

A further essential criterion is that there should be a possibility to *thoroughly ventilate* the apartments. The purpose of this is to provide protection against summer overheating.

Blinds are useful in cold winters also because by opening them the lower angle winter sunbeams can reach inner spaces and be utilised as heat.

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[1] This tested and verified calculation procedure based on European standards serves the purpose of determining the energy characteristics of buildings. With the help of PHPP the calculations required for the quality assurance of buildings can be performed easily and in a transparent manner. The databases containing the components suitable for erecting passive houses (e.g. windows, glazing, building components, air-conditioning, etc.) form part of the planning package. It also includes the simplified data entry operations that facilitate design, such as the input of surfaces with the assigned U-value. Source: [5].

[2] Heat transfer coefficient

Design free of thermal bridges

It is essential that thermal loss is minimised when erecting passive houses. To achieve this a special layer, the thermal envelope is required which should be thick enough, have an adequate thermal insulation value and should be contiguous. The thermal envelope is the surface of the heated part of the building in contact with the outside world. This envelope may not contain considerable thermal bridges.

Granting air tightness

The occurrence of airflow requiring additional energy consumption must be taken into consideration when designing the buildings. In order to avoid this the good quality of materials used and precise execution is the solution.

Heat recovery ventilation

Clean air with proper temperature plays a key role in all houses. Adequate ventilation is of vital importance in case of passive houses by which approx. 70-90% of the thermal energy of the removed spent air can be recovered. The energy parameters created this way meet the criteria of "passive houses".

In apartment buildings (and even in office buildings) cleaned air and polluted air occur equally. The various rooms generally have clean air while kitchens, bathrooms and toilets contain polluted air.

By applying the passive house technology air is blown into rooms with clean air and air is extracted from rooms with polluted air. The fine aerosol and dust filter (HEPA) cleans the air and eliminates dust and various pollens. This technology results in air that is cleaner than the air coming in through an open window. As ventilation is continuous, the problems of mould formation and precipitation of moisture is also solved. "In addition the system saves almost twenty times more energy than the energy required to operate it! The rate of the required ventilation is 0.3-0.8 times the building volume."

The application of renewable energy resources is typically desirable in these type of houses. Solar collectors contribute to the production of household hot water while air-water or water-water heat pumps are used to move water.

It is important to know that passive houses require only a fraction of the energy required by traditionally constructed buildings. Bearing in mind current energy prices the construction of passive houses is without exception profitable in the long run, not to mention the fact that we are talking about buildings that fit into the environment better and also better suit the requirements of sustainability.

By the winter's cold setting in the temperature in passive houses is minimum 16 °C thanks to the super-insulated walls and the complex construction therefore only heating limited to the minimum is required.

However, this technology can protect people in hot summer days as well. Passive cooling – that is keeping the building cool – is not a new invention. Going back to the construction methods of old times, the adobe houses, it is obvious that the pleasant cool of the house was typically provided by thick walls, the shade of the eaves and the veranda, and that the windows are closed during the day and opened wide during the night.

In the rooms of passive houses the summer temperature is 25-26 degrees on average. If additional cooling is required pipe coil is installed into the ground that continues in the reinforced concrete floor. Non-freezing liquid circulates in the pipes which absorbs the heat generated in the building and passes it on to the ground. The methods of passive cooling help reducing energy hunger. [6]

3. Figure. Passive cooling

Taking into consideration that – according to *Article 9 of the directive of the European Parliament and Council 2010/31/EU*[3] – the member states shall ensure by 31 December, 2020 that all new buildings are nearly zero energy buildings and after 31 December, 2018 new buildings occupied and owned by public authorities are nearly zero energy buildings[4], the practical application of the passive house technology could provide an obvious solution. Besides new buildings this requirement scheme can also be applied in case of traditionally constructed buildings though the technology can be further considered in many other areas taking into account the requirements of our times.

Advantages of passive houses compared to conventional construction methods, among others:

Emission reduction,
Sustainability,
Use of renewable energy,
Environmental awareness,
Reduction of energy hunger,
Long-term optimal investment.

Both the National Energy Strategy and the New Széchenyi Plan stipulates the future tasks of energy saving. This technology delivers the tool that can be used to improve the quality of life in coming decades.

NEW OPPORTUNITIES FOR THE HUNGARIAN DEFENCE FORCES

The building stock of the Hungarian Defence Forces cannot be described as new. The majority of the buildings existed at the turn of the century already and it was typical of recent years that no new buildings were erected. The exceptions are the DF Health Centre (Honvédkórház – Military Hospital) and a few official quarters but the majority of the real estate is obsolete and out-of-date. There were some sales also e.g. HM-III. (Hűvösvölgyi Street) and the facility at Zách Street is not managed by the army any more.

Taking the indices of the passive house technology the following can be laid down:

- Compact volume shaping is insufficient because the passive house technology did not exist at the time of erecting the buildings;
- The thermal bridge-free design is incomplete because the so-called thermal envelope through which heat loss could be further minimised is missing from the beginning;
- Air tightness is inappropriate because the quality of the material used fails to satisfy the energy-saving requirements of our days;
- Heat recovery ventilation is not resolved since only conventional methods ensure ventilation instead of blowing in and extracting air.

[3] The addendum to the directive can be found here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:081:0018:0036:HU:PDF [7]
[4] http://www.greenpressblog.com/search/label/PHP

According to a statement at present 14,539 buildings in 1,176 facilities of the Defence Forces use up various energies. In 2010 the cost of electricity, natural gas, district heating, coal firing, other fuels, water and drainage was in aggregate HUF 9,110 million.[8]

In addition to the exorbitant amount the main problem is caused by harmful emission, mostly CO_2 emission, and the gigantic wasting of energy which is principally due to obsolete heating technologies, inadequately closing windows and thin walls.

Although the conversion of existing buildings would consume enormous amounts but would result in considerable savings and sustainable buildings in the long run.

The advantage of the passive house technology is that this construction method may not only be used in case of erecting new buildings.

Converting the existing building stock into passive buildings would render significant energy reduction possible.

For this basically the following conditions should be met:

- Replacement of old windows by 3-layer, inert gas filled windows,
- Additional insulation of walls – thereby terminating thermal bridges and mould forming,
- Switch-over to renewable energy e.g. solar collectors, geothermal energy … etc.,
- Implementation of heat recovery ventilation.

As the orientation of the existing buildings cannot be changed the heating power of the Sun can best be utilised or subdued by increased glass surfaces or by mounting external blinds.

Comparing the above with the typical characteristics of the passive house construction technology it is evident that although the switch-over from the conventional construction method to the passive technology would cost a lot in the short run but it would most probably result in significant energy savings through which the volume of emitted contaminants and thus the unfavourable effect of greenhouse gases would be reduced.

Nevertheless the passive house technology could not only provide a solution in case of fixed buildings in respect of the applicability by the army.

Examining the question from another aspect it turns out that the conversion of mobile buildings into passive ones would reveal new opportunities for the mobile forces deployed by the army. These mobile assets can be converted into passive ones. This would in turn create new application areas and opportunities (in disaster situations, in the course of missions, etc.) while these building structures would not have any harmful effects of any sort on the environment.

The army is present:

- at the time of natural disasters (e.g. flood, inland waters, landslide, etc.)
- at logistics and transportation duties (storage, accompanying consignments)
- during military training and exercises;
- in foreign service, in the course of performing military missions
- at the level of institutional operations
- in guarding and protection… etc.

The duties of the Hungarian Defence Forces are regulated by Article 45 of the Fundamental Law of Hungary and the National Defence Act. The Fundamental Law specifies the special law and order. According to that the following may take place:

- state of emergency (Article 48 of the Fundamental Law);
- emergency (Article 49 of the Fundamental Law);
- preventive protection situation (Article 50 of the Fundamental Law);
- surprise attack (Article 51 of the Fundamental Law);
- dangerous situations (Article 52 of the Fundamental Law) [9].

In the course of mobilisation the special machine pool and the particular equipment, in the course of humanitarian activities the deployable gear should be moved, transported and human resources should be rested and protected. [10]

It is not only the transportation equipment that could be converted and equipped with solar cells for instance, which would also significantly reduce harmful emission, but also warehouses covered with roofs could be converted into storages operated by solar collectors. Furthermore the conversion of containers used for storing tactical equipment and for living/sanitary/guarding purposes into passive containers would also create new application opportunities for further considering the passive house technology.

The scope of container application is very wide; moreover when deploying the mobile forces of the Hungarian Army they could be of considerable help in certain unexpected situations. (E.g. stowing away in safety and resting etc. civilian and professional staff in case of weather-related disasters.)

These could prove to be useful not only under domestic climate extremes but also at the varying temperature conditions of mission activities or at the storage of demanding equipment. (E.g. the storage of paintings requiring constant temperature and belonging to the group of professional human materials.)

During conversion efforts should be made to fully observe military provisions and already existing requirements regulated by law because such an environment conscious conversion of the equipment could only take place by taking into account the standards and military requirements.

Moreover the assets turned into environment friendly assets could present themselves on military programmes (e.g. Open Days) where they could not only fulfil their original functions but would be exemplary from an environment conscious aspect as well.

SUMMARY

Climate change requires global thinking and local actions. The principles of sustainability affect many areas and answers need to be found to the effects of climate change.

One of these responses could be in the long run that the passive house construction technology, present in the architectural profession in Hungary only for a few years, becomes general.

The special design of floorings, walls, façades, the typical orientation, insulation, multilayer windows filled with noble gas all serve the purpose to keep the energies of the house inside and the cold outside, while the heat of the Sun and the geothermal energy are sensibly utilised.

The results of passive house construction are so outstanding that it is worth keeping track of them and develop them further.

By building these kinds of almost zero energy houses the harmful emission can be drastically reduced, the energy demand can be greatly cut down (which can be met by local sources without exception) and positive changes can be achieved in the long run concerning the concentration of greenhouse gases in the atmosphere.

An additional advantage of the passive house technology is that – besides erecting new houses – such deep renovation of already existing buildings contributes to developing a more sustainable world to a great extent.

In Hungary the technology is still immature and is mostly restricted to houses and building complexes while it contains some new opportunities unexploited so far that have remained untapped in many areas.

In addition to converting the buildings managed by the army into passive buildings the military equipment that can be declared as unique may also be reconsidered using this technology (e.g. armoured vehicles, containers, storages, etc.).

On the other hand the newly developed equipment may be successfully applied in areas such as missions, military and tactical instructions and other programmes, and with these possible responses can be given also to the negative consequences of climate change.

The assets modernised and reconsidered this way can be characterised not just by their expanded functions but also meet the expectations and legal provisions of the 21st century that take into account environmental aspects as well.

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