ENVIRONMENTAL ASSESSMENT OF STRUCTURAL DESIGN OF RESIDENTIAL BUILDINGS WITHIN THE PROJECT ECOPARK ODOLENA VODA

Jan Růžička
CTU in Prague, Faculty of Civil Engineering, Department of Building Structures, Thákurova 7, 166 29 Prague, Czech Republic, jan.ruzicka@fsv.cvut.cz

Štepán Mančík
CTU in Prague, Faculty of Civil Engineering, Department of Building Structures, Thákurova 7, 166 29 Prague, Czech Republic, stepan.mancik@fsv.cvut.cz

Summary

Environmental assessment of structural design, material and technological concept of buildings is very complex and includes a large number of technical as well as non technical parameters and represents a wide multictriterion problem.

The presented study shows structural and material assessment of 3 family houses in passive energy standard designed within the project "Ecopark Odolena Voda – Technology Transfer Centre" which involves together 15 buildings in passive energy standard (2 office buildings, 1 attached house with 4 flats, 13 family houses).

The assessment has been done in two levels: (i) environmental criteria (embodied energy, embodied CO2, embodied SO2, amount of used materials, amount of renewable and recycled materials or used primary natural sources, fully or partially recyclable materials or non-recyclable materials), (ii) multicriterion analysis using SBToolCZ methodology covering environmental, socio-cultural and economical criteria.

The goal of this case study was the evaluation of the impact of structural design on the environmental quality a building [1]. The study links to previous environmental assessment and case studies [2] and shows the methodology and possible approach to environmental evaluation of structural and material design of the building.

Keywords: environmental assessment, sustainable buildings, low-energy and passive houses

1 Project "Ecopark Odolena Voda – Technology Transfer Centre"

1.1 Concept

The main goal of the project "Ecopark Odolena Voda – Technology Transfer Centre" is to show possible technological concepts towards energy efficient and environmental effective buildings.

All presented structural technologies involve wide range of used materials, on one hand common materials (ceramics, concrete, foamed concrete, lime-sand, timber structures…) and on the other hand alternative materials (earthen structures, recycled structures, high performance materials, low-cost materials…). The project shows also

a design approach according to building utilization and architectural, structural and technical differences between office buildings and residential buildings.

Fig. 1 Project “Ecopark Odolena Voda – Technology Transfer Centre” - 2 office buildings, 1 attached house with 4 flats, 13 family houses (all buildings in passive energy standard).

1.2 Structural variants of assessed buildings

1.2.1 SO 07 – Wooden based structure (2x4 system)

- two-storey family house with saddle roof and residential garret
- wooden based structure using 2x4 system on concrete strip footing, wooden ceiling, wooden roof truss system, mineral fibre thermal insulation, clay plasters on OSB (walls), gypsum boards on lower ceiling, wooden staircase

1.2.2 SO 09 – Lime-sand structure

- two-storey family house with shed roof
- lime-sand brick wall system on base slab, reinforced concrete ceiling in 1st and 2nd floor, ETICS based on polystyrene thermal insulation, floor on terrain isolated with foam glass gravel, concrete staircase

1.2.3 SO 11 – Ceramic structure

- two-storey family house with flat roof
- ceramic brick wall system on concrete strip footing, one-layer external wall in 1st floor, ETICS based polystyrene in 2nd floor, ceiling in both floor with filigran beams and ceramic fillers, concrete staircase

2 Environmental assessment methodology

2.1 Environmental parameters of the assessment

The mentioned methodology was adopted on the basis of [3]. The applied software based on MS Excel sheets calculates the values of following indicators:

- environmental parameters - conventional environmental performance measures of building materials: (i) embodied energy use, (ii) embodied emissions CO2,ekv., (iii) embodied emissions SO2,ekv. (iv) self weight,

- input materials - construction phase – used raw materials and material sources: (i) renewable materials and raw natural materials, (ii) recycled materials, (iii) materials from non renewable sources,
- output materials - deconstruction/demolition phase- possible further use of materials: (i) fully recyclable materials, (ii) partly recyclable materials (with down cycling effect), (iii) non-recyclable materials (waste).

The data of embodied energy and embodied emissions CO2,ekv., SO2,ekv. were taken from the catalogues of building structures [4], [5] and [6].

2.2 Technological and structural division of the structure

Structural design of a building incorporates a decision making process concerning structural system selection, material and technological design, and influences ambient structures and substructures. That's why the structures were divided into "fabric" and "others" even though this sorting doesn't match completely with the technological processes in construction.

- structural group "fabric": (i) footing structures incl. concrete bed based on structural context – footing/continuous footing, load action, (ii) vertical structures - load bearing walls and columns, peripheral walls, partition walls including internal surface treatments, (iii) horizontal load bearing structure - ceilings; balconies, load bearing roof structure (iv)staircase structures
- structural group "others": (i) thermal insulation –in peripheral walls including external surface treatments, in floor on the terrain, in roof, (ii) acoustic insulation (iii) water proof layers, (iv) load bearing floor structure

The specifications of structural parts of the building didn´t involve windows and balcony doors, interior doors, floors above the floor bearing structures, roofing above the roof bearing structure, plumbing, joinery (internal parapets), metalwork (railings around staircases and balconies, shading elements, ...).

3 Environmental assessment - results

The results of environmental assessment (Fig. 2) show differences between structural variants in all environmental criterions.

The most interesting result is dramatic decrease of overall weight of used structural materials in the wooden based structural variant. The amount of used materials in the 2x4 system is 4 times smaller in comparison with other structural variants (ceramic and lime-sand structure).

4 Conclusions

The final results of the case study illustrate differences between technological and material solution of the structural design of the building structure from the environmental point of view. The differences are obvious but on the other hand the final quality of all assessed

houses in passive energy standard must be considered. Environmental assessment of other buildings within the project of Ekopark Odolena Voda is still in progress.

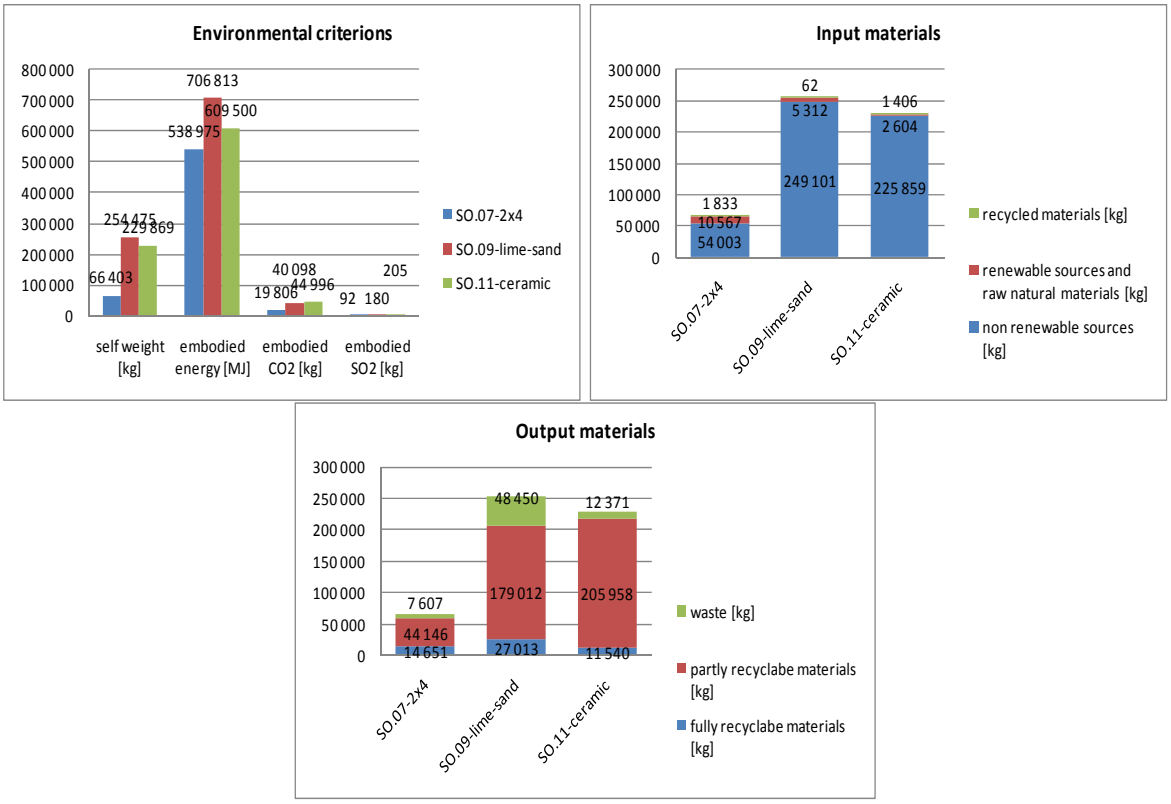

Fig. 2 Environmental assessment results

This outcome has been achieved with the financial support of the Ministry of Education, Youth and Sports, project No. 1M0579, within activities of the CIDEAS research centre.

References

[1] *Agenda 21 for Sustainable Building,* CIB Report Publication 237, Czech translation: ČVUT v Praze, Praha, 2001, ISBN 80-01-02467-92

[2] RŮŽIČKA, J., FIALA, C., LUPÍŠEK, A., MUKAŘOVSKÝ, J., VONKA, M.: *Environmantal and Life Cycle Assessment of Structural Design of Residential House – Case Study.* Proceedings of the CESB07 conference, Prague 2007, ČBS, September 2007, pp. 232-239, ISBN 978-80-903807-8-3.

[3] VONKA, M.: Life cycle assessment, Ph.D. thesis, Prague, 2006

[4] *SIA Dokumentation D 0123: Hochbaukonstruktionen nach ökologischen Gesichtspunkten*, Zürich 1995

[5] WALTJEN, T.: *Ökologischer Bauteilkatalog. Bewertete gängige Konstruktionen*, Springer-Verlag/Wien 1999

[6] MÖTZL, H., ZELGER, T.: *Ökologie der Dämmstoffe*, Springer-Verlag/Wien 2000