Ing. Alena Tažiková, PhD., prof. Ing. Mária Kozlovská, PhD.
Technical University of Košice,
Civil Engineering Faculty

EFFECT OF THE CONSTRUCTION COST CALCULATIONS TO THE SUSTAINABLE DEVELOPMENT OF BUILDINGS

The article deals with the approach to the optimal design of construction with an emphasis on environmental load. The load is determined quantifying environmental costs of building materials and environmental costs of finished buildings in their life cycle. The parallel calculation of construction costs and environmental costs have lead to the creation of the next generation of sustainable development buildings. The purpose of this article is to analyze the current situation of parallel construction costs and environmental costs abroad and in Slovakia.

Key words: Sustainable construction, environmental costs, Life Cycle Assessment.

Розглядається підхід до оптимального проектування будівництва з акцентом на екологічне навантаження. Навантаження визначено підсумком кількості екологічних витрат на будівельні матеріали та екологічним навантаженням від готових будівель протягом їх життєвого циклу. Паралельний розрахунок вартості будівництва та екологічних витрат привели до створення наступного покоління будівель зрівноваженого розвитку. Метою статті є аналіз поточної ситуації з паралельними витратами на будівництво та екологічними витратами за кордоном і в Словаччині.

Ключові слова: збалансоване будівництво, екологічні витрати, оцінка життєвого циклу.

Introduction

For decades, research has been devoted to the topic of influencing environment by construction. Currently, the time and cost are the main objectives of the project. Article highlights on the importance of costing not only construction costs but also environmental costs. Calculation of environmental costs can reduce overall costs throughout the life cycle of buildings. This also helps to choose building materials and construction technology, which have the least negative impact on the environment.

Modern buildings save energy and are friendly to the environment. Buildings consume more energy and produce more CO_2 than transportation and industry. Therefore, they must be built in the spirit of sustainability – economically, socially and environmentally. Most of the energy in the building is consumed for heating, water heating and air-conditioning. Today for construction and reconstruction is needed to keep rules of construction physics – the correct use of solar energy, ventilation, and low-temperature heating. Modern building must be built according to sustainable approach. For a sustainable building must be evaluated: building requirements for the construction, operation demands, claims and demands to demolish and the disposal of waste.

Construction of sustainable buildings is a worldwide trend. These buildings can be recognized by certificates of sustainable construction. Certification has become a tool for ecological and cheaper buildings. Cheaper construction will provide a common calculation of construction and environmental costs. The major certification schemes include: LEED (USA) and BREAM (United Kingdom) systems. In Germany it is DGNB and in Czech Republic SB Tool CZ.

The aim of the article is enforce the introduction of financial instruments to promote sustainable construction. This tool makes more attractive use of materials, equipment and measures to achieve sustainability in new construction as well as reconstruction and revitalization of existing buildings to become more sustainable. The introduction of financial tools can go hand in hand with legislative instruments. It is necessary popularization and promotion of these tools in public support for the creation of legislation in the Parliament.

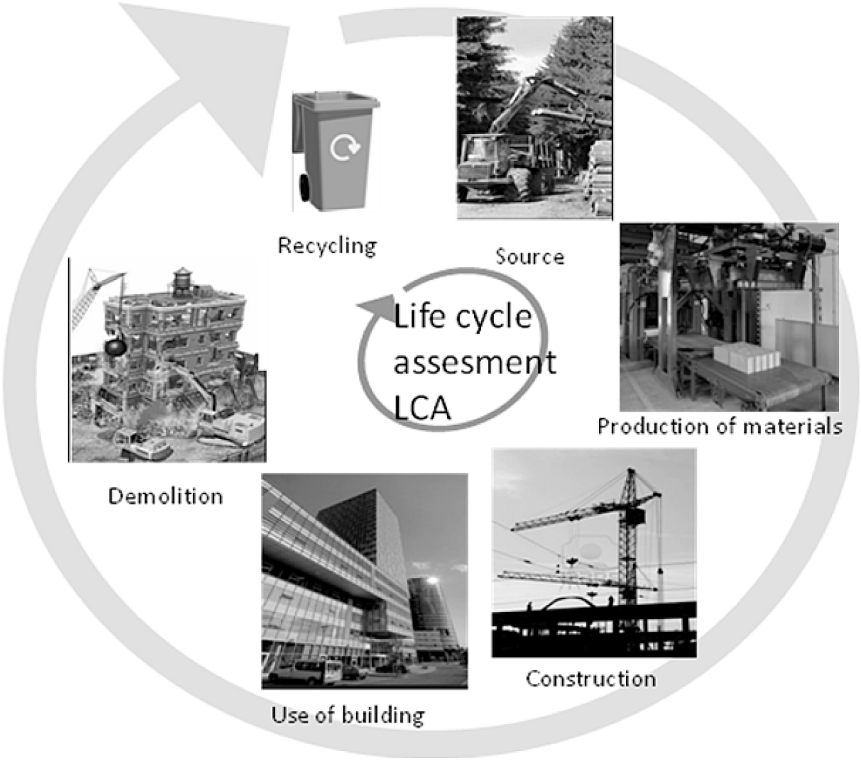

Fig. 1. Life Cycle Assessment (LCA) of buildings

Life Cycle Assessment of buildings

To determine the environmental burdens of buildings should take into account the entire life cycle of building materials and products (LCA – Life Cycle Assessment). LCA – is a complex and systematic method for analyzing the impact of products and processes on human health and the environment throughout the product life cycle.

LCA consists of four steps:

1 Define objectives and scope

2 Analyze stocks LCI (Life Cycle Inventory)

3 Assess the impacts of LCIA

4 Interpretation of results

LCI – is a method of accounting that is, used to monitor the input and output material and energy flows associated with each step in the process, or in making the product.

LCIA – the assessment of the effects of product life cycle terms of the variables potential human and environmental impacts of LCI data.

LCA should not be confused with the analysis of life-cycle costs (LCCA-Life-Cycle Cost Analysis).

LCCA takes into account the costs of environmental stress and may be an integral part of the life cycle assessment (LCA) [3].

In conjunction with the environmental costs is discussed the introduction of extended producer responsibility (EPR) on the environment. Model EPR has to ensure that green buildings are also economically advantageous. In calculating the environmental cost of construction is necessary to take into account the entire life cycle of construction works, not only the production of construction products, building construction or a site phase, but also operation and maintenance of buildings as well as the end stage of life of the building – its reconstruction, reuse, demolition. The ability to recognize costs associated with the entire life cycle of buildings already in the design phase of construction, namely the calculation of construction costs, are the vision of an integrated proposal. Thanks to the international standardization processes have agreed the basic principles and presentation formats for environmental assessment in terms of Life Cycle Inventory (LCI) and Life Cycle Assessment (LCA). Stages of an LCA according to ISO 14044:2006 is on Fig.2.

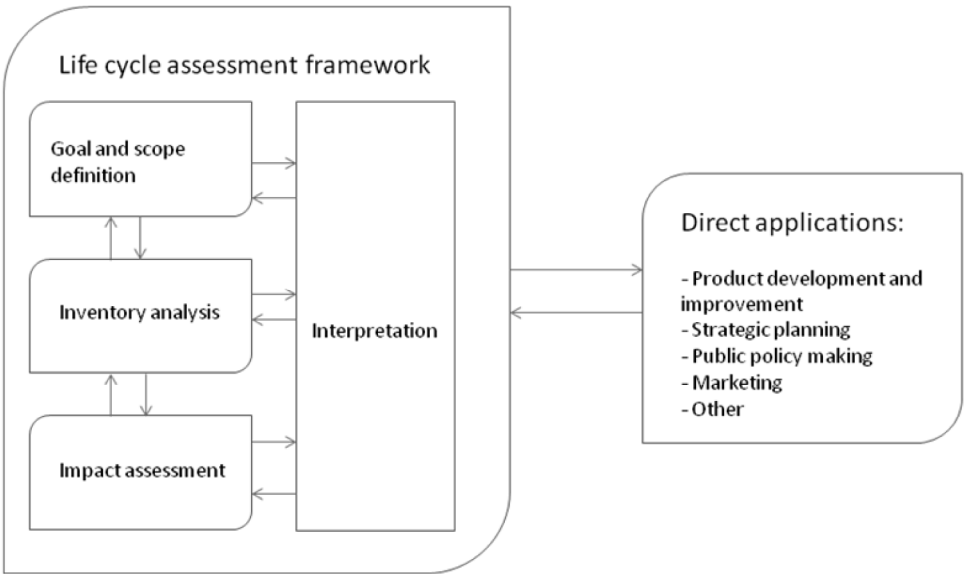

Fig. 2. Stages of an LCA as per ISO 14044:2006.

Thanks to the international standardization and ISO 21930:2007 – Environmental declaration of building products, there are more and more producers of construction products, which are preparing environmental statements about their products (Environmental Product Department – EPD). The EPD has to provide information for assessment of planning, design and construction. They are verifiable, accurate and comprehensive estimate of any impact on the environment. EPD is based on the LCA standards, but it may also include information about a product or material only in a certain phase of LCA. As a result, there is little knowledge of the effects of different variants of buildings on the environment already in the design phase of the project. The main problem remains the lack of environmental information summarized in the database, which should be used in software applications for the valuation of buildings. Valuable outputs for the user, in our case calculator of construction costs, have studied the methodology of the database to select the correct information – specifically environmental information structures. It is necessary to follow certain rules, for example, do not remove the data from databases that have a different methodology, since the resulting environmental information shall not be assignable to a specific limit of the system (Fig. 3).

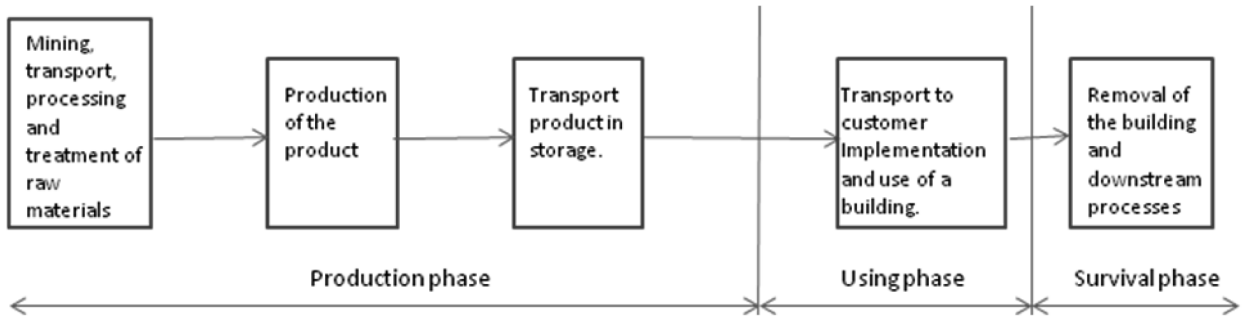

Fig. 3. Phases for calculating environmental costs

Construction sustainability

The growing popularity of green buildings and green building programs expanding demand and availability of environmentally friendly products. For designers and specialists these changes lead to greater opportunities for improving the environmental burden of many construction products. At the same time, the assessment of health and environmental impacts of materials is a complex process, which can also lead to conflicting arguments. For example, what is worse for the environment? The thermal insulation envelope, which at its production significantly impact on the environment, or when on the building will not insulation envelope, which resulting in increased consumption of energy for heating. In the world begins to expand set of green products and tools to support project teams in making informed evaluations and selections. For most construction projects, building materials are selected on purpose,

aesthetics and cost. Considering to "green" or environmentally preferable products, the traditional parameters are extended of the health and environmental impacts.

Environmentally preferable products have less negative effects on human health and the environment when compared with competing products that serve the same purpose.

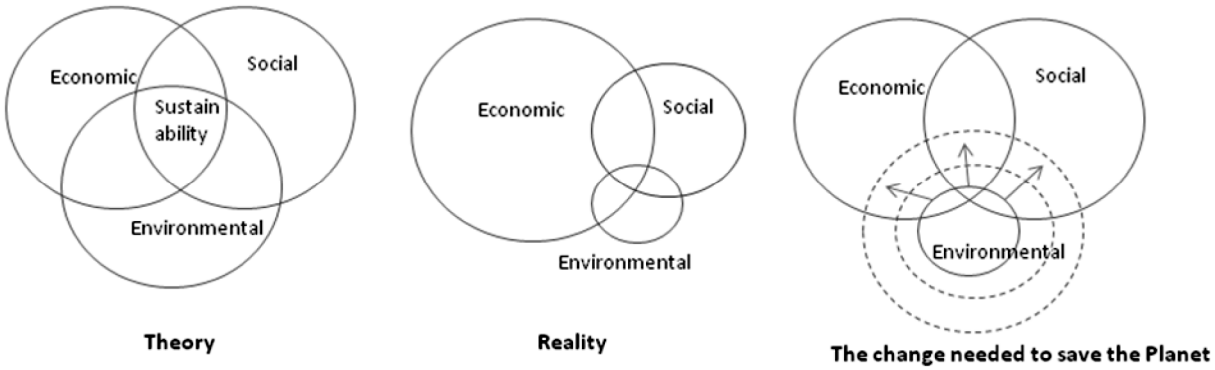

Fig. 4. Three pillars of sustainable development Source: http:/www.iucn.org/programme

For several authors [4-9], refers to the need to consider environmental costs already during pre-construction. In the design phase of construction is necessary to consider the selection of building materials and products and prioritize environmentally-friendly forms. It is necessary to think about the theory of sustainable development (SD) and above SD in real life. As seen in Fig.4 and individual pillars of sustainable development have different radii at present, therefore, it is necessary to do some steps to balance their perception.

The method for joint calculation construction and environmental costs in the Slovakia

In Slovakia, the most commonly used calculation tool for creating budgets is currently CENKROS Plus. CENKROS Plus is software of measurement and management of building production through cost. This system covers all activities associated with the preparation and execution of the contract and their costs. The program allows preparation of high-quality bid, easy costs calculating, effectively used spending and billing work carried out and compiling price estimates by the financial indicators. The system is designed for cost calculator, preparer, purchasers, designers and suppliers of construction work [12]. Possible model for joint calculation the construction and environmental costs is shown in the Table 1 and in the Table 2. There are the current outputs of the program CENKROS plus, which are extended by columns with environmental costs.

Table 1

Possible model for joint calculation the construction costs and environmental costs

Estimate summary (summary of the costs and total price)

Building (construction) name: The sample of road
Structure name: Model budget
Structure part name:
Date: 1. 1. 2013

Construction costs

Description	Supply (in total)	Work (in total)	Total cost	Total weight	Environmental costs	Total costs
2	3	4	5	6	8	9
Major Building Production	21 279,6	188 964,9	210 244,5	5247,5	Data from EPD databases	Construction costs + Environ-mental costs
Ground works	7 675,6	24 784,9	32 460,5	3,2		
Foundations	0,0	1 048,5	1 048,5	0,0		
Road Construction	0,0	148 923,4	148 923,4	5232,7		
Other Construction	13 604,0	3 141,2	16 745,2	11,6		
Transfer of materials	0,0	11 066,9	11 066,9	0,0		
Other	0,0	0,0	0,4	0,0		
Complete	21 279,6	188 964,9	210 244,9	5247,5	XXX	YYY

Table 2

Possible model for joint calculation the construction costs and environmental costs

Estimate cost - overview

Construction name		JKSO classification	
Structure name		EČO file struct. no.	
Structural part nam		Locality	Slovakia
		Company ID	VAT no.
Employer			
Designer			
Contractor			
Estimate number	Worked up by	Date	

Units of measure and indexes

Quantity	Costs / 1 m.u.	Quantity	Costs /	Quantity	Costs / 1 m.u.
0	0,00	0	0,00	0	0,00

Estimate costs in EUR

A	Basic costs + Environmental costs			B	Additional costs		C	Construction site costs		
1	HSV	Supply	21 279,60	8	Overtime work	0,00	13	Construction site installations		0,00
2	Main production	Assembly	188 964,95	9	Overhead work	0,00	14	Outside - site transport		0,00
3	PSV	Supply	0,00	10	Relic	0,00	15	Regional influences		0,00
4	Associated	Assembly	0,00	11		0,00	16	Operational influences		0,00
5	"M"	Supply	0,00				17	Other arrangement costs		0,00
6	Structural work	Assembly	0,00				18	Construction site from estimate		0,00
7	BC (line 1-6)		210 244,54	12	AC (line 8-11)		19	CSC (line 13-18)		0,00
20	Hour accounting rat		0,00	21	Completion ac	0,00	22	Other costs		0,38

		D	Total costs	
Designer		23	Sum 7, 12, 19-22	210 244,92
Date and signature	Stamp	24	VAT 20,00 % 210 244,92	39 946,53
Employer		25	VAT 20,00 % 0,00	0,00
		26	**Price with VAT (l. 23-25)**	**250 191,45**
Date and signature	Stamp	E	Extra charges and allovances	
Contractor		27	Supply of employer	0,00
		28	Sliding annex	0,00
Date and signature	Stamp	29	(dis) Advantage +-	0,00

Conclusion

The calculating of construction costs together with environmental costs is dependent on the existence of environmental data (EPD database) on a suitable base (IFC), to ensure its widespread use. It is equally important to develop an tools and formats in which environmental information will be connecting to the calculated construction costs, and that this environmental information to assign their economic impacts. Similarly as in European countries and in Slovakia after 2020 will be need the calculations of the environmental costs still topical in the design phase of the project in order to choose the best possible solution with respect the principles of sustainable development. The article pointed out the possible outputs calculated construction costs so that to contribute to compliance with the principles of sustainable development.

Acknowledgements

The article presented a partial research result of project VEGA 1/0840/11 "Multi-dimensional approaches to support integrated design and management of construction projects." Solution of this project was financially supported by a scientific grant agency VEGA.

1. Holthe K.: Improved building design by joint calculating building costs and environmental costs? In: First International Conference on Improving Construction and Use through Integrated Design Solutions, 10–12 June, p. 268-281, CIB IDS 2009. 2. Šoltés T., Kozlovská M.: Construction project managing through new form of project delivery. – 1 elektronický optický disk (CD-ROM).In: Organization, Technology and Management in Construction : 10th International Conference : 07 – 10 September 2011, Šibenik, Croatia. – Zagreb: University of Zagreb, P. 1-12. – ISBN 978-953-7686-02-4, 2011. 3. O'Connor J., Meil J.: LCA in construction: status, impact, and limitations. White paper., Athena Sustainable Materials Institute, July 2012. 4. Trusty W.: Misconceptions and Misunderstanding about LCA In: Online Building Safety Journal 2010. 5. Spišáková, M., Hyben, I., Heredoš, P. Assessment of environmental risks during the construction process, SGEM 2012 12th International Multidisciplinary Scientific GeoConference Albena, Bulgaria, P. 75-82, 2012. 6. Župová, L.: Predicting the costs and duration of construction projects (CD-ROM). In: Young Scientist 2012 : 4th PhD. Student Conference of Civil Engineering and Architecture : Košice, Slovakia, May 22-25,. – Košice : TU, 2012 S. 1-6. – ISBN 978-80-553-0904-0, 2012. 7. Struková, Z. Lean production principles in construction projects design and delivery. In: Geodesy, architecture and construction, Lviv, Ukraine. p.72-73, 2011. 8. Bašková, R.: Building process time structure modelling. In: Selected Scientific Papers: Journal of Civil Engineering. Roč. 2, s. 96-105, 2007. 9. www.athenasmi.org 10. www.theepstengroup.com 11. www.ecopoint.sk 12. www.cenkrosplus.sk 13. www.ogni.at 14. Struková, Z., Líška, M.: Application of automation and robotics in construction work execution / Zuzana Struková, Matej Líška – 2012. In: AD ALTA: Journal of Interdisciplinary Research. Vol. 2, no. 2, p. 121-125. – ISSN 1804-7890, 2012.