Збірник наукових праць. Галузеве машинобудування, будівництво
Academic journal. Industrial Machine Building, Civil Engineering

http://journals.nupp.edu.ua/znp
https://doi.org/10.26906/znp.2021.56.2508

UDK 624.012

Introduction of heat and energy-saving structures in construction as a condition of its sustainable ecological and economic development

Rohovyi Stanislav[1], Boginska Lydmila[2]*

[1.]Sumy National Agrarian University https://orcid.org/0000-0002-9431-5884
[2.]Sumy National Agrarian University https://orcid.org/0000-0001-8635-7980
*Corresponding author E-mail: Lyudmila.boginska@snau.edu.ua

The article identifies the main aspects of sustainable construction development in the implementation of the development strategy. Approaches and proposals for interrelated components of improving the efficiency of construction production, which are based on interdependent and complementary actions to achieve the competitiveness of the construction industry and are relevant to the functioning of the construction industry. Directions for improving construction production through the introduction of heat-saving structures at construction sites are proposed. The conclusions analyze the results of the construction industry. It is determined that the use of heat-saving structures, technologies, the formation and implementation on this basis of a strategy of long-term sustainable development - one of the construction priorities.

Keywords: sustainable development, construction production, heat-saving structures

Впровадження теплоенергозберігающих конструкцій в будівництво як умова його стійкого еколого-економічного розвитку

Роговий С.І.[1], Богінська Л.О.[2*]

[1, 2] Сумський національний аграрний університет
*Адреса для листування E-mail: Lyudmila.boginska@snau.edu.ua

У статті визначені основні аспекти стійкого розвитку будівництва в рамках реалізації стратегії розвитку. Розглянуто підходи і розроблено пропозиції щодо взаємопов'язаних складових підвищення ефективності будівельного виробництва, які ґрунтуються на взаємозалежних і взаємодоповнюючих діях досягнення конкурентоспроможності будівельної галузі і є актуальними для функціонування будівельного комплексу. Запропоновані напрями вдосконалення будівельного виробництва через впровадження теплоенергозберігаючих конструкцій на об'єктах будівництва. Задача, що розглядається в статті, полягає у пошуці нових підходів до вирішення еколого-економічних проблем будівельного виробництва за допомогою застосування теплоенергозберегаючих конструкцій. В роботі досліджується взаємозв'язок між випуском та виведенням на ринок теплоенергозберегаючих матеріалів й конструкцій нового покоління (коли для вироблення теплової енергії використовують поновлювані джерела енергії (енергію сонця, вітру і т.п.)), які дозволяють економити традиційні джерела теплопостачання та енергозабезпечення і еколого-економічним розвитком будівельної галузі. У висновках проаналізовано результати розвитку будівельної галузі. Визначено, що ефективне залучення природних ресурсів на інтерактивній основі, застосування теплоенергосберегаючих конструкцій, технологій, формування і реалізація на цій основі стратегії довгострокового стійкого розвитку - один з пріоритетів будівництва.

Ключові слова: стійкий розвиток, будівельне виробництво, тепло енергозберігаючі конструкції

Introduction

The construction industry is a key sector of the economy, designed to solve the most important tasks for the implementation of the socio-economic development strategy of the region and the state as a whole. The modern construction industry is forced to take into account the market instability and dynamism. For this reason, the following trend is important - any construction company needs to adapt to new economic conditions in a transient survival environment.

Construction is designed to create an artificial environment that ensures human life. Until now, the environment has been considered as a source of negative effects on the newly created man-made artificial environment. Construction as a powerful reversible factor influencing the environment has been the subject of research relatively recently. As practically necessary, certain limits of this problem are subject to study and solution (for example, waste disposal, air purification in settlements, etc.). Construction production has an anthropogenic impact on nature at all stages - from the extraction of building materials to the operation of the commissioned facilities.

Disruption of relationships within the ecosystem, the likelihood of serious consequences for a given region or area, is some negative results of construction activities. Large-scale combustion of extracted fuel leads to irreversible changes in the environment, up to changes in climatic conditions on the planet. This understanding to some extent contributes to the formation of the need for environmental safety and encourages manufacturers to develop, produce and market heat-saving materials and structures of the new generation (when renewable energy sources (solar, wind, etc.) are used to generate heat). They help to save traditional sources of heat supply and energy supply and are the main direction of ecological and economic development of the construction industry.

Review of research sources and publications

Baranovskiy V., Melnik L., Lesnoy A., Onegina V., Popova A. have analyzed in-depth theoretical and practical aspects of sustainable development in their works.

The authors of works devoted to the formation problems of the Concept of sustainable development are Vernadsky V., Girusov E., Gorshkov V., Landel M., Matrosova V., Paton B. and others.

Of the foreign specialists who dealt with sustainable development issues, it is worth noting: Mill J., Schumpeter J., Harrod R., Domar E., Solow R., Romer P., Porter M., Kotler F., Hay D., Morris D., Meadows D., Saaty T., Siegel J., Target D., Hargshoorn G., Oiken V., Plath R., Richardson Ch. and others.

The issue of using heat and energy-saving materials and structures in the production was raised in the works of Aleksandrovsky S., Bogoslovsky V., Vlasov O., Balmer R., Ilyinsky V., Gusarsky K., Srovsky S., Likova A., Lukyanova V., Koryakins A., Upenietse L., Bakhare D., Savitsky M., Semko A., Stroy A., Tabunshchikova Yu., Ushkova F., Fokin K. and others.

Definition of unsolved aspects of the problem

However, the insufficient elaboration mechanism of sustainable development of the construction complex, taking into account the involvement of innovative building materials production and heat-saving structures provides further study of this topic.

Objective of the work and research methods

The study aims to search for new approaches to solving environmental and economic problems of construction production through the introduction of heat-saving structures.

The goal was achieved by the following methods:

– theoretical studies based on modern developments of the strategy for the development of the construction industry;

– research of innovations in the field of theory and practice of creating new building structures with increased thermal efficiency;

– mathematical modeling.

Basic material and results

The efficiency of the construction complex is directly dependent on the growth in demand for construction products, work, services in the materials replacement, structures produced by more innovative ones through successful scientific and technical innovations that significantly improve, optimize construction processes and are accompanied by resource, technological, environmental, economic, budgetary effects (Fig. 1).

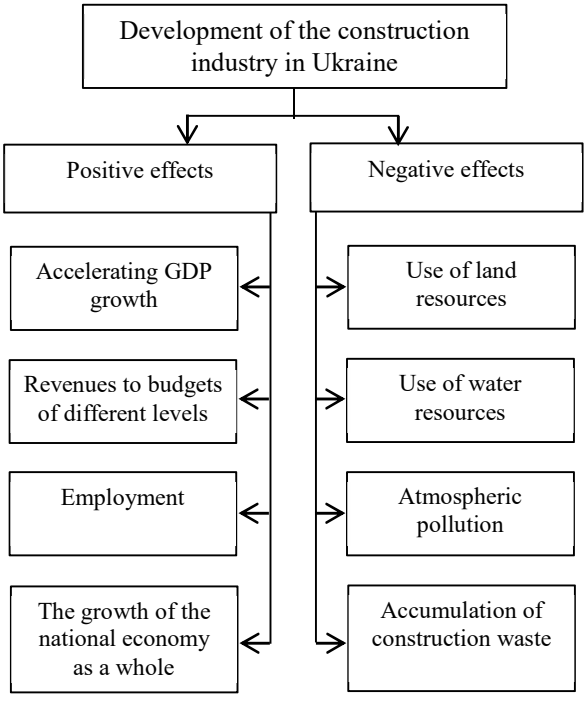

Figure 1 – The results of the construction industry

Production efficiency implies sustainable development and success in the future. The interpretation of the definition of "sustainable construction" has been in place recently. The first international conference on sustainable construction (Tampa, USA, 1994) proposed

the following definition: “Sustainable construction means the creation and responsible maintenance of a healthy artificial habitat based on the efficient use of natural resources and environmental principles.” This definition was further developed in the decisions of the Second Conference (Paris, 1997): “Sustainable construction is the support of a healthy economy in order to ensure a quality of life while protecting human life and the environment; minimization of damage caused to self-healing of the environment, human health, biological diversity; optimal use of non-renewable resources and constant use of renewable resources” [8].

In modern economic conditions, the main emphasis shifts from solving problems identified by the analysis of the optimal use of resources available to the construction company, the problems of existing production situations, to find ways to solve them (Fig. 2).

Relevant in today's conditions is the search and approval of new approaches to sustainable development, taking into account the current and future state of environmental resources, which should be reflected in the mechanisms for the implementation of the country's resource and environmental policy.

Energy and resource-saving are the general directions of the technical policy of Ukraine in the field of construction and a prerequisite for its sustainable development [6].

Development is a multi-criteria, complex process that illuminates the individual characteristics of each enterprise and depends on its strategic goals. Only managed development can be sustainable. The sustainable development of an enterprise is a full-fledged reflection of its competitiveness in market conditions. Under these conditions, it is important to draw up an expert assessment of the development of a particular construction company (Figure 3).

Environmental friendliness in construction is achieved through the introduction of heat-saving structures and technologies. Control and management of energy-saving and heat saving in the construction industry must be carried out both at the state level and at the level of individual enterprises, as well as at all building life cycle stages.

It is expedient to reduce energy costs in construction by applying the latest technologies of thermal renovation of buildings by increasing the thermal insulation capacity of the enclosing structures of construction objects. The choice of thermal insulation materials takes into account the natural and climatic conditions of the construction area, architectural and structural solutions of buildings in accordance with environmental and economic monitoring.

For a long time, the issue of energy savings in construction, as well as in the national economy as a whole, was not given the necessary attention. According to the standards in force in Ukraine, the resistance to heat transfer of building envelopes was reduced compared to European standards on the walls - 1.2-3.5 times, on the floor and ceiling - 2 times, on the windows - 1.3 times. As a result, we have significant costs of fuel and energy resources in the operation of housing [8].

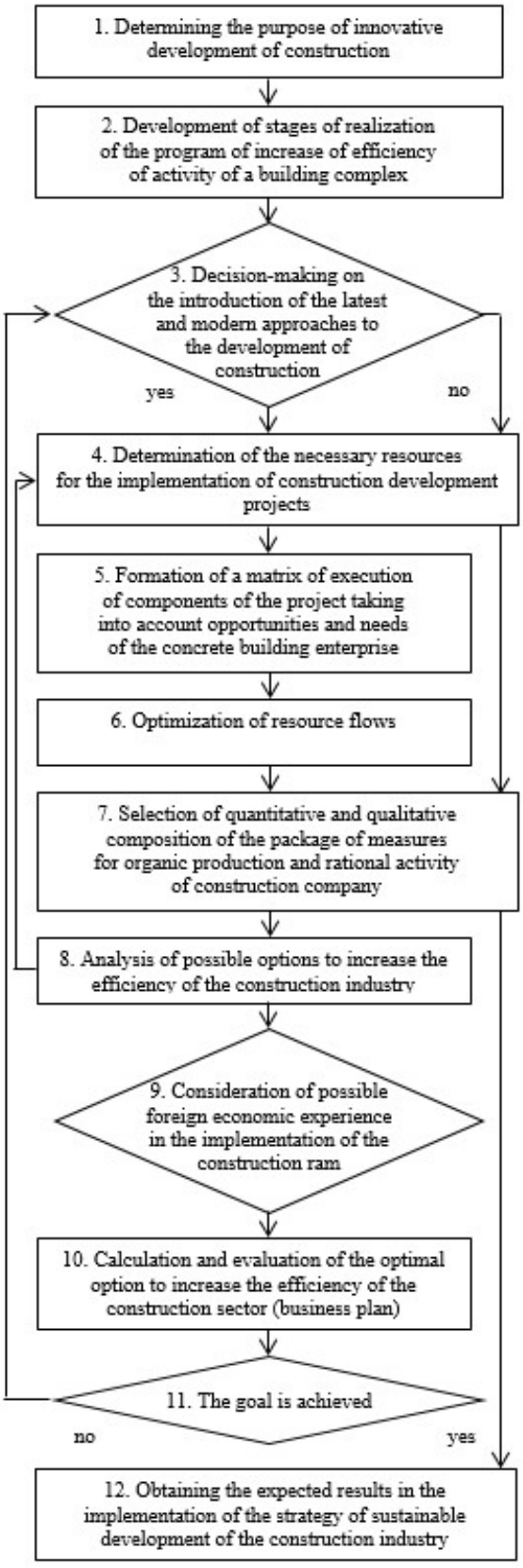

Figure 2 – Algorithm of the construction development program
(*developed by the author*)

In this algorithm, an important link is the definition of indicators for assessing the state and development prospects of business entities, competitiveness.

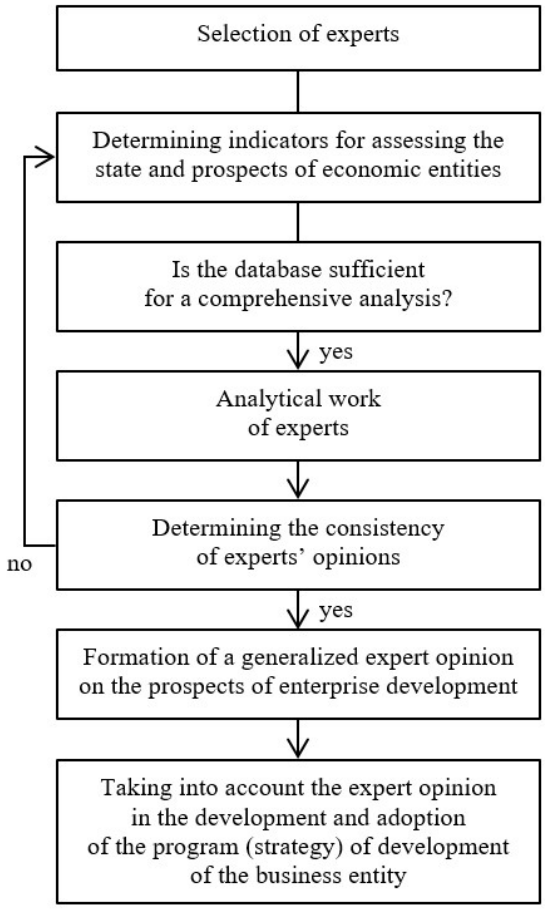

Figure 3. Algorithm of expert assessment of the business entity development (construction company)
(*developed by the author*)

Modern building codes in European countries set energy consumption at 80-100 kWh / m^2 per year. In the new generation of houses that are designed and built according to the concept of Passive House, the level of energy consumption can be reduced to 15-30 kWh / m^2 per year, depending on the region of construction. The determining factor that allows providing such a standard is the use of effective thermal insulation in building structures [7, 11].

Based on the accumulated experience of design organizations in Ukraine [5], analysis of the principles of ensuring the energy efficiency of buildings adopted in European countries, where problems connected with heat and energy saving is given priority values, developed Ukrainian building codes DBN B.2.6-31: 2006 "Thermal insulation of buildings". These rules provide:

– an increase of the minimum level of thermal protection enclosing structures of residential and office buildings on average by 15-40% for exterior walls, 20-25% for coatings, 20% for windows;

– standard indicators of the maximum permissible values of heat loss for heating buildings;

– introduction of energy certification of buildings for new construction and reconstruction;

– introduction of norms for indicators of thermal reliability of heat-insulating shells of buildings and structures [4].

It should be noted that the reserves of fuel energy resources (natural gas, oil, coal) are limited. The ways to solve the problems of preserving and restoring the ecological balance of natural and anthropogenic life systems are as follows:

– formation of scientific foundations for rational resource and energy consumption in urban planning, taking into account regional differences;

– formation of the scientific foundations of the "city - building – structure" model;

– development of a regulatory and legal framework for heat and power saving;

– implementation of new promising low-cost technologies with two to four times lower heat and energy consumption;

– implementation of constructive and architectural solutions of increased energy efficiency under construction and reconstruction.

For the competent decision of this problem, it is necessary to carry out complex inspections of a building heat-insulating cover for the definition of places of the greatest heat losses and ways of their reduction.

This work should include acquaintance with the design documentation for the construction site, conducting an estimated assessment of heat loss, and, if necessary, conducting instrumental studies of thermal insulation of fences.

Numerous and intensive researches are carried out in our country and abroad, directed basically on the search of easy and heat-and-energy protecting designs differing in low complexity of erection, durability, and maintainability.

Such close attention to the design of effective enclosing structures is explained, on the one hand, by the important place they occupy in the structure of the building, and on the other hand - by the role, they play in solving the problem of saving fuel and energy resources.

Foreign and domestic experience and accumulated knowledge suggest that the implementation of heat-efficient construction should move towards reducing heat loss of the building, efficient use, and production of energy.

To assess the effectiveness of the work done to reduce the building heat loss, the efficient use of energy in it and its efficient production, the European Association "Active House" proposes to use three main criteria:

– comfortable living (healthy lifestyle);

– energy (energy balance of the building - the total amount of energy generated and consumed by the house should ultimately make up a positive energy balance)

– environment (the effect of the building's impact on the environment should be minimal) [5].

The introduction of heat and energy-saving technologies is a today requirement. It is estimated that the heat cost and energy saving is recouped in two to three years.

Heat and energy saving in an apartment building is, first of all, reducing heat losses by insulating walls, floors, ceilings, windows,s, and doors.

According to the rating "Ukrainian Energy Index – 2011", the energy efficiency of the Ukrainian economy is 52% of the EU level [1].

Improving energy efficiency to European levels will save approximately € 11.8 billion annually.

The main priority in solving this problem is the thermal modernization of buildings. Saving energy resources as a result of thermal modernization is several times higher than the savings from improving the means of generating heat. At the same time, thermal modernization of buildings leads to a decrease in heat losses in boiler houses and heating networks, as it reduces the required volumes of produced and transported heat carriers.

Ukraine must comply with EU directives on energy efficiency, in particular, Directive 2010/31 / EU on the energy performance of buildings and Directive 2006/32 / EU on the efficiency of the energy end-use and services. Obviously, no modernization of the means of generating and transporting heat can and closely compare in efficiency with thermal modernization at the consumer [2, 12].

Thermal modernization of external walls with the protection of heat-insulating material from external influences with a protective and decorative plaster layer has the following disadvantages:

– seasonality of work performance;

– unacceptable to apply plaster in direct sunlight, rain, and strong wind;

– the system fragility;

– the need for the device of expansion joints 6 mm wide, which compensate for the deformation of the plaster layers from fluctuations in temperature and humidity;

– increased requirements for the vapor permeability of the outer layers of additional insulation while maintaining their ability to provide protective functions;

– rapid contamination of the facade;

– increased requirements for the rigidity of heat-insulating dowels, which leads to the formation of cracks and destruction of the outer decorative and protective layer;

– impossibility to conduct operational control over the state of the heat-insulating material;

– the high operational cost of the system [9, 13].

The most expensive measure in the thermal modernization of the building is the insulation of enclosing structures. The estimated payback period of this measure is from 7-8 years when using heat-insulating materials of Ukrainian production, and from 12 years - when using imported materials. However, by warming the greatest energy-saving effect is reached.

In this case, the insulation of the building is inevitably accompanied by its overhaul, which in turn increases the service life of the building, the degree of its comfort.

Therefore, when calculating the payback, it is necessary to take into account these advantages of thermal modernization, which will significantly increase the economic attractiveness of such projects [10, 14].

In the initial phase of a construction project, it is useful to be able to assess the performance of a future facility. An integral part of one-time and operating costs are the costs of the construction part of the building. It is important to note that this part of the cost is not involved in the technological process, so its minimization is very useful.

Conclusions

The model of sustainable development is implemented in the interaction process between society and the environment by combining the economic, social, and environmental interests of society.

The ecological factor becomes system-forming in the concept of sustainable economic development.

However, the problem of the environmental factor of sustainable development is still insufficiently developed by economics in both theoretical and applied aspects.

The effective attraction of natural resources on an interactive basis, application of heat-saving constructions, technologies, formation, and realization on this basis of the strategy of long-term sustainable development is one of the priorities of construction.

Thermal protection of buildings requires a fundamental revision of the materials used and technical solutions of building envelopes. Now it is almost impossible to provide the necessary indicators of thermal protection in single-layer structures of brick walls or structurally insulating lightweight concrete with high density and thermal conductivity. Compliance with current regulations requires the use of multilayer structures with effective types of insulation materials.

The production base of effective thermal insulation materials needs to conduct research on the development of such materials and technical solutions for fencing structures based on them from local raw materials and industrial waste. This will contribute to the sustainable development of the construction industry.

References

1. *Рейтинг енергоефективності України*. Режим доступа: http://www.energyindex.com.ua

2. Карп И.Н., Никитин Е.Е. *Пути решения проблем коммунальной энергетики*. Режим доступа: http://esco-ecosys.narod.ru/2011_12/art104.pdf

3. Патон Б.Є., Долінський А.А., Геєць В.М., Кухар В.П., Басок Б.І., Базєєв Є.Т., Подолець Р.З. (2014). Пріоритети Національної стратегії теплозабезпечення населених пунктів України. *Вісник Національної академії наук України*, 9, 29-47

4. ДБН В.2.6-31:2016 (2017). *Теплова ізоляція будівель*. Київ: Мінрегіонбуд України

5. Мировые тенденции повышения энергоэффективности зданий (2012). *Энергосбережение*, 5, 38-42

6. Богінська Л.О. (2020). Визначення стратегії розвитку будівельного підприємства. *Інфраструктура ринку*, 30, 123-127

7. Balmer R.T. (2011). *Modern Engineering Thermodynamics*. Elsevier

8. Hepbasli A. (2012). Low exergy (LowEx) heating and cooling systems for sustainable buildings and societies. *Renewable and Sustainable Energy Reviews*, 16(1), 73-104

9. Husarski K., Srokowski S. (1978). Problem dostosowania rozwiazan budowlanych do zmiennoscitechnologieznuch. *Inwest. Budow.*, 24, 48-49

10. Korjakins A., Upeniece L., Bajare D. (2013). Heat insulation materials of porous ceramics, using plant filler. *4th International Conference Civil Engineering`13 Proceedings. Part I Construction and materials*, 169-175

11. Beregovoi V.A., Proshin A.P., Beregovoi A.M, Soldato S.N (2000). Heat-Conducting Properties of Small-Power- Hungry Cellular Concrete. *Asian Journal of Civil Engineering (Building and Housing)*, 1(4), 56-64

12. Proshin A.P., Beregovoi V.A., Beregovoi A.M, Volcova E.A. and oth. (2001). New thermal insulation materials. *Problems and prospects in ecological engineering*. Tenerife, Spain, 108-110

13. Voller V.R., Felix P., Swaminathan C.R. (1996). Cyclic phase change with fluid flow. *Int. J. Numer. Meth. Heat Transfer Fluid Flow*, 6, 57-64

14. Pelke R. (1976). *Energieeinsparung in der Klimatechnik*, 6, 156-158

1. *Energy efficiency rating of Ukraine*. Access mode: http://www.energyindex.com.ua

2. Karp I., Nikitin E. *Ways to solve problems of communal energy*. Access mode: http://esco-ecosys.narod.ru/2011_12/art104.pdf

3. Paton B., Dolinsky A., Geets V., Kuhar V., Basok B., Bazeev E., Podolets R. (2014). Priorities of the National strategy of heat supply of settlements of Ukraine. *Bulletin of the National Academy of Sciences of Ukraine*, 9, 29-47

4. DBN B.2.6-31:2016 (2017). Thermal insulation of buildings. Kyiv: Ministry of Regional Development, Construction and Housing of Ukraine

5. World trends in improving the energy efficiency of buildings (2012). *Energy saving*, 5, 38-42

6. Boginska L. (2020). Definition of strategy of development of the construction enterprise. *Market Infrastructure*, 30, 123-127

7. Balmer R.T. (2011). *Modern Engineering Thermodynamics*. Elsevier

8. Hepbasli A. (2012). Low exergy (LowEx) heating and cooling systems for sustainable buildings and societies. *Renewable and Sustainable Energy Reviews*, 16(1), 73-104

9. Husarski K., Srokowski S. (1978). Problem dostosowania rozwiazan budowlanych do zmiennoscitechnologieznuch. *Inwest. Budow.*, 24, 48-49

10. Korjakins A., Upeniece L., Bajare D. (2013). Heat insulation materials of porous ceramics, using plant filler. *4th International Conference Civil Engineering`13 Proceedings. Part I Construction and materials*, 169-175

11. Beregovoi V.A., Proshin A.P., Beregovoi A.M, Soldato S.N (2000). Heat-Conducting Properties of Small-Power- Hungry Cellular Concrete. *Asian Journal of Civil Engineering (Building and Housing)*, 1(4), 56-64

12. Proshin A.P., Beregovoi V.A., Beregovoi A.M, Volcova E.A. and oth. (2001). New thermal insulation materials. *Problems and prospects in ecological engineering*. Tenerife, Spain, 108-110

13. Voller V.R., Felix P., Swaminathan C.R. (1996). Cyclic phase change with fluid flow. *Int. J. Numer. Meth. Heat Transfer Fluid Flow*, 6, 57-64

14. Pelke R. (1976). *Energieeinsparung in der Klimatechnik*, 6, 156-158