Georgia Employment and Infrastructure Initiative
საქართველოს დასაქმებისა და ინფრასტრუქტურის ინიციატივა

ASSESSMENT OF ENERGY EFFICIENT CONSTRUCTION MATERIALS AND PRODUCTS MARKET IN GEORGIA

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Contents

SECTION 1. INTRODUCTION

Since the proportion of the total energy budget which goes into the heating and cooling of buildings is large, it is important to control the exchange of heat with the surroundings. The effective design of building and use of energy efficient construction materials can significantly reduce energy consumption over conventional design solutions. Other energy saving opportunities in the buildings can be achieved through the use and maintenance of energy efficient heating systems as well as the use of energy efficient lighting systems and appliances.

Retrofitting a structure, which makes modifications to an existing building without major construction or design changes, can also bring about significant reductions in heating (cooling) costs.

CHF Georgia, within the "Georgia Employment and Infrastructure Initiative" (GEII) program is implementing a school rehabilitation program. Schools are located in the former conflict zones of Gori and Kareli districts of the Shida Kartli region.

The main purpose of this report is to identify new energy efficient opportunities: construction materials and locally produced products, as well as goods which are imported to Georgia and which are currently available on the local market. It has also been written with due consideration to the needs and priorities of the school buildings rehabilitation program. Accordingly, general upgrading solutions, conclusions, and recommendations for school buildings are given.

The assessment of construction materials and products provided in this report was developed to track additions and changes that took place in the local construction materials market since March 2008, when the USAID report was published[1]. This current report provides more technical data and general technical solutions that can be applied specifically to school construction. It's notable that the range of energy efficient products on the local market, as recently surveyed, appears narrower in comparison to the previous year.

SECTION 2 INSULATION MATERIALS FOR UPGRADING BUILDING ENVELOPE

2.1 Mineral wools

The term "mineral wool" refers to three types of insulation that are basically the same:

- "stone wool/ rock wool" made from basalt, an igneous rock
- "glass wool" or "fiberglass" made from recycled glass
- "slag wool" made from steel-mill slag (not currently available on the local market).

2.1.1 Basalt (stone) wool

Recently, a Georgian basalt fiber plant “BPG” (Basalt Products of Georgia Ltd) located in the industrial sector of Rustavi city, 25 km from Tbilisi, began producing a “stone wool” mineral

[1] “Energy Efficient Construction Materials Sector in Georgia”, the report developed in 2008 for the USAID by Alesya Parshina

insulation product. Following years of research and through the introduction of technological innovations at BPG an efficient and economically viable technology of manufacturing basalt fiber has been developed from the existing former Soviet Union military technology. The company is certified by ISO 9001.

The foil-faced basalt wool is available on the local construction market. It is mainly used for insulating pipes in heating systems. "BPG" also started to produce basalt non-woven mats for the insulation of a building's shell. Non woven mats are made of 100% basalt fibers with high thermal insulation properties. Basalt mats were tested by Danish Technological Institute.

The advantages of basalt mat insulation in comparison to glass wool (based on the results of the test report) are listed below:

a) Basalt mat is a more environmentally friendly product, and doesn't consist of organic binders compared with glass wool;
b) Basalt Mat provides the same thermal insulation qualities as much thicker mineral wools and mats, and with a lower specific weight.
c) Modern international fire norms require insulation materials with a working stability of at least 650 ^{0}C in civil buildings. Basalt mat fulfils this requirement and is therefore considerably more economic and a better product in terms of fire resistance than Silica wools or mats.

Table 1 illustrates thermal conductivity coefficients of the Basalt Mat products.

Table.1

Average temperature [^{0}C]	50^0	300^0	600^0	800^0
λ-Thermal Conductivity Coefficient [W/m^0 K] for density -130kg/m^3	0.031	0.056	0.161	0.274
λ-Thermal Conductivity [W/m^0 K] for density Coefficient -150kg/m^3	0.031	0.054	0.151	0.268

BPG suggests that one application of basalt mat could be the insulation of walls and roofs of the building. Figure 1 and Figure 2 illustrate this approach.

The price of basalt mat on the local market is about USD 3.86/m^2 (6.50 GEL) the price of foil-faced basalt wool for piping insulation purposes is about USD 4.46/m^2 (7.50 GEL). The product is supplied in 10m to 30m long x 1m wide rolls and with a thickness of 8mm.

Basalt needle mat, which does not contain evaporating hard resin binders, is considered to be an ecologically friendly product and is permitted for use in interior areas of civil construction. Basalt mat's low thermal conductivity allows small thicknesses to be used (8mm to 10 mm) and, with a simple fixing method, enables further cost savings to be made of insulation works. The reduction noticed in the quantity of stone wool on the local market, in comparison to last year, can be attributed to the fact that the producer started to manufacture more basalt wool insulation products.

Currently, Geolan stone wool (without foil) can also be found on the local market. This is manufactured by FIBRAN SA, of Terpni - SERRES, Greece. It is imported by a Georgian company called *"art decor+"*.

Geolan stone wool manufacturing began in June 2002, following the opening of the FIBRAN group's new industrial unit for the production of *stone wool* materials. This plant covers a total area of 11.000 m^2 in Terpni - SERRES. The production process involves the fusion of minerals in electric twin-ovens. This highly advanced unit is one of only a few units worldwide which operate such technology, which is environmentally friendly.

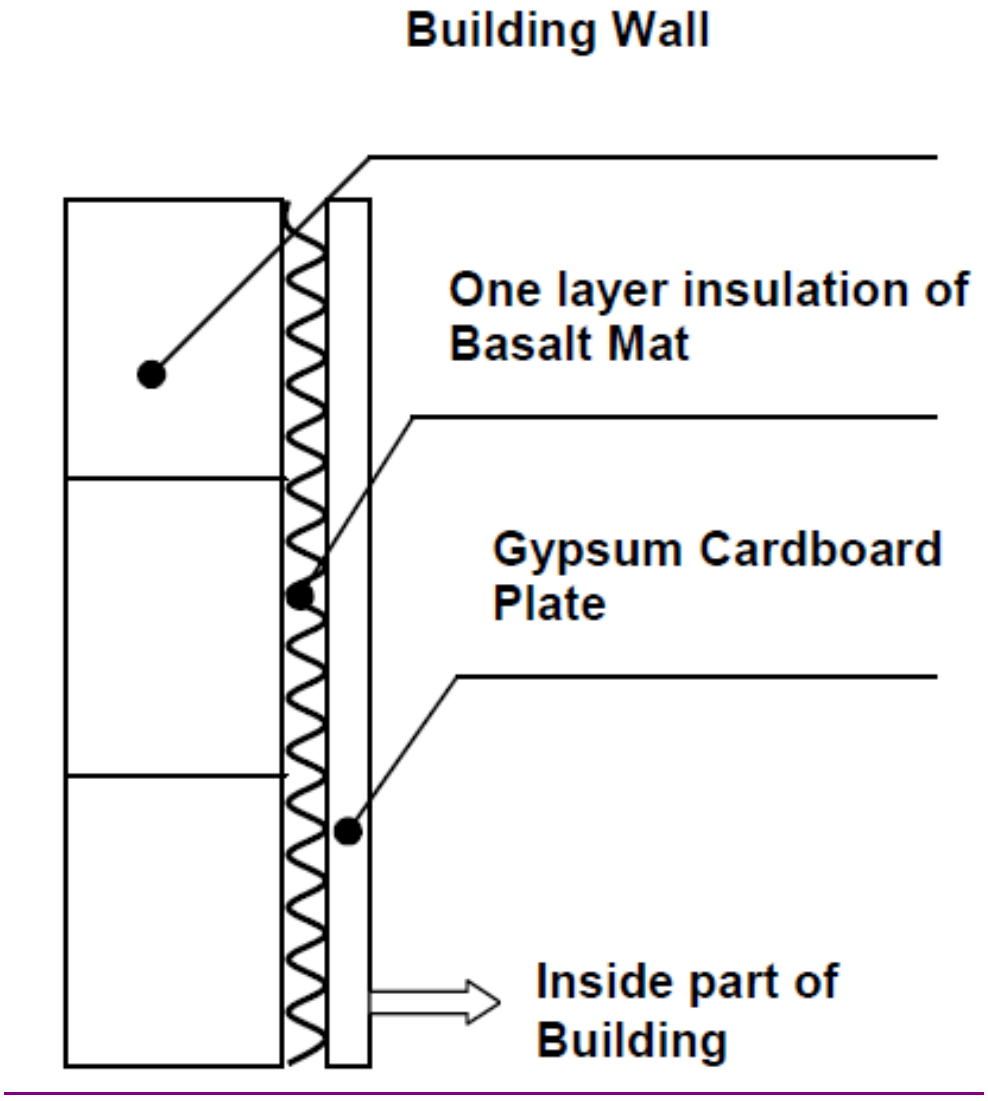

Figure 1. Application of Basalt Mat for insulation of the wall

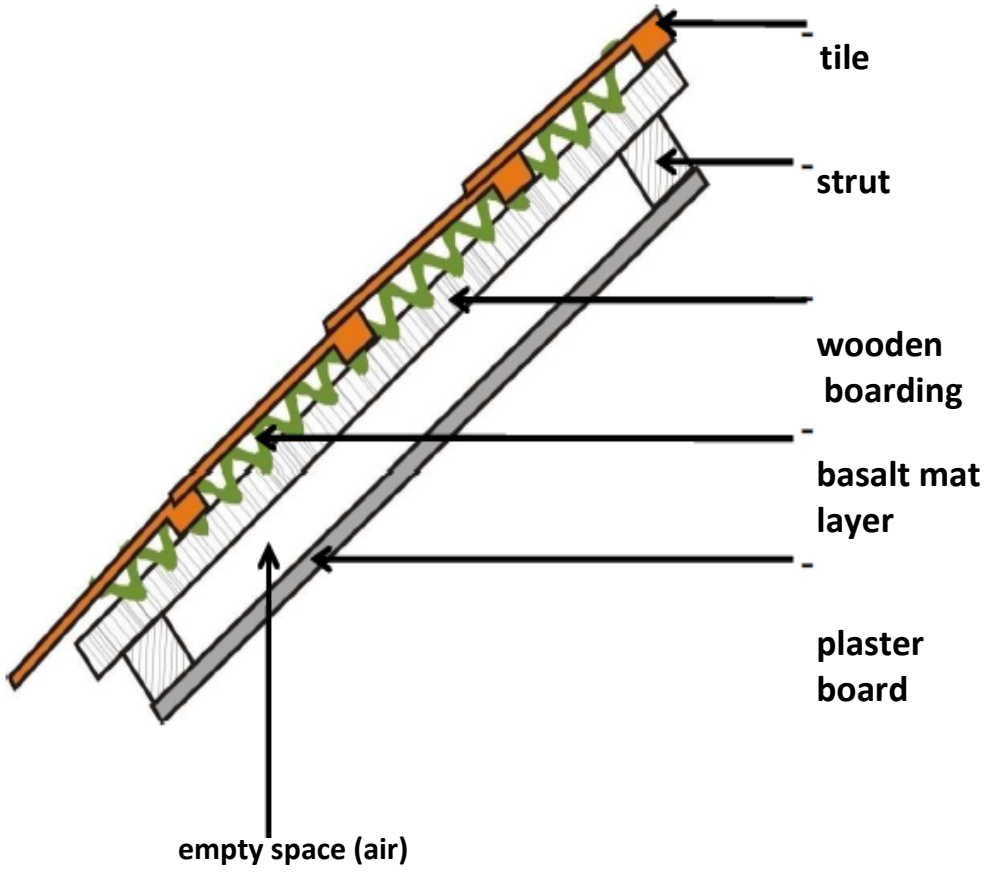

Figure 2 Application of Basalt Mat for insulation of the roof

Geolan produce high quality products in accordance with EC Council Directive 89/106/EEC and in strict compliance with European Norm EN 13162. The main characteristics of this product are given in Table 2 below. One package consists of 10 pieces; each piece is 0.72m^2. As can be seen in the table, the market price of the stone wool/m^2 is about USD 5.95 to USD 6.00 (10GEL), which represents a significant reduction in comparison to last year's market price of USD 10.70.

Table 2.

Name of the product	**Size of each piece (mm)**	**Thickness (mm)**	**Coefficient of thermal conductivity W/(mK)**	**Thermal resistance (m^2 K)/ W**	**Price per m^2 USD**
"Geolan-stone wool"	1200x600	50	λ= 0.035	R=1.4	5.95 -6.00

This product can be recommended for upgrading structure (roofs) of the school buildings within the CHF rehabilitation program, but a detailed cost benefit analysis should be conducted for identification of the most cost effective measures for each school.

2.1.2 Glass Wool

Currently glass wool is imported from Turkey and Russia. The glass wool available on the Georgian market which is of Turkish origin mainly consists of products manufactured by two producers "IZOCAM" and "ODE". This product is mainly used for insulating roofs.

Izocam - glass wool is manufactured as a 50mm thick foil-backed glass wool blanket in rolls of 14m x 1.2m. The coefficient of thermal conductivity is λ= 0.04 W/(mK), and the thermal resistance is **R=** 1.25 m^2K/W. The company operates a Quality Management System (QMS) in accordance with ISO 9001.. On the Georgian market "IZOCAM" faced glass wool is available in the form of rolls which cover 16.8 m^2. The density of the material is 12 kg/m^3 and the average price is between USD 26.79 to USD 28.57 (45.00 GEL to 48.00 GEL). Izocam - glass wool is also available as unfaced (i.e. without a foil backing) in the same size of rolls. The price per roll of unfaced glass wool is about USD 22.00 (37.00 GEL).

"ODE" glass wool has the same thickness, width and length parameters. The coefficients of thermal conductivity and thermal resistance of this Turkish product differ slightly. The thermal conductivity is λ= 0.043 W/(mK), and the thermal resistance is **R=** 1.15 m^2K/W.

The well known brand of Knauf glass wool, which is imported from Russia, can be found on the Georgian market. The size of each roll is 10m x 1.2m wide, and with the same thickness of 50mm. Coefficients of thermal conductivity and thermal resistance are: λ= 0.04 W/(mK) , and **R=** 1.25 m^2K/W respectively. The local market price for Knauf glass wool is USD 41.67 (70.00 GEL) per roll.

2.1.3 Slag Wool

This material is not being considered for installation in the schools rehabilitation project because it is not available on the local market.

2.2 Insulating plasters

2.2.1. Perlite plaster

In recent years, much attention has been focused on the use of expanded perlite sand for plasters which, unlike plasters based on river sand, have a density not exceeding 700 kg/m^3.

Such plaster is one of the most advanced insulating materials that can be used in construction, created on an expanded perlite base with good insulating indicators, which makes its use effective, compared to traditionally and currently used plaster materials (cement-sand, mixture and other).

Technical indices of perlite plaster material:

- Volume weight, kg/m^3 450-550
- Bending strength, MPa 0.9-1.2
- Compressive resistance, MPa - 2.0-3.5
- λ coefficient of thermal conductivity Wt/m.C 0.039 0.041
- Sound absorption coefficient-during 200-2000 Hz frequency 0.35-0.65

By adding pigments to plaster mixtures any color can be obtained, eliminating the cost of a paint finish. Dry plaster mixtures are supplied packed in bags.

Local mining company "Paravan Perlite" Ltd produces expanded perlite for insulating plaster purposes. $1m^3$ of expanded perlite makes up 20 bags with a total weight of approximately 70kg to 75kg costing around USD 60.00 (85.00 GEL) for smaller quantities, but discounts for larger quantities are available. Company "NCT LTD" also offers $1m^3$ of expanded perlite for just USD 39.00 (65GEL). Insulating materials using expanded perlite also possess excellent sound absorption properties, and soundproofing materials based on expanded perlite can be used in buildings where acoustics are important. Expanded perlite is chemically inert, incombustible, fireproof, non hygroscopic and frost-resistant material.

The heat-insulating properties of 3cm thick heat-perlite plaster are similar to those of 15cm of brickwork. Plaster can be applied to brick, concrete, slag concrete, expanded metal, wood and may be painted or papered without carrying out any additional works. It can be used to improve thermal efficiency in both heated and unheated rooms.

"Paravan Perlite" Ltd has gained experience in application of perlite products for thermal insulation properties of the building. *One of their recommendations is to use expanded perlite in bags for insulation of roofs. It is usually placed underneath the hydro insulation material.*

Thermal insulating indices of perlite plaster relative to other materials are given in Figure 3.

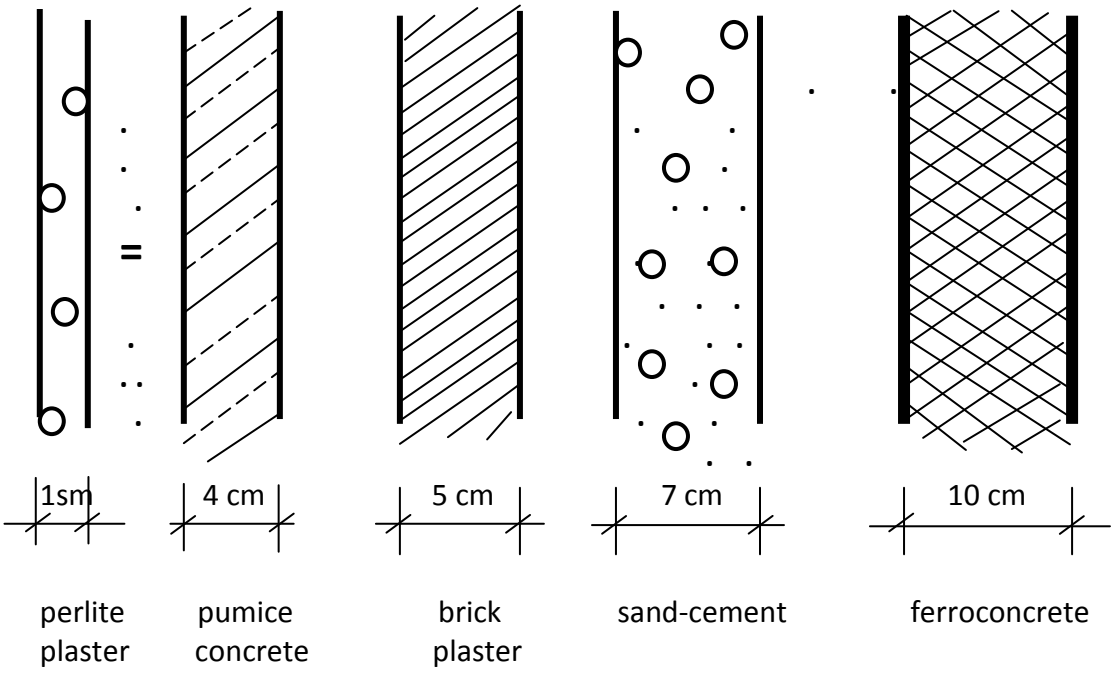

Figure 3. Thermal insulating indices of perlite plaster relative to other materials

Light mortars, based on expanded perlite, are widely used in construction (Figure 4). A dry mix (with gypsum or cement) can be simply mixed with water on site, and applied. It is also used to fill spaces and cavities in walls, blocks, and bricks, and to smooth seams and cracks. This composition has the following characteristics: average density - 650 kg/m^3; tensile strength - over 1.7 N/m^2; compression strength - over 5 N/m^2. This mortar is particularly well suited for construction using

light bricks and foam concrete, as well as perlite concrete with thermal technical parameters similar to those of the mortar. Masonry structures which use such mortars have no cold bridges.

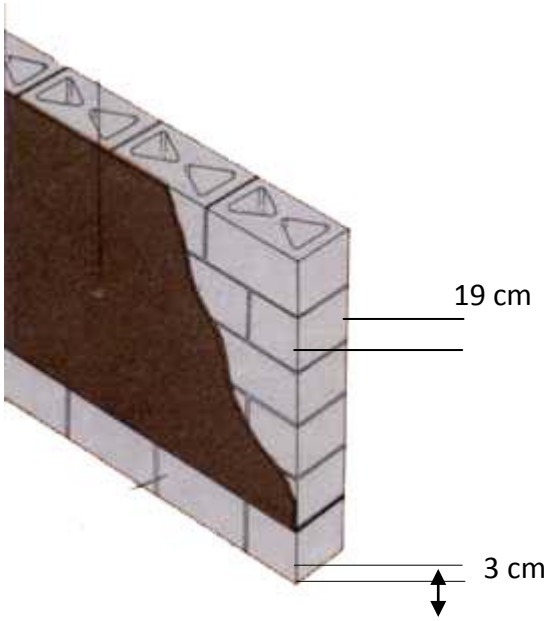

Figure 4 Application of perlite plaster on the wall

For cavity insulation of walls, dust-free perlite sand is used with a bulk weight of between 60 kg/m^3 and 100 kg/m^3. The space between bearing masonry and face work is filled, layer-by-layer, after laying 3-4 rows. In order to avoid shrinkage in service, the filled layer is been compacted by about 10%. If necessary, the insulation layer may be made up to any required thickness. Having high thermal insulation properties, expanded perlite does not age and is not destroyed by animal or plant pests. Filling (Figure. 5) can be done directly from bags or by special applicator tools.

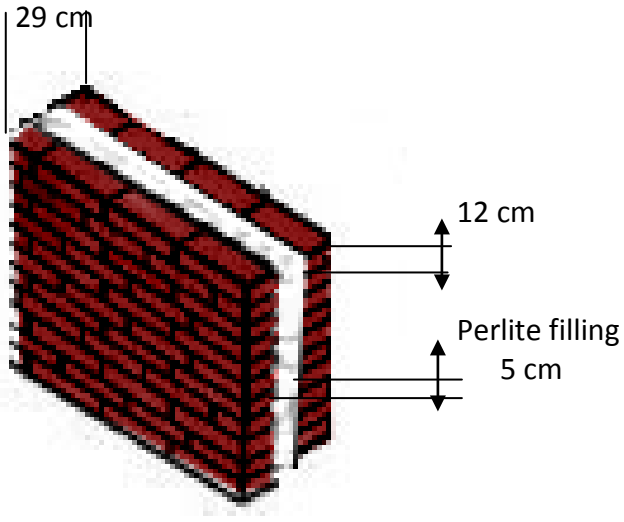

Figure 5. Perlite filling is used among the brick walls

Company “NCT LTD” also offers perlite plaster on the local market. Perlite plaster products (gypsumperlite) offered by above–mentioned company are produced on perlite material imported from Armenia. Other small business companies like GSC “Perlite” are also engaged in the production of perlite plasters in Georgia. Price of 1m^3 perlite for plaster purposes offered by GSC “Perlite” constitutes 80 GEL.

2.3 Polystyrene **(Foam Plastic)**

Polystyrene (PS) foam is a lightweight, rigid plastic insulation material, available either as EPS (Expanded Polystyrene, produced from polystyrene beads) or as XPS (directly Extruded Polystyrene). XPS foam boards are widely used in the construction and building industry. They provide a cost-effective solution for upgrading the thermal and acoustic needs of buildings and can be used in all types of buildings. Polystyrene foam is used worldwide for a wide range of insulation applications, throughout the residential, commercial, institutional, and industrial building sectors. From floor to roof, including its well-known use as cavity wall insulation, polystyrene foam provides versatile insulation solutions, adaptable to many situations. The thermal conductivity of polystyrene depends on its density, but polystyrene with typical values of between 0.027 Wt/m.C and 0.04 Wt/m.C are available on the local market.

Demand for polystyrene in Georgia has increased during recent years. It is mostly used by the private sector for insulation purposes of the buildings. However it is not environmentally friendly and this should be weighed against its insulation properties.

Polystyrene is produced locally in Georgia by company Interplast Building Materials Company and Kemkheli Ltd. - Thermo Insulation materials. Prices on polystyrene produced by Interplast are illustrated in Table 3, below.

Table 3

Product Description - size (cm) / volume (m^3)	Price per m^2 USD/ (GEL)
Polystyrene 100x100x2 - 0.02m^3	0.90 / (1.50)
Polystyrene 100x100x3 - 0.03m^3	1.44 / (2. 40)
Polystyrene 100x100x4 - 0.04m^3	1.92 / (3. 20)
Polystyrene 100x100x5 - 0.05m^3	2.34 / (3. 90)
Polystyrene 100x100x6 - 0.06m^3	2.82 / (4. 70)
Polystyrene 100x100x7 - 0.07m^3	3.36 / (5. 60)
Polystyrene 100x100x8 - 0.08m^3	3.72 / (6. 20)
Polystyrene 100x100x9 - 0.09m^3	4.20 / (7. 00)
Polystyrene 100x100x10 - 0.1m^3	4.68 / (7. 80)
Polystyrene 100x100x14 - 0.14m^3	6.65/ (11.09)
Polystyrene 100x100x15 - 0.15m^3	7.13/ (11.88)
Polystyrene 100x100x18 - 0.18m^3	8.55/ (14.26)
Polystyrene 100x100x20 - 0.20m^3	9.50/ (15.84)

The prices of polystyrene produced by “Interplast “company are almost the same as they were one year ago.

Kemkeli Ltd-Thermo Insulation materials prices per cubic meter (m^3) are USD 32.90 (55 GEL) for material with a density of 8kg/m^3 and USD 48.00 (80 GEL) for material with a density of 15kg/m^3.

Imported polystyrene (from Turkey and from other neighboring countries) can also be found on the local construction market. GRC Company is one of the main importers of XPC polystyrene in Georgia. Except polystyrene company also imports glass wool stone wool as well as waterproofing materials for flat roofs. Imported polystyrene is packed in the packages. Price of each package is

starting from 11.40 USD 20 (GEL), amount of square meters varies according to thickness of the polystyrene board as illustrated below in the Table 4.

Table 4

Material Thickness (cm)	Quantity per package (m^2)	Price USD (*GEL*)
2	10	1.20 (*2.00*) to 1.50 (*2.50*)
3	8	1.50 (*2.50*) to 1.80 (*3.00*)
4	6	2.00 (*3.33*) to 2.40 (*4.00*)
5	5	2.40 (*4.00*) to 3.00 (*5.00*)

2.4. Hydro insulation product opportunities of Georgian construction market

The representative of Grace Construction Products Company in Georgia offers structural waterproofing membranes to prevent water migration which are used for such civil engineering substructure applications as slabs and basement walls. The company offers different waterproofing membrane products depending on the requirements of a particular situation. On average, waterproofing membrane application costs between USD 28.00 and USD 35.00 per square meter.

Companies "ORDEX" and "SIKA" also are operating on the local construction market offering structural waterproofing membranes.

"Ordex" offers waterproofing paints one and two component systems, which cost 4.16 USD (7 GEL) per square meter for one component system and 7.14 USD (12GEL) for two component system.

After application such waterproofing paints are rubberized.

"Thoroseal" mortar in packages is offered on the local market. Product is imported from Turkey. It is produced by Weber manufacturer that operates in Turkey.

Throseal mortar is waterproof material and is used for application in building components where are waterproofing requirements.

It comes in 25 kg packs and costs about 77.4 USD (130 GEL) on the local market. This amount is enough for 25m^2 double application of this material on the surface.

SECTION 3. LIGHT CONSTRUCTION MATERIALS

Below are the descriptions of various lightweight materials used for construction. Benefit of using lightweight materials is that they are more energy efficient, saving energy and money, which is demonstrated in the text below

3.1 Pumice blocks

There are large pumice reserves on the territory of Georgia. Pumice traditionally was used in construction sector of Georgia and that is the reason why pumice blocks are mostly recognized by construction companies as a light construction material blocks. Presently pumice blocks are produced in Georgia by different manufacturers. Some of the construction companies are producing pumice blocks in small enterprises for their own business needs.

Density of pumice blocks is around 1000÷1200 kg/m^3, coefficient of thermal conductivity can be expected not higher then : λ = 0,6 [W/m^0 C].

Main producers of pumice blocks are "NCT LTD" (New Construction Technologies) and LLC "Evrobloki".

Technical parameters of the pumice blocks produced by LLC "Evrobloki" are given in the Table 5. Company "NCT LTD" produces the same standard size blocks as it is shown in the Table 5, as well as non standard pumice blocks with the sizes: 75x200x400; 250x200x400; 300x200x400.

Table 5

Size	Weight (kg)	Price USD/GEL
100x200x400	8	0.39/0.65
200x200x500	16	0.78/1.3
200x300x400	16	0.99/1.65

Prices on pumice blocks produced by "NCT LTD" according to size of the blocks are 0.78-0.90USD (1.30-1.50GEL)

3.2 Perlite blocks

Perlite blocks are currently produced in Georgia. The main player of this construction market segment is the mining company "Paravaneperlite Ltd." Other small business companies like GSC "Perlite" with the mining license are also manufacturing perlite products in the country.

Small companies aren't characterized by stable business they appear and disappear from time to time, for instance company Semi Ltd reported that they had to stop production of perlite blocks due to the absence of demand on this product. Recent war as well as unstable political situation in Georgia that coincided with the world financial crisis negatively affected small business in Georgia.

Perlite blocks are produced on the base of expanded perlite –environmentally friendly material, which is characterized by good thermal properties. Perlite blocks can be used for enhanced energy efficiency of the building envelope.

"Paravaneperlite Ltd." company's prices on perlite blocks are illustrated below in the Table 6.

Table 6

Light concrete blocks(type)	Size, (mm)	Weight, (kg)	Price. USD/GEL
Solid perlite concrete block	390x90x190	4.5	1.08/1.8
	390x190x190	9.0	1.80/3.0
	390x240x190	12.0	1.98/3.3
Hollow perlite concrete block	390x100x190	3.5	0.84/1.4
	390x190x190	6.5	1.38/2.3
	390x290x190	8.5	1.80/3.0

Thermal conductivity of the perlite concrete blocks according to the density is shown in the Table 7.

Table 7

Density kg/m^3	Thermal conductivity λ [W/m^0C]
1200	0.35
1000	0.28
800	0.22
600	0.15
400	0.10

Analysis of energy consumption of the building with the perlite blocks was done in the research with the use of the "Energy Passport" concept. [2] Energy savings resulting from the use of the perlite blocks are reaching to 51% compared with the commonly used heavy blocks.

Energy efficiency opportunities of perlite blocks should be widely publicized for better promotion of these products. Prices of perlite blocks produced by "Paravanperlite" within one year period remain the same. Company "NCT LTD" also produces perlite blocks with the size 300x200x400mm with the price around: 0.96-1.0 USD (1.62-1.69 GEL).

3.3 Slag blocks

It is known that slag is a by-product of smelting ore to purify metals. World experience shows that this previously unwanted recycled product can be used in the manufacturing high performance slag concrete blocks. Blocks of slag have been already used in the construction of retaining walls and foundations worldwide.

Mining company "Paravaneperlite Ltd." came up with the idea to use slag by-product in Georgia from "Rustavi metal" plant for the production of the high performance slag light concrete blocks and started to manufacture light slag concrete blocks. Company produces high quality slag blocks, technical parameters of slag concrete blocks produced by "Paravaneperlite Ltd." are given in the Table 8 and Table 9.

Table 8

Light concrete blocks(type)	Size, (mm)	Weight, (kg)	Price. USD/GEL
Slag concrete block	390x100x190	6.0	0.52/0.86
	390x190x190	11.0	0.84/1.40
	390x290x190	13.5	1.26/2.1

Table 9

Density kg/m^3	Thermal conductivity λ [W/m^0C]
1400	0.55
1200	0.45
1000	0.35
800	0.23

[2] PhD Y. Matrosov, PhD K. Melikidze, N. Verulava "Survey of current construction practices and recommendations to building industry to improve energy efficiency in Georgia." http://www.winrock.ge/files/microsoft_word_-_eng_matrosov_-_final_report_1_.pdf

600	0.20

3.4 Foam concrete (aerated concrete) blocks

Foam concrete is a type of porous concrete. According to its features and uses it is similar to aerated concrete. The synonyms used regarding foam concrete are:

- Aerated concrete
- Lightweight concrete
- Porous concrete

Foam concrete is created by uniform distribution of air bubbles throughout the mass of concrete. Foam concrete is produced by mechanical mixing of foam prepared in advance with concrete mixture, and not with the help of chemical reactions. Foam is prepared in special device - foam generator and after that mixed in special mixer.

Foam concrete blocks are one of the most advanced light construction blocks produced in Georgia. The main producers of foam concrete blocks are companies: 'Porobeton Ltd," and "Evrobloki Ltd".

The coefficient of thermal conductivity for foam concrete or aerated concrete block was obtained from the company "Porobeton Ltd" and can be defined as $\boldsymbol{\lambda}$ = 0,154 W/m·^{0}C. Company produces two types of foam concrete blocks with the sizes: 600x300x100(mm) for partitions and 600x300x200(mm) for exterior walls. Thermal resistance of the exterior walls built from blocks with the size 600 x 300 x 200(mm) will be **R**-value is 1,95 m$^{2.0}$C/ W.

Assessment of thermal properties of the building constructed from foam concrete blocks was done in report with the use of electronic version of "Energy Passport"[3].

According to research results building constructed from foam concrete blocks can save 58% energy each year during heating period, compared to the building constructed from the heavy concrete blocks. Price of manufactured foam concrete blocks produced by "Porobeton Ltd" company for exterior block (600x300x200mm) remains stable and constitutes 3 USD/(5 GEL). It has not changed within one year period.

Company "Evrobloki Ltd" produces thermo blocks based on combination of the concrete and foam concrete components. Prices on thermo blocks are illustrated in the Table 10.

Table 10

Size (mm)	Price USD/GEL
100x200x400	0.54/0.9
200x200x500	0.99/1.65
200x300x400	1.47/2.45

Another product that is manufactured by "Evrobloki Ltd" is foam concrete block. Technical parameters of the above foam concrete blocks are illustrated in the Table 11.

[3] PhD Y. Matrosov, PhD K. Melikidze, N. Verulava op cit .

Table 11

Size (mm)	Price USD/GEL
100x300x600	1.26/2.1
200x300x600	2.40/4.00

Coefficient of thermal conductivity of the foam concrete blocks produced by “Evrobloki Ltd” are around λ 0.22÷0.26[W/m·^{o}C].

3.5 Simprolit polystyrene concrete blocks and polystyrene concrete systems

Simprolit blocks are manufactured from a new material, "super-light" polystyrene concrete. In the class of light-weight concretes simprolit polystyrene concrete is one of the lightest composites and the weight of simprolit products is several times less then the weight of similar materials. By using simprolit blocks for facade and partition walls the load carried by structural members becomes considerably reduced, consequently reducing dimensions, required reinforcement and weight of these members which has direct influence on the price of the building.

LLC ” Simprolit Georgia” started to manufacture Simprolit polystyrene concrete blocks in Georgia. Besides blocks company produces Simprolit Wall Systems intended for building energy efficient, quakeproof, light enclosures from monolithic concrete using nonremovable thermal moulds (bearing walls, partitions, structural walls, overhead covers, etc.). Wall thermal moulds are represented by two hollow thin wall (50 mm) blocks with two vertical voids, made from 200 kg/m^3 density thermal insulating Simprolit polystyrene concrete.

There is also Simprolit Facade Systems intended for heat insulation of external walls of existing buildings using thermo insulating Simprolit plates.

Nowadays demand for simprolit blocks as well as for the other Simprolit products is low. Size of manufactured simprolit blocks is: 500x190x250(mm), weight-3.2 kg and price constitutes: 2.26/3.76GEL.

For walls made with blocks having 700 kg/m3 density the thermal conductivity coefficient amounts to λ=0.223 W/m^0 C, and for the same walls made with blocks having 600 kg/m3 density it equals λ=0.191 W/m^0 C.

SECTION 4. CONSTRUCTION TECHNOLOGY BASED ON THE USE OF NON-REMOVABLE CONCRETE MOULDS

Company “Alioni 99” has developed building construction technology based on the use of non-removable concrete moulds and already started to construct hotel building in Tbilisi. The proposed technology consists in following:

- concrete units of non-removable moulds are manufactured at a factory;
- labeled mould units on pallets are delivered to construction site where the building foundation should be already prepared;
- foundation slabs should be placed horizontally aligned and fixed along the exterior wall perimeter;

- angle and line units that make the external outline of the exterior walls are placed into the provided locks of the fixed above-foundation slabs;
- *heat insulation* material is applied to reinforcement extension from the inner side of the placed units;
- at the points of exterior walls where building frame members are designed, frame reinforcement is fixed to the foundation;
- in the same way units that make an internal outline of exterior walls are placed into locks of foundation slabs;
- the pints of exterior walls where building frame members are designed should be separated from the other part of exterior walls by partitions;
- the whole space between the placed mould units excluding pillar location areas should be poured with *foam concrete* to form the wall core. Density of foam concrete for seismic regions should be at least 800kg/m^3;
- then the next courses of mould units are placed;
- outer units of exterior walls of permanent moulds continue to be placed one over another incessantly;
- pouring of ceiling, girders and pillars with structural concrete are performed simultaneously.

Advantages of the proposed construction technology

The construction technology proposed by company "Alioni 99" has the following advantages over the construction methods that are currently used in Georgia:

- simple, rapid, high quality wall erection;
- simultaneous process of exterior wall and building frame erection;
- enhanced *energy efficiency* level of the thermal performance of the buildings;
- high quality and durability of wall finishing;
- there is no need to use tower crane;
- construction site dimensions are substantially reduced;
- consistent quality is ensured.

Disadvantages of the proposed construction technology

The construction technology proposed by company "Alioni 99" has the following disadvantages over the construction methods that are currently used in Georgia:

- requires detailed delivery instructions or on-site storage;
- minimizes local labor utilized as part of construction process;
- reduces reliance on small- and medium- business skilled laborers.

SECTION 5. PVC METAL-PLASTIC DOORS-WINDOWS

Windows and balcony doors are the most vulnerable areas of the building envelope. Under old Soviet "Construction Thermal Engineering" codes it wasn't required for Tbilisi climatic conditions to design buildings with double glazed windows as well as balcony doors. Thermal performance properties of the exterior walls were also designed without energy efficiency considerations.

Energy policy of the former Soviet Union was based on low energy prices, which affected regulations and in turn, design solutions. Thus the main construction infrastructure that remains from the old Soviet period is designed with single glazing windows and doors and stationary heating systems which means that they had to compensate heat losses constantly during the heating period due to the poor thermal performance characteristics of walls and windows.

Double glazed windows can save up to 19% energy even if walls are designed not higher then mandatory thermal resistance $\mathbf{R}^{man}$ level. This level was required under old Soviet codes and nowadays most of construction companies, in the absence of new codes in construction thermal engineering prefer to stick calculations of the exterior walls to that level.

Now, the situation in Georgia has drastically changed regarding energy efficiency of windows and doors. All construction and development companies include double glazed windows and balcony doors as a standard feature of new apartments. It can be noted that production of double glazed windows and doors represent the most dynamically developing segment of construction sector.

Local Georgian company "Interplast" is producing 4 chamber PVC (polyvinylchloride) metal – plastic doors-windows profiles for Georgian climatic conditions. The company uses innovative technological methods and high quality raw materials for production of PVC profiles.

The basic window-door profiles that Interplast produces, and their respective prices, are shown below.

Table 12

PVC element/ per linear meter	Price USD/GEL
Frame profile	2.19 / 3.65
Mullion profile	2.59 / 4.32
Sash profile	2.79 / 4.65
Drainer sash profile	3.68 / 6.14
Door sash profile	4.18 / 6.97
Door sash profile with the opening	4.18 / 6.97
Windowsill profile	6.72 / 11.20

Dio Ltd is one of the main importers of window-door PVC profiles from Germany. Dio's prices per square meter of window- door profiles vary in average from 80 USD and for thicker profiles: 157 - 214.3 USD according to the color and some other particularities.

Albatross offers "Salamander" profiles from Germany for 17 USD per linear meter for white color and 19 USD per linear meter for color profiles. Other small businesses periodically are importing window-door profiles. It should be noted that window and door glazing isn't produced in Georgia. It is imported from Turkey, Iran, Russia and other neighbor countries.

SECTION 6. SANDWICH PANELS

Sandwich panels are used for quicker and cheaper construction of the buildings. In Georgia, "Interplast" produces these panels for above-mentioned purposes.

Use of sandwich panels in construction has following advantages:

- -simplicity and quickness of building process;
- -thermal insulation of the buildings;
- -high resistance to atmospheric factors;
- -simplicity of dismantling (if is necessary)

Sandwich panels produced by “Interplast” are shown in the Figure 6

Figure 6 Sandwich panels produced by company “Interplast”

Company “Interplast” prices on sandwich panels are illustrated below in the Table 13.

Table 13

Type of the sandwich panel	Size	Price USD/GEL
sandwich panel 0.5; Metal -0.55-0.40	m^2	22.19 /37.0
sandwich panel 0.6; Metal -0.55-0.40	m^2	23.99 / 40.0
sandwich panel 0.7; Metal -0.55-0.40	m^2	25.79 / 43.0
sandwich panel 0.8; Metal -0.55-0.40	m^2	26.40 / 44.0
sandwich panel 0.9; Metal -0.55-0.40	m^2	26.99 / 45.0
sandwich panel 0.10; Metal -0.55-0.40	m^2	27.59 / 46.0
sandwich panel 0.12; Metal -0.55-0.40	m^2	28.79 / 48.0

SECTION 7. LIGHTING

Traditional incandescent lamp creates light by heating a small coil or filament of wire inside a glass bulb. Making an incandescent lamp glow requires a large amount of energy to heat the filament. In a typical light bulb, 90% of the energy applied to the filament is wasted in the form of heat. Therefore, only 10% of consumed energy is paid for lighting. Energy efficient lighting technologies like compact fluorescent (CF) bulbs can provide the same lighting using much less energy. For example the standard 75 W light bulb gives approximately the same lighting level as 20 W CF bulb. It is also important to note that CF bulbs are designed to last ten times longer than an incandescent bulb.

Efficient lighting has been identified as the highest priority energy efficiency measure resulting in reduction of energy at a very low cost. Replacement of incandescent bulbs by fluorescent bulbs (CF) will be the most profitable for Georgia on a large scale.

Full implementation of efficient lighting has the potential to reduce the need for budget subsidization in the energy sector by $26 million every year[4].

Currently, CF bulbs aren't produced in Georgia; they are imported from Turkey, China and other countries.

SECTION 8. SOLAR WATER HEATING SYSTEMS

Sunlight—solar energy can be used to generate electricity, provides hot water, heat, and light to buildings. Solar water heating systems can operate by using solar energy for domestic hot water purposes saving electricity, gas and wood. The function of the solar energy equipment is to convert sunlight to heat that can be used for: (a) domestic hot water space heating; (b) space heating. There are mainly two different technological solar water heating systems: flat collectors and vacuum pipes. Principally the systems may be also divided in two groups: passive and active. Solar water heating passive system for buildings has two main parts: a solar collector and a storage tank. Passive systems are mostly used for small applications like family houses (Figure 7). Active systems include such additional components as circulating pumps, controllers, etc. They are used in larger applications and may be also considered for space heating purposes (Figure 8).

Currently in Georgia there are several solar water heating system companies operating that are involved in production import, maintenance and installation of solar water heating systems, but only a limited number of companies can offer qualified installation and maintenance of the systems. The main players of this market segment are "Sustainable Energy Center-Sun House", "AYDIO", "Specheliotbomontaji JSC".

Prices on the market on imported solar water passive heating systems depend on the country of origin as can be seen in the Table 14.

Company "AYDIO" offers solar heating system by given below prices;

- 115 liter storage tank - 690USD/1150(GEL);
- 145 liter storage tank - 870 USD/1450 (GEL);
- 200 liter storage tank- 1260USD/2100(GEL)

Prices on active solar systems offered by "Sustainable Energy Center-Sun House" constitute:

- 200 liter storage tank- 4500 USD/7500(GEL);
- 300 liter storage tank- 5500USD/9169(GEL);
- 500 liter storage tank- 6900USD/11500(GEL);
- 800 liter storage tank- 9900USD/16500(GEL);
- 1000 liter storage tank-11900 USD/19834(GEL)

[4] http://www.winrock.ge/files/energy_efficiency.pdf Report done by WEG and Winrock International: "Energy Efficiency Potential in Georgia and Policy Options for Its Utilization"

Figure 7. Passive solar water heating system

Table 14

Country of origin	Storage tank	Price USD/ GEL
China	100 liter	359.40 / 600
Turkey	100 liter	779.66 /1300
Germany	100 liter	1079.50/1800

Photovoltaic-PV (solar cell) systems convert sunlight directly into electricity. A solar or PV cell consists of semi conducting material that absorbs the sunlight. The solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. PV cells are typically combined into modules that hold combined number of cells.

Prices for PV cell systems in Georgia: imported from China, 5 USD (8.4 GEL); imported from Germany, 6 USD (10.1 GEL). In both cases, installation prices can reach 12 USD (20.3 GEL).

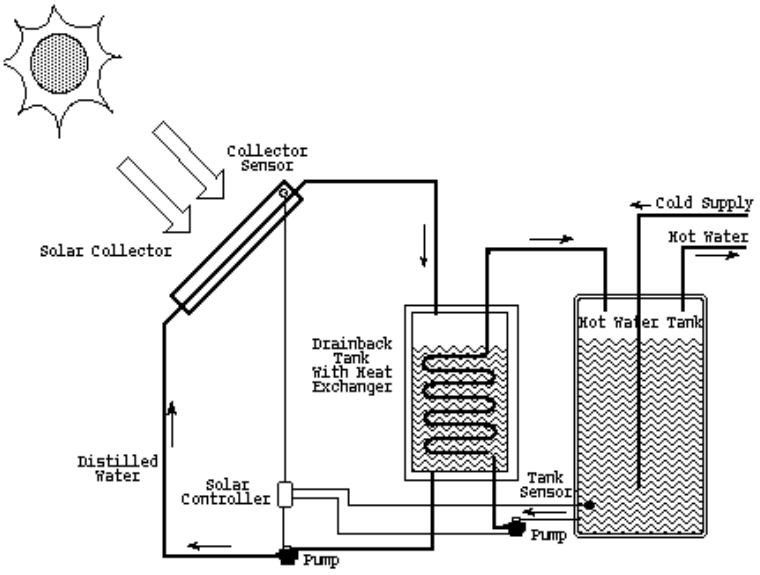

Figure 8. Active solar water heating system

SECTION 9. REASONS FOR INVESTING IN ENERGY EFFICIENT CONSTRUCTION MATERIALS

Development dynamics of construction sector is illustrated in the Table 15 according to data provided by the State Department of Statistics of Georgia.

Table 15

Construction	2003	2004	2005	2006	2007	2008 (preliminary)	2009 IQ
Turnover, mln. GEL	309.0	387.4	778.8	1125.3	1604.6	1319.4	186.9
Output, mln. GEL	297.9	377.1	746.1	1184.9	1717.2	1334.8	185.9
Value added, mln. GEL	89.1	127.1	245.9	401.4	630.6	...	...
Intermediate consumption, mln. GEL	213.2	256.5	523.0	784.5	1087.6	...	...
Fixed assets, mln. GEL	85.9	127.2	258.7	474.9	635.1	...	...
Number of employed persons, person	18874	21344	38560	46681	52572	33032	22754
Average wages and salaries per employed persons, GEL	199.5	237.9	292.3	391.0	495.1	662.5	594.5

As it can be summarized construction sector was one of the most dynamically developing sectors of the country's economy before war and global recession affected Georgia economy.

As it was estimated in research, (done in September 2008) advanced construction and development companies understand the importance of enhanced energy efficiency of the thermal properties of the building envelope but due to the absence of regulations (energy efficient thermal performance codes) these companies aren't implementing such solutions, except in some rare cases[5].

Nevertheless, the main reason to invest in Georgian energy efficient construction materials, despite their higher prices, remains they may significantly reduce energy consumption during the winter period. Cost benefit analysis done on the basis of "Energy Passport" electronic version research identifies that perlite blocks can save about 51% of energy consumed for heating purposes and aerated concrete can even save up to 58% of energy.

Georgian government promised support for future development of construction sector, however it is important to raise public awareness towards energy efficiency trends in construction sector because uninformed public can be counted as one of the obstacles to solve this problem.

Such adjusted policy in the residential sector – the major sub sector from the standpoint of energy consumption that accounts 49% of energy in country's total energy consumption balance – can be viewed as well-timed and urgent due to the current political situation which requires from Georgia improvement of the country's energy security. Reduction of energy consumption will contribute to the strategic goal aimed at filling the gap between energy supply and energy demand. In the future perspective, reduced energy consumption in residential sector will contribute to the country's development in a sustainable manner which is important also within framework of a

[5] PhD Y. Matrosov, PhD K. Melikidze, N. Verulava op cit .

number of international, multilateral and bilateral agreements that require concrete energy efficiency and conservation actions from Georgia.

Increased energy efficiency in the new buildings can also contribute to the environmental protection, rational use of non-renewable natural resources, improved health of building occupants that are exposed to fewer toxins in construction materials, as well as a reduction of carbon dioxide emissions and other substances that influence the “greenhouse effect”.

SECTION 10. CONCLUSIONS AND RECOMMENDATIONS

1. The main difference that was noticed during one year period on the local construction market materials is that Georgian basalt fiber plant “BPG” (Basalt Products of Georgia Ltd) local producer started to operate in Rustavi and introduced high quality insulation rock wool products and basalt mats, both unfaced and with the foil, prepared by company’s technology which was internationally adopted and patented. This product is highly recommended for upgrading structure of the buildings (roofs) and can be suggested for implementation stage of school rehabilitation project in Shida Kartli within CHF program. BPG products have the same thermal conductivity values as the imported stone wool products but compared with the Geolan (Greece) stone wool product they are much cheaper.
2. “Paravan Perlite” Ltd plasters that are also locally produced are recommended for upgrading purposes of building’s structure. Paravan Perlite has gained good experience in upgrading structure of the buildings. Paravan Perlite recommendation is to use expanded perlite in package bags for insulation of roofs with the subsequent application of the mortar or structural waterproofing hydro insulation material. Application of pressure on the expanded perlite packages is recommended before next structural component is applied.
3. “Paravan Perlite” Ltd plasters can be used for upgrading thermal properties of the exterior walls by adding gypsum to expanded perlite. Thermal insulation materials created on expanded perlite basis also are the best sound absorber and soundproofing materials with high acoustic indices, which makes it possible to use them in buildings for acoustic comfort creation. Expanded perlite is chemically inert, incombustible, fireproof, non-hygroscopic, frost-resistant and steady against rodent and other pests.
4. For hydro insulation purposes, waterproofing products can be recommended and are offered by representatives of the “ORDEX” company. Price of abovementioned products are cheaper than products offered by “Grace” company.
5. More detailed recommendations can be given in each particular case bearing in mind particularities of each rehabilitation site, existing situation of the each school building and conducted cost benefit analysis for identification of the best, cost effective energy efficient measures.

SECTION 11. CONTACTS

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