System approach to peat raw materials for production of building materials

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Abstract. The paper presents systematic approach to the definition of requirements to peat raw materials to use them as a basis for building materials. The introduced approach to the classification of peat based on the composition and structure is suitable for research and development of building materials and technological processes. The approach allows using the same technique for peat as for traditional raw materials.

1. Introduction

The intention to increase energy efficiency of buildings and operation of houses requires research and promotion of building materials of higher quality at lower cost applicable in the building envelopes. Thus, production of building materials made of local environmentally friendly raw materials becomes demanded. Russian raw materials base is characterized by significant amount of peat which is a renewable raw material. In its natural state peat has low heat conductivity, porosity and antiseptic properties which makes it efficient use in construction.

Technology of peat based building materials production which is being developed by the authors takes into account the potential of peat due to its composition and structure and ability to regulate these properties. Peat's compound consists of organic and organic-mineral complexes and by modifying these complexes improvement of the binding properties of peat and increase the speed of formation material's composition is reached. Therefore peat can find wide application in production of wall structures, heat insulation building materials and multifunctional additives that provide strength and hydrophobic properties for cement-based building mixtures. Correspondingly, theoretical study, development and implementation of the techniques for modification of peat and peat based mixtures are important. These will improve the technologies of peat based building materials production. A systematic approach will provide good basis for determining quality characteristic for the walling building materials production on all stages of their life cycle.

2. Materials and methods

Analysis of the performed studies shows that the most worthwhile application of modified peat is as an active component (modifying additive, binding) in composite building materials.

Artificial structuring of peat can be treated as one of the ways of controlling the properties of natural dispersed materials as it affects the strength, hydro physical and structural properties of materials. Figures 1 and 2 present the approaches to the regulation of structure and properties of peat based composite (micro and macro level of peat-wooden composites) walling materials.

The formation of peat based composite materials with predetermined and predictable properties is possible if we know how the modification of single structural elements and their interaction affects the process of the structure's formation

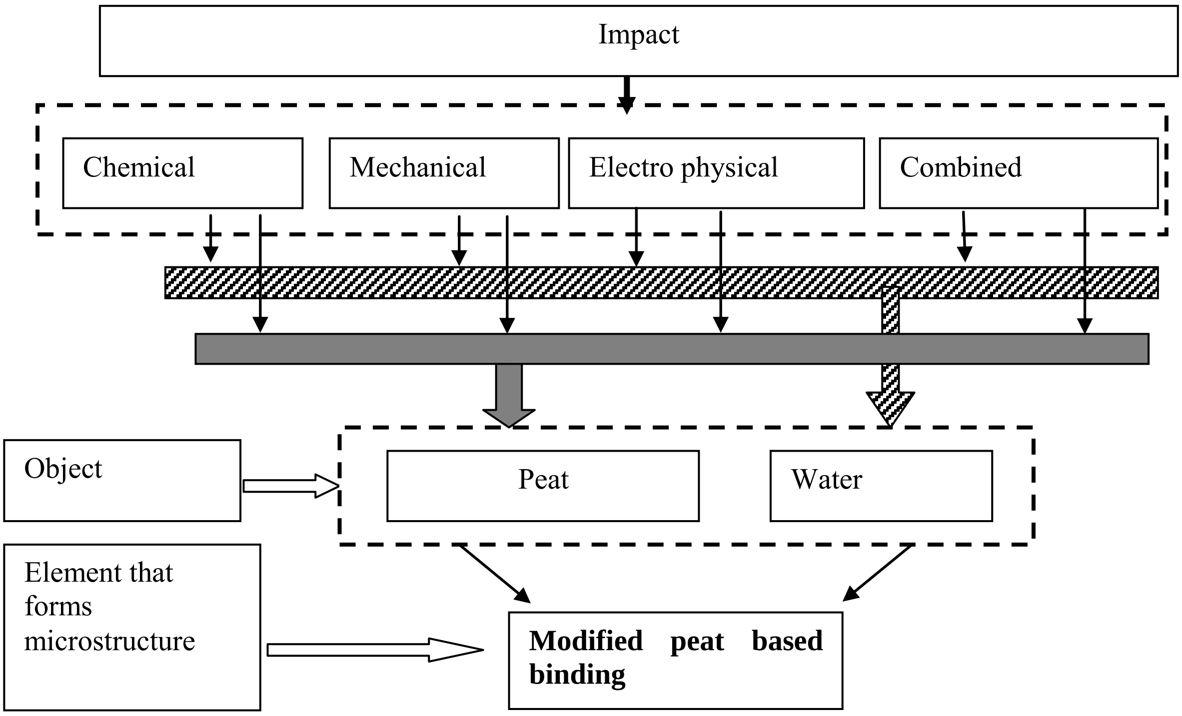

Figure 1. Types of modifying impact on the components of peat based walling materials to form a microstructure.

Thus control over the structures of peat compositions during the formation of energy efficient materials as well as control over the end-use requirements is associated with different ways of modification that can be performed on the different steps of the production cycle: raw material – molding sand – product.

The presented models are resulted from the analysis and generalization of multiple experimental studies. This paper presents and proves a dual-component (filler and peat based binding) model of a composite material. The filler provides a special core while peat based binding material glues the filler's grains and fills the core's spaces. The properties of the peat based binding can be regulated by modifying of peat.

Peat contains a large number of active functional groups of various compounds which allows controlling the structure and forming peat based composite materials with predictable and controllable properties. This hypothesis is based not only on the knowledge of the separate components of natural raw material, but on the regularities of interaction of functional groups with different arming and core forming components of the composition that are widely applied in building materials.

One of the main factors of the formation of rational hardening structures in composite building materials is compatibility of active (binding) and core components. The compatibility considers a material compound, structure and deformation properties.

The selection of filler was performed based on the following criteria: (i) low average density; (ii) high porosity; (iii) strength much higher than of the peat based binding; (iv) similar deformation properties; (v) similar chemical and group compound.

The analysis resulted in the selection of wooden filler as a core formatting material for the peat based binding. At low temperature wood behaves similar to pear regarding its material compound and temperature deformations [1-4].

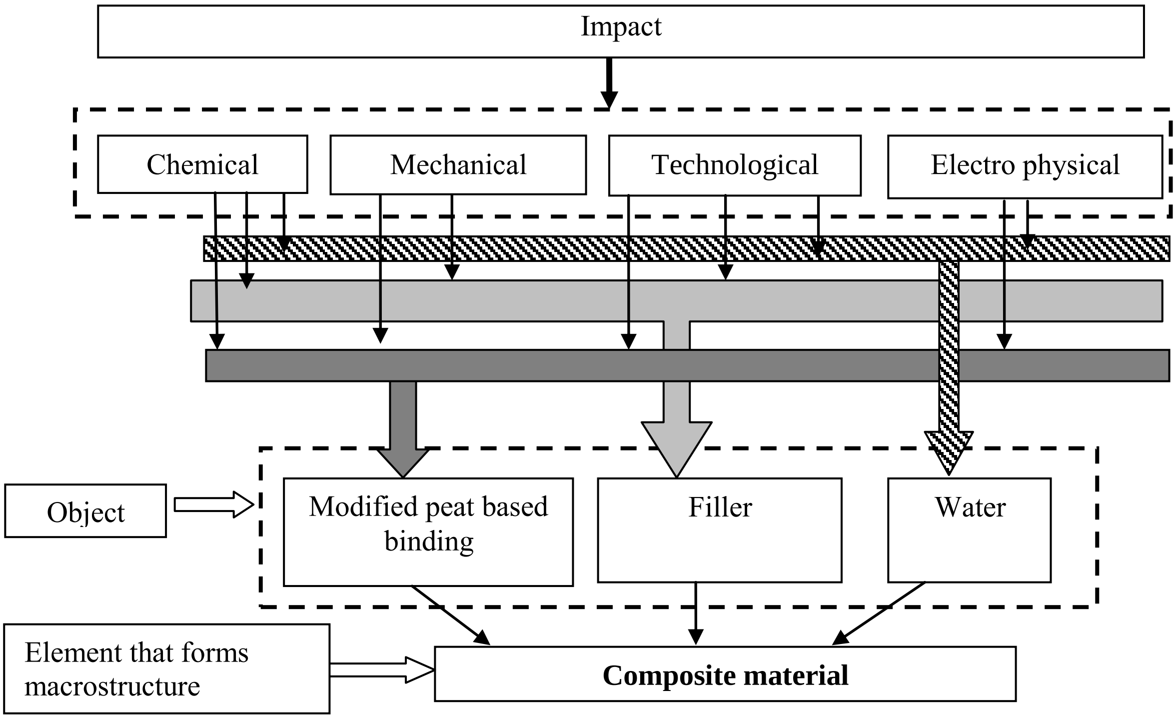

Figure 2. Types of modifying impact on the components of peat based walling materials to form a macrostructure.

3. Research model

It is necessary to mention that the proposed model considers that the binding and the filler contain lignin, humin substances, cellulose, sugar and mineral materials. The structures of the peat and wood are heteroporos, polydisperse, multilayered. The structures are related to the coagulation i.e. moving high elastic structures, where the interaction between single elements is driven by the hydrogen bonds of water molecules. These features allow physical and chemical interactions during the structure formation of the homogeneous composite materials.

The specific features of the peat-wooden composites in comparison to cement based concrete are: the larger phase separating surface; the number of physical and physical-chemical contacts in the volume unit of the material; higher porosity; geometrical and size characteristics of pores that change during preparation, formation and hardening.

The particles of the filler of different size are being enveloped and glued by the peat binding during the formation and drying processes. The peat mass obtains binding properties as a result of mechanical-chemical activation. This provides strong connections between structural components.

Smaller fractions of the filler and peat binding make a condition for the core to be glued. The proposed physical model pays much attention to the physical-chemical interaction of watered particles of the binding and filler. The similar model was used for cement based concretes in [5,6].

The above mentioned processes have not been studied for the cases when peat based binding is used as gluing element and wood is used as filler. The proposed model of peat based composite material allows producing a macro porous heat insulation material [7-11]. This material can be potentially inconsistent with the environment especially if humidity changes which can cause change in main specifications: strength, deformability, heat conductivity, frost resistance. Additional structural elements such as micro pores and arming fibers are being formed to increase the quality of the material (Figure 3).

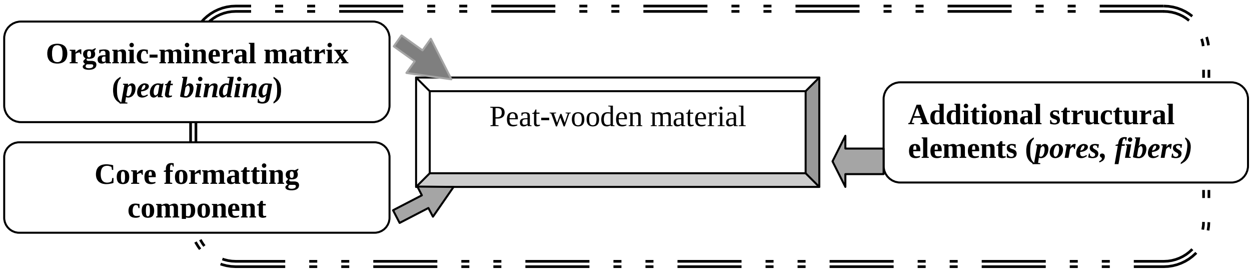

Figure 3. Physical model of a peat-wooden material.

The main controlling processes for structures' formation of composite peat-wooden materials are similar to cement systems and correspond to the general principles of material science [12-16]:

1. Matrix and filler components relations corresponds to the type of the binding. This provides the optimal ratio of the components according to the filler's strength criteria considering type of the filler, its dispersity, morphology of its particles and its compound.

2. Main structure formation processes for the peat-wooden composite materials develop in time. The following phenomena can be observed: (i) formation of a special core from the filler's grains; (ii) micro reinforcement of a peat matrix; (iii) formation of structural mechanical, physical, mechanical-chemical bindings in the chain "peat binding – filler - bulking agent" depending on the mineral-organic ration of peat.

3. Balance of structural bindings at formation of composite peat-wooden material was provided by a contact interaction by: (i) mechanical linkage; (ii) capillary contraction.

4. The following control factors are applied at the formation of the required structure of peat-wooden materials: (i) peat-binding-filler ratio; (ii) liquid body percentage in the mixture; (iii) conditions and options forsol, gel, and colloid states introduction, which causes formation of condense and crystal contacts in the system.

Structural model of peat-wooden material depends on the matrix and filler components as well as reinforcing elements as presented in Figure 4.

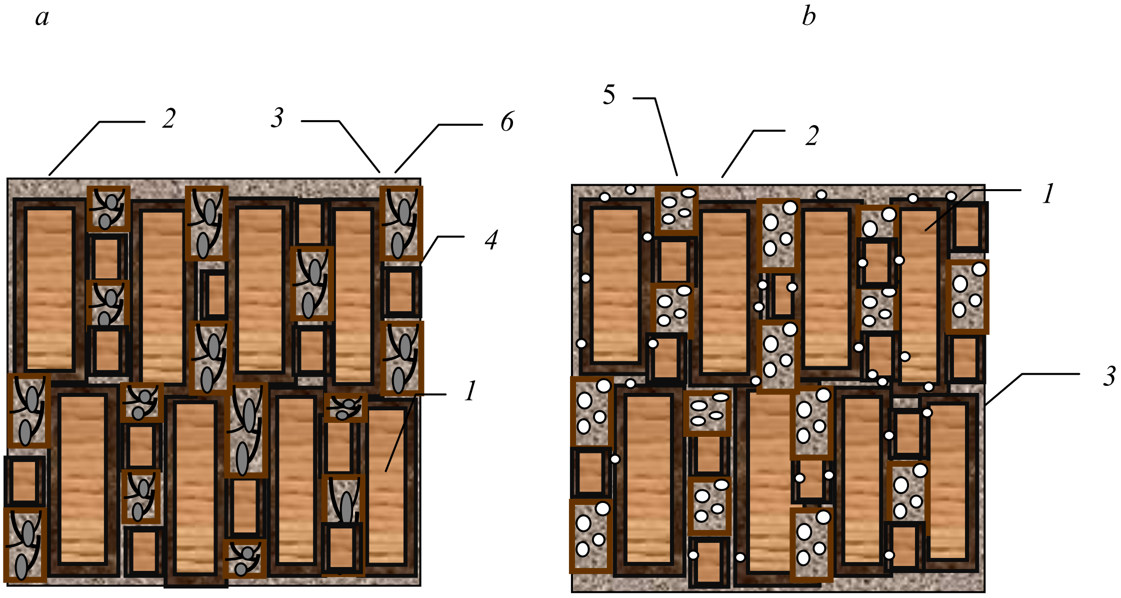

Figure 4. Structural model of a composite peat-wooden material:
a– construction-heat insolation; *b*– heat insolation; *1* – wooden filler; *2* – peat binding; *3* – contact zone; *4* – fibers; *5* – pores; *6* – micro filler

A basal binding system can be used for heat insolation peat-wooden materials. While porous system is applied for constructing heat insolation materials. Porous system requires that the extra reinforcing components such as micro fibers and fillers are added to matrix. Basalt binding is formed while peat binding porisation. The proposed structural model allowed proving a process that controls structure and properties of energy efficient peat-wooden walling materials. The control is possible on micro and macro level (Figure 4).

4. Conclusion

The paper proposed proved two component physical model of heat efficient insolation material. Wooden filler provides a spacious core. Peat binding glues grains of the filler to fill the spaces of the core. The properties of the peat binding can be controlled using different modification techniques. A selection of wood as a core formation material for peat based composite materials was scientifically proved. Peat and wood have chemical and structural affinity.

Structural model of peat as a raw material for building products was introduced. The model allows proving a selection of the way to modify peat and provide possibility to produce building materials with demanded properties. It was proved that the main peat raw selection criterion is a ratio of organic and mineral functional groups.

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