Methodological basis for selecting experimental research for building materials

1st Tatiana Eremina
Institute of Integrated Safety in Construction
Moscow State University of Civil Engineering
Moscow, Russia
main@stopfire.ru

2nd Fedor Portnov
Institute of Integrated Safety in Construction
Moscow State University of Civil Engineering
Moscow, Russia
wastingtimefilmart@gmail.com

Abstract

This paper for the first time proposes methodological frameworks built by generalizing empirical data on the mechanochemical characteristics of materials using interdisciplinary methods. This methodology optimizes research for any composite materials while maintaining targeted research methods and eliminating impractical and related experimental studies with reduced work costs and as a result of environmental impact.

Keywords: Fire safety; the performance of the designs; The physical and chemical properties of the materials; fire retardant; planning of experiment; interdisciplinary research methods

I. INTRODUCTION

The problem of predicting the behavior of building materials in the conditions of their exploitation is one of the significant and promising issues in the development of the construction complex. The behavior of building materials and structures is described by a number of characteristics. Exploitation characteristics include mechanical characteristics - strength (depending on the type of design), shock resistance, wearability, etc., characteristics describing the features of the use of building materials and structures - adhesive ability, reflectivity, thermal insulation, characteristics describing the stability of water by external factors - laity, hydrophobic, etc. There is also a criterion such as durability, describing the minimum possible time of normal operation of materials and structures in certain climatic conditions. In addition, the operation of materials and structures can occur emergencies that create abnormal conditions, such as vibrational impact, elevated temperatures and fire, low temperatures, hurricane wind impact

The above features of building materials and structures suggest the existence of special regulatory methods of research. For example, in the Russian Federation there is a regulatory document GOST 30403-2012 "Building constructions. Fire hazard testing method." This method allows to assess the behavior of the construction structure in natural conditions - part of the sample is in the fire chamber, which simulates the fire, and part of the sample is separated by a partition with an ale, which allows to assess the behavior of unheated structures in the event of a fire. Based on the results of such tests, the structure is assigned a fire hazard class [1-3].

For most characteristics that describe the behavior of building materials and structures in emergency situations, there are a large number of appropriate assessment methods that create conditions for tests close to the real. However, a significant problem with such tests in research work aimed at the development of new building materials and structures is the high cost, labor costs, and negative impact on the environment (e.g., in fire tests of construction structures).

II. METHODOLOGICAL BASICS OF RESEARCH

As you know, in addition to operational and other characteristics described above, building materials also have all the known properties of physical and chemical systems. Accordingly, it is possible to conduct a comprehensive analysis of building materials and structures using physical and chemical research methods.

Physics and chemical analysis methods allow to study in detail the specifics of the behavior of building materials and structures in different conditions. Such methods include: methods of thermogravimetric analysis of the structure, X-ray spectroscopy, chromato-mass spectrograms, elemental analysis, IR spectroscopy, pH-metric [4-13].

Despite the significant results of the use of such methods in practice in the development of new building materials and structures, such methods are used as additional after-site tests.

In order to create a more efficient and optimal development environment for new building materials and structures, a methodological framework for the selection of experimental research needs to be developed.

Based on the large number of research carried out by the authors, the following approach is proposed, based on the separation of experimental methods on the application of them depending on the level (scale) of the objects under study (materials):

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- Micro level;

- supramolecular level;

- Research on the material;

- Design research.

The choice of this approach is related to the specifics of data processing, as well as the preparation of the samples under study. At the micro level, the results are based on the study and analysis of the quantitative patterns of intermolecular connections and their energy. A minimum sample canopy is used as samples for testing. The supramolecular level allows us to consider the structure of dispersal systems with the possibility of their detailed quantitative analysis. A fragment of the material is considered. In the study of the material, it is possible to prepare small reference samples reflecting the basic physical, chemical, mechanical and operational characteristics. In the study of structures, fragments of theoretical or actual functioning objects are selected as objects that allow to reproduce real conditions of operation, as well as emergencies.

Table 1. Interdisciplinary methods of microlevel research

Micro-level research methods
Physical and chemical characteristics:
Heat conductivity assessment
Temperature assessment
Heat-intensity assessment
Thermo-gravimetric analysis
Isothermic calorimetry
Determining Gibbs Energy
High-quality elemental analysis:
X-ray spectroscopy
Chromato-mass-spectrogram
Elemental analysis
IR-spectroscopy
pH-metro

Table 2. Interdisciplinary methods of supramolecular research

Methods of research at the supramolecular level
Assessment of the porous structure:
Specific surface
Porosity
Distribution of pores by size
Assessment of surface structure:
Electronic microscopy
The edge of wetting

Table 3. Interdisciplinary methods of research at the level of materials

Material-level research methods
Performance:
Assessment of water absorption
Assessment of water resistance
Assessment of hydrophobic
Assessment of permeability
Definition of adhesion
Assessment of heat resistance
Assessment of thermal aging
Fire retardant characteristics:
Assessment of fire hazards
Assessment of fire retardant efficiency
Mechanical characteristics:
Strength assessment
Stretching score
Evaluation of the shift
Bend assessment
Methods to control the quality of the material structure
Obtain data on the characteristics of the surface of compositions (electron microscopy)
Assess the edge angle of wetting
Ir-spectroscopy
Study of fire retardants by pH-marker (complex study of the chemical composition of water solutions (rigidity, anion chromatography, pH-metro))

Table 4. Interdisciplinary methods of research at the level of designs

Design-level research
Performance:
Assessment toorrosional durability
Evaluation erosie
Assessment of bio resilience
Assessment of UV sustainability
Assessment of heat resistance
Fire hazards:
Assessment of the fire resistance limit
Mechanical test:
Large-scale trials

The methods described above allow for a comprehensive assessment of building materials and structures of any type and are the methodological basis for a large-scale study.

III. STUDY COMPATIBILITY CHART

Despite the theoretical importance of the research methods described above, it is necessary to address the issue of optimization of research in order to predict the properties of construction structures and materials.

The authors' developments in the design of composite and fire retardant materials using interdisciplinary research methods suggest that the lowest-scale (micro and supramolecular level) studies are correlated with a larger level and can be extended to a number of assumptions that characterize the chosen scale. This is how an approach has been developed, which is described as a compatibility diagram

This diagram describes the relationship between interdisciplinary research methods at different levels and shows the possibility of using smaller test results to predict the behavior of the subject at a larger level.

The use of such a diagram is associated with extensive research on the results of interdisciplinary research methods on a limited number of sites. This selects a functional criterion, the indicators derived from studies that can allow the prediction of the properties of similar building materials and structures to obtain the necessary conclusions (see Figure 1).

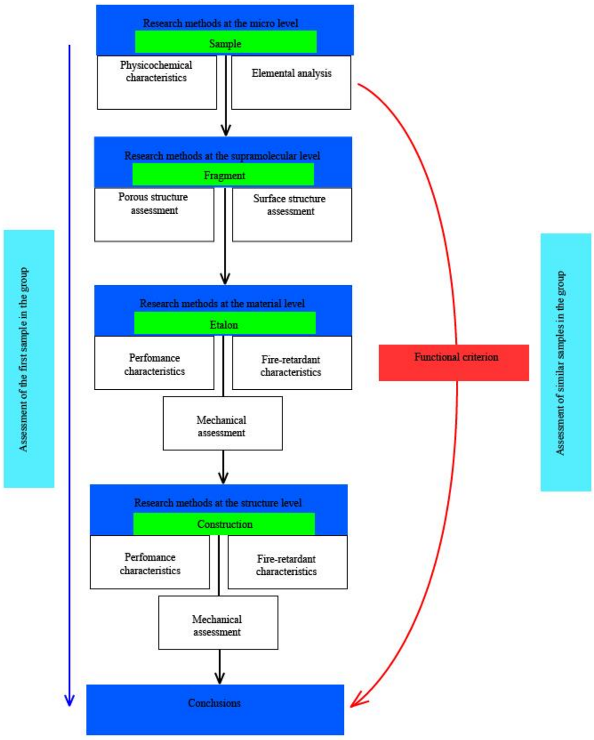

Figure 1. Study compatibility chart

An example is the study of wood fire danger. A number of papers provide examples of research into the various factors that influence these characteristics. In most cases, a wide range of methods are used, which fits into the proposed compatibility chart. At the same time, several types of elemental analysis, thermal research methods and methods for determining fire hazard characteristics can be used, as well as detailed structural analysis for a large list of similar properties of samples. It should be taken into account that such groups of samples may have a similar functional criterion (e.g., functional chemical link), the change of which in different samples can lead to a change in performance. Therefore, in such cases, one micro-level method of research, such as X-ray analysis, can be selected to predict performance characteristics that relate to the level of the structure.

IV. CONCLUSIONS

For the first time, an algorithm for generalizing empirical data on the mechanochemical characteristics of materials using interdisciplinary methods in the form of a compatibility diagram has been proposed;

A practical example of how to use a compatibility chart is shown.

This methodology optimizes research for any composite materials, preserving targeted research methods and eliminating impractical and related experimental studies with reduced labor costs and, as a result, environmental impact

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