Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 150 (2016) 1643 – 1647

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2016

Problems of Residential Building Ensuring Safe Operation with Wall Panels Made of the Autoclaved Aerated Concrete

V. Salnikov[a], V. Belyakov[a,]*, V. Veselov[b]

[a] *Ural Federal University named after the 1st President of Russia B.N.Yeltsin, 19 Mira Street, Yekaterinburg 620002, Russia*
[b] *Institute of Construction Design Limited Liability Company, Tcheluskincev str, 2/5 of. 51, Yekaterinburg 620014, Russia*

Abstract

The article 'Problems of Residential Building Ensuring Safe Operation with Wall Panels Made of the Autoclaved Aerated Concrete' presents research methods for the estimation of the wear degree for lightweight aggregate concrete panels.

Peer-review under responsibility of the organizing committee of ICIE 2016

Keywords: cellular concrete panel; emergency state; moisture; wear; concrete repair; engineering safety

1. Introduce

In present-day periodical press there appear more and more articles about accidents, the collapse of bearing structures of dilapidated houses from the housing stock, of medical, sports and entertainment constructions crashing because of insufficient bearing capacity and a lack of reliable criteria for wear estimation after long-term use and the impact of extreme natural phenomena.

Physical wear of constructive elements of a house, as well as the necessity of their scheduled removal due to emergency state, is defined in accordance with IBC (Industry Building Code) 53-86(p) 'Rules for estimation of residential building wear' [1]. However, such characteristics for external cellular concrete walls are not included into either the Methods of estimation and certification of engineering safety for buildings and structures, provided by the Russian Ministry of Emergency Measures, or into IBC 53-86(p).

* Corresponding author. Tel.: +7-922-228-3482; fax: +7-343-247-1133.
E-mail address: belyakow@inpad.ru

Peer-review under responsibility of the organizing committee of ICIE 2016
doi:10.1016/j.proeng.2016.07.145

Meanwhile, buildings with such walls constitute a considerable part of the housing stock in the Ural region. That is why the absence of methods for defining the characteristics of physical wear of gas-ash concrete walls, as well as the terms for their scheduled repair, can significantly influence the scope and the efficacy of capital investment into repair and reconstruction works for these buildings [2, 3]. This is applicable to the cases of underestimation and unjustified overestimation of the wear degree of constructions. Besides, the degree of physical wear of external wall panels influences the choice of heat insulation scheme and the calculation of the rational value of heat insulation costs.

With no reliable methods for estimating the state of such constructive elements made of lightweight concrete, there is a risk of accidental destruction of wall constructions, which, in turn, endangers the lives and the safety of people who live in these buildings.

2. Research methods

Ural Federal University named the 1st President of Russia B.N. Yeltsin in tandem with the workers of FSI All-Russian Scientific Research Institute of Civil Defense and Emergency Measures have conducted research of the indicators for physical wear of cellular concrete sheet walls, which will provide the basis for defining the duration of their active use till the moment of scheduled repair and their stability under conditions of anomalous natural disasters and fires.

The authors of the paper have analyzed the possibility of applying the indicators, used in IBC 53-86 (p) [1], to cellular concrete panels. The indicators given in IBC define the degree of physical wear and emergency state as such.

The character of wall destruction of large-panel residential buildings of old construction type is shown on Fig. 1.

Fig. 1. The destruction of concrete wall panel, of the linking with façade surface finish, and the disruption of waterproofing joint between the wall panels of a residential building

The specifics of the construction of cellular concrete panels are the obligatory façade surface finish, with standardized indicators of waterproofing properties.

The indicators of panel wall wear, specified in IBC, are not immediately connected with the level of waterproofing of the surface finish. At the same time, IBC does not include a number of indicators, a change in which characterizes the actual wear of panels, and the most important qualities of cellular concrete, namely, solidity and thermal physic indicators. These depend on concrete moisture, which should be normative throughout the term of use. As will be seen below, these indicators cannot be directly used to define the degree of physical wear of cellular concrete panels.

In view of the complexity of the problem of developing norms to define the main factors of engineering safety for cellular concrete wall constructions, which carry the load in use, a long period time is required to work on these normative indicators. Meanwhile, day-to-day issues do not allow postponing the development of a reliable definition of the physical wear and the necessity of cellular concrete panels repair.

On the one hand, underestimating required costs of defect elimination and panel repair works, especially with bigger volumes of large-panel housing to be repaired, can lead to insufficient financing of repair works for residential and public buildings, and ultimately, to failures in implementing the national project 'Affordable housing'.

On the other hand, an unjustified increase in the costs planned to ensure the stability of a bearing constructions can lead to an improper use of budget financing.

The task set in this paper can be realized in the following way.

At the first stage it is necessary to develop temporary indicators; at the second stage, having conducted all necessary research works, we need to set justified normative values for the indicators of physical wear of cellular concrete panel walls.

We believe that the fundamental principle when defining the norms of physical wear of panel walls should be the division of indicators into two groups: the first group should include indicators that describe the façade side of panels, the state of panel joints and the like, whereas the second group should show indicators that define the state of the material, i.e. cellular concrete.

At the first stage, at the very beginning, it is admissible to use the indicators shown in IBC for panel walls to define the indicators of physical wear of façade surface, provided that they will be corrected and laboratory test research results of the durability of façade surface finish for panel walls will be taken into account.

As for wall panels themselves, we cannot apply the wear indicators shown in IBC to make a conclusive decision about the necessity of overhaul; even the full set of these indicators will not show emergency state of the panel. Wear indicators do not show essential qualities of panels, namely, concrete solidity, its thermal indicators, the state of main reinforcement and attachment fittings with specifics of soil in the building base taken into account.

To define the wear degree of the panel and the volume of repair works, we analyzed changes in cellular concrete solidity and its thermal qualities over a period of long-time use. A change in thermal qualities of cellular concrete over a period of time can be calculated through the changes in moisture levels of cellular concrete. The graph (Fig. 2.) shows the data of the changes in moisture levels of cellular concrete in Yekaterinburg according to the research conducted by UrlapromstroiNIIproject and the authors of this paper.

As seen from the graph, the moisture level is kept below the norm over a period of long-term use (up to 45 years).

It is also evident that this indicator cannot be used to estimate physical wear of panels since it stabilizes over a period of long-term use.

3. The results of the work

A change in solidity of cellular concrete is due to the influence of seasonal alternation of freezing and thawing; the amount of influence they exert depends of cellular concrete moisture [4]. According to the data [5], in Yekaterinburg cellular concrete with steady-state moisture has frost resistance for over 100 years' use.

These data were received after many years of continual trials of freezing and thawing on pressurized samples of cellular concrete with different levels of moisture from 3 to 45% of the total mass.

Consequently, this indicator cannot also be used to estimate the wear degree of cellular concrete panels at the first stage [6, 7-16].

Therefore, the only indicator, a change in which can conclusively state the wear degree of the panel, the necessity of its repair and generally, the appropriateness of repair, is the state of reinforcements, that is, the intensity of corrosion (the degree of corrosion damage).

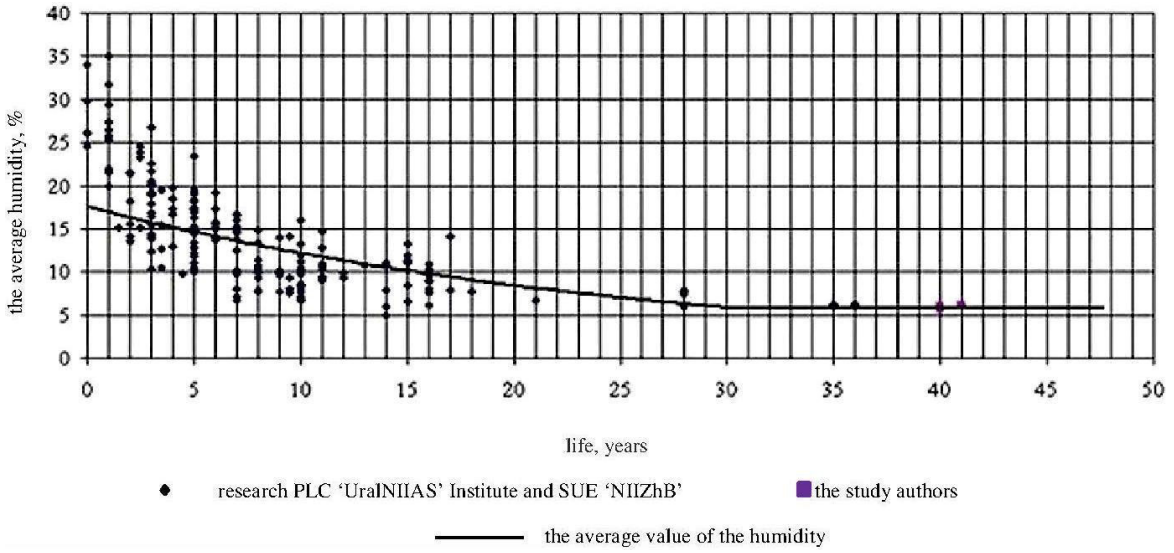

Fig. 2. Changes in moisture levels of cellular concrete

To define the physical wear of cellular concrete panels by the state of steel reinforcement corrosion at the first stage, we can reservedly use the methods for defining the corrosion degree of reinforcements, suggested by SUE 'NIIZhB' and PLC 'UralNIIAS' Institute (when buildings with such panels are being inspected).

Dividing the problem of defining the physical wear of cellular concrete panel walls into two stages will enable timely development of necessary additions to IBC, which will relate to cellular concrete panel walls.

We offer to use the results thus obtained to perfect and develop the norms and regulations of the Methods of monitoring the state of bearing constructions of buildings and structures written out by the Ministry of Emergency Measures of RF [17] and the Methods of estimating and certifying the engineering safety of buildings and structures written out by the Ministry of Emergency Measures of RF [18] for defining the state of building structures made of lightweight energy-efficient concrete.

4. Conclusion

This paper offers the order of defining physical wear indicators, wear degree, and the necessity of cellular concrete panel walls repair that will ensure a justified and reliable estimation of finance required for repair works and consequently, their scheduled completion.

This will give an opportunity to define the feasibility of increasing heat-proofing qualities of panels, and also to prognosticate the term of use for cellular concrete panel walls until their scheduled repair.

A reliable definition of physical wear degree for panel walls will help evade possible conflicts between housing communities and administrative bodies when defining home ownership terms for financing repair works.

We believe that the most dependable method to measure the physical wear of cellular concrete panels is estimating the state of main reinforcement of the panels.

References

[1] IBC 53-86, Rules for estimation of residential building wear, Stroiizdat, Moscow, 1987.
[2] Zh.A. Omarov, Dynamic tests of a dwelling house's fragment with bearing walls from gas-blocks, in: Proceeding of International Conference on Earthquake Engineering Earthquake Engineering in the 21st Century-IZIIS 40 EE-21C, Skopje/Ohrid, Macedonia. (2005) 4–41.
[3] J. Write, G. Fronford, Durability of building materials: durability research in the United Stated and influence of RILEM on durability research, Mater. Et constr. 18 (1985) 205–214.
[4] V.V. Babkov, D.V. Kuznetzov, R.R. Sahibgareyev, P.K. Khalimov, Problems of durability of cellular concrete, Bashkirskii Journal of Chemistry. 2 (2006) 12–14.
[5] E.S. Silayenkov, The durability of cellular concrete products, Stroiizdat, Moscow, 1986.
[6] F.A. Blakey, Some Effects of carbon dioxide on mortars and concretes, ACJ Journal. 28 (1956) 3.
[7] K.M. Alexander, Possible mechanism for carbo- nation shrinkage and grazing, based on the study of thin layers of hydrated cement, Australian Journal of Applied Science. 4 (1959).
[8] T.S. Powers, A Hypothesis on carbonation shrinkage, Journal of Portland Cement Association, Research Development Laboratory. 2 (1962).
[9] W. Kinni, Comparison of drying shrinkage of autoclave and air cured concrete at different humidities, in: Lightweight Concrete, R1LEM, Goteborg, 1961.
[10] M. Venuat, Garbonation of Beton, Review of Materials. 639 (1968).
[11] J. Alexandre, Influence of carbonation on the reversibility of the withdrawal, Review of Materials. 685 (1973).
[12] W. Manns, Q. Schatz, Via the effect on strength of Zcmentmorteln by Carbonatisation, Concrete Stone newspaper. 4 (1967).
[13] Z. Sauman, Carbonation of porous concrete and its main binding components, Cement and Concrete Research. 6 (1971).
[14] H.H. Stenour, Some Effects of Carbon Dioxide on Mortar and Concrete, Discussion AC1 Journal. 8 (1959).
[15] S.L. Mevers, Effects of carbon dioxide on hydrated cement and concrete, Rock Products. 1 (1949).
[16] J. Alexandre, Influence of carbonation on the compressive creep in concrete, Building Materials Journal. 684 (1973).
[17] Methods of monitoring the state of bearing constructions of buildings and structures, FSI All-Russian Scientific Research Institute of Civil Defense and Emergency Measures, Moscow, 2008.
[18] Methods of estimation and certification of engineering safety for buildings and structures of the Russian Ministry of Emergency Measures, FSI All-Russian Scientific Research Institute of Civil Defense and Emergency Measures, Moscow, 2003.