Evaluation of Stress State of Tile Adhesive Based on the Developed Dry Construction Mixture

Valentina Ivanovna Loganina¹, Olga Victorovna Karpova¹, Maksim Vasilevich Ariskin², Kristina Vladimirovna Zhegera¹

1. Department of ‘Quality management and technology of building production’
   ‘Penza state university of architecture and constriction’
   Russia, Penza, 440028, Street Titov, 28

2. Department of ‘Building construction’
   ‘Penza state university of architecture and constriction’
   Russia, Penza, 440028, Street Titov, 28

E-mail: loganin@mail.ru, jegera@yandex.ru, m.v.ariskin@mail.ru

Abstract: The article contains the calculation of the temperature distribution over the cross section of frame structures, the review of the state of stress of the adhesive layer, depending on thermal stresses arising in the walling for city Penza. It also contains the values of maximum tensile and compressive stresses along spread and thickness of the adhesive layer. It is found out that the adhesive layer with the use of synthesized aluminosilicates in its formulation is resistant to fracture and exfoliation.

Keywords: dry building mixes; modifying additives; synthesized aluminosilicates; cement based dry adhesive mixture.

1. Introduction

To regulate the structure and properties of dry building mixes, modifying additives are added in their composition [1 – 4]. Previous studies have shown the efficacy of the use of synthesized aluminosilicates in the lime and cement dry building mixes as a modifying additive [5 – 6].

The formulation of dry adhesive mixture based on cement is developed, which can be used as tile adhesive for coating of facades and interior walls of buildings with ceramic tiles. The formulation of dry adhesive mixes includes Portland cement M400, mineral aggregate with fraction ratio of 0,63-0,315:0,315-0,14 respectively 80:20 (%) and apparent density of 1538.2 kg/m³, plasticizer Kratas ol, redispersible powder Neolith P 4400 and synthesized aluminosilicates.

2 Experimental study

In the course of further studies, we evaluated the state of stress of the adhesive layer from the effects of temperature as a factor of destruction to assess the possibility of use of the developed tile adhesive in different climatic regions.

With that end in view, thermal technical calculation of the filler structure was carried out; its structural concept is shown in Fig. 1. The calculations were performed for the city Penza, located in the climatic region II B and humidity zone 3 (dry) [7 – 9].

As the wall material of the filler structure we used ceramsite concrete with a density of $\rho = 1600$ kg/m³ and a thermal conductivity coefficient of $\lambda = 0,58$ W/(m·°C), as an insulating material – foam polystyrene with a density of $\rho = 40$kg/m² and a thermal conductivity coefficient of $\lambda = 0.038$ W/(m·°C). Ceramic tile with a density of $\rho = 2600$ kg/m² and thermal conductivity $\lambda = 1,2$W/(m·°C) was used. The tile adhesive under study has a thermal conductivity coefficient $\lambda = 0,58$ W/(m·°C).

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The temperature distribution over the filler structure section was calculated. Taking into account the received temperature value thermal stresses arising in the adhesive layer with the thickness of 5 mm were calculated.

The calculation was carried out for the length of the adhesive layer (of tile adhesive) 102 mm. The design scheme is presented in Fig. 2. Calculations were performed using a universal program system of finite-element analysis Mechanical APDL (ANSYS).
3. Results and discussions

Figure 3 shows the values of tensile stresses along the spread of the adhesive layer - $\sigma_x$ (a) and the thickness of the adhesive layer - $\sigma_z$ (b) during one year for the city of Penza.

It was found out that the maximum tensile stresses on the axis X (Fig.3, a) occur in the contact area of the adhesive layer with ceramsite concrete and in the contact zone of the adhesive layer with ceramic tile in March and are equal to $\sigma_x = 1.68$ MPa and $\sigma_x = 1.24$ MPa respectively.

Along the axis Z (Fig. 3, b) an adhesive layer maximum tensile and compressive stresses arise. Maximum tensile stresses occur in the center of the adhesive layer and in the marginal zone of the adhesive layer in September, and are equal to $\sigma_z = 0.02$ MPa and $\sigma_z = 0.24$ MPa respectively. Maximum compressive stress in the marginal contact zone of the adhesive layer thickness occurs in March and equals $\sigma_z = -0.49$ MPa on the border with ceramic tiles.
Figure 3 The change in stresses $\sigma_x$ (a) and $\sigma_z$ (b) in the adhesive layer during one year (Penza): 1 - on the border with ceramsite concrete (line OA Fig. 2.); 2 - on the border with ceramic tiles (line CB, Fig. 2.); 3 - the center of the adhesive layer (line OC, Fig. 2); 4 - the marginal zone of the adhesive layer (line AB, Fig. 2)

Analysis of the data presented in Figure 4 shows that maximum shearing stresses in the adhesive layer on the border with ceramsite concrete are observed in February and are equal to $\sigma_{xz} = 0.11$ MPa, and in September on the border with ceramic tiles - $\sigma_{xz} = 0.29$ MPa.

Figure 4 The change in shearing stresses $\sigma_{xz}$ in the adhesive layer during one year in Penza: a - on the border with ceramsite concrete (Fig. 2, line OA); b - on the border with ceramic tiles (Fig. 2, line CB)

As can be seen from the data presented in Figure 5, maximum shearing stresses occur in the marginal zone (Fig. 2, line AB) in September and are equal to $\sigma_{xz} = 0.29$ MPa, and in the center of the adhesive joint (Fig. 2, line OC) they are observed in March and are equal to $\sigma_{xz} = 0.00039$ MPa.

Figure 5 The change in shearing stresses $\sigma_{xz}$ in the adhesive layer during one year in Penza: a - marginal zone (Fig. 2, line AB); b - the center of the adhesive layer (Fig. 2, line OC)
4. Conclusions

The maximum stress values obtained were compared with the values of cohesion and adhesion resistance of cement based tile adhesives which are equal to $\tau_{cog} = 2.2$ MPa and $\tau_{adg} = 1.2$ MPa respectively.

The presented results of the calculations allow to suggest that the adhesive layer with the use of synthesized alumosilicates in its formulation is resistant to fracture and exfoliation.

5. References


