Solar Active Plaster for the Renovation of Existing Buildings

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INTRODUCTION

Semitransparent insulation systems (solar active plasters) could offer a high advantage compared to conventional insulation materials. Hollow glass spheres placed in a host medium are studied within a feasibility analysis for future use at the renovation of existing buildings. Application rules for the simulation have been gathered by [1] and the study is partly based on the findings of [2]. The simulation model is created with a model method in the Application Builder Tool.

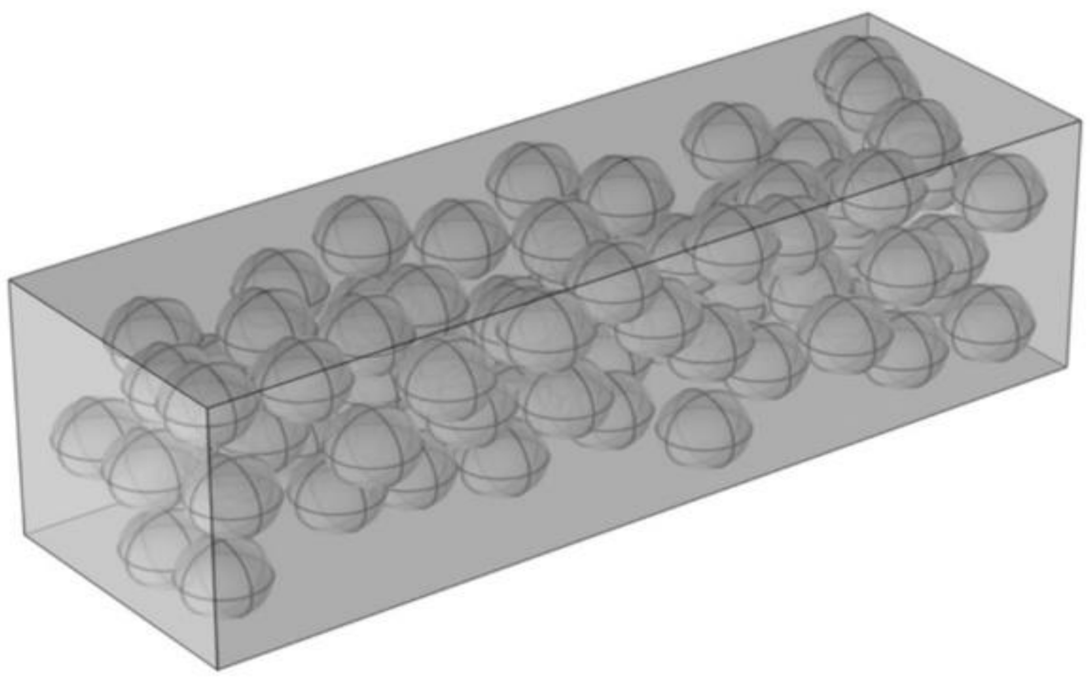

Figure 1. Simulation model of the hollow spheres randomly distributed within the plaster block without collision effects

COMPUTATIONAL METHODS

For the simulation, the raytracing method (Ray Optics Module) is used to determine how much of the initial rays can stride through the semitransparent domain. Most important for the physical description (reflection and refraction) are the Fresnel Equations and the attenuation of rays in the domain (see Eq. 1, 2 & 3).

$$r_s = \frac{n_1 \cos(\Theta_i) - n_2 \cos(\Theta_t)}{n_1 \cos(\Theta_i) + n_2 \cos(\Theta_t)} \quad (1)$$

$$r_p = \frac{n_2 \cos(\Theta_i) - n_1 \cos(\Theta_t)}{n_2 \cos(\Theta_i) + n_1 \cos(\Theta_t)} \quad (2)$$

$$I = I_0 e^{\left(-\frac{2k_0KL}{N}\cos\propto\right)} \quad (3)$$

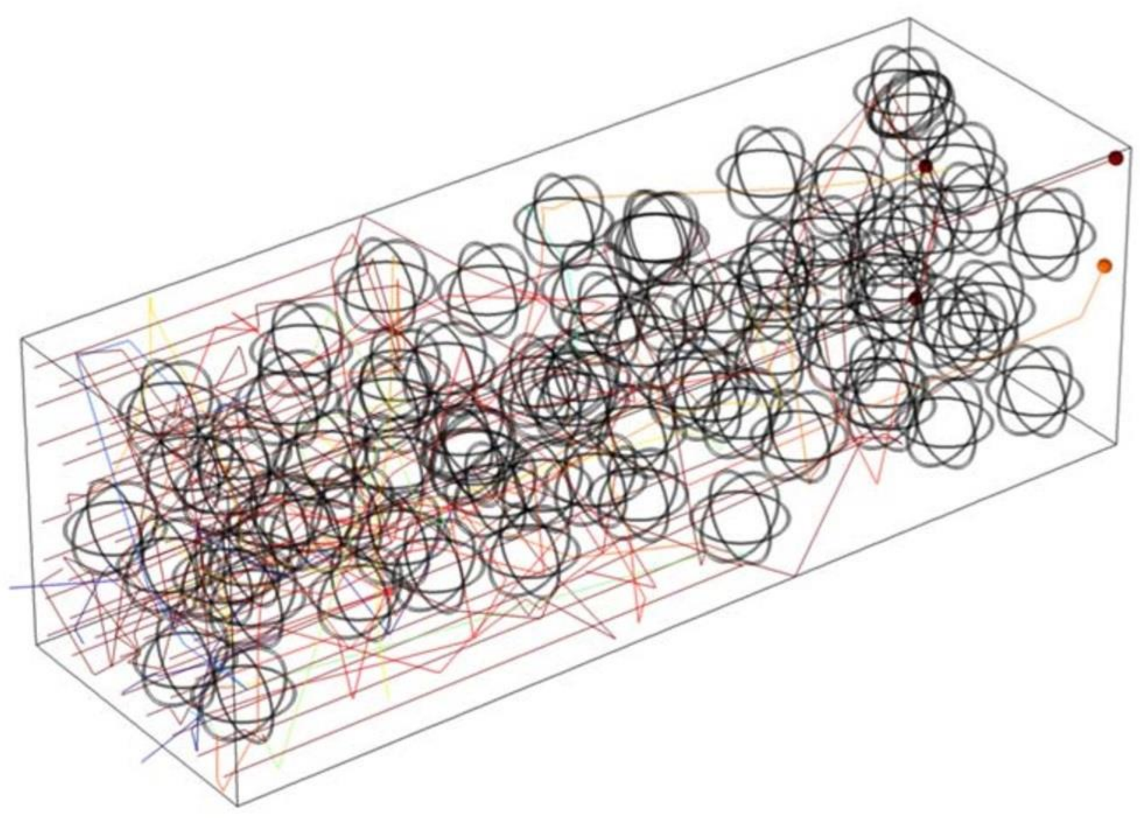

Figure 2. Exemplary path of rays through the generated domain

RESULTS

Theoretical considerations show the needs for the design of a solar active plaster. The observations in the following figures include various examined parameters. The studied factors for the hollow glass spheres are related to the number of boundary layers the rays have to stride in the domain. A fewer number of boundary layers results in a higher degree of light transmission.

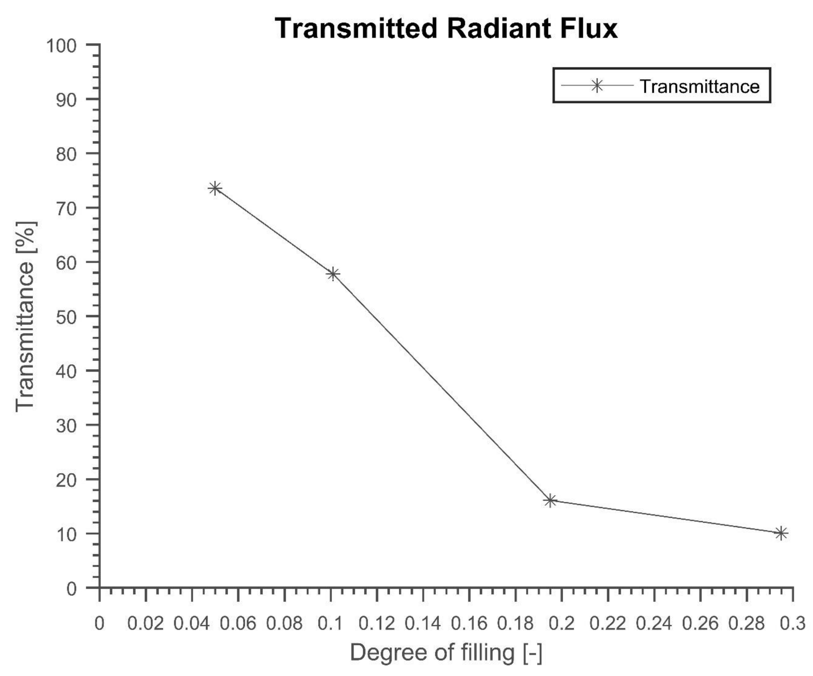

Figure 3. Influence of the degree of filling

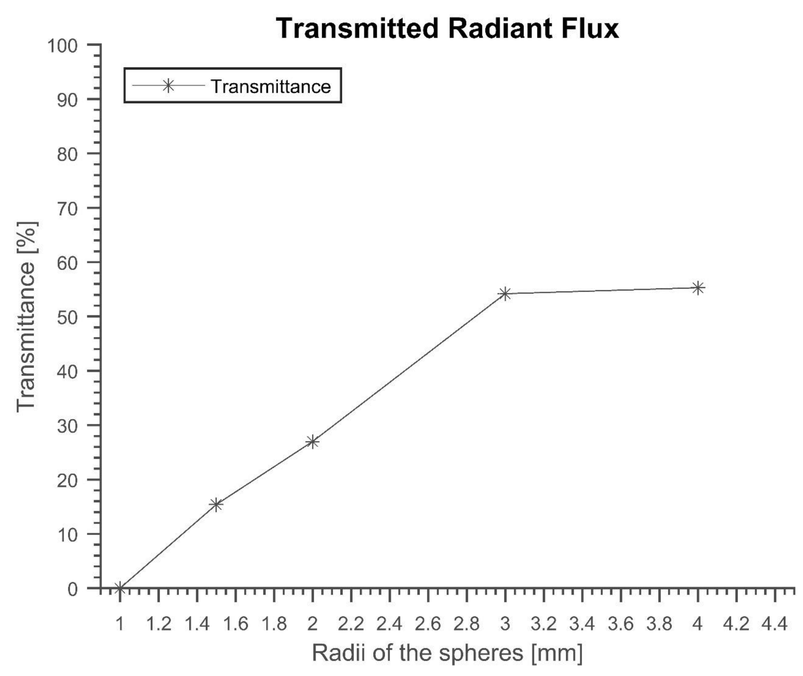

Figure 4. Influence of the sphere radius

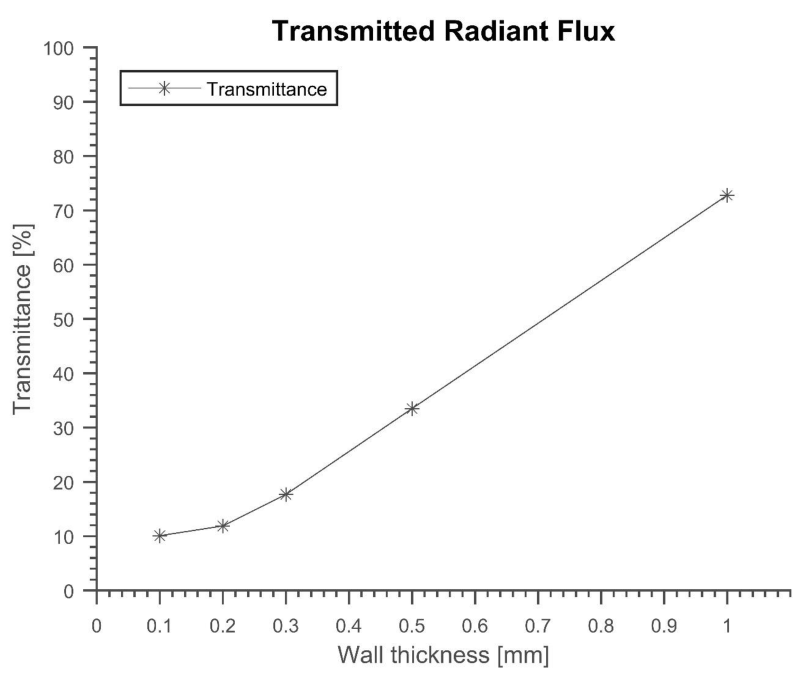

Figure 5. Influence of the sphere's wall thickness

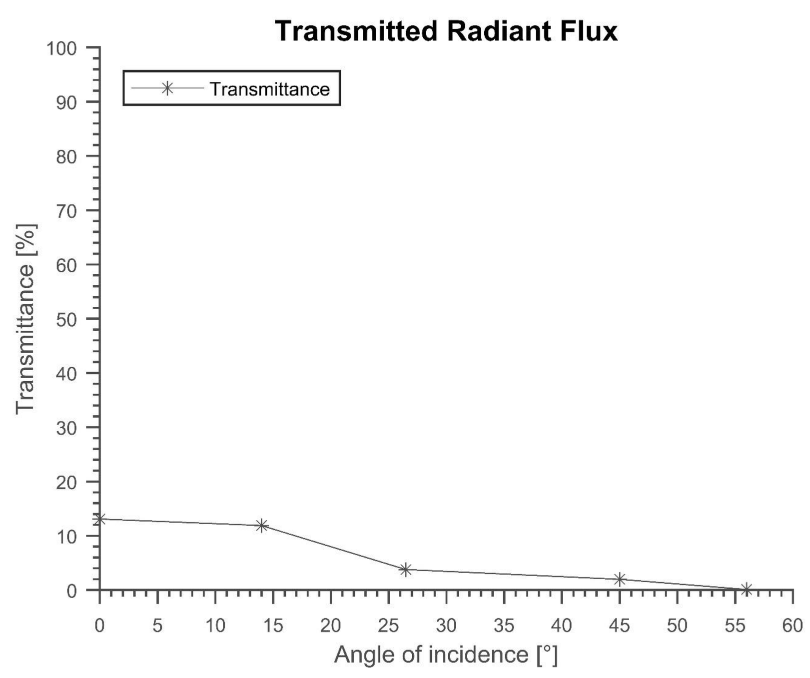

Figure 6. Influence of the rays incident angle

CONCLUSIONS

In theory, the findings indicate, that a semitransparent solar active plaster, can transmit pertinent amounts of solar radiation under the given restrictions. The observations show two main problems:

- Binder materials used by the plaster industry don't fulfil the requirements of the low extinction coefficient
- Hollow spheres of the size in the mm-range bring mechanical problems and might have to be substituted with non-hollow spheres.

REFERENCES

1. J. Randrianalisoa, D. Baillis, Radiative properties of densely packed spheres in semitransparent media: A new geometric optics approach, Journal of Quantitative Spectroscopy & Radiative Transfer, Vol. 111, p. 1372-1388, 2010.
2. T. Naganuma, Y. Kagawa, Effect of particle size on light transmittance of glass particles dispersed epoxy matrix optical composites, Acta Mater, Vol. 47, No. 17, pp. 4321-4327, 1999.

Acknowledgements

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