Aerogel thermal insulation – One of the first applications in Czech Republic

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Architecture and research studio Space Innovations (SPIN), founded by the Czech architect Ondrej Doule, insulated family villa house constructed in 1921 using aerogel thermal insulation. Aerogel is mostly used in space sector for scientific research and for thermal insulation of space suits. The goal of the SPIN research studio supported with this experiment is to inform and to enable technology transfer and utilization of advanced technologies and materials from space sector in terrestrial architecture.

The choice of the aerogel thermal insulation for reconstruction of the villa from 1921 had a strong rationale. “Thermal insulation thicker than 1 cm would negatively affect the original architecture of the facade, especially its details. Application of regular polystyrene or mineral insulation would build up additional volume on the building facade, making it impossible to preserve and reconstruct the architectural details. Unlike these regular materials, aerogel insulation with its fractional...”
thickness allows application of traditional hand cast render techniques preserving the original look of the villa from 1921”, explains Ondrej Doule.

One of the main benefits of the aerogel insulation is its significantly lower thermal conductivity in comparison to traditional insulation materials. The insulation used on the 1921 villa is only 1 cm thick (see Figure 1) and its application therefore does not mean destructive action for the building architecture. The insulation was „inserted“ under the core layer of the render without altering the building appearance.

Aerogel material of similar type is used in astronaut space suits that have to meet strict criteria for thermal insulation performance and flexibility. The aerogel originally used and optimized for space sector finds vast applications in terrestrial architecture and in the near future also in other industrial branches (textile or car industry).

The only drawback of the aerogel insulation, especially when used on family houses, is its high price. The cost of aerogel is multiple times higher than price of traditional thermal insulations. However, investment in aerogel can be easily justified in the project where architecturally significant buildings need to be insulated. The utilization of aerogel improves also fire protection of the building while enabling „breathing“ of the building and transfer of humidity from the structure outwards (Figure 3). Aerogel is very suitable also for curved shapes (such as spiral staircases, vaults) and structures from any materials (brick, wood, steel, stone structures).

**Parameters of aerogel according to producer:**

- Thickness: 10 mm
- Width (on roll): 1 475 mm
- Thermal conductivity (EN 12667, 10°C): 14 mW/m-K
- Fire resistance (ASTM E84): Class A

![Figure 2 – Manipulation with aerogel thermal insulation is very easy. It’s light, tough and easy to cut in any shape with strong paper cutter.](image-url)
Figure 3 – Wall insulated with aerogel (left) with casting metal mesh attached (electrical infrastructure area sprayed on the aerogel to prevent infrastructure damage). The wall on the right is repaired flattened, with penetration paint and glue applied; it is ready for the aerogel blanket to be attached to it.

Figure 4 – The reconstructed facade completely coated in aerogel (including window details) and casting metal mesh. Infrastructure is highlighted with spray paint on the aerogel before it is anchored to the wall to avoid infrastructure damage. Facade is ready for the mortar spraying.
Figure 5 – Profile - Aerogel „in section“, metal mesh and two mortar layers applied on an original brick wall with repaired render. Aerogel with metal mesh are attached with 15cm plastic nail and with glue (almost final stucco layer of the original facade without thermal insulation on the right).

Workflow during aerogel insulation process – experimentally verified by the architecture and research studio SPIN:

1. **Manipulation and protective gear:** Although the aerogel is not dangerous to health, it is recommended to wear gloves and respirators during manipulation (Figure 2). After unpacking of the aerogel insulation role (Figure 6) there is very fine particles dust released which is very adhesive. Material is very tough and easy to manipulate with (aerogel insulation is a composite of aerogel and textile fibers).

Figure 6 – Improvised system for aerogel unwinding (80m2 is equivalent approximately 150kg).

2. **Measuring and cutting:** The aerogel is attached to the brick walls mechanically and chemically. Aerogel is distributed in roles (Figure 6), it’s therefore necessary to cut the material in pieces according to requirements for manipulation, anchoring and dimensioning of the construction (façade). One centimeter thick aerogel can be easily cut with a sharp paper cutter (cutting on hard pad / wood board) or with a small rotary saw. Both techniques were tested and found suitable. Cutting with a cutter requires more force but it can be done in any condition (on the ground, on a table, or while placed on the wall). Cutting with a rotary saw is very easy but requires special working board with space below the cutting edge.

3. **Preparation of the insulation base (old wall):** Surface of the repaired wall (using basic render or cement to fill holes and create uniform flat surface) is impregnated with a wall penetration solution to improve adhesive properties of the wall surface and to remove dust particles.
4. **Gluing:** The glue (during this reconstruction we very effectively used water based glue for mineral wallpaper) is applied on the clean surface of the wall and on one side of the aerogel insulation (using a paintbrush). The insulation is immediately attached to the wall and fixed in the right position with two plastic nails.

5. **Anchoring:** Aerogel blanket is coated with metal mesh for mortar spraying. It is important to be very careful with infrastructure in the old buildings and avoid any wiring and pipes that could run in the walls. It is convenient to mark the infrastructure routing on the aerogel with a color spray before the holes for plastic nails (anchors) are drilled. A regular gardening metal Zinc mesh (2cm hexagon) was used during this construction (lower price and good properties for straining over details and irregularities). The mesh was anchored by 6 nails per 1 m² according to aerogel producer recommendations.

6. **Mortar spray:** Anchored insulation with metal strained mesh is ready for mortar spray. Mortar spray is applied by manual mill and 3-5 thin layers create excellent base for manual mortar casting and final stucco details (Figure 7 right).

![Figure 7 – The facade covered with aerogel and highlighted infrastructure (left) – the facade with mortar sprayed over aerogel with metal mesh (4 thin layers) (right).](image)

Final manual mortar casting and creation of the stucco details is not part of this project phase. The entire reconstruction including windows replacement (by windows provider) was performed as a DIY (do-it-yourself) project without hiring an expert or a construction company. Experts were invited only for insulation of electrical wires (Figure 7 - top) and for scaffolding construction for a few hours. Reconstruction of the facade and application of the aerogel insulation on area of approximately 70 m² (including 5 windows) took approximately 10 days of nonstop works with help of 5 volunteers (in total approx 240 man-hours, not including de-construction of the scaffolding and final facade hand casting and stucco details).

Mortar hand casting and stucco details sculpting, which were carefully recorded before the facade cleaning, will be performed in the next months.

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