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Lightweight Thermal Insulation Materials Promoting Inclusivity in Construction Workforce

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Two transitions, one opportunity

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1

Material transition

Climate commitments, circular-economy principles and the need to cut embodied energy and carbon are reshaping construction materials.

2

Workforce challenge

Women and workers of varying physical capabilities remain significantly underrepresented, particularly in site-based roles.

3

The gap

Thermal and environmental benefits of lightweight insulation are well documented. Their implications for the physical demands of work, and for accessibility, are not.

Approach: literature review plus analytical mapping

1 Narrative literature review

- Two research questions: how lightweight materials support ergonomic solutions for diverse worker needs, and how lightweight insulation can promote inclusivity in training programmes
- Sources found with ScienceDirect's AI-assisted discovery tool (now LeapSpace)
- Not a formal systematic review; results are synthesised in two tables

2 Analytical framework

- Maps density, weight per unit, installation technique and equipment needs of four SNUG materials (from project documentation)
- Two dimensions: physical barriers and skills transition
- No statistical meta-analysis and no empirical field data

Four SNUG materials, viewed through a workforce lens

Results

The four SNUG material innovations

Aerated eco-concrete blocks

420–441 kg/m³

λ 0.111–0.119 W/(m·K); slag-based binder replaces Portland cement

Self-levelling PCM mortars

Phase change materials

Thermal energy storage; high fluidity spreads autonomously

Aerogel-based solutions

Up to 99.8 % air

Blown-in recycled aerogel waste and aerogel-enhanced lime plasters

Bio-based hemp panels

190–300 kg/m³ (lab)

λ below 0.055 W/(m·K); hemp fibres bonded with tannin-based adhesive

Lightweight materials and ergonomics

Ergonomic aspect	Lightweight material contribution	Citations
Reduced physical strain	Easier handling, transport and installation	[1–5]
Adaptability	Modular/prefab systems; suitable for diverse worker profiles	[1, 3, 6, 7]
Enhanced safety	Lower injury risk; supports ergonomic equipment use	[1, 3, 6, 8, 9]
Integration with technology	Enables lightweight ergonomic monitoring systems	[10–13]
Customisation and sustainability	Local/recycled materials; ergonomic product design	[1, 6, 9]

Lower dead load reduces repetitive lifting, carrying and assembly strain, and the risk of work-related musculoskeletal disorders.

Key features promoting inclusivity in training

1

Reduced material weight

Easier handling and installation for diverse trainees

2

Recycled/waste inputs

Training in sustainable, innovative practices

3

Improved workability

Accessible for trainees with varying skill levels

4

Prefabrication potential

Less reliance on heavy equipment, broader participation

5

Cost savings

More accessible training due to lower project costs

6

Strength–insulation balance

Basis for a standardised, inclusive curriculum

Aerated eco-concrete blocks: 24 kg to 6.9 kg

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Conventional block

≈ 24 kg

200 × 200 × 400 mm at 1500 kg/m³

→

SNUG block

≈ 6.9 kg

Same size at 430 kg/m³

≈ 71 % lighter

Derived from the paper's block weights

- Portland cement fully replaced by slag activated with lime and calcium carbide slag
- Compressive strength comparable to conventional autoclaved aerated concrete; thermal conductivity 0.111–0.119 W/(m·K)
- Plausible pathway: lighter units lower cumulative load in masonry, particularly in high-rise work. Empirical workplace studies are still needed.

Self-levelling PCM mortars: from trowelling to timing

Less emphasis

Sustained physical trowelling

A repetitive motion linked to musculoskeletal disorders

→

More emphasis

Proper mixing, temperature control and timing

Understanding phase-change temperatures and thermal behaviour

- Workability similar to or better than commercial references, with positive feedback from installers at the Norway demonstration site
- Floor installation still involves material transport and awkward postures; a comparative ergonomic assessment is needed to know whether the balance really shifts

Aerogel solutions: equipment and technique over lifting

Blown-in insulation

Recycled aerogel waste (Agitherm) or construction and demolition waste. Demands shift from lifting and fitting to equipment operation, hose management and quality control.

Aerogel-enhanced lime plasters

CDW-based aerogel granules give comparable thermal performance. Application technique matters more than handling strength within the lime plastering trade.

- Aerogel is exceptionally light, but equipment and hose systems still need physical handling
- Whether this changes who does the work depends on how companies structure and allocate tasks

Bio-based hemp panels: large format, light for their size

30–42 kg

Large-format panel, 18 × 1830 × 3660 mm (250–350 kg/m³)

≈ 15 kg

Lab-scale panel, 1000 × 1000 × 50 mm at 300 kg/m³

< 0.055

Thermal conductivity, W/(m·K)

- Industrial production at 250–350 kg/m³; laboratory panels reach 190–300 kg/m³
- Large format reduces joints, mechanical fasteners and installation time per m²
- Installation (cutting to fit, mechanical or adhesive attachment, render finishing) emphasises precision over heavy lifting
- Light weight is particularly advantageous at height or in confined spaces

Across materials: from strength toward know-how

Material	Main shift in demands	Remaining physical demand
Eco-concrete blocks	Lower unit weight (≈ 6.9 kg vs ≈ 24 kg)	Repetitive masonry handling
PCM mortars	Trowelling → mixing, temperature control, timing	Material transport, awkward postures
Aerogel solutions	Lifting and fitting → equipment operation, quality control	Equipment and hose handling
Hemp panels	Fewer joints; precision cutting and fixing	Handling large-format panels

SNUG materials collectively shift installation emphasis from physical strength toward technical knowledge, precision and equipment operation.

Discussion: two potential pathways

1 Physical barriers

- Lower unit weight could lower barriers for workers with less upper-body strength, if other demands do not rise
- Assumes strength is a genuine barrier; research shows it interacts with equipment, ergonomics, training and social expectations
- Capability varies more within genders than between them

2 Skills transition

- Technical demands: PCM temperatures, rapid setting, blown-in equipment, aerogel granulates, bio-based moisture limits
- May attract different candidate pools
- Depends on adapted training, employer hiring practice and whether such training is truly more accessible

Limitations: handle claims with care

Theoretical only

No workforce composition data, ergonomic assessments or training outcome studies exist yet for SNUG materials.

Bigger barriers elsewhere

Harassment, discrimination, lack of mentorship and pay inequity are frequently cited as more significant than physical demands.

Stereotype risk

Emphasising gender differences in physical capability can reinforce stereotypes.

System dependence

New materials may create new barriers; outcomes rest on hiring, training, union policy, culture and policy interventions.

Conclusions

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1

Logical connection

Lighter blocks, large-format panels, equipment-oriented aerogel applications and self-levelling mortars could lower physical barriers while advancing environmental goals.

2

Premature claim

Saying these materials effectively support gender inclusion would be premature without empirical research on workforce composition, ergonomic demands and training outcomes.

3

Genuine opportunity

The transition to sustainable construction can intentionally integrate social and environmental goals.



Thank you

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