Lightweight and Fire Resistant Foam Concrete Blocks

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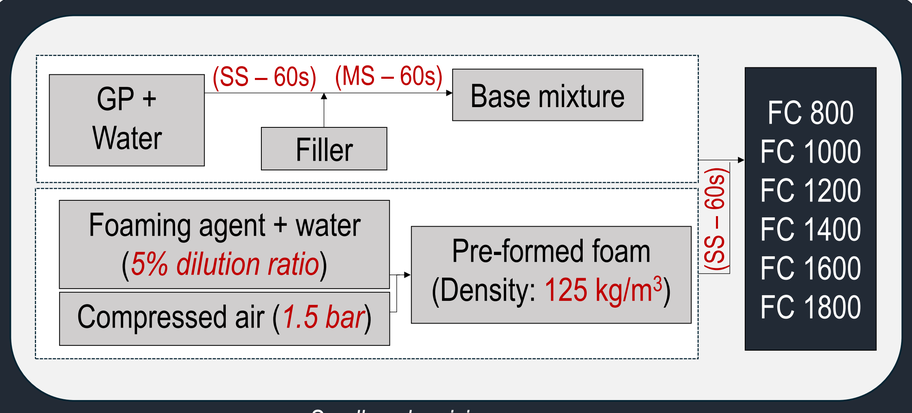
Background

Walls behave as excellent building element for minimizing fire spread in buildings.

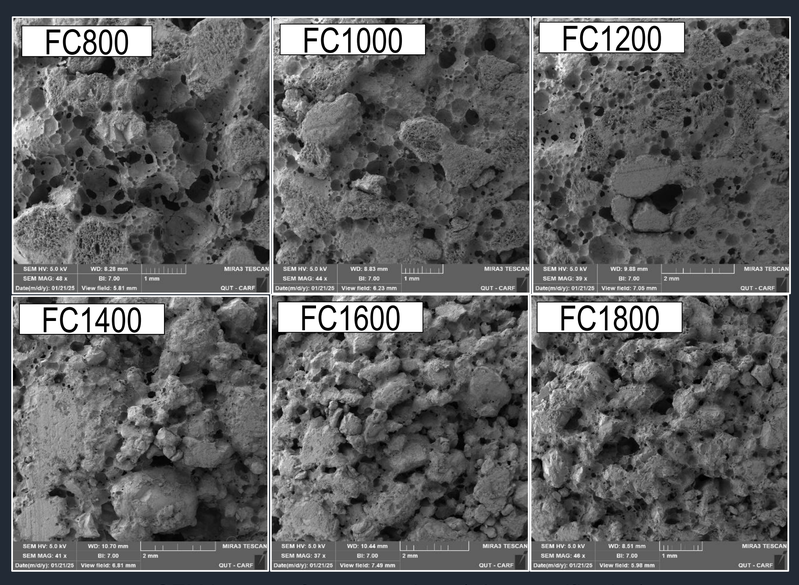
I. ***LSF walls*** - rapid lose of mechanical properties of CFS at elevated temperatures (*require proper external protection*)
II. ***Masonry walls*** - cracking severity, integrity failure, spalling and structural collapse are the key issues (*necessitate proper alternative fire resistance material*)

Aiming for ***lightweight components*** made of ***foam concrete (FC)*** *for walls intended for structural and non-structural characteristics* with ***fire resistance***

Material-level mixture preparation

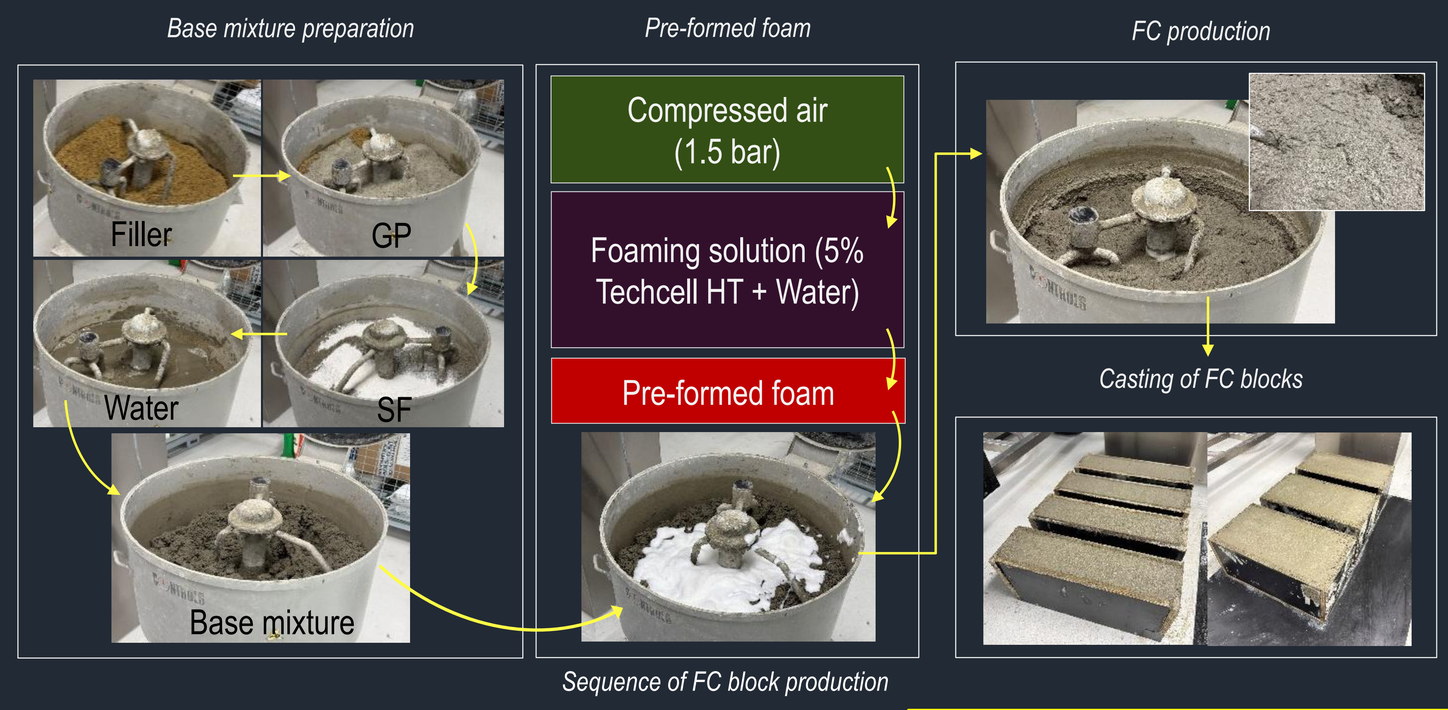


Small-scale mixing sequence

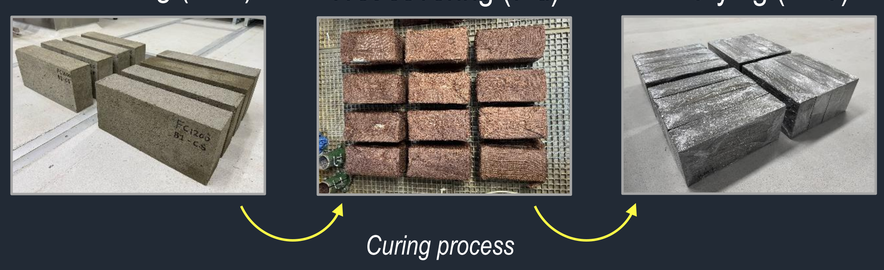


SEM images of cross-sections (50x magnification)

Component-level (block) preparation



Sequence of FC block production



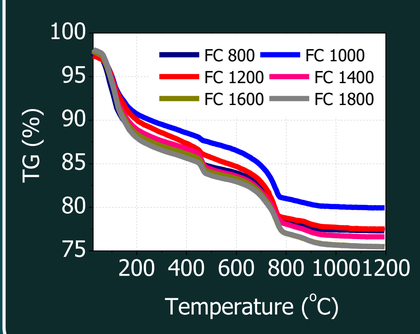
Curing process

Blocks' dimensions:

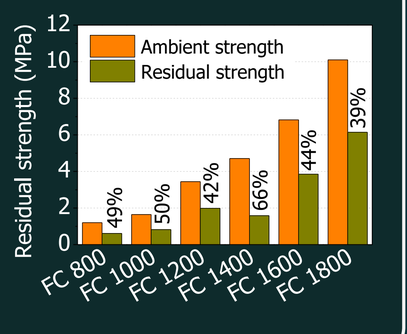
a. Type I: 390 mm (L) × 190 mm (H) with 90 mm thickness (T90)
b. Type II: 390 mm (L) × 190 mm (H) with 140 mm thickness (T140)
c. Type III: 390 mm (L) × 190 mm (H) with 190 mm thickness (T190)

Elevated-temperature thermal properties

Thermal mass



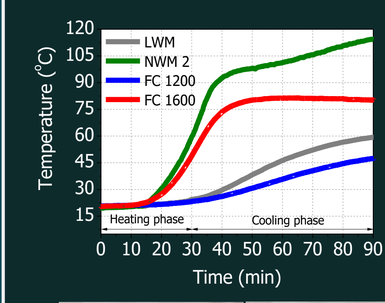
Residual strength after fire exposure



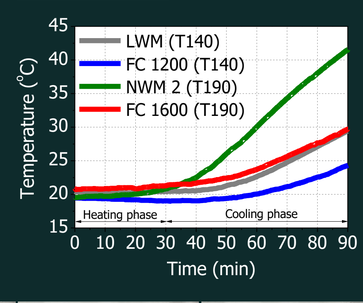
Bushfire (BAL-FZ) resistance

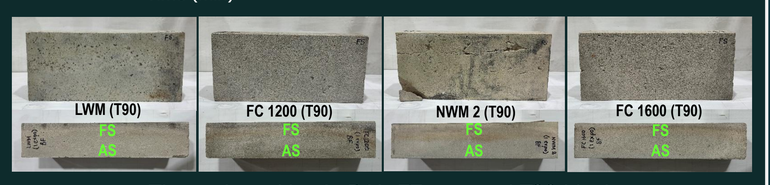
AS surface time-temperature profiles

T90 blocks



T140 & T190 blocks



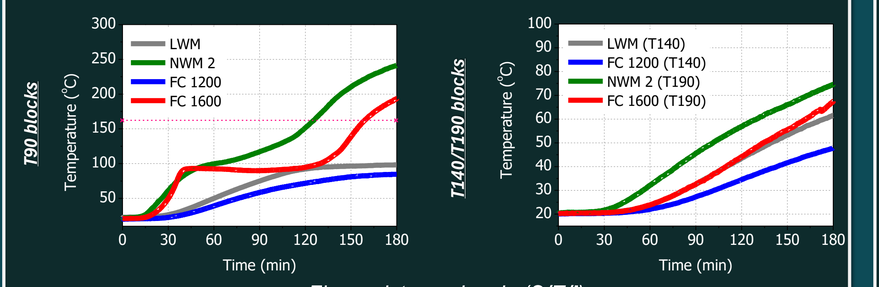


Thermal cracking in BAL-FZ exposed T90 blocks

- No insulation failure was recorded up to 90 min
- No integrity failure was observed

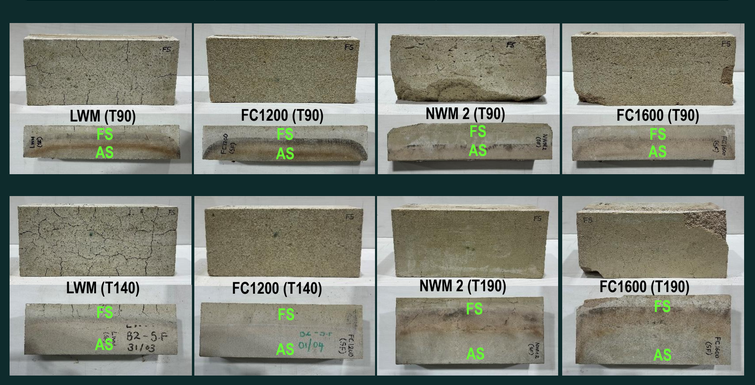
Standard fire resistance

AS surface time-temperature profiles



*Fire resistance levels (**S/E/I**)*

Block	T90	T140 , T190
LWM	-/180/180	-/180/180
FC1200	-/180/180	-/180/180
NWM 2	-/125/125	-/180/180
FC1600	-/160/160	-/180/180

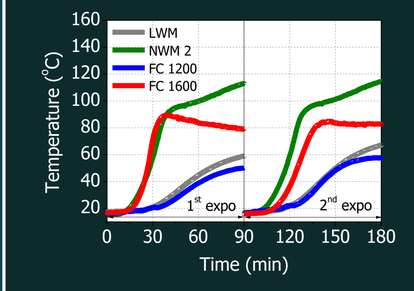


Thermal cracking in standard fire-exposed blocks

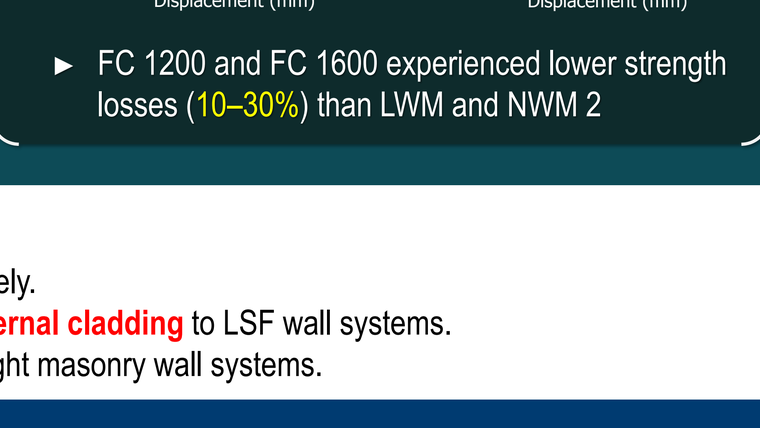
- FC 1200 and LWM (T90) avoided insulation failure, FC 1600 delayed failure to nearly 170 min, and no integrity failures observed.

Repeated BAL-FZ resistance

AS surface time-temperature profiles



- All T90 blocks sustained the repeated BAL-FZ simulations (180 min)
- T140 and T190 blocks were not investigated for repeated exposure.



Thermal cracking in repeated BAL-FZ exposed T90 blocks

Post-fire residual behaviour

Post-fire compressive force-displacement relationship

T90 blocks

T140/T190 blocks

- FC 1200 and FC 1600 experienced lower strength losses (10–30%) than LWM and NWM 2

Conclusions and Recommendations

- FC1200 and FC1600 showed better elevated temperature thermal properties under non-load bearing and load bearing criteria, respectively.
- **FC1200** T90 block revealed superior resistance to standard fire, BAL-FZ and repeated BAL-FZ attacks – Ideal for **non-load bearing external cladding** to LSF wall systems.
- **FC1600** T190 block (increased thickness or better post-fire exposed stiffness) could be ideal for **light-load bearing standalone** lightweight masonry wall systems.

Acknowledgement

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References

Fu, Y., Wang, X., Wang, L. and Li, Y. (2020) 'Foam Concrete: A State-of-the-Art and State-of-the-Practice Review', *Advances in Materials Science and Engineering*, 2020. Available at: https://doi.org/10.1155/2020/6153602.
Gencel, O., Bilir, T., Bademler, Z. and Ozbakkaloglu, T. (2022) 'A Detailed Review on Foam Concrete Composites: Ingredients, Properties, and Microstructure', *Applied Sciences*, 12(5752). Available at: https://doi.org/10.3390/app12115752.
Newman, J. and Owens, P. (2003) 'Properties of lightweight concrete', *Advanced Concrete Technology*, *Elsevier*, 1st Edition, MA, USA, ISBN: 0-7506-5105-9.
ISO 834.1 (2021) 'Fire-resistance tests – Elements of building construction- Part 1: General requirements', International Organization for Standardization, UK.