Foam concrete for roof slopes and floor levelling

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Preface

Foam concrete is predominantly used as a void-filling material for trench reinstatements and disused ducts or sewers[1]. Its application as a screeding material for roof slopes or as a floor levelling material is less well known. The objective of this article is to focus on roof slope applications and briefly consider floor-levelling and floor-fill applications.

General

Foam concrete is a mixture of cement, water and mechanically generated foam. The foam is manufactured by exerting high shearing forces on a diluted foaming agent in the presence of (compressed) air. The foaming agent is a surfactant typically made from animal proteins. Sand, fly ash, stone dust or other fillers may be added to save money and/or achieve particular properties.

Fresh foam concrete has a paint-like viscosity, making it easy to convey via pumps and hoses. This viscosity and almost self-levelling nature simplify placing at the pouring location and reduce the labour required for placing and finishing. The choice of cement type and amount, together with the quantity of foam added to the mix, determine the main properties of foam concrete: adjustable density and strength.

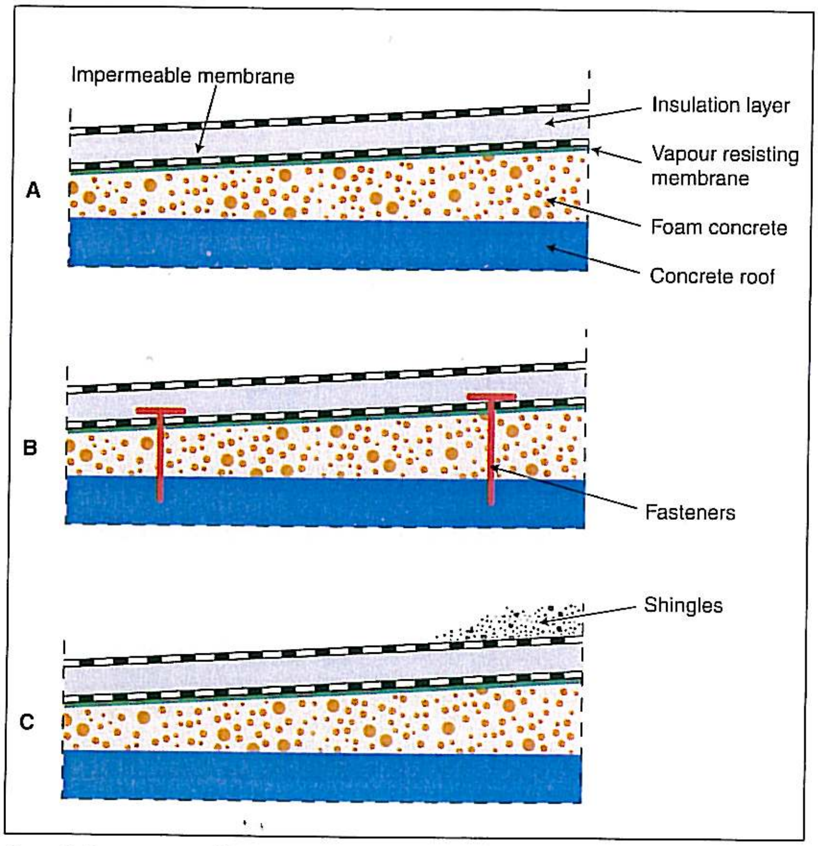

Figure 1: Cross-sections of three roof construction techniques using foam concrete.

Roof slopes

Low-density foam concrete has many applications, but is particularly suitable for profiling the positive slope to drains on flat concrete roofs. Other roof-like applications with foam concrete are:

- protective sub-layer on top of impermeable roof membrane for roof car parks or roof gardens
- levelling existing roof construction, with possible remains of ballast shingles, combined with the application of a new roof slope
- void fill between ducts and conduits on a roof floor, also combined with the application of a new roof slope on top.

There are several reasons why foam concrete is particularly suitable for making roof slopes:

- speed: daily production of 90m^3 (equivalent to 1000–1500m^2 depending on screed thickness)
- accessibility: use of flexible hose allows for easy access on roofs
- simplicity: complex roof layouts do not pose a problem for in-situ roof slopes produced from foam concrete. No requirement for stair stepping with polystyrene boards or screeding with traditional grouts. Double sloping roofs (two directions) do not cause problems, provided that sufficient level markers are used to indicate the required slopes
- low density: typical densities range from 900 to 1100kg/m^3, resulting in minimal additional loads to the structural roof
- level: by adding sand to the mix, slopes of 16mm/m are achievable, and the foam concrete surface can be finished with a tolerance of ±10mm relative to the required level while maintaining the required slope.

Figure 2: Placing the foam concrete on the roof.

Figure 3: Float-finishing the foam concrete.

Figure 4: The finished foam concrete roof slope.

Roof construction types

There are three main roof construction types applicable to the use of foam concrete as a screed for profiling the required slope (see Figure 1).

Type A – roofing membrane glued on upper surface of foam concrete where the:

- foam concrete density is 1100kg/m³ and compressive strength is 5MPa
- impermeable roofing membrane is glued on topside of foam concrete
- membrane beneath foam concrete is only vapour resisting.

Type B – roofing membrane fixed to topside of foam concrete with mechanical fasteners:

- foam concrete density is 900–1000kg/m³ and compressive strength is 4MPa
- impermeable roofing membrane screwed to the foam concrete surface
- with extra thermal insulation layer: membrane on the foam concrete is only vapour-resistant.

Type C – ballasted roof

- foam concrete density 900kg/m³ and compressive strength is 3MPa
- impermeable roofing membrane not connected to foam concrete
- roofing membrane ballasted with shingles or concrete tiles with extra thermal insulation layer: membrane on foam concrete is only vapour-resistant.

Roof slope project

Before foam concrete is applied to the roof, all holes, recesses, joints and other possible leaks must be sealed or boxed out with formwork to prevent foam concrete loss. Roof gullies require special attention so that foam concrete does not seep into the drains, ruining the water-discharge capacity. Whenever autoclaved aerated concrete (AAC or 'gas' concrete) is used as a structural roof it has to be treated with a curing compound. This is to prevent excessive moisture absorption from the fresh foam concrete. The roof needs to be cleaned of all foreign objects and standing water needs to be removed. Walls that continue above the roof level must be protected against cement splashes. Level markers are positioned using a grid

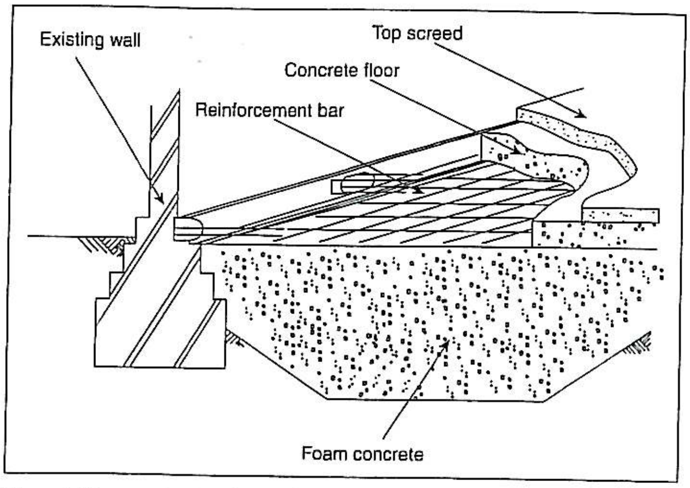

Figure 5: Diagram showing the use of foam concrete to upgrade a neglected farmhouse ground floor.

of 3m in both directions to permit proper slope finishing of the foam concrete.

Figure 2 shows the foam concrete being applied to the roof. Minimum thickness is 30mm, so foam concrete does not fracture during the remaining building process. The transport hose is fitted with a diffuser to allow foam concrete to flow at an acceptable speed without an unacceptable amount of splashes. The operative holding the diffuser applies the approximate thickness of foam concrete required, looking at the level markers laid out earlier with bricks and mortar. The operative using the float finishes the foam concrete surface so that the correct slope is achieved while maintaining the required thickness (see Figure 3). A finished roof section is shown in Figure 4. Depending on ambient weather, it will take three to six days before the foam concrete can be accessed without causing damage. Type A construction may take longer than the other techniques, as the foam concrete needs to lose most of its moisture via evaporation before the roof membrane can be applied to the foam concrete.

Floor levelling

Foam concrete can be easily transported to site through flexible hoses. Owing to the almost self-levelling nature of the material, it is ideally suited as a levelling material. A problem with precast hollow core slabs is the difference in height between the centre of the floor and end of the slab near the wall. This can be levelled easily with foam concrete. The levelling layer can be topped with a pump-applied self-levelling synthetic anhydrite floor screed or a traditional sand–cement screed. Cable ducts mounted on a structural concrete floor can be encapsulated using foam concrete simultaneously as a void filler and levelling layer around the ducts. Raising the level of an old floor is expensive when using ordinary concrete, but putting a foam concrete sub-base on top of the old floor before laying a new concrete floor on top is more efficient. Depending on the average thickness for the levelling layer, different densities of foam concrete are applied. A general guideline is:

- 30–50mm layer depth: use 1000–1200kg/m^3 density with average 4–6MPa compressive strength
- 50–80mm layer depth: use 800–1000kg/m^3 density with average 3–4MPa compressive strength
- 80mm and more: use 400–600kg/m^3 density with 1–2MPa compressive strength.

The multiple advantages of foam concrete were demonstrated on the renovation (see Figure 5) of a farmhouse ground floor. The original wooden floor had decayed and needed to be replaced. First, the old floor, including the supporting beams, was removed. Next, the crawl space was filled with 500kg/m^3 density foam concrete, serving as a good solid sub-base for fixing the required reinforcement and casting a new, structural concrete floor. Finally, the concrete floor was screeded. The reasons for the selection of foam concrete for this application were:

- soft soil areas susceptible to settlement: foam concrete reduced the added load to crawl space grade
- addition of thermal insulation: every 120mm of this foam concrete results in a further thermal RC value of 1m^{2}K/W. RC refers to the sum of resistances of contact. This relates to wrapping the concrete with insulation and controlling the temperature. Overall, 600mm of foam concrete was poured, increasing RC by 5m^{2}K/W.
- bearing capacity of foam concrete slab limits the required thickness for structural concrete floor and beams
- it is a fast and economic solution
- foam concrete does not rot or decay.

Reference:

1 COX, L. and VAN DIJK, S. Foam concrete: a different kind of mix, *CONCRETE*, Vol. 36, No. 2, February 2002, pp.54–55.