

The Challenges of making a lightweight tile

John Fifield

Why a lightweight tile?

- In the 1980's the government freed up cash for home improvement and specifically included the roof.

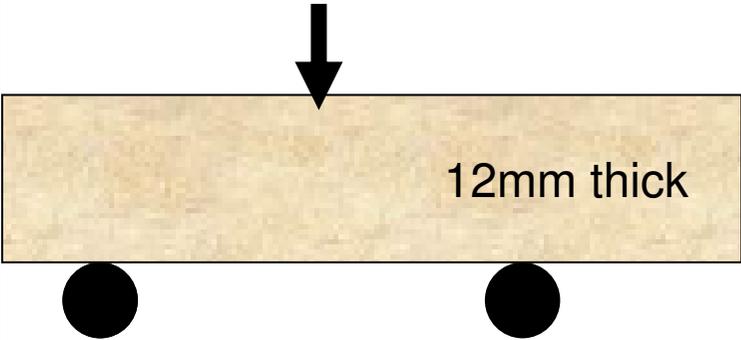


Local Authorities did not have the resources to inspect properties to take heavier concrete tile to replace slates.

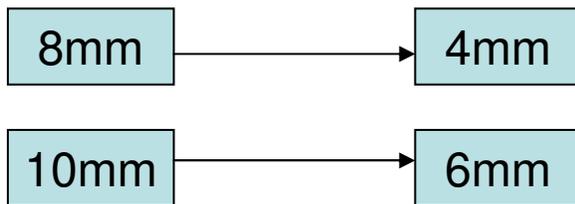
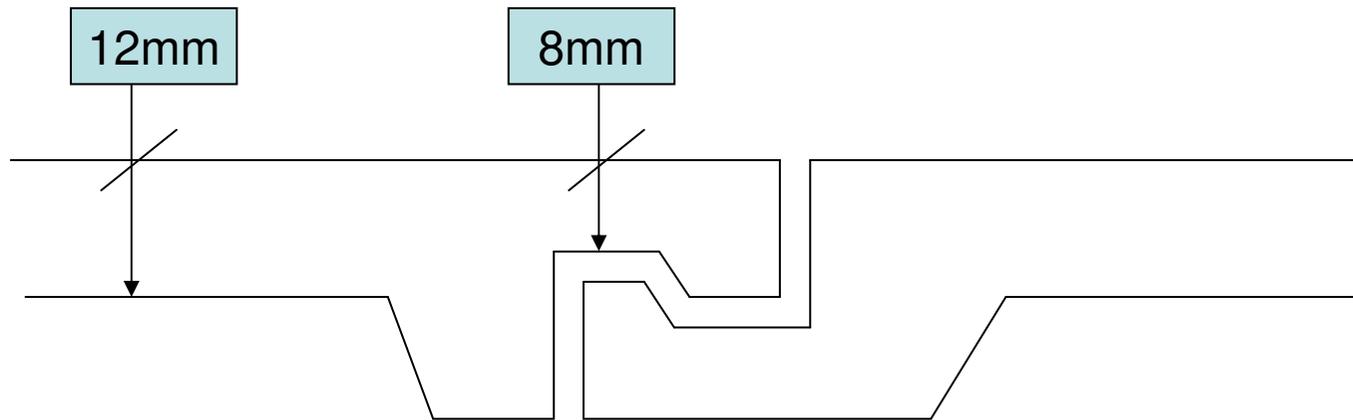
A default value of 30kg/m² for the replacement roofing product was adopted.

But standard concrete tiles were 45kg/m² making a lightweight version attractive.

To reduce weight of concrete tiles we needed to consider dimensional and material options

| Tile Thickness | Strength | Material Options |
|--|--|------------------------|
|  <p>12mm thick</p> | Standard tile strength 1800N | Expanded Clay |
|  <p>8mm thick</p> | Computed tile strength $1800 \times 8^2 / 12^2 = 800\text{N}$ | Sand |
|  <p>10mm thick</p> | Computed tile strength $1800 \times 10^2 / 12^2 = 1250\text{N}$ | Expanded Slate, pfa |

Assessing the geometric options



Conclusion

Can not have interlocks less than 6mm so lightweight aggregate essential

Selecting a lightweight aggregate

- The lightest aggregates would keep the tile dimensions standard
- Tougher but denser lightweight aggregates would mean making thinner tiles
- We set out to evaluate strength/density ratios of the available materials

Developing Lightweight Concrete Tiles



A Summary of
the lightweight
aggregates that
I remember
being produced
in the UK

In the 1960's there
was even a
lightweight aggregate
trade association.

Developing Lightweight Concrete Tiles



All but four plants had closed

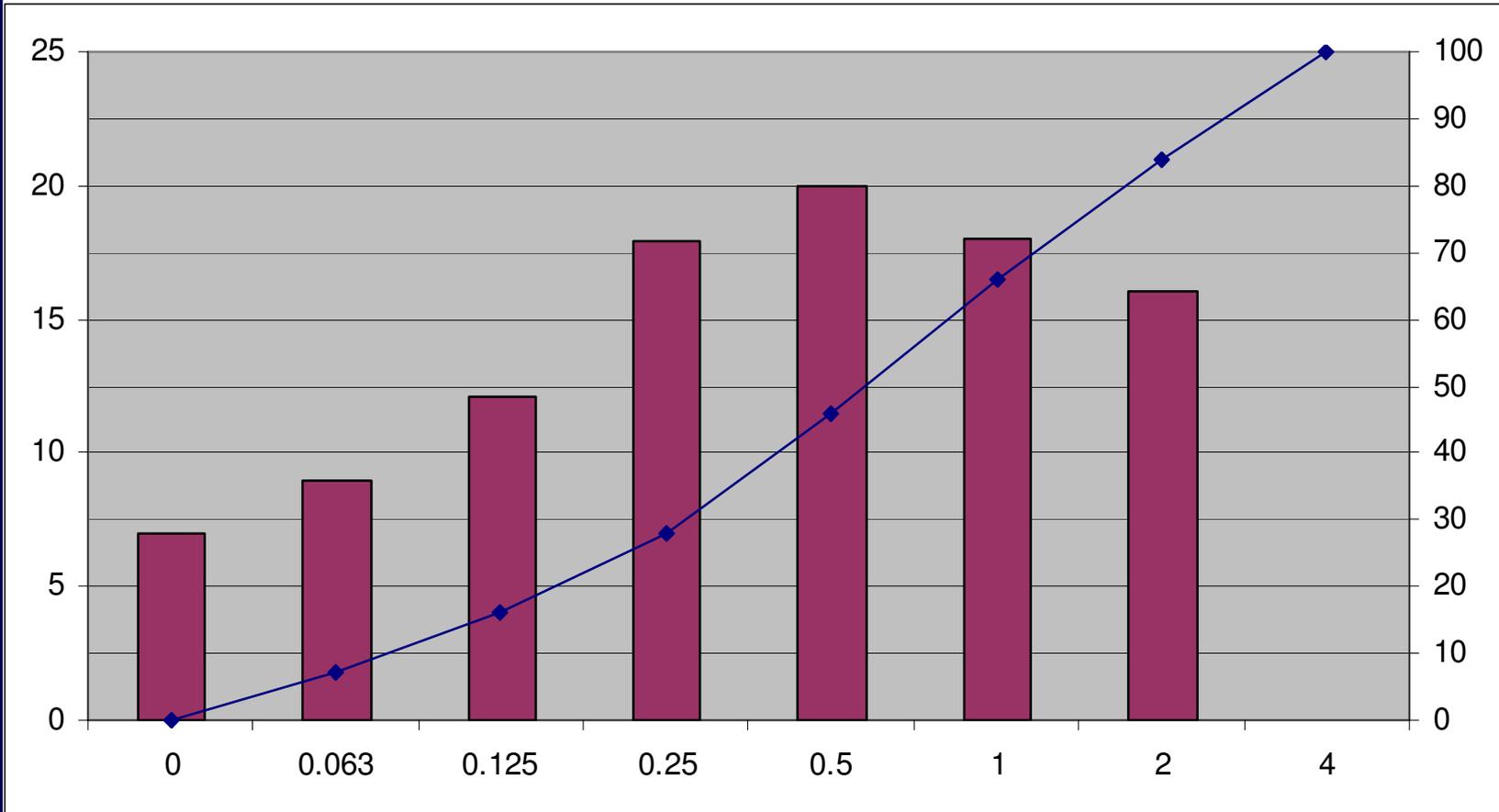
Trials showed that we were more likely to meet the BS for concrete tiles with Lytag. It had a superior strength/density ratio even allowing that the tile would need to be thinner

Developing Lightweight Concrete Tiles

Tilbury Lytag was chosen

Best strength/density ratio

Ideal material grading for tile production



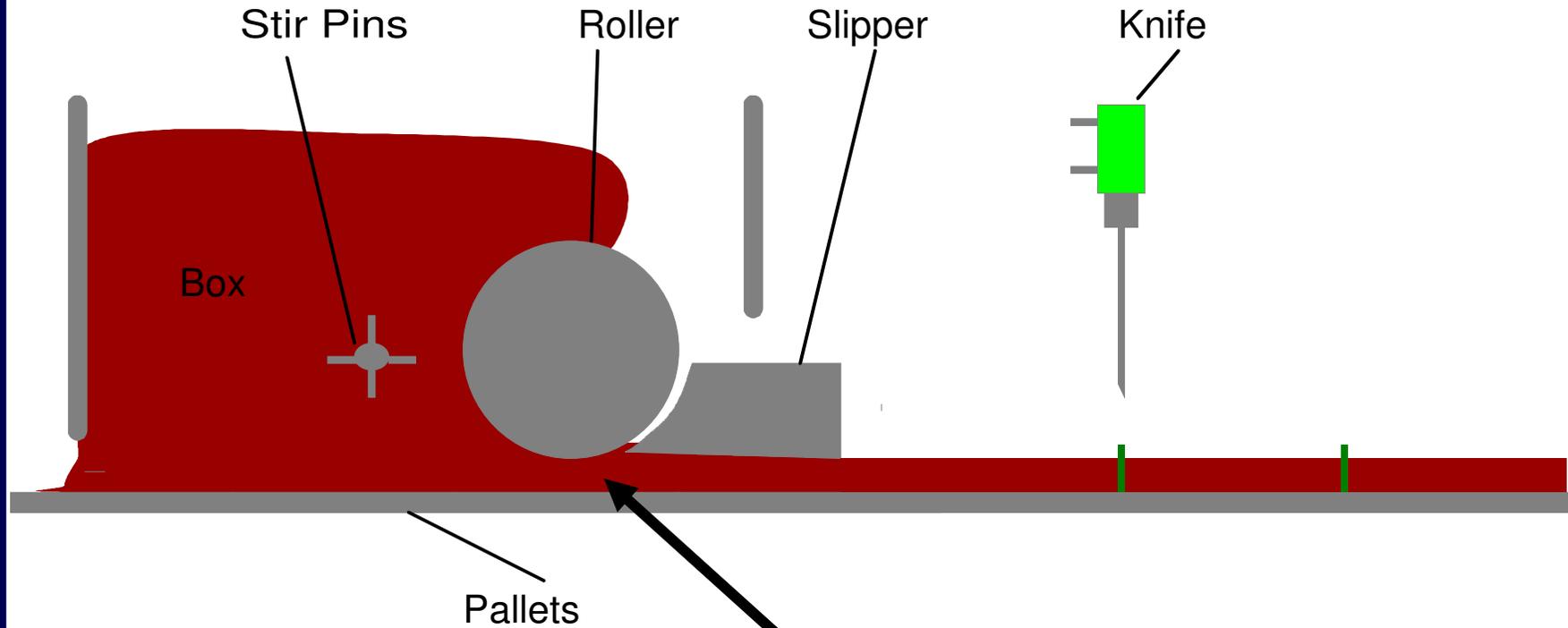
Tilbury Lytag Grading

Challenges to meet standard

- Flexural strength had to be improved
 - Option to add silica fume
 - Up to 35% improvement in flexural strength
 - Impact resistance lower, concrete more brittle
 - Option to add acrylic co-polymers
 - Up to 90% improvement in flexural strength
 - Impact resistance improved
 - Specific product from Scott Bader also gave control over air entrainment, small bubble size in the cement/acrylic paste

Developing Lightweight Concrete Tiles

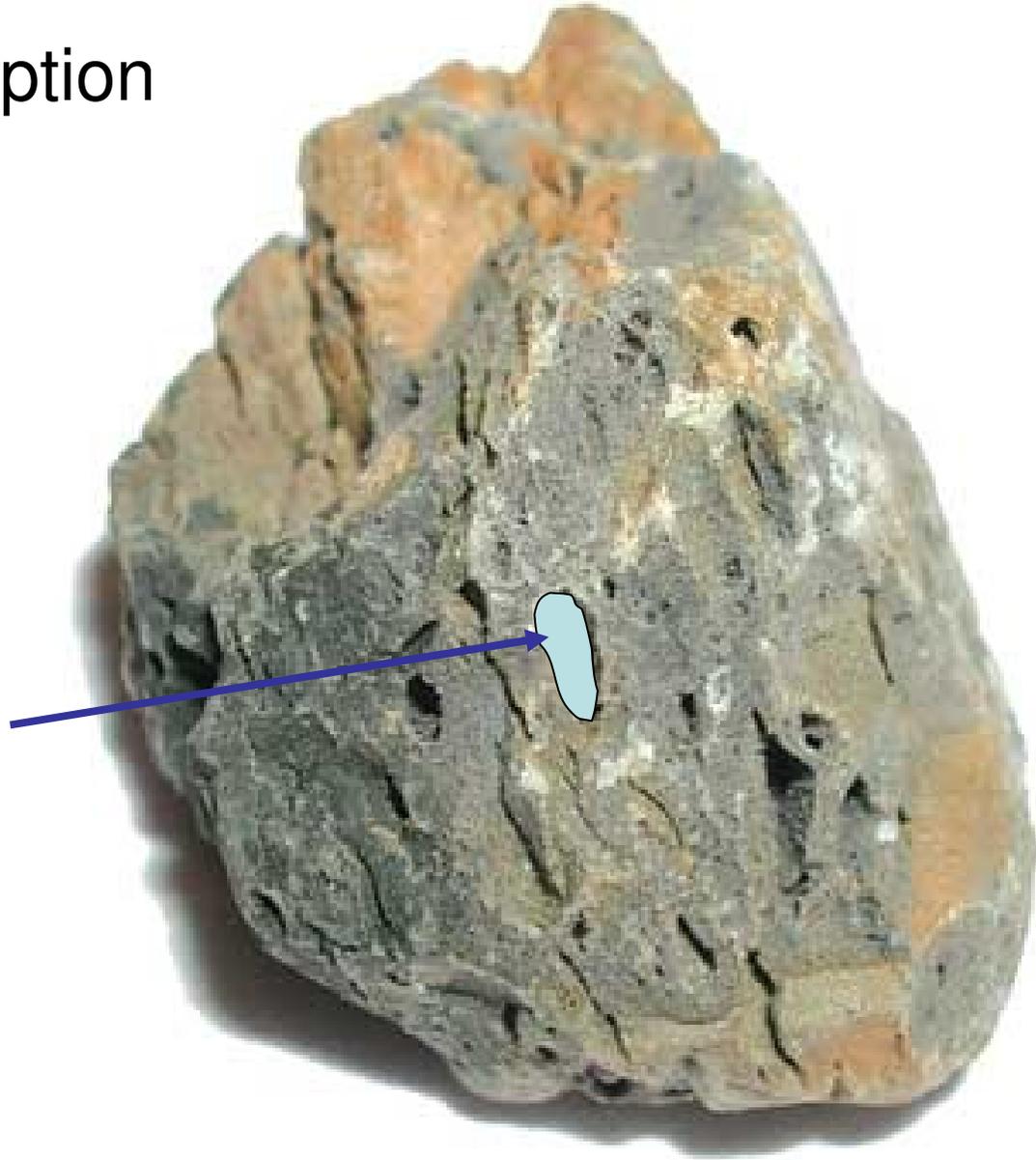
But the processing also needed to be improved
Aggregate absorption making extrusion difficult



Very high pressure applied

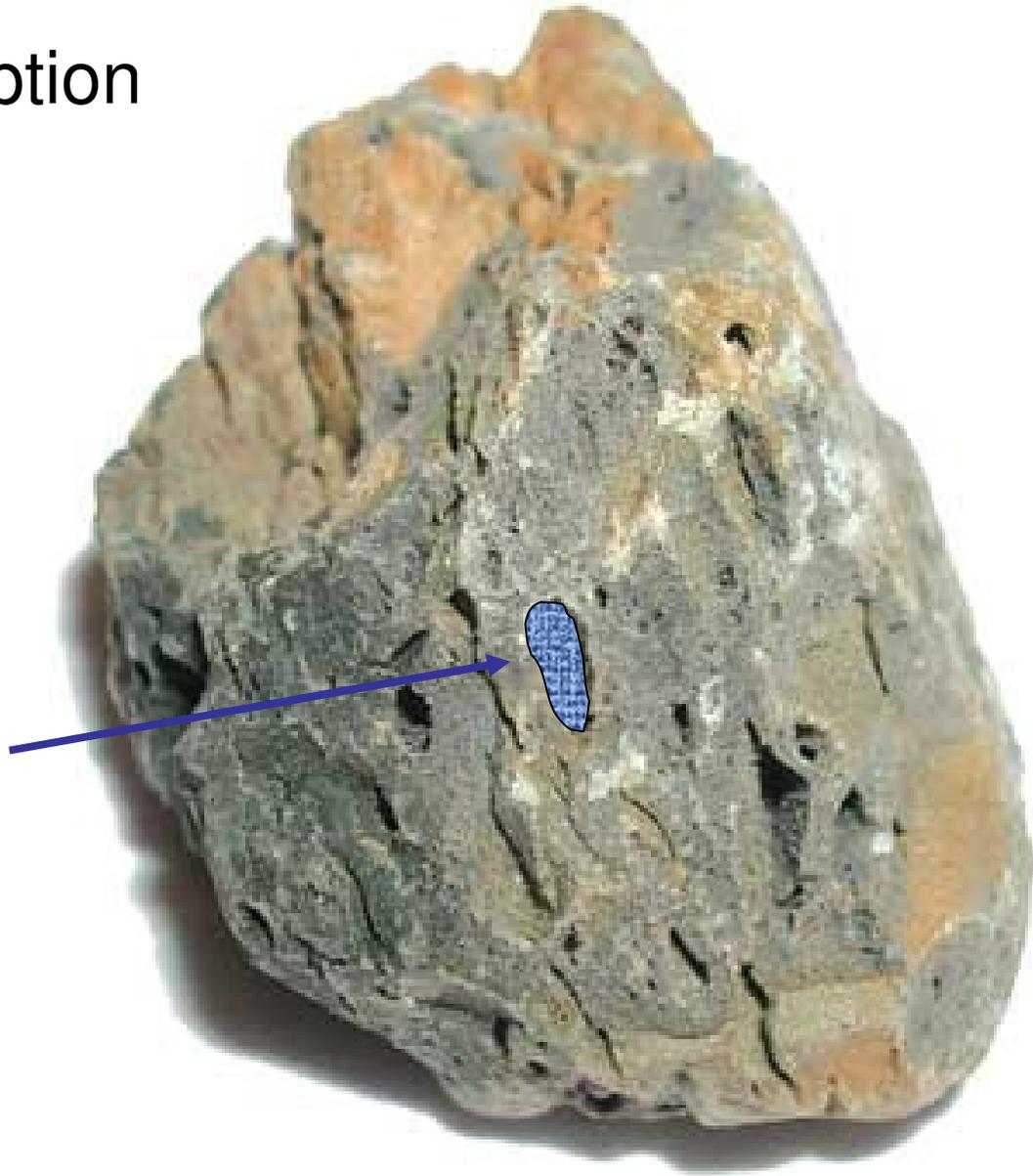
Improving Absorption

Pre wetting the aggregate fills the pores near the surface



Improving Absorption

Adding cellulose at the pre wet stage still fills the pores near the surface



Improving Absorption

When the cement is added the cellulose gels making it more pressure resistant



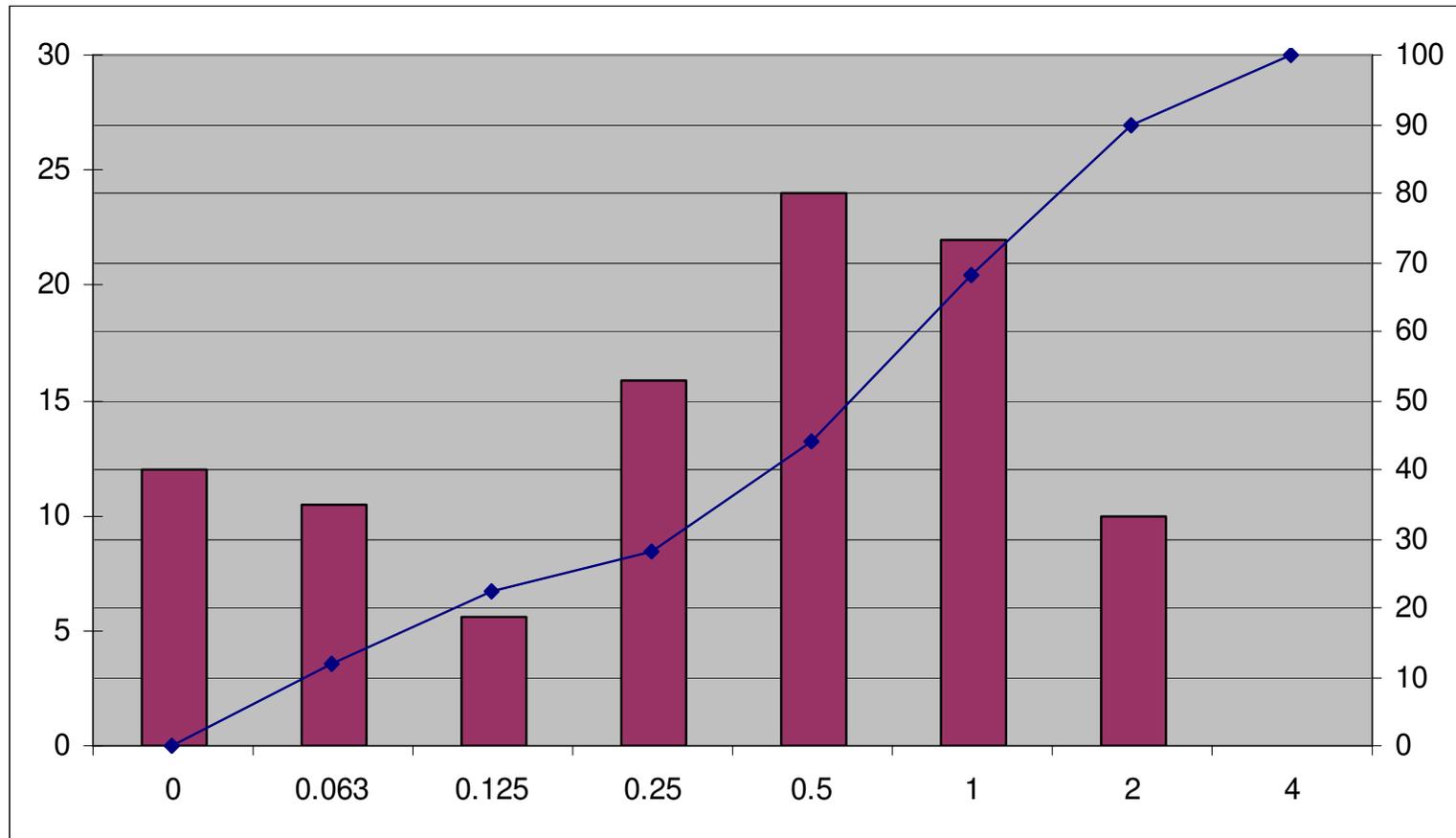
Production Data

- Patented Mix design:-
 - Tilbury Lytag, methyl cellulose, cement, acrylic co-polymer, water
- Tile Properties:-
 - 30kg/m²
 - met all BS requirements, less brittle than standard tiles
- Orders flooded in
 - 2 million tiles to Birmingham alone in one year
 - But then Lytag closed Tilbury

Production continued with Lytag from Rugely

The aggregate was gap graded, not ideal for tile extrusion

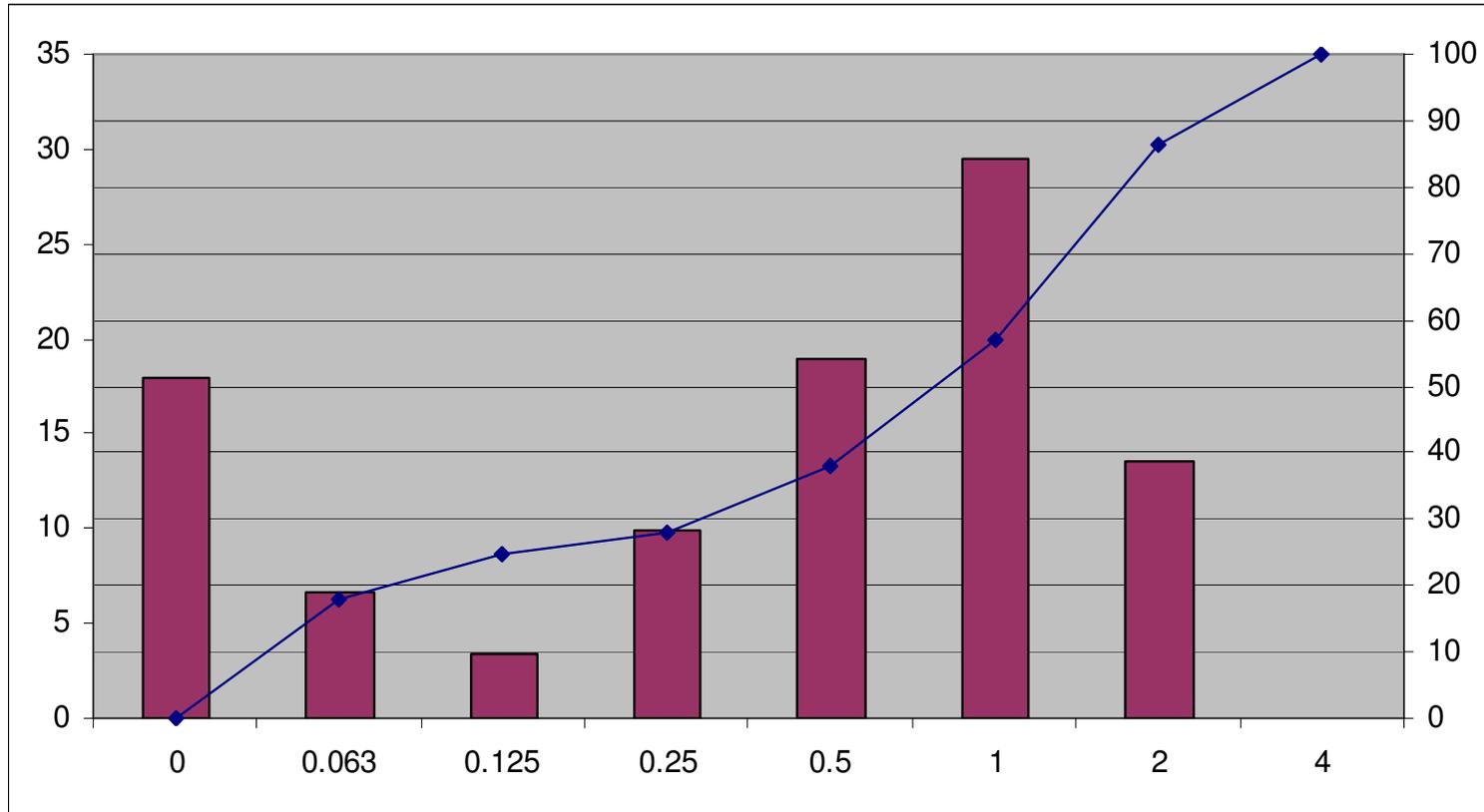
Lytag produced separated fines to fill the gap



Rugely Lytag Grading

Then Rugely closed

Eggborough gap grading more acute than Rugely, quality suffered



Eggborough Lytag Grading

And then Eggborough closed

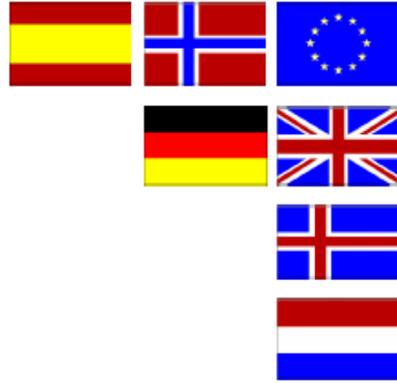
- Vasim, Nijmegen had closed
- All trials with Polish Lytag failed
- So Forticrete withdrew lightweight tiles from the market.

But then in 2009

Requests for lightweight tiles began again and the search for a suitable lightweight aggregate resumed

EuroLightCon

With a little help



European Union – Brite EuRam III

Light Weight Aggregates

EuroLightCon

Economic Design and Construction with
Light Weight Aggregate Concrete

Document BE96-3942/R15, June 2000

Project funded by the European Union
under the Industrial & Materials Technologies Programme (Brite-EuRam II)
Contract BRPR-CT97-0381, Project BE96-3942

Exfoliated slates
were identified

- France (GEM Granulex)
- Germany (Berwilit and VTS Ulopor)
- USA (Stalite)

BERWILIT - shale

Lightweight aggregates for concrete, mortar and grout manufactured according to EN 13055 or factory setting

| | | | | | | | |
|-----|-----|-----|-------|-------|-------|--------|--------|
| 0/2 | 0/4 | 2/4 | 2/8 G | 4/8 N | 4/8 S | 8/16 N | 8/16 S |
|-----|-----|-----|-------|-------|-------|--------|--------|

Grain shape:

cubic

Grain surface:

keram. Shell

sh.
Oberfl

ceramic shell

Grain size [mm]:

0-2

0-4

2-4

2-8

4-8

4-8

8-16

8-16

Particle density [g / cm³]:

1.65

1.55

1.35

1.08

1.10

1.25

1.10

1.20

Bulk density [kg / m³]:

900

850

700

540

570

625

575

625

Grain strength [N / mm²]:

NPD *

NPD *

NPD *

4.0

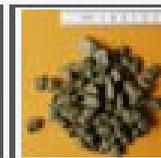
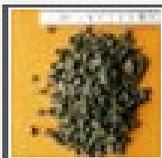
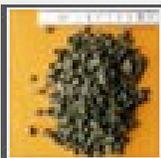
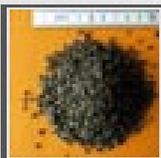
4.5

5.0

4.3

4.8

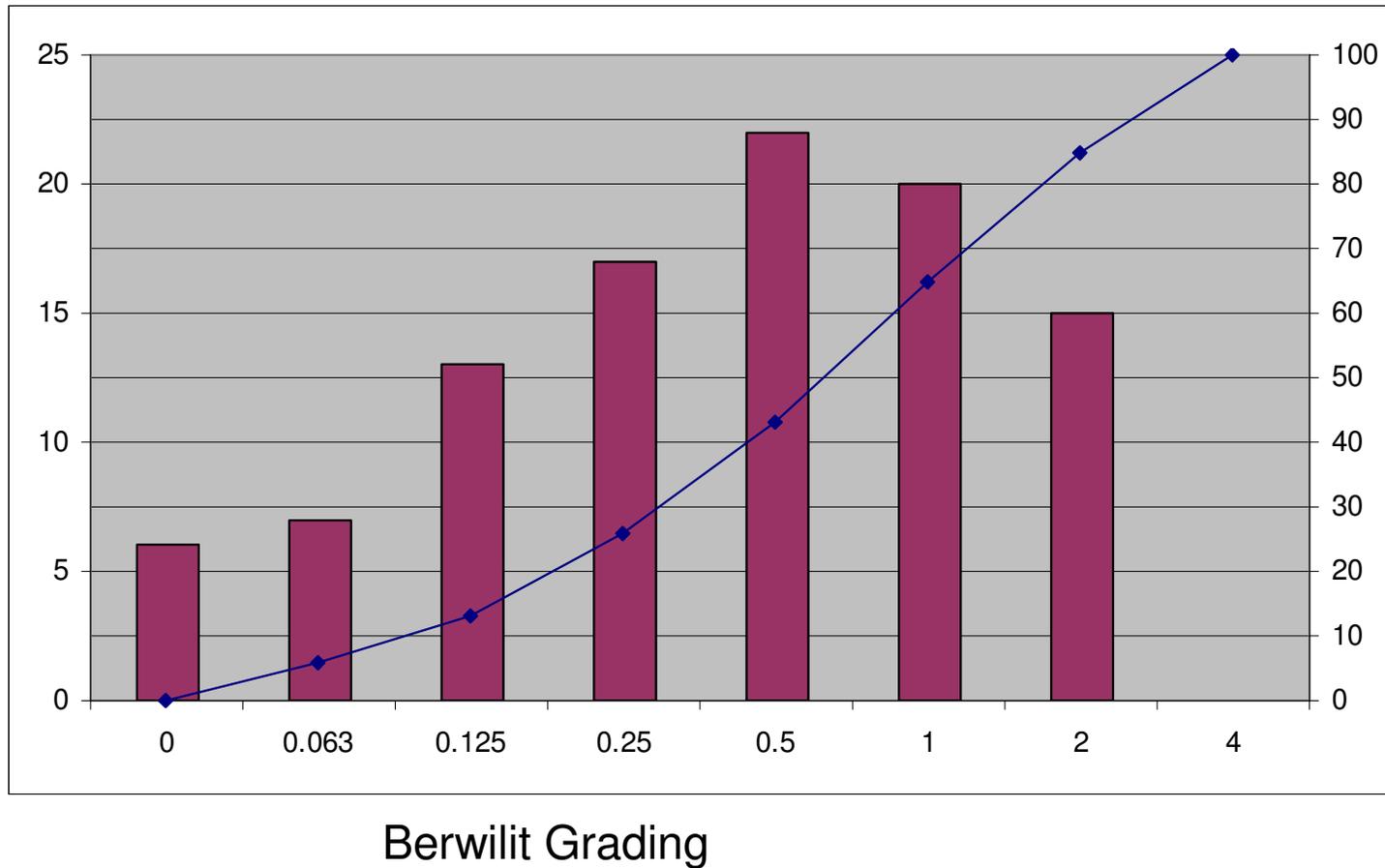
*) NPD = not determined property



Developing Lightweight Concrete Tiles

Berwilit had the best strength/density ratio and an ideal grading

Best of all its density allowed Forticrete to make thicker than before



Berwilit Production

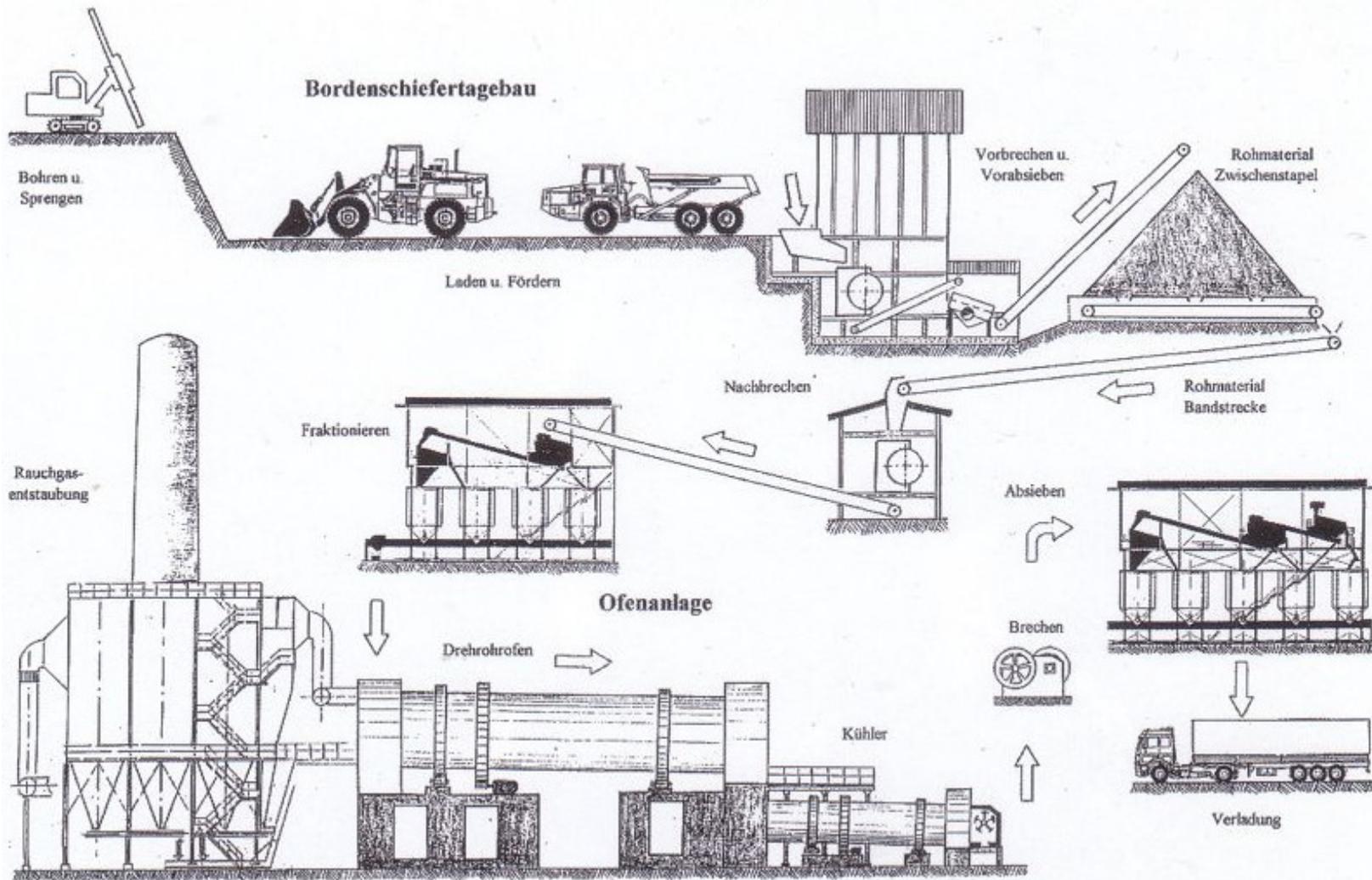


Quarrying

90% Quartzite

10% Slate Waste

Berwilit Production



Berwilit Production

Stage 1

Slate is
crushed

2012 10 10



Berwilit Production



Stage 2

Crushed
slate fed
to kiln

Berwilit Production



Berwilit Production



2012 10 10

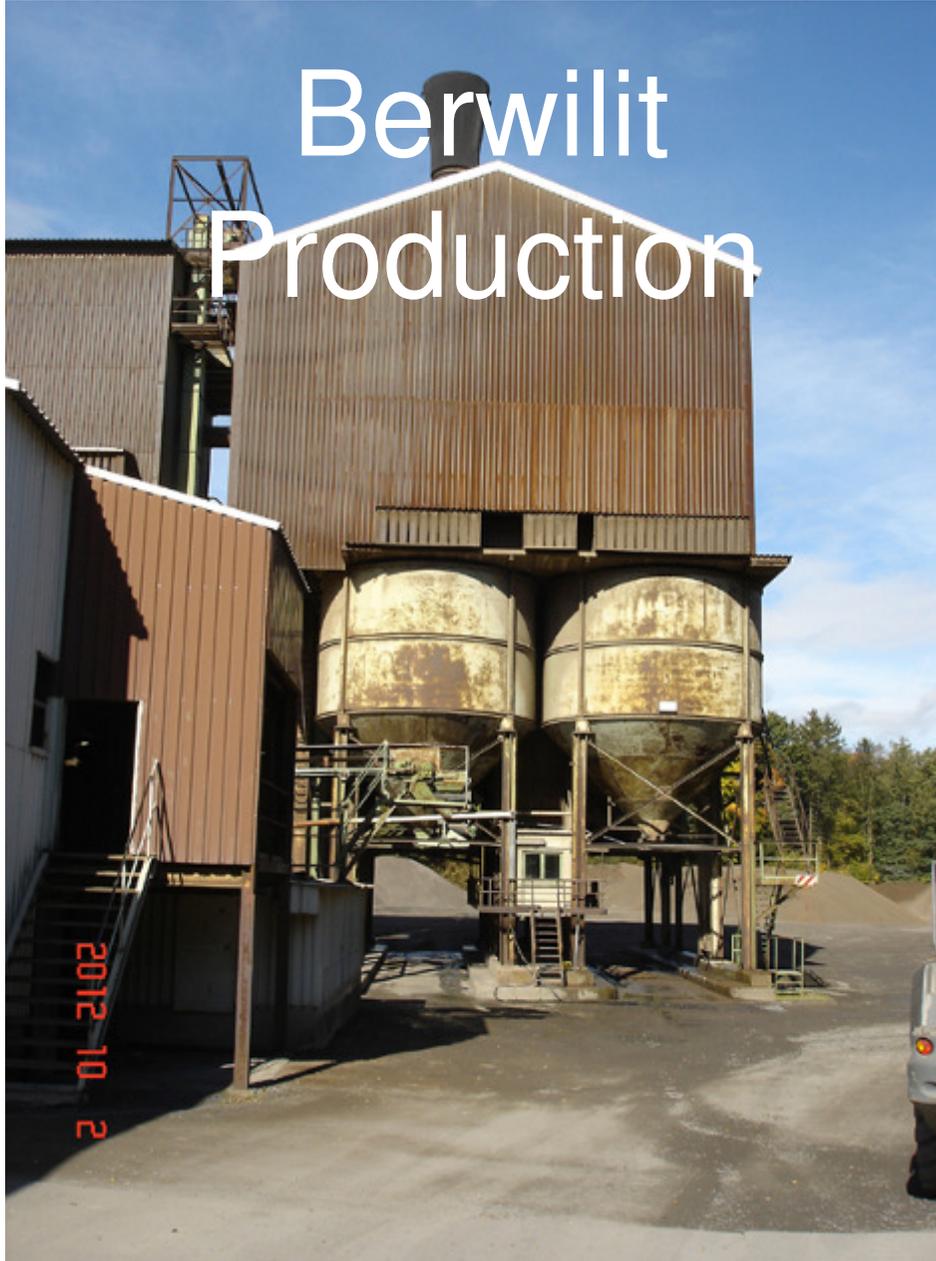
Berwilit Production



Stage 4

Cooled
product

2012 10 10



Final Product

Stored in silos

Excess stored
on ground

500 miles but competitive!



Tile Production, best ever



Beautiful Roofs



Happy customers

Conclusions

- The ongoing manufacture of lightweight tiles has been both satisfying and challenging
- Some of the techniques have been employed on other products
- Grading of the finer fractions of lightweight aggregates is a vital kpi for its users with the European manufacturers being more aware