Lightweight Aggregate(LWA) in Matrix of Cellular Lightweight Concrete (CLC)

Tremendous increase in compressive strength in cellular lightweight concrete (CLC) is achieved when using lightweight aggregate as a filler in the matrix of cellular concrete. The ratio of **strength** over density in such compositions increases by as much as **300 even 400%.**

At the same time, compared to such a composition of conventional concrete and lightweight aggregate, thermal **insulation increases** by about the same times-fold percentage, namely also by **up to 500 %.** The reason being the thermal bridge principle, where the matrix is responsible for the insulation and not the lightweight aggregate. The lower the density of the aggregate used, the better the ratio of strength over density of the composite concrete to be produced. To achieve a sizable result, the density of the lightweight aggregate should be as close as possible to 400 kg/m³ (aggregate-density). Instead of expanded clay, any other aggregate may be used, such as expanded shale, pumice and others used in conventional concrete.

The most popular density in CLC for structural application is 1.200 kg/m³. Almost all of the over 200.000 buildings completed in over 50 countries in the past 30 years had been produced in a density of 1.200, very rarely in 1.400 and exceptionally in 1.600 kg/m³. The achievable strength in these densities are : 1.200/6-8, 1.400/8-12, 1.600/12-16 N/mm²

Ratio of Strength over Density of CLC/LWA of different Compositions.

Density of CLC (kg/m³) 50% of	**1.200**	**1.400**	**1.600**
Achievable Strength of CLC N/mm²	6-8	8-12	12-16
Density of LWA (kg/m³) 50% of	**400**	**400**	**400**
50 : 50 Mix	1.600 : 2	1.800 : 2	2.000 : 2
Oven-dry density in kg/m³	**800**	**900**	**1.000**
Available strength in neat CLC in N/mm²	800/2-3	3-4	4-5
Expected strength in N/mm²	**6-8**	**8-12**	**12-16**

REMARK : Whilst the density of CLC reduces substantially by the lower density LWA in the matrix of CLC, the strength of the latter remains constant. When replacing natural gravel in **conventional concrete** by LWA, the density of this composition reduces to minim**. 1.300 kg/m³,** the thermal insulation of this composition practically remains unchanged low, due to the thermal bridges caused by the high lambda of the mortar/conventional concrete of the matrix.

Size and density of Lightweight Aggregate

The lighter the LWA the better will be the ratio of strength over density of the composition mix selected. The size of the LWA and its shape varies. Granulation of up to 4 mm is used to produce lightweight mortar/plaster (LWM/LWP). As suitable granulate size for blocks and structural building elements is 8 – 12 mm. A more even matrix is achieved with round aggregate.

Methods to prepare the Mix

Generally it is recommended to use by volume 50% each of CLC and LWA. If the matrix of the LWA used is known, this volume has to be added to the amount of CLC computed. It is also possible however to take 50% of each and adjust the volume by the amount of foam added. When selecting the density, it is further recommended **not** to add the full amount of the designed volume of foam, but first add only 80-90% of it, eye-balling the rest, until the requested density is achieved. Once foam had been added, no adjustment by any other of the material used is possible. There are different methods of preparing compositions of CLC and LWA. They are the following :

In all mixes LWA has to be properly soaked – as in the use in conventional concrete – to ensure that an otherwise dry aggregate draws water from the wet-mix. Some companies keep their LWA constantly in water, taking it directly from the yard to the mixer, letting surplus water drop off.

Method I

1. Charge the mixer first with the total amount of soaked aggregate and keep mixing
2. Add the designed amount of sand (see Neopor mix design)
3. Add the designed amount of cement (see Neopor mix design)
4. Add the designed amount of water (see Neopor mix design)
5. Add the designed amount of foam (see Neopor mix design)
6. When mix is homogenous, check wet density and adjust, if necessary

Method II

1. Charge the mixer with sand (see Neopor mix design) keep mixing
2. Add the designed amount of cement (see Neopor mix design)
3. Add the designed amount of water (see Neopor mix design)
4. Add the designed amount of soaked LWA
5. Add the designed amount of foam (see Neopor mix design)
6. When mix is homogenous, check wet density and adjust, if necessary

Method III

As Method II, however adding LWA only last, after sand, cement, water and foam.

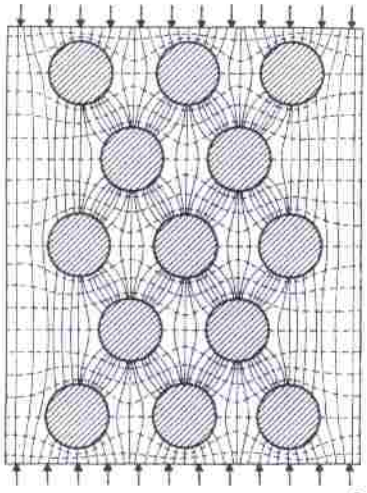
How to evaluate the aggregate density of LWA

An empiric way of determining the specific density of LWA used is, to fill a containment of net 1 litre completely to the top with the aggregate (bulk density). After taking the net weight of the aggregate, the "matrix" of the containment of LWA is filled with water also to the top. The difference in weight/volume of the matrix is added to the bulk-weight of the LWA. The aggregate used has to be oven-dry before weighed.

Example :	Bulk Density	350 grams (aggregate)
	Matrix	200 grams (water)
	Specific Density 550 grams/litres (kg/m³)	

Compressive strength relating to Material used in Concrete

In conventional concrete the strength is based on the **strength of gravel** and not on the cement used. It is just the opposite in concrete where LWA is used in conjunction with structural
cellular concrete is been used, offering higher strength than offered by the aggregate. It is therefore, that the strength of the composite mix will remain to a large extend identical to the strength offered by the "neat" CLC, before adding LWA. The following drawings show the tension, distributing in the concrete used to establish the strength (An extract from ASTM)



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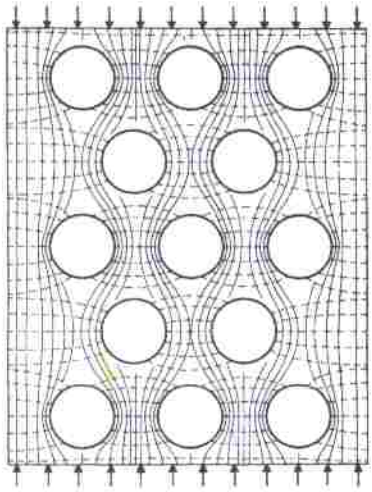

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Illustrations on left

The reaction to developing tension when under pressure of a matrix of regular concrete and one with LWA shows, that in regular concrete the tension travels from one (natural) aggregate to the other due to the higher strength of the aggregate, whilst with LWA in the matrix, the higher strength is the matrix and the tension therefore passes around the LWA. –

In a mix of CLC/LWA the strength therefore is determined by the strength of the matrix, thus by the CLC.

Comprehensive information on the subject is available upon request.

CLC/LWA/Neopor/hgk/03-04