construct

Euro-Agg®

argex Concrete

from 500 to 2000 kg/m^3
from 1 to 90 N/mm^2

Royal Atlantis - Dubai

TABLE OF CONTENTS

1. ARGEX EXPANDED CLAY AGGREGATES

100% environmentally friendly

Argex is a light pellet of expanded clay (mineral origin) produced in a rotary kiln at 1,100°C. Argex is a high quality, durable lightweight aggregate, that has been used for over half a century. They consist of a brown microporous shell and black core with cellular structure. The main characteristic of Argex is low density combined with high strength. In addition, the aggregate holds many other important characteristics, and it can be described as an « all-in-one » product, providing a huge range of properties vital for sustainable construction.

Types	Grading (d/D - mm)	Loose Bulk Density	Particle Density (prd)
		(kg/m³)	(kg/m³)
Rounded	AR 1/5 - 580	580	1030
	AR 0/4 - 650	650	1050
	AR 0/4 - 700 Coating	700	1085
	AR 4/10 - 430	430	750
	AR 3/8 - 500	500	875
	AR 4/12-380	380	660
	AR 8/16 - 340	340	600
Crushed	AG 0/4 – 500 N	500	950
Mix rounded-crushed	AM 0/4 - 600	600	1050
	AM 4/8 – 700 (Coating)	700	1230
	AM 0/8 - 750 Coating	750	1230
	AM 0/5 - 530 Chapemix	530	960
Other types/gradings are available on demand.			

Argex supplies an extensive range of clay aggregates (see table) from the lightest to the high density. Technical specifications for each pellet size are available on www.argex.eu (DoP1 & Technical sheet). The choice of the right Argex aggregate depends on the requirements you make of the concrete to be used. Argex aggregates are in accordance with EN 13055 «Lightweight aggregates».

CE 0965-CPR-GT0525

2. ARGEX LIGHT

Today's building materials have to meet far greater demands than it was the case earlier. In the sign of safety and environmental protection have terms such as fire protection, thermal insulation and sustainable construction gained importance. A particular challenge for architects, planners and structural engineers. With lightweight Argex concrete you have an ideal material that the required properties - in addition to simple processing, high mechanical capacity and considerable creative freedom – fulfilled.

HUGE COMBINATIONS
densities - compressive strength

LOW WEIGHT for handling, dead weight building, etc

EASY TO APPLY

FREEZE-THAW RESISTANCE & long term DURABILITY

Excellent FIRE RESISTANCE & INCOMBUSTIBLE

WEIGHT CONCRETE

HIGH RATIO compressive vs. low density

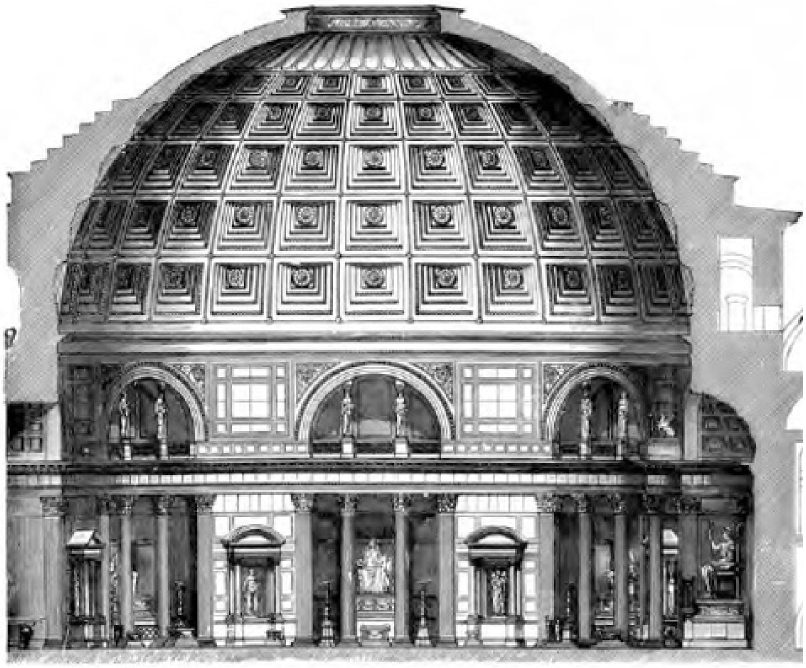
Good THERMAL INSULATION (Λ) & good reduction of thermal bridge (Ψ)

Good ACOUSTICAL INSULATION despite low density
& High SOUND ABSORPTION (with open structure LAC)

RECYCLABLE & circular economy

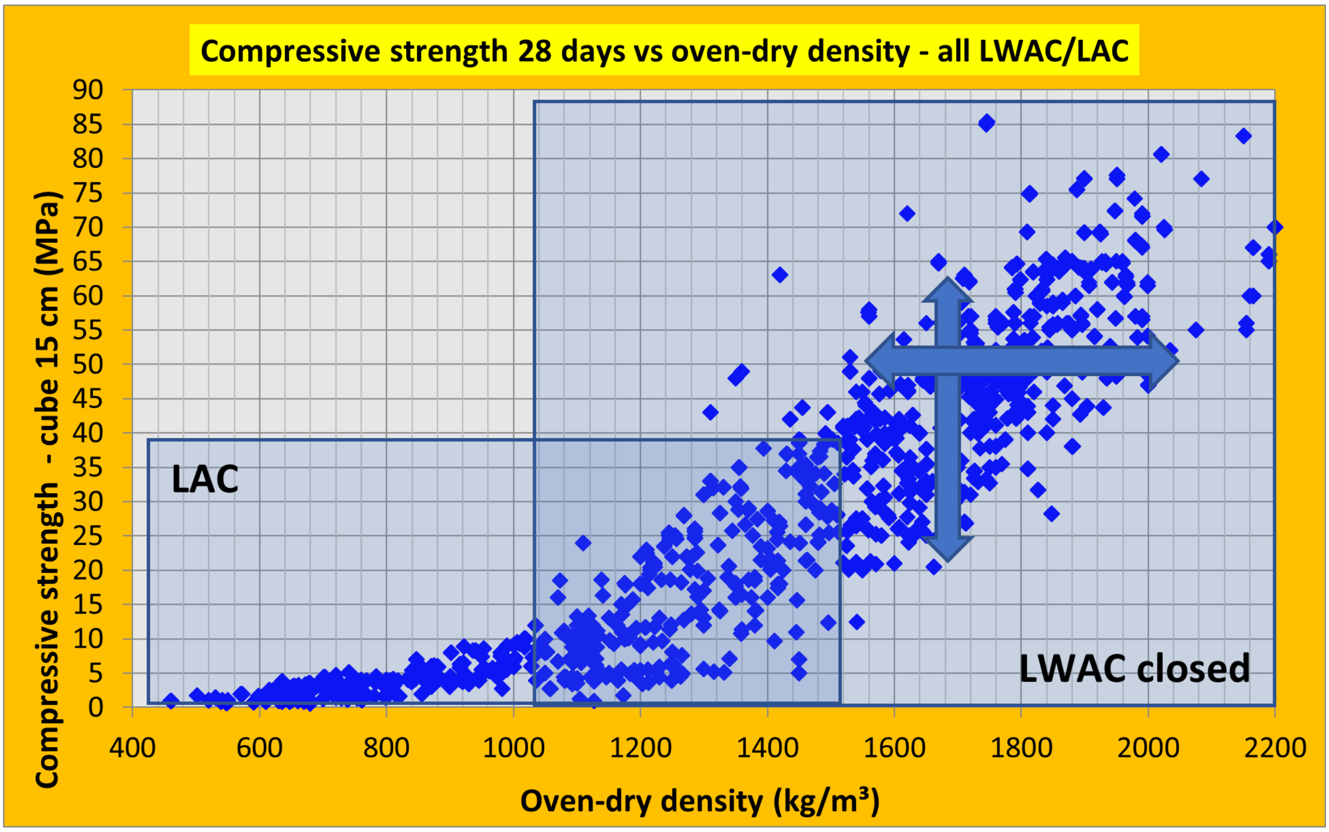
PUMPABLE version

Low coefficient of THERMAL EXPANSION



Even the ancient romans used a lightweight concrete (Pantheon).

Huge range of density-compressive strength combinations:



3. ARGEX NO FINES CONCRETE (LAC)

The first Argex no fines concrete type (100% LAC no fines) is a mixture of Argex aggregates and cement grout that encloses the pellets and adheres them to each other at their contact points. The concrete has a very open structure: there is 35 to 40 % hollow space between the pellets.

Its properties are defined in EN 1520. The dry density of LAC ranges from 400 ≥ ρd ≤ 2000 kg/m3. EN 1520 covers strength classes LAC 2 to LAC 25 (see tables below for strength and densities classes).

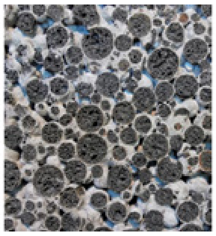
LAC is used for structural elements like loadbearing walls, roof elements, slabs and beams, and for non-structural components like noise barriers.

Lightweight | Thermal insulation | Drainage (& buffer capacity) | Load bearing capacity walls (two stories) & compressive strength

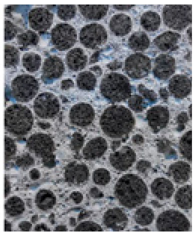
Some properties of LAC can be improved significantly when the open structure is filled with a porous matrix (aerated cement paste) and/or with a part of ligth Argex or normal sand. **Those two LAC represent the second (porous matrix) and the third (Semi LAC) type of LAC.**

The picture below gives an idea of two different LAC types in comparison with a structural LC. LAC is characterized by defined voids between the aggregates that remain in the structure after compaction. These voids are created by limiting the cement paste content to the amount required for binding the aggregates at the points of contact. There is no standardized definition regarding the minimum pore volume threshold to consider a concrete as "open porous".

LC with a dense matrix structure



LAC with open pore structure



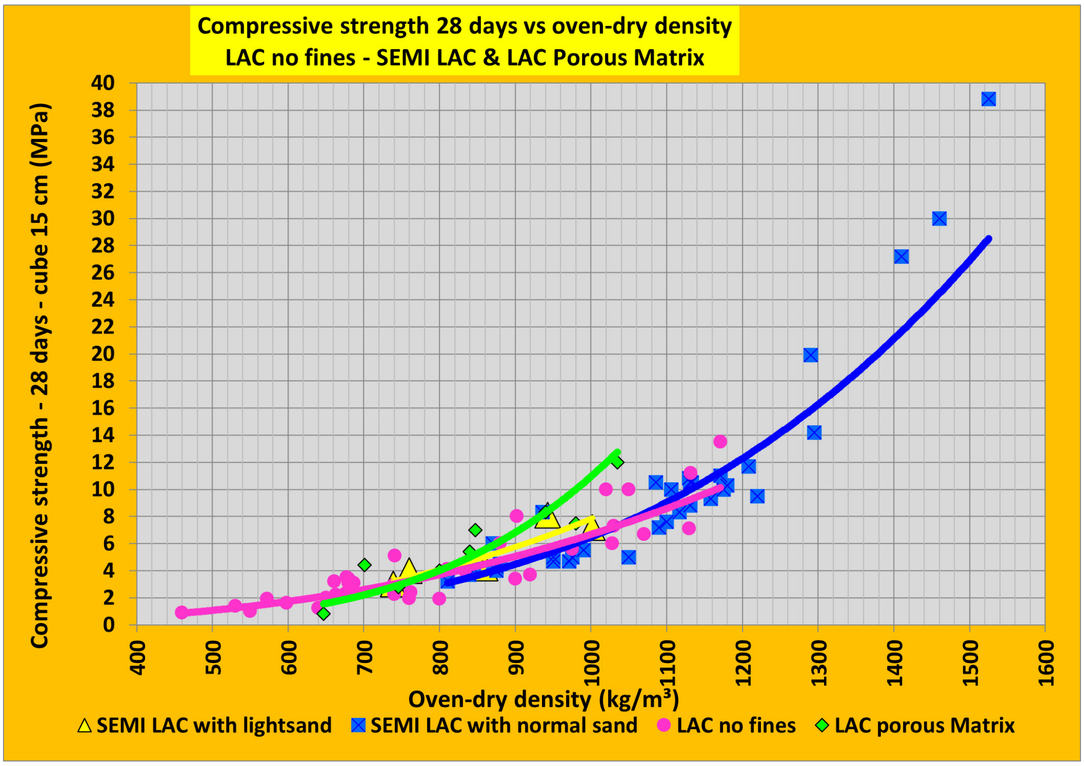
LAC with a porous matrix filling the open pore structure

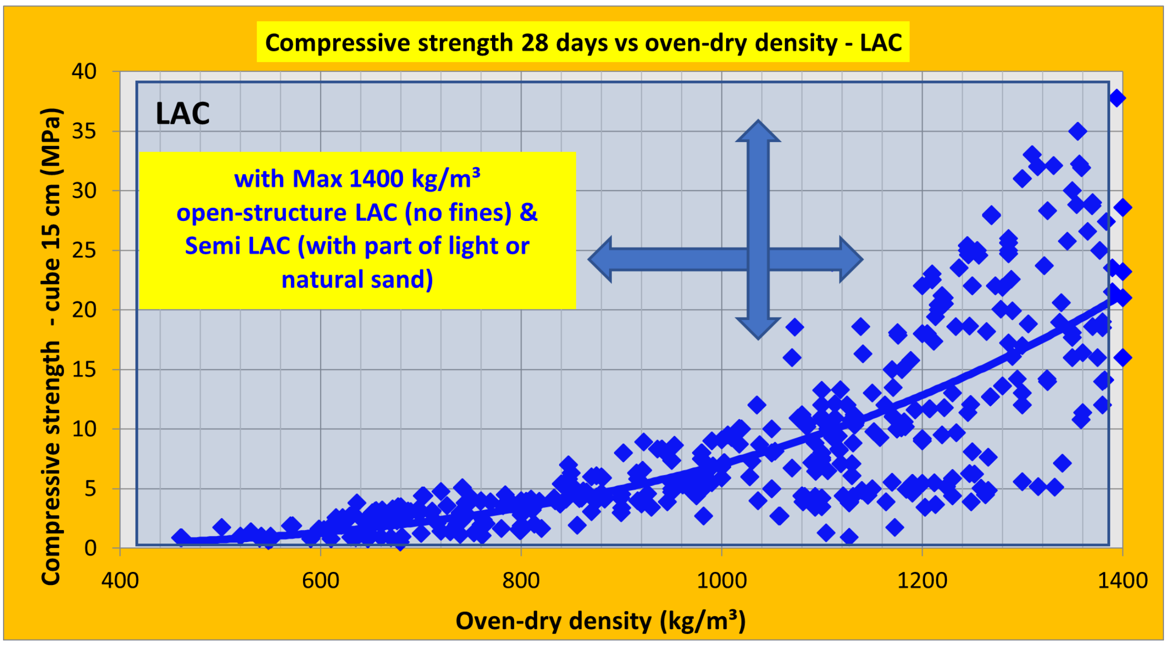
Density class	0,5	0,6	0,7	0,8	0,9	1	1,2	1,4	1,6	1,8	2
Mean dry density (kg/m³)	≥ 400	> 500	> 600	> 700	> 800	> 900	> 1 000	> 1 200	> 1 400	> 1 600	> 1 800
	≤ 500	≤ 600	≤ 700	≤ 800	≤ 900	≤ 1 000	≤ 1200	≤ 1 400	≤ 1 600	≤ 1 800	≤ 2 000

Strength class	LAC 2	LAC 4	LAC 6	LAC 8	LAC 10	LAC 12	LAC 15	LAC 20	LAC 25
f_{ck}	2	4	6	8	10	12	15	20	25
$f_{c,3}$ [a]	≥ 4	≥ 7	≥ 9	≥ 11	≥ 13	≥ 15	≥ 18	≥ 24	≥ 29

[a] Required mean compressive strength of each test set of three consecutive specimens. Strength in MPa.

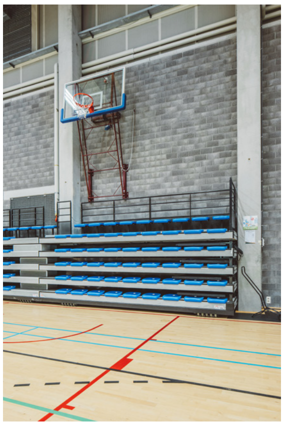
Typical correlation of the three different types of LAC : 100% no fines LAC, LAC porous matrix and Semi LAC (partly filled with light or normal sand):





Lightfillings with LAC for pathways or roads

Masonry blocks (semi LAC)



Lintels & precast walls (semi LAC)

4. ARGEX LIGHTWEIGHT CONCRETE CLOSED STRUCTURE (LC)

Lightweight | High compressive strength vs. low density |

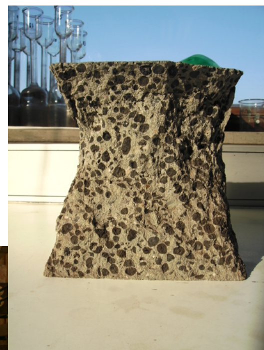
Structural applications (precast, readymix,...)

Structural lightweight concrete (LC) is covered as material in EN 206 and its application is regulated in EN 1992. Minimum strength class is LC8/9 referring to a characteristic cylinder strength of 8 MPa and a characteristic cube strength of 9 MPa.
The design standard requests a minimum strength class of LC12/13. LC has an oven dry density of 800 ≥ ρd ≤ 2000 kg/m3. The density range is divided into density classes with a span of 200 kg/m3.
For prestressed precast concrete products, the minimum strength class of LC shall be LC 16/18, unless the manufacturer can provide technical evidence that the strength class can be lowered.

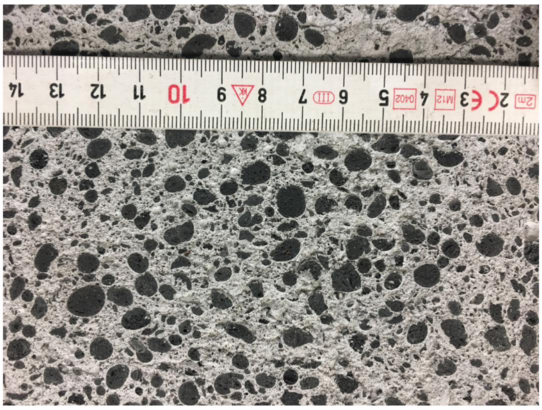
Compressive strength class	Minimum characteristic cylinder strength $f_{ck,cyl}$ (N/mm²)	Minimum characteristic cube strength $f_{ck,cube}$ (N/mm²)
LC 8/9	8	9
LC 12/13	12	13
LC 16/18	16	18
LC 20/22	20	22
LC 25/28	25	28
LC 30/33	30	33
LC 35/38	35	38
LC 40/44	40	44
LC 45/50	45	50
LC 50/55	50	55
LC 55/60	55	60
LC 60/66	60	66
LC 70/77	70	77
LC 80/88	80	88

A free and unrestricted combination of strength and density classes is possible. However, the figure below shows that specific LC strength classes require certain density classes (D) for a proper definition. Compared to other types of lightweight concrete, LC has a dense cement matrix and its surface can hardly be distinguished from normal weight concrete (NC).

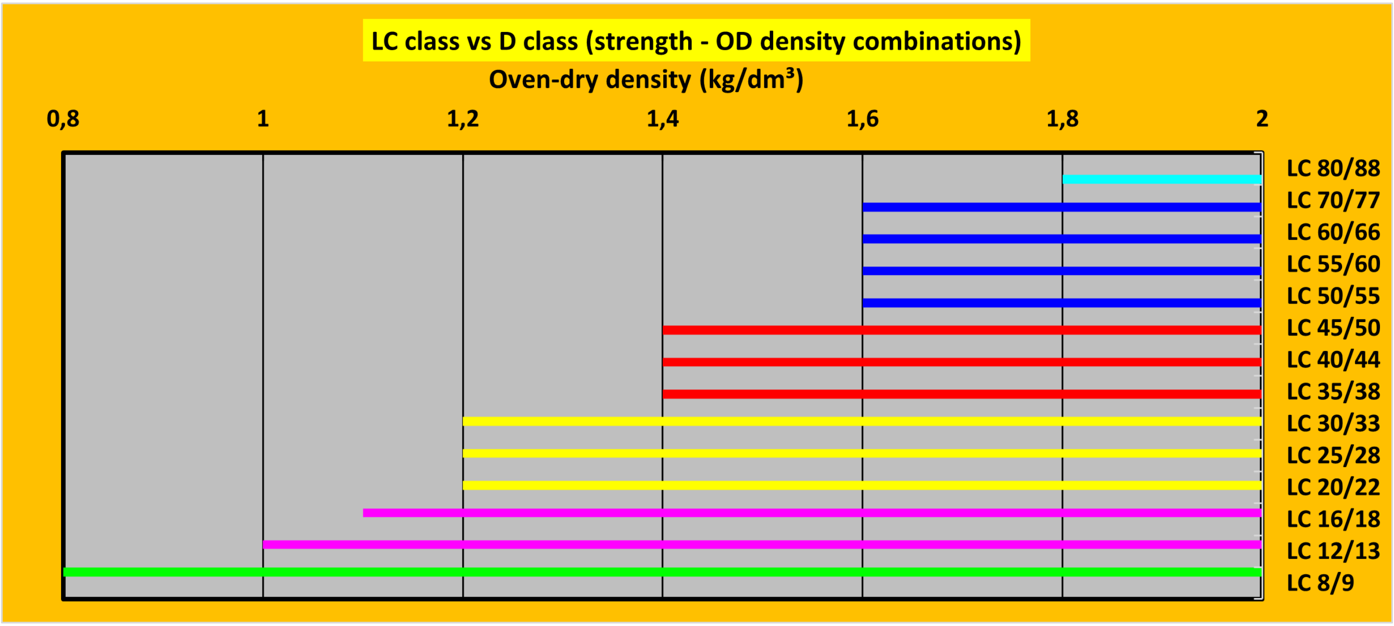
Density class	D 1,0	D 1,2	D 1,4	D 1,6	D 1,8	D 2
Oven-dry density (kg/m³)	≥ 800	> 1 000	> 1 200	> 1 400	> 1 600	> 1 800
	≤ 1 000	≤ 1200	≤ 1 400	≤ 1 600	≤ 1 800	≤ 2 000



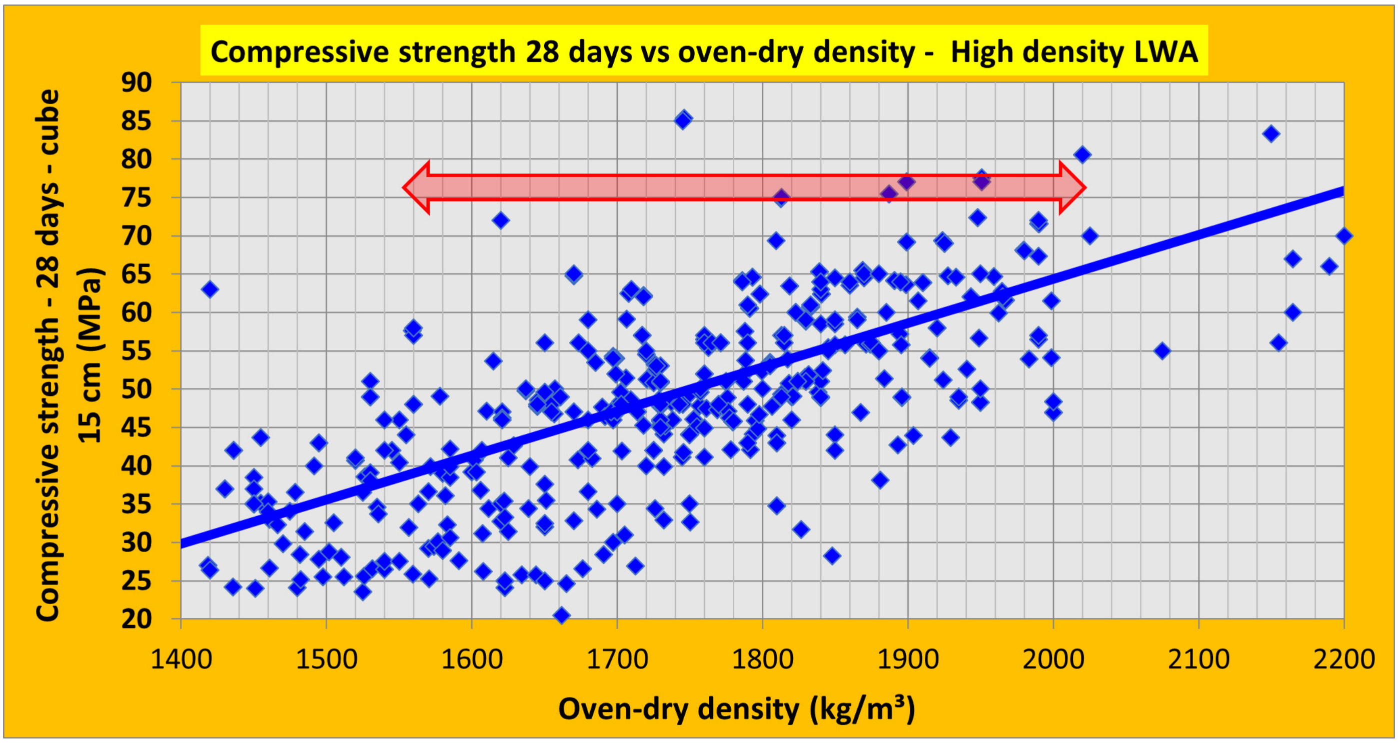
External surface of dense LC and example of internal matrix based on Ligthweight aggregates & sand:



Density-compressive strength classes combinations:

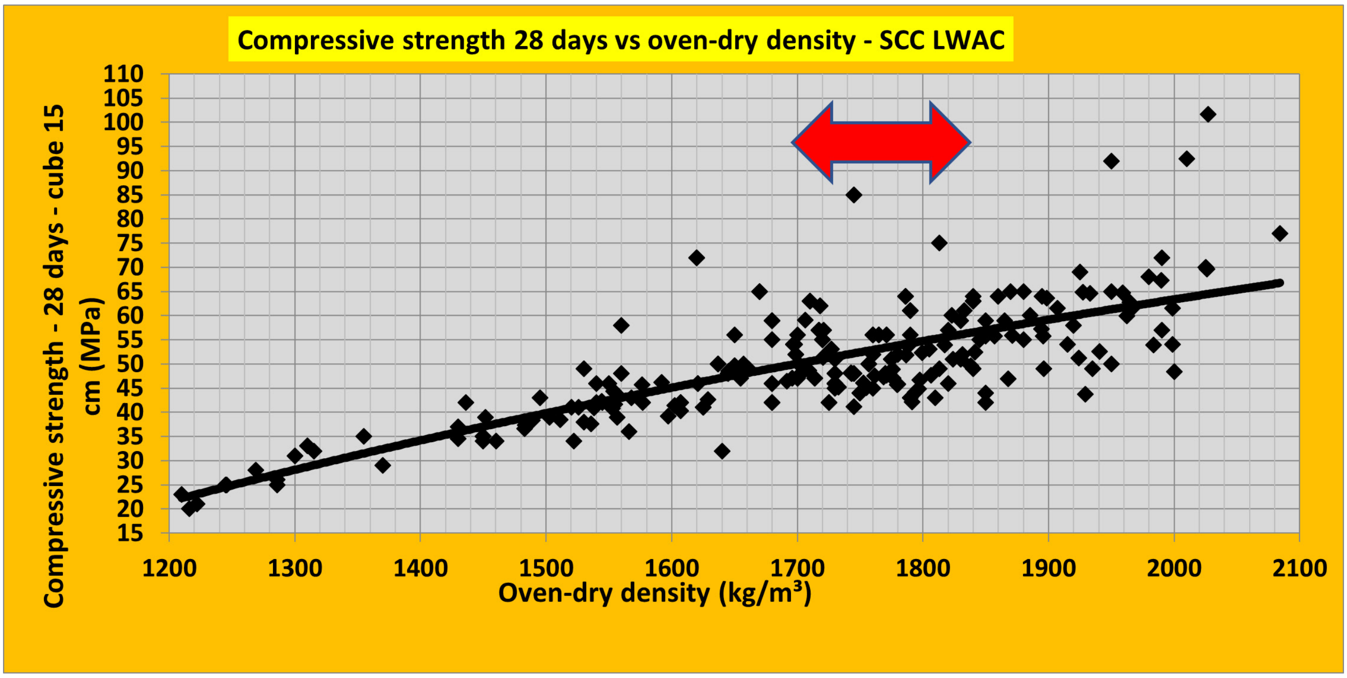


Correlation density-compressive strength with high density Argex AM4/8-700:

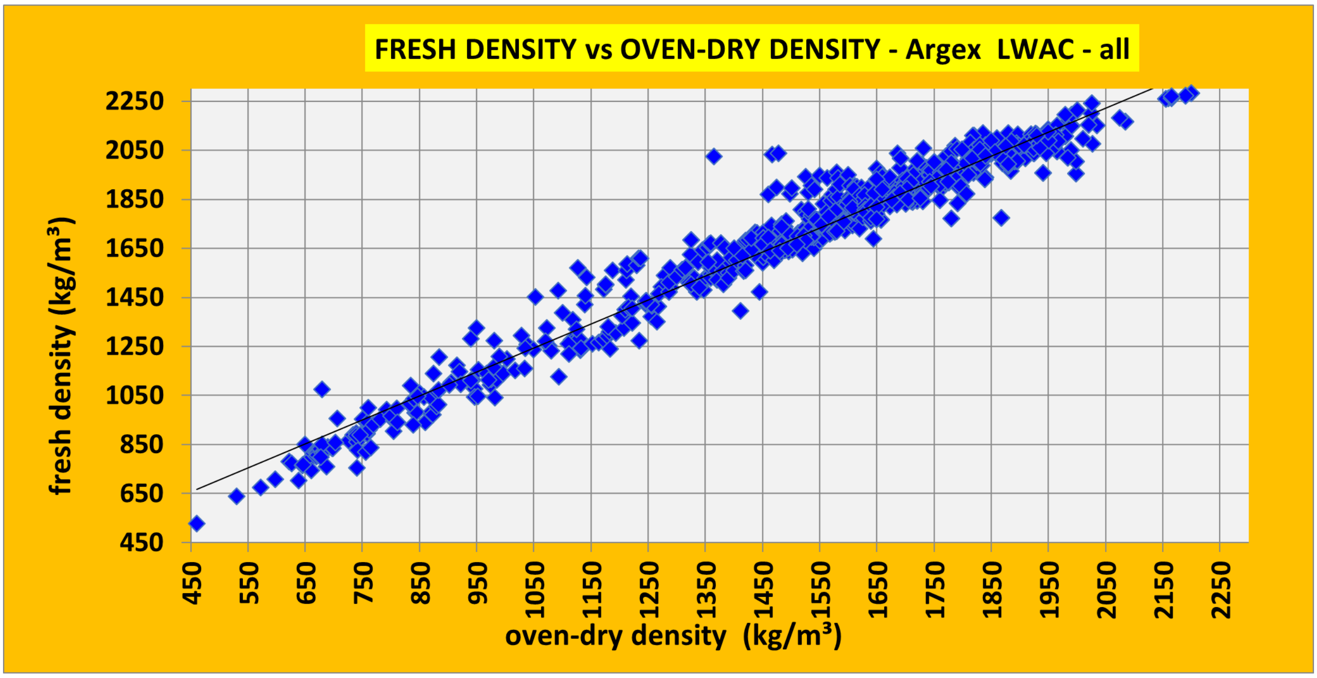


LC has an oven dry density of 800 ≥ ρd ≤ 2000 kg/m3 as showed in the EN 206 density classes table. Meaning any project focused on fresh or plastic density target must take into account this information only used as specification vs EN 206. Argex could help and provide the mix design based on fresh or plastic density as well.

Correlation density-compressive strength Argex SCC (with or without light sand):

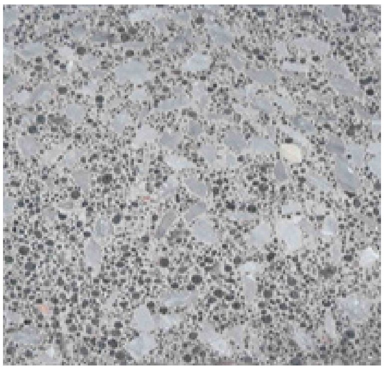


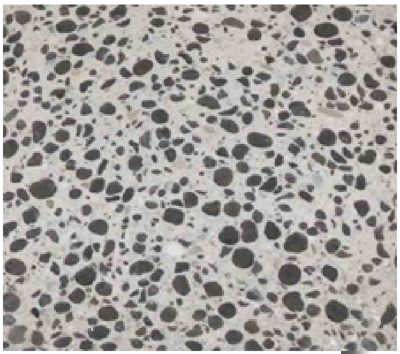
Typical correlation oven dry density vs fresh density for LC and LAC:



Normal Aggregate

Most LC use a combination of lightweight coarse aggregate and normal weight sand. The decision depends among others on the requirements regarding specified strength and density, thermal conductivity etc. The quality and availability of LWA gradings are further factors that influence the optimum ratio of normal weight aggregate and LWA.





Matrix with normal coarse aggregates & Argex light sand, coarse & light sand Argex and Argex coarse aggregates & normal sand

Binder Materials

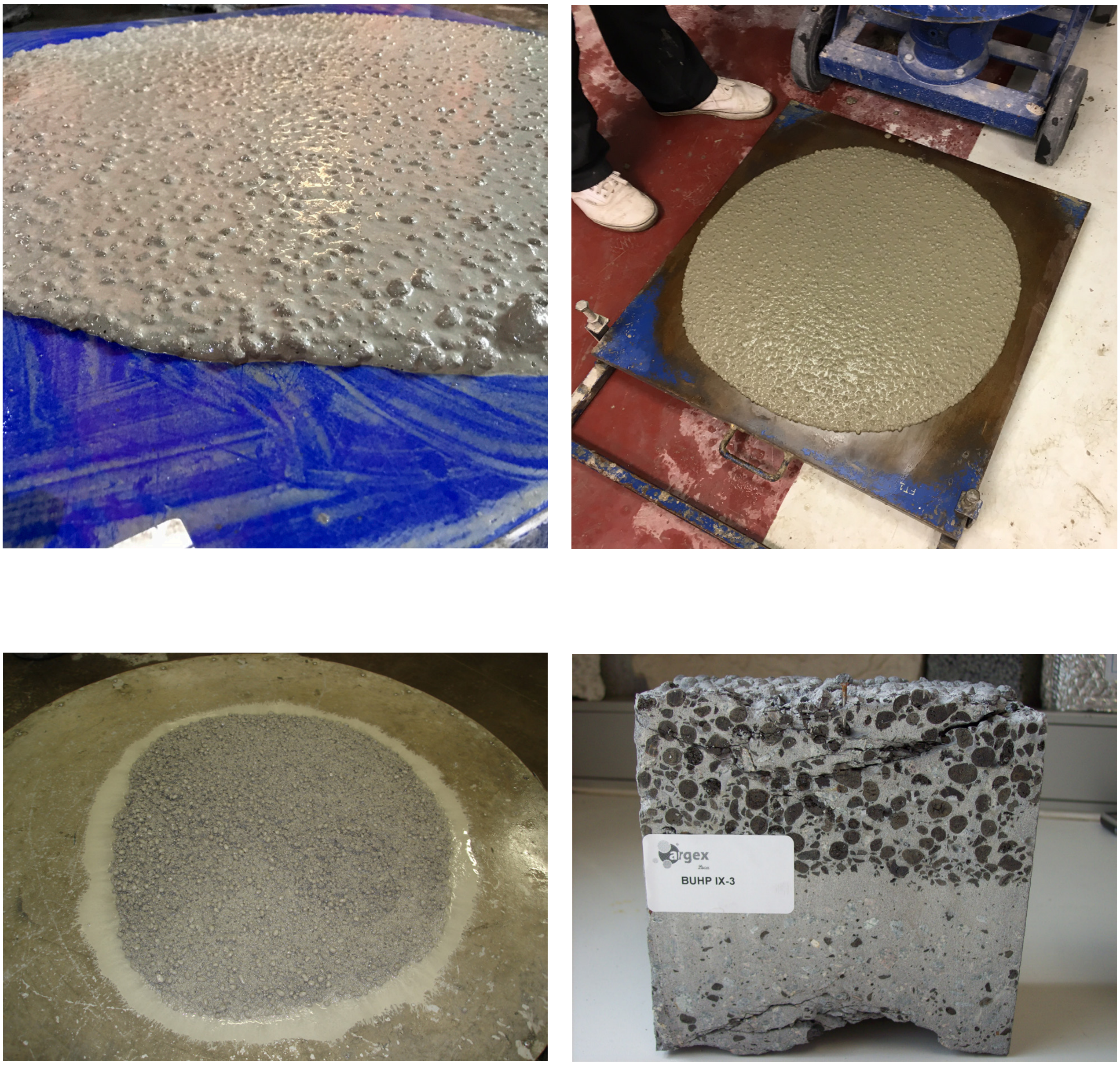
LC can be produced with any cement available. For LC made with LWA it is recommended to use a cement with a modest specific heat release, like blast furnace cement, or cements in combination with fly ash, calcined clay, granulated blast furnace slag or limestone filler. These LC have a low thermal conductivity which could lead to high temperatures in the core of the construction element during hydration.

Water

Any kind of water used in normal concrete production can be used for LC as well. This includes recycling water.

Admixtures

Any admixture used in normal concrete production can be used for LC as well. The compatibility with the binder and LWA used should be checked beforehand, as for NC. This holds especially for LWA that may have different surface charges compared to normal weight aggregate. Initially dry or only prewetted LWA will absorb parts of liquid admixtures if these are added too early to the mix. In some cases **(SCC version or Pumping version – see Pumpmix Brochure)** Argex recommends the use of presaturated Argex aggregates to avoid absorption of the admixtures into the LWA. The use of Stabilizer is highly recommended for S5 or SCC flow. In order to prevent too sticky LC, the ideal dosage is around 0.1% on cement (liquid stabilizer) or 500 to 1000 gr of powder stabilizer.



Examples of segregation of fresh concrete (bleeding) and of hard concrete.

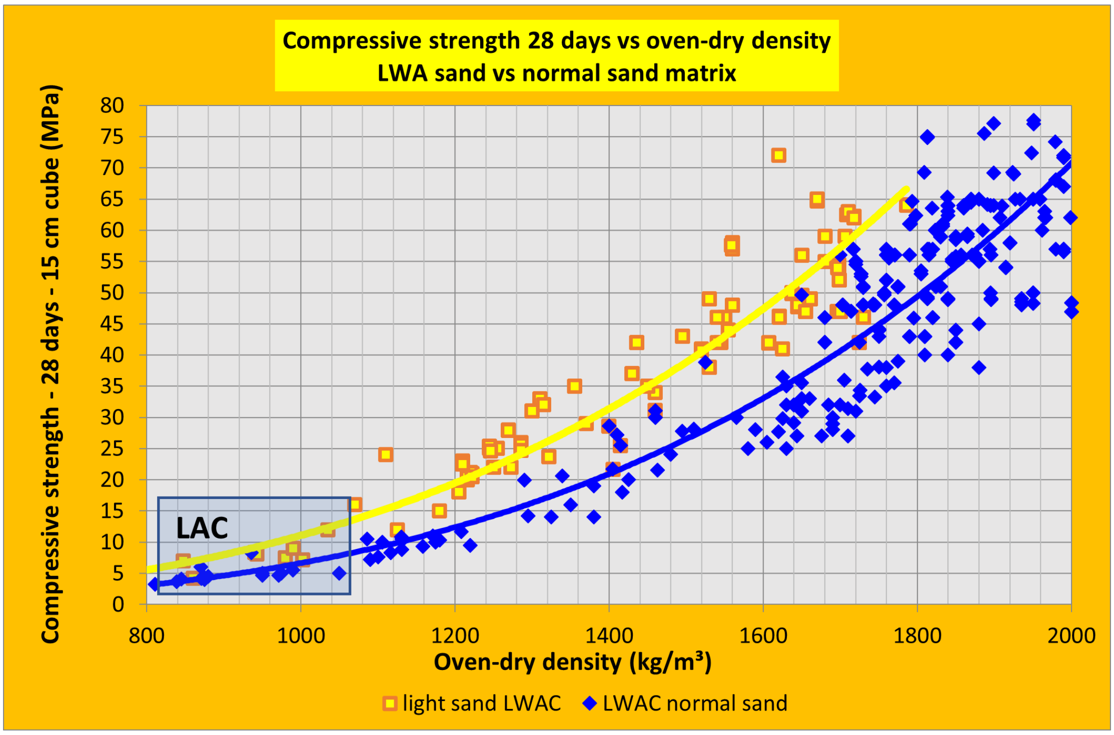
No segregation thanks to the well mix design (concrete grading etc) as the use of stabilizer.

There is a relevant test of segregation control in accordance with EUROLIGHTCON BE96-3942/R21-June 2000. The test principle is based on measuring the density of the upper and lower part of a specimen of LCSCC. A possible segregation of LWA will then lead to a reduced density of the upper section of the specimen due to the tendency of the aggregate to float in the more dense matrix material. The “segregation index”, SI is defined as the density of concrete from the top divided by the density of the concrete from the bottom layer. For LC, the index is [1 ± 0.05] if no segregation is occurred.

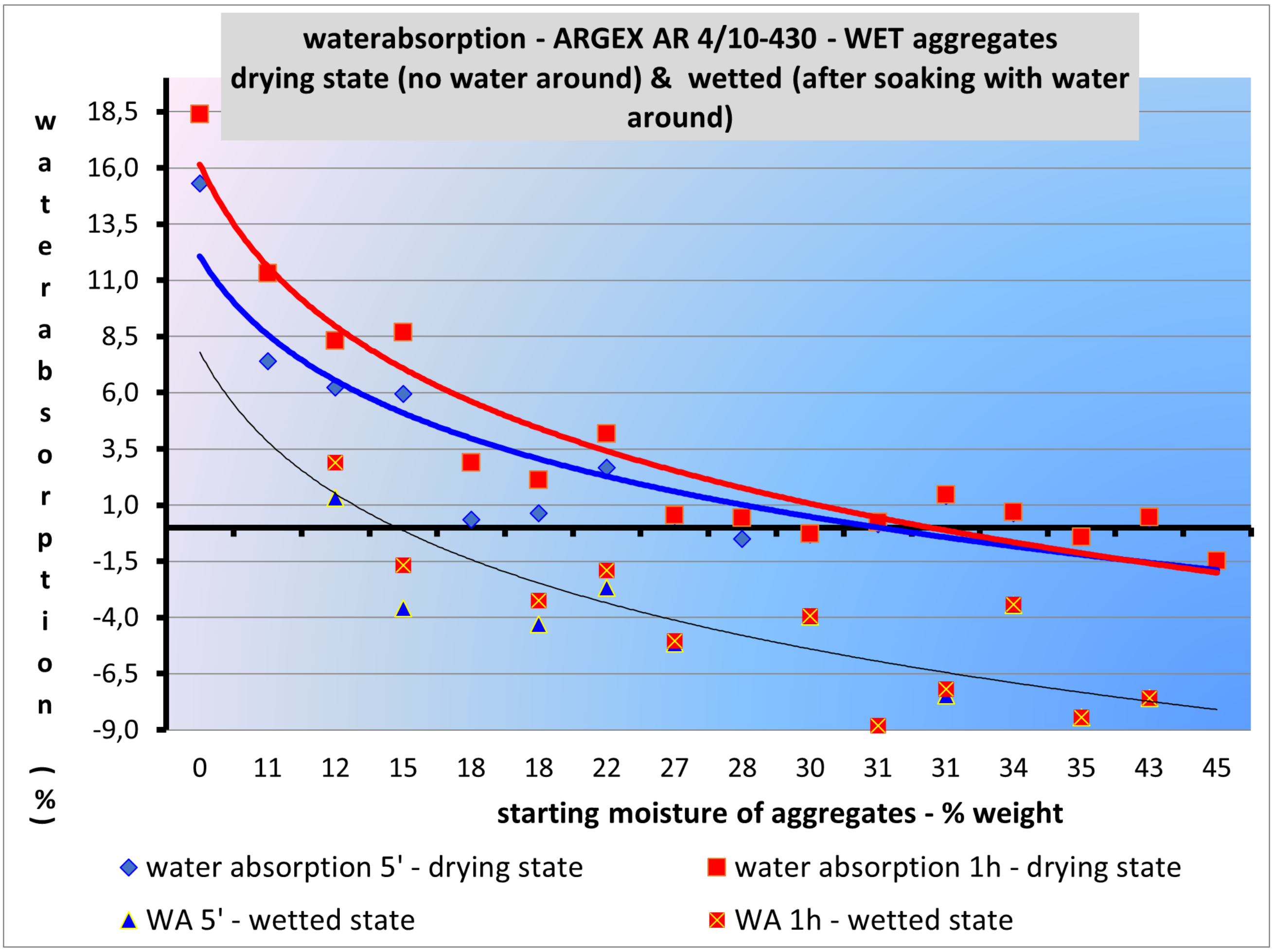
Mix Design of LC

The mix design for LC differs fundamentally from NC due to the dominant impact of the LWA used. Proportioning of LC must consider the boundary conditions like strength, density and durability, but also takes into account the casting situation and equipment. When designing for a certain strength, a coarse LWA must be selected which has sufficient strength capacity. Argex Technical could support with the mix designs for any project.

The strength of selected coarse LWA sets the ceiling for the LC strength. The threshold above which the LWA is decisive and the strength of the matrix becomes a secondary factor for the potential LC strength is called strength limit. Above this strength limit, binder content and water to binder ratio play a secondary role in LC. However, they also determine the durability properties of LC and thus have to be chosen properly. The type of sand has a major impact on thermal conductivity and on oven-dry dernsity (by 200 kg/m³ or more when the Argex lightweight sand is replacing totally or partly the normal sand – see below typical correlation); and maintaining the compressive strength too.



Mix design of LC should always disclose the water added to account for the water absorption of the LWA. The w1h value indicates the water absorbed by coarse LWA within 1 hour and is a common parameter in practice. This experimental value, however, does not respect the actual moisture stage of the coarse LWA, which in turn has an impact on the effective water absorption. Fot that reason Argex could provide the water absorption of coarse aggregates at the as-used moisture state instead of the oven-dry state as requested by the EN 1097-6 (see below). It is even more important to account for the high water absorption of fines LWA. Argex proposal related to this topic is to consider 75% of the water absorption (w1h) of coarse aggregates and 75% of the water absorption (w5') of fines measured according to EN 1097-6 (reduced % due to the cement paste replacing pure water).



When water after soaking for instance is still present, the amount of free water around the aggregates must be taken into account (till 2-6% of wet weight).
Any mix design for LC must be given in dm³/m³ based on volumetric share of the constituents. The weight is an inaccurate measure for LC. Nevertheless, this weight information shall be provided together with the particle densities used in the mix design. By doing so, the air void content must be given as well. Measurements of the air void content following ASTM C 173 must always be double-checked considering the yield and the fresh density achieved.

Mixing and Delivery of LC

The dosage of the LWA should be volumetric wherever possible. Since in most concrete plants gravimetric weighing is available only, the moisture content and absorption of the LWA as well as their loose bulk density must be checked at appropriate intervals and changes taken into account to adjust the dosing. All other components are measured as usual.

During mixing, the LWA are ideally filled in first. Up to two thirds of the required mixing water and the water compensating the absorption are added to the running mixer and mixed in for about 30 seconds. This is particularly important when Argex sand is used. Next, the powders and sand is given into the mixer, followed by the remaining mixing water. Admixtures should be added as late as possible and in the best case with the remaining mixing water to prevent uncontrollable absorption into LWA (for SCC or high flow LC, we recommend to fix the stabilizer for instance 0.1%, then adjust the Superplasticizer vs the required flow).

The minimum mixing time of LC, after the addition of all constituents, should be prolonged from a range of 30 to 60 s, compared to NC.
Structural lightweight concrete is preferably produced in a compulsory mixer. If possible, the mixer blades should have a plastic lining in order to avoid unnecessary crushing of the LWA, especially in the case of very light LWA. Workability will be reduced due to the higher water absorption of the crushed LWA.
The fresh LC should be checked for unit weight and yield. One option is the comparison of the fresh density with the density in the mix design.

As a result of the water absorption of the lightweight aggregates, the duration of transport and placing has a greater impact on the workability of LC.

Placing and Handling of LC

LC does require the same placing techniques as used for NC. The pumping of LC is common practice thanks to the use of water-saturated LWA and adapted mix designs – see Argex Pumpmix brochure. The main issue is still the maintaining of homogeneous LC thanks to the right mix design (grading etc) and the use or not of the Stabilizer admix.


argex
PROUD MEMBER OF THE H2O GROUP

Argex **granules** are lightweight aggregates made from Boom clay. They have a high **insulation capacity** and are non-combustible. Thanks to their light weight, they are very easily processable. Moreover, these sustainable granules are **environmentally friendly.**

PUMPMIX
PUMPABLE ARGEX CONCRETE

TYPES

PUMPMIX L
"Light"
D 1.2 - 10 N/mm²
D 1.4 - LC12/13
D 1.6 - LC20/22

PUMPMIX S
"Structural"
D 1.8 - LC30/33 to LC40/44
D 2.0 - LC35/38 to LC45/50

60 London Wall (UK)
M7 London Stratford (UK)
Hybride bridge SNCF Béthune (FR)
Martin's Patershof - Mechelen (BE)

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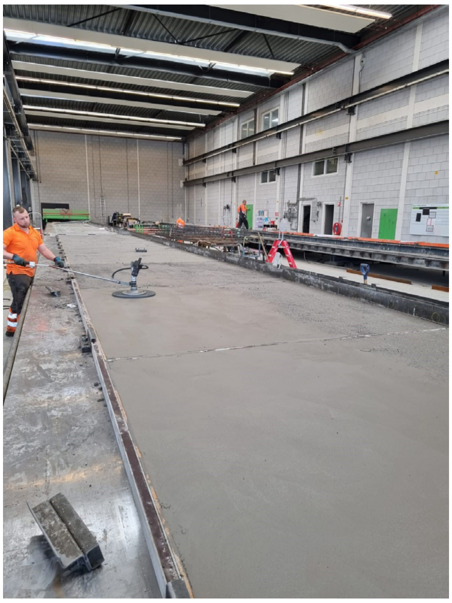
The air trapped in the pores of the LWA forces again the water out of the LWA. This often leads to segregation effects of the LC and can indicate pumping fails. Such behavior can even occur despite a previous, longer lasting (e.g., 24 h) water storage of the LWA. It can be remedied by specially adapted, almost self-compacting LC mix designs. A suitability test including a pumping test is always recommended before pumping on construction sites.

LC Applications

Precast wall elements (sandwich panels) with external fair-faced NC & LC inside - below example of finishing (polishing)



Precast wall elements for houses and complete house with LC roofs, floors & walls

Precast balconies

Precast beams & stairs

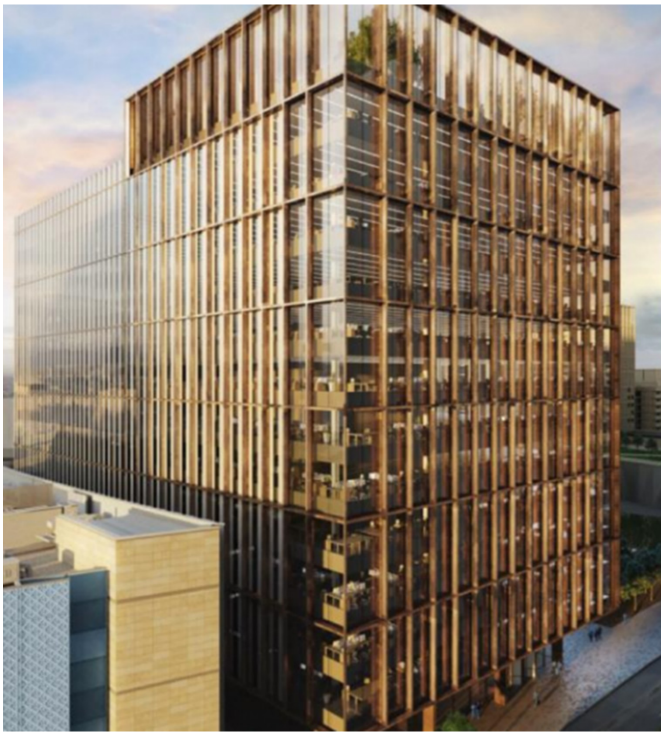
Precast lids & troughs

Precast fences & water tanks

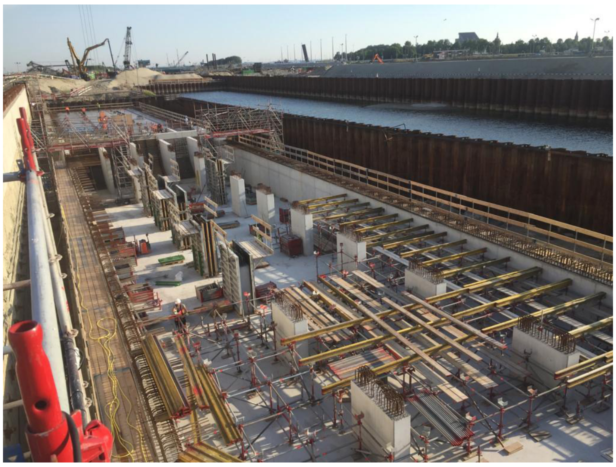
Bank Street London - Byrne - CEMEX - LC 30/33 D1,8 - steel deck

Composite bridge steel - FR/LUX - LC 35/38 - D1.8

M7 London - Stratford - Byrne - HANSON - LC 30/33 D1,8



NL - Terneuzen docks/sluice - De Rycke Beton - BAM/DEME - LC 35/38 D2.0



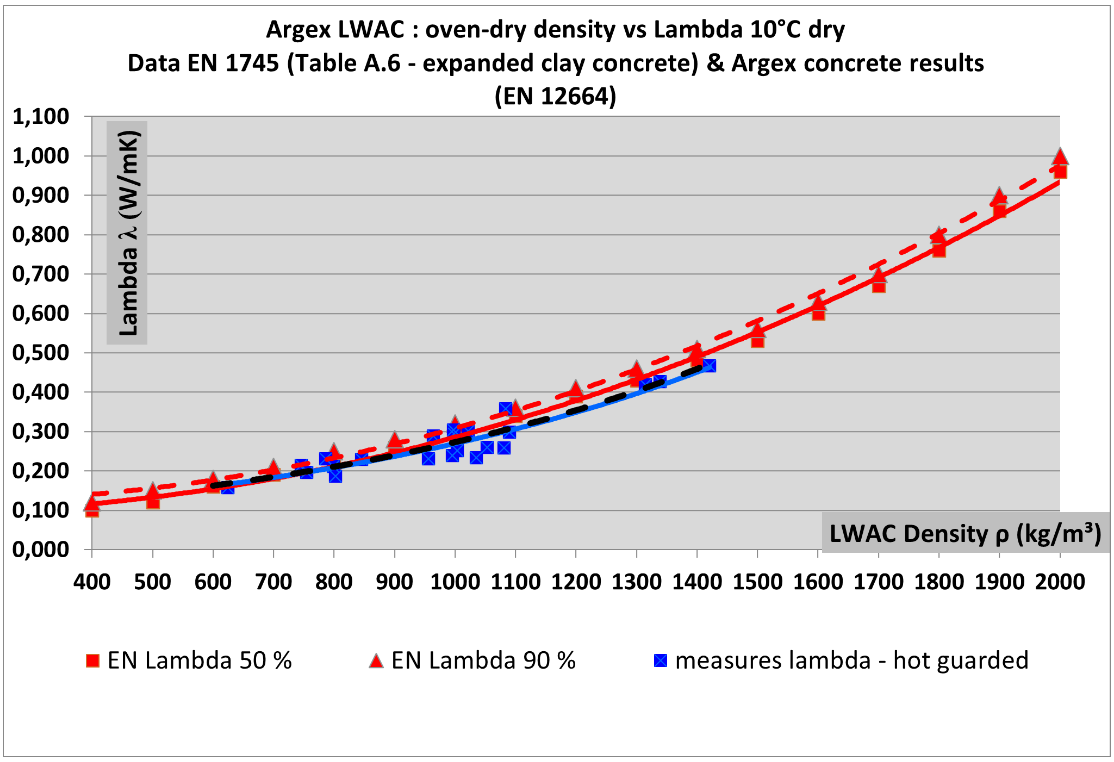
Royal Atlantis - The Palm - Dubai - LC 40/44 - D1.8

60 London Wall - City of London - Byrne - Tarmac

5. OTHER CHARACTERISTICS AND DURABILITY

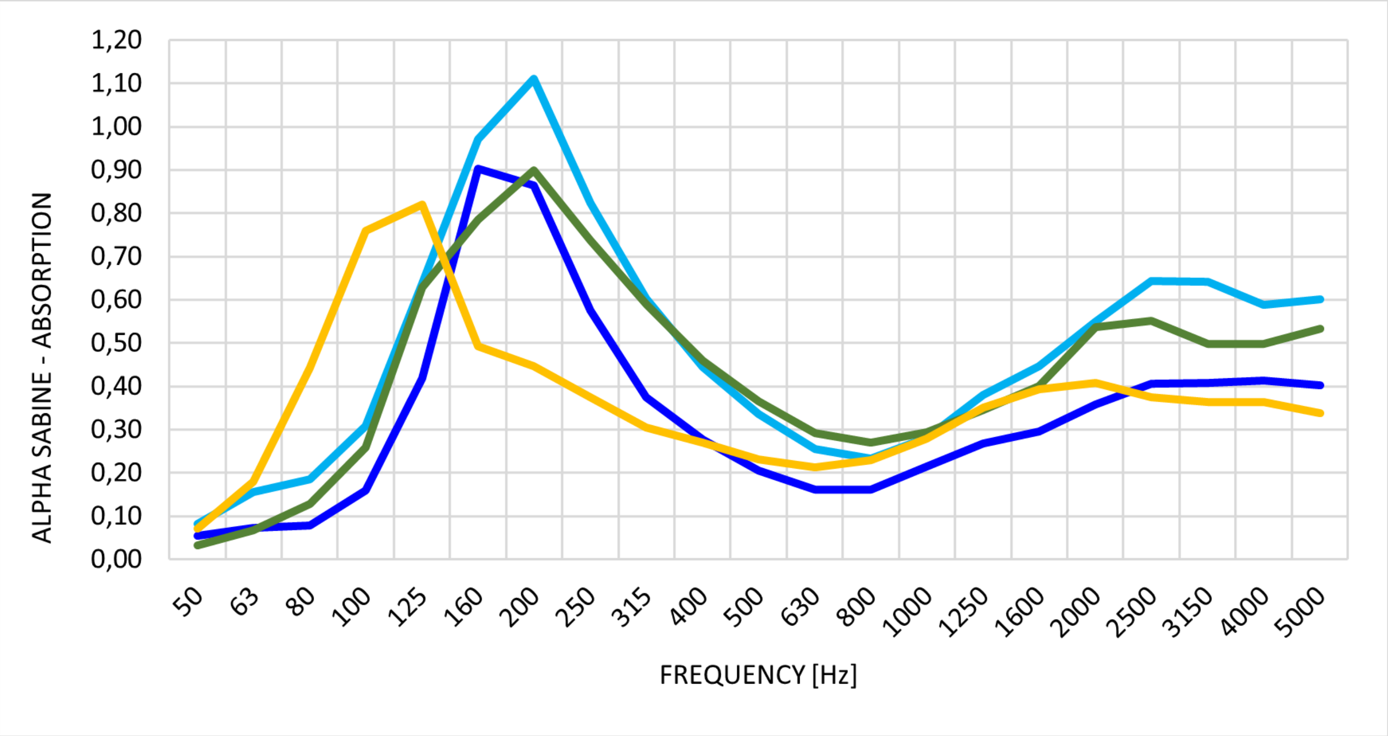
Thermal insulation

The presence of Argex in LAC/LC considerably lowers the coefficient of thermal conductivity: it is thanks to the air enclosed in the cellular texture of the clay pellet that heat transfer is considerably restricted in comparison with NC. Concrete with light aggregates is accordingly used worldwide to improve the thermal insulation of buildings. The coefficient of thermal conductivity λ (W/mK) is usually expressed in relation to the dry density of the LAC/LC. Below the typical correlation of λ10°C dry vs oven-dry density based on tabulated values (EN 1745) and on measurements in lab (EN 12664 Hot guarded plate):

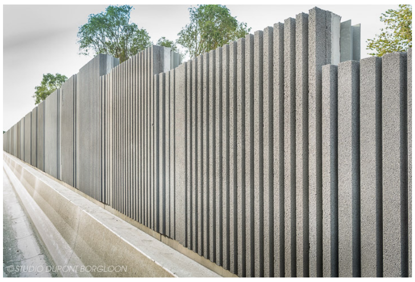


Acoustical comfort

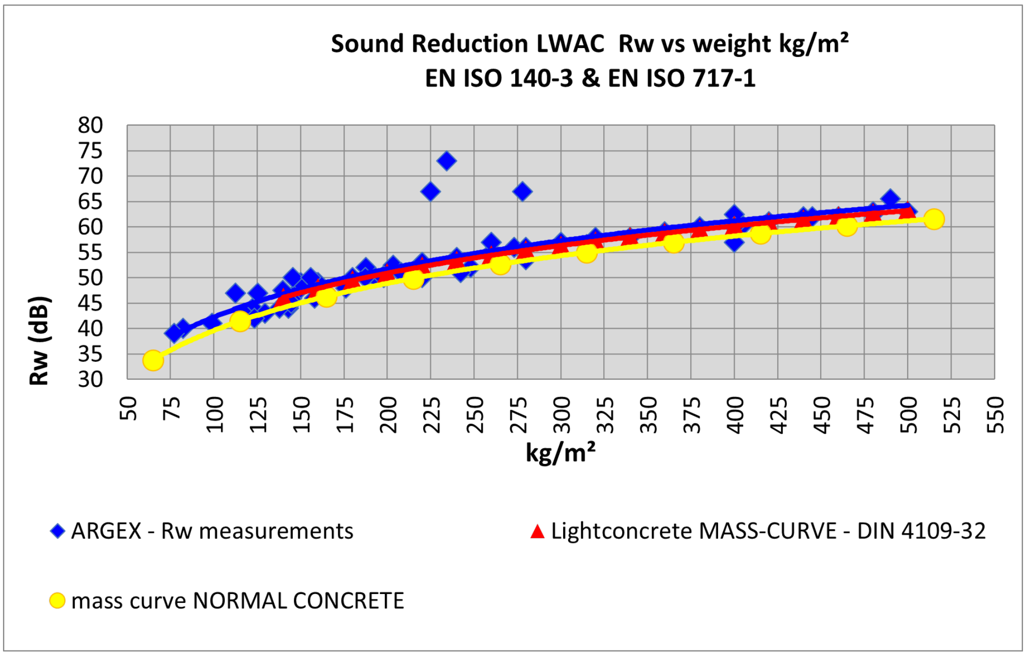
Thanks to the microporous internal structure of Argex aggregates, as well of the LAC itself (in accordance with the 100% LAC mix design using coarse Argex aggregates like 4/10 or 1/5 mm), the acoustical absorption is very important. The absorption is expressed by the Alpha Sabine (αs) parameter vs frequency and is based on acoustical measurements in lab as presented in the figure below for some Argex Climasono blocks with different texture (aggregate size) and thickness. One of the major applications is the noise barrier as showed with the pictures.



Noise barriers & blocks masonry



The second main acoustical characteristic is the insulation between two rooms. The sound insulation of a wall is measured using the attenuation index acoustic Rw: it indicates the difference in level sound between the emission room and the reception. Argex ClimaSono building blocks (or LAC/LC) insulate noise better than standard concrete blocks at the same weight/m² and this in spite of a reduced mass. ClimaSono blocks are an exception to the mass law, thanks to their structure microporous cell of Argex aggregates. Below the typical correlation of Rw index vs mass/m² (including plaster if any) showing better results than NC for the same weight/m² and nice correlation with the proposed mass law of LAC/LC in DIN 4109-32.



Fire resistance

LAC & LC concrete has better fire-resistance than NC. These higher values are attributable to its **low thermal conductivity** (lower temperature increase in the concrete), **low thermal expansion around 6 to 9 x10^{-6} 1/°C** (less stresses in the concrete and risk of cracking reduced), the **A1 reaction to fire class** (94/611/EC – incombustible) and its **lightness**. The **insulating property** of LAC/LC gives better protection to the concrete reinforcement than NC, so concrete units of a smaller size can be used (between 5 and 20% less depending on the required concrete density).

Some guidelines for high fire resistance, as well refractory LC or mortars are available on demand.

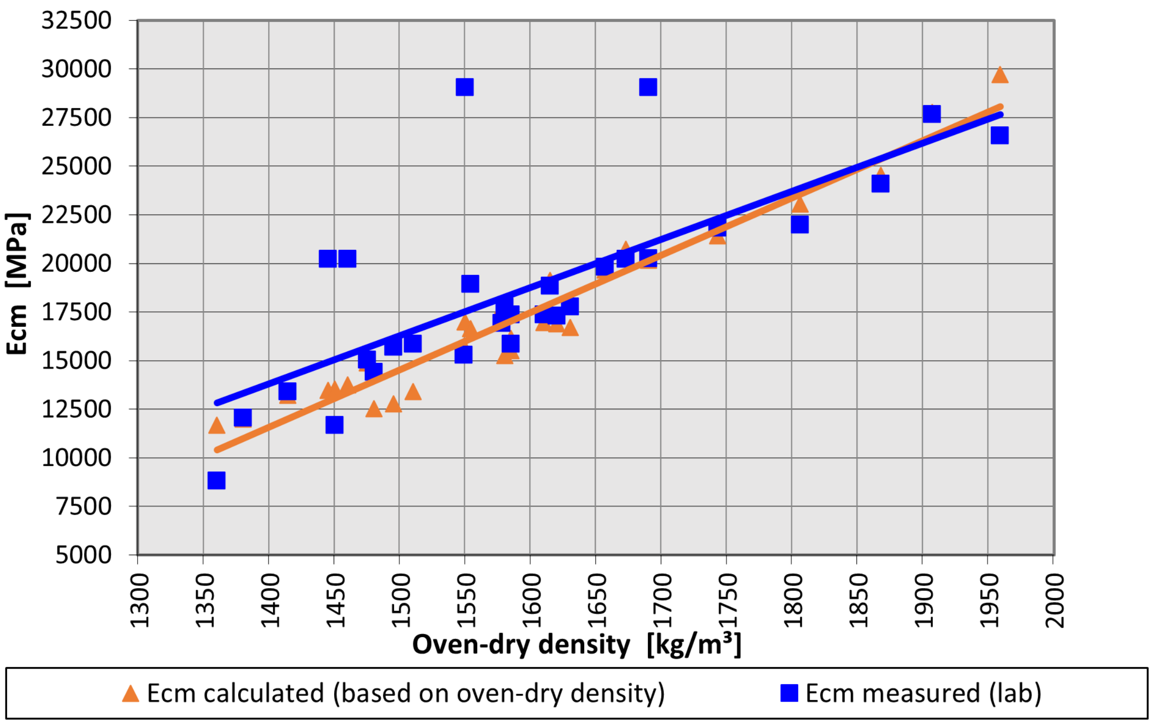
Mechanical characteristics

The mechanical characteristics can be either measured in the laboratory according to standardised methods, or calculated according to Eurocode 2 EN 1992-1-1 for LC or EN 1520 for LAC.

For instance the EN 1992-1-1 can be used for any LC design/calculations, as well calculations of characteristics like tensile strength, the elastic deformation, creep & shrinkage, the ultimate bond strength etc.

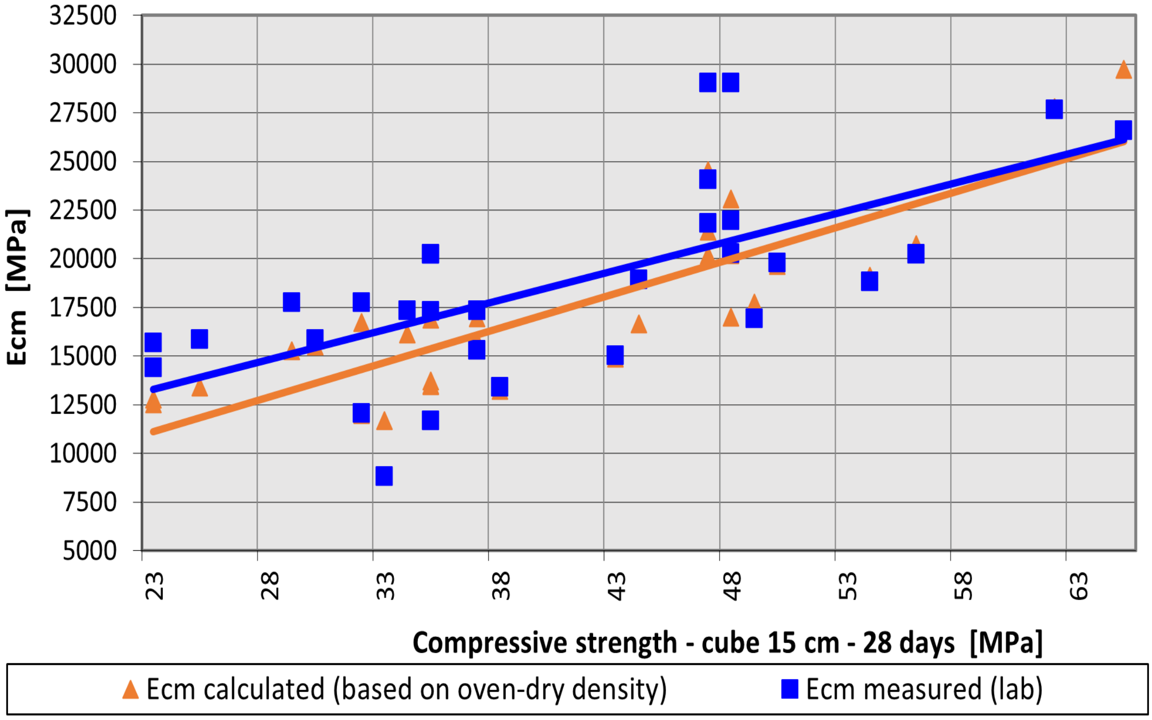
Some of them are given hereunder as indicative values of Argex LC's. Since the the range of oven-dry densities and of the compressive strengths is huge, as well their combinations; it is relevant to request the data or calculation for a specific project.

Elastic deformation (modulus) – calculated values & measured values vs oven-dry density:

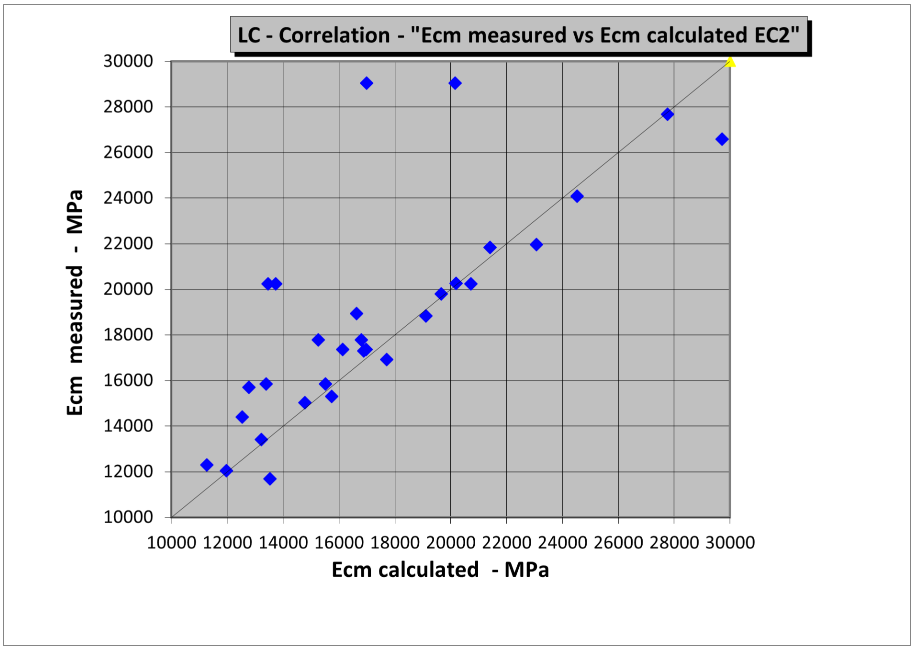


The correlation seems obvious and the calculations are quite closed to the measured values given some safety.

Elastic deformation (modulus) – calculated values & measured values vs compressive strength:



Elastic deformation (modulus) – calculated values & measured values : calculated value based on measured oven-density of samples used for the measurements.

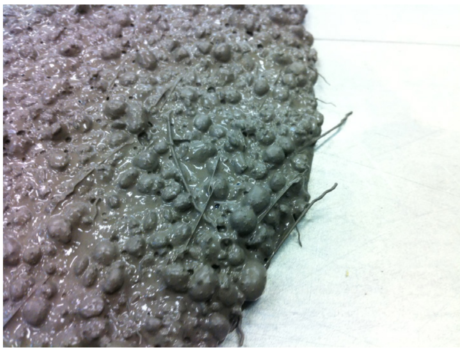


Tensile strength

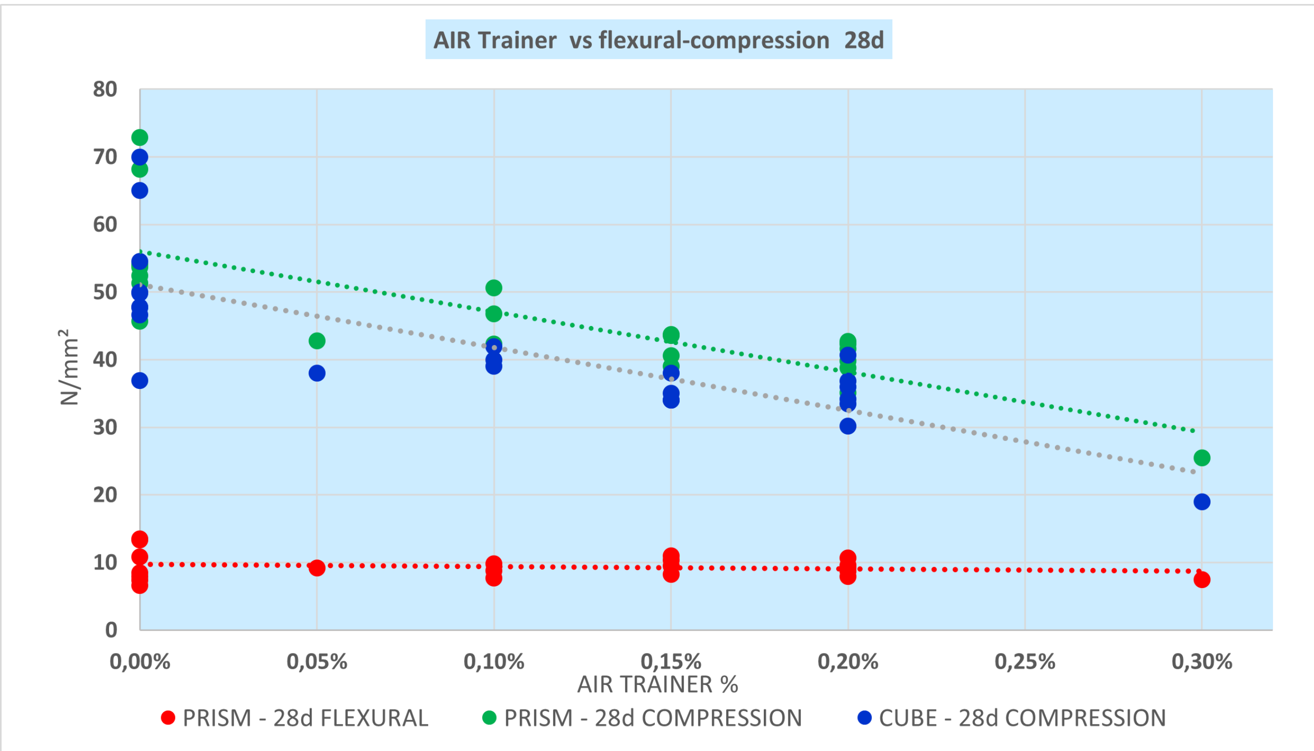
The ratio tensile strength/compressive strength is around 5 to 10% for a LC > 20 MPa compressive. Meaning fctm around **1 to 5 MPa**.

Flexural strength

The flexural strength is 3 to 6 times lower than the compressive strength. Typical values from **3 to 10 MPa** without fibers what will lead to better values. The use of fibers (steel or others) is possible in LC.

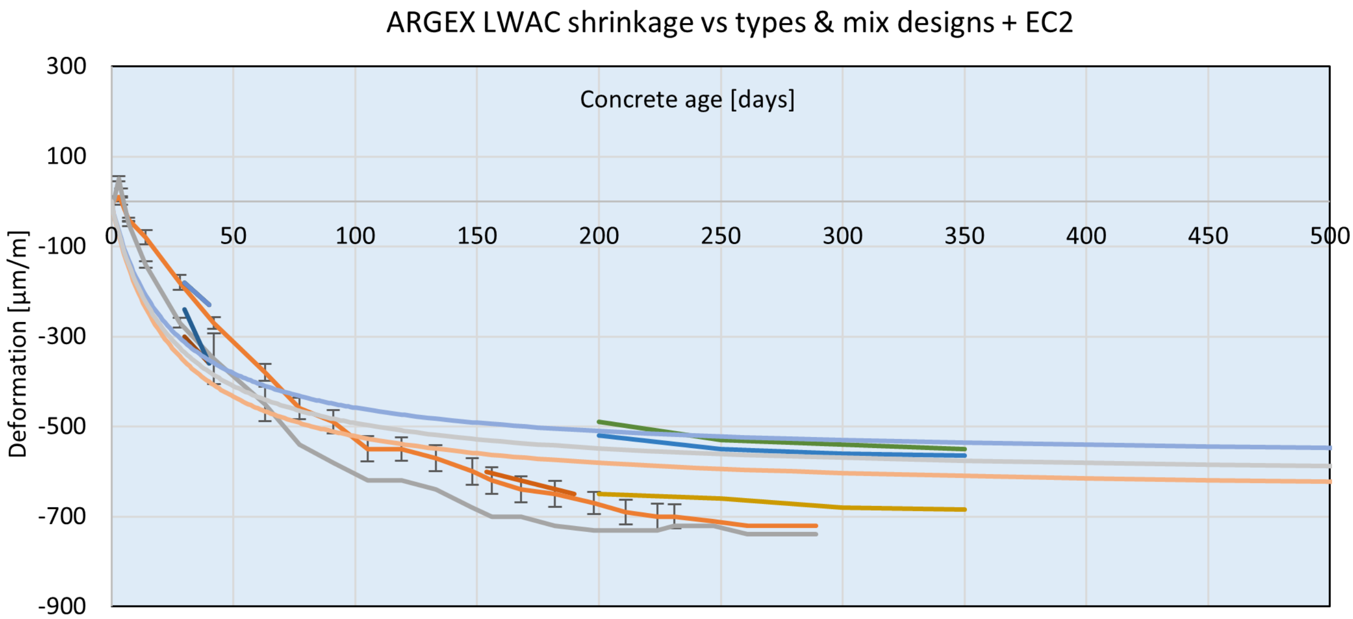


Interesting correlation showing little effects of air trainer on the flexural strength (4x4x16 prism) in comparison with the compressive strength:



Shrinkage

This characteristic could be calculated in accordance with the EN 1992-1-1 fixing parameters like relative moisture, cement type etc. Results based on measures are varying a lot due to the impact of mix design, cement type, total amount of powder, W/C, concrete grading etc. Below the figure shows typical variations of different LC's.



Autogenous shrinkage in High Strength Normal Concrete (with low W/C)

ACI says that "internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water."

>> Therefore internal curing is for curing concrete **from the inside out**.

>> Internal water is generally supplied via internal reservoirs such as **pre-saturated lightweight aggregates (LWA)**.

The benefits are not only the reducing of the autogenous shrinkage but also

- Improve cement hydration
- Important when supplementary cementitious materials (such as silica fume, fly ash, metakaolin, ..., as well as the fines of LWA) are included in the mixture
- Less stress concentration

Durability

The EN 206 and EN 1992-1-1 are covering the LC as well.

If the concrete is in conformity with the limiting values, the concrete in the structure is deemed to satisfy the durability requirements for the intended use in the specific environmental condition, provided:

- the appropriate exposure classes were selected;
- the concrete has the minimum cover to reinforcement in accordance with the relevant design standard required for the specific environmental condition, e.g. EN 1992-1-1;
- the concrete is properly placed, compacted and cured, e.g. in accordance with EN 13670 or other relevant standards;
- the appropriate maintenance is applied during the working life.

Environmental conditions
For LC the same indicative exposure classes can be used as for NC.

Concrete cover and properties of concrete
For LC the values of minimum concrete cover given in the Eurocode 2 shall be increased by 5 mm.

Data on freeze-thaw, carbonation, chloride diffusion etc are available on demand. LC present long term experiences from many decades, as well from the Pantheon to offshore structures in the seas.

6. NORMATIVE REFERENCES

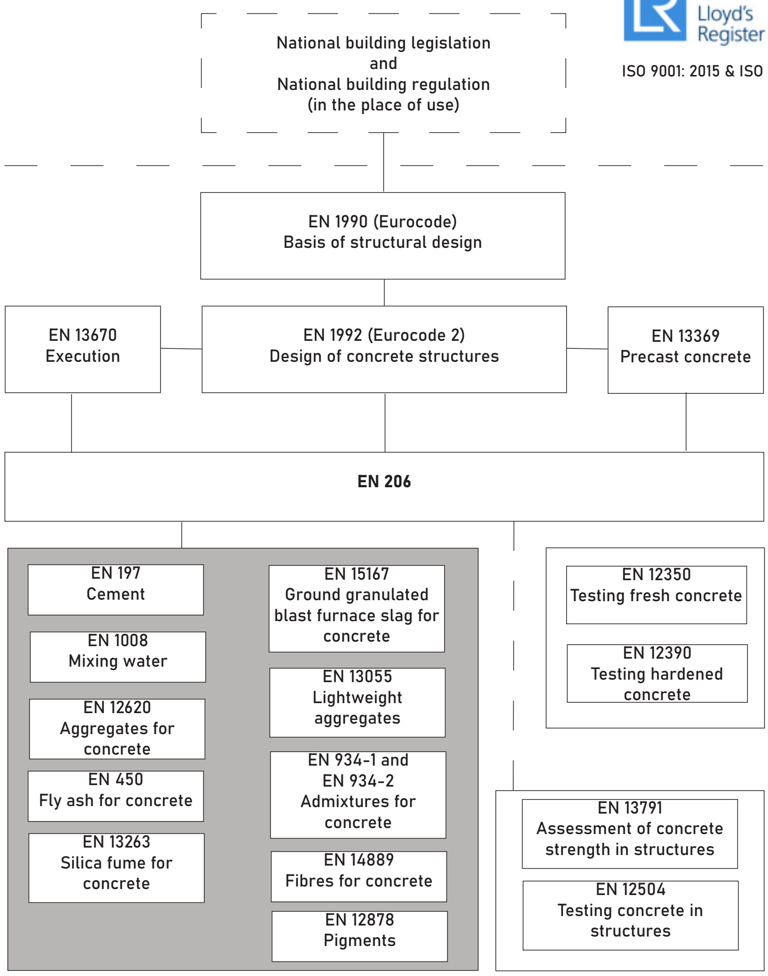
- EN 206 : Concrete - Specification, performances, production and conformity
- EN 1520 : Prefabricated reinforced components of lightweight aggregate concrete with open structure
- EN 1992-1-1 : Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
- EN 13369 : Common rules for precast concrete products. This standard is a common reference for all specific product standards (precast elements like stairs, wall elements etc covering LC too).
- EN 13670 : Execution of concrete structures
- Testing on fresh concrete: EN 12350-1 to -12
- ASTM C 173 «Standard test method for air content of freshly mixed concrete by the volumetric method»
- Testing on hardened concrete: EN 12390-1 to -7
- Test on segregation "EUROLIGHTCON BE96-3942/R21, June 2000"

Relation between standards:

ISO 9001: 2015 & ISO 14001: 2015

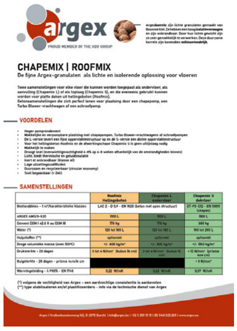
EN 13055

0965-CPR-GT0525



7. LINKS

- Chapemix/Roofmix brochure
- Pumpmix brochure
- Maxrete Premix Bags: www.maxrete.co.uk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CHAPEMIX | ROOFMIX
VOORDELEN
SAMENSTELLINGEN


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PUMPMIX
PUMPABLE ARGEX CONCRETE
TYPES
PUMPMIX L
"Light"
PUMPMIX S
"Structural"

argex Concrete

from 500 to 2000 kg/m³

from 1 to 90 N/mm²

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