Application of Lightweight Concrete

Karl-Christian Thienel, Univ.-Prof. Dr.-Ing.
Department of Civil Engineering and Environmental Sciences
Institute for Construction Materials
Bundeswehr University Munich
Werner-Heisenberg-Weg 39
85579 Neubiberg, Germany
e-mail: christian.thienel@unibw.de

ABSTRACT
A brief survey is given of various applications of structural lightweight concrete (LC) covering the entire range of densities.

Keywords: Lightweight concrete, LC, self-compacting lightweight concrete, SCLC, infra-lightweight concrete, ILC, lightweight aggregate, LWA, thermal conductivity; lightweight sand.

1 COMBINATIONS OF STRENGTH AND DENSITIY CLASSES OF LIGHTWEIGHT CONCRETE

Structural lightweight concrete (LC) is a very versatile material due to the combination of sufficient strength with a minimum of structural weight. Depending on the intended use the focus is either primarily on load bearing capacity and a corresponding minimum density as it is the case e. g. for bridges or offshore structures. On the other hand the focus is on reducing the thermal conductivity of LC while providing only a necessary minimum strength as for instance in the case of external fair faced concrete walls for private houses. Irrespective of the intended use both, strength and density are somewhat connected and need to be considered in equal measure. Fig. 1 gives an impression of the correlation between strength classes for LC and the necessary dry density according EN 206 [1].

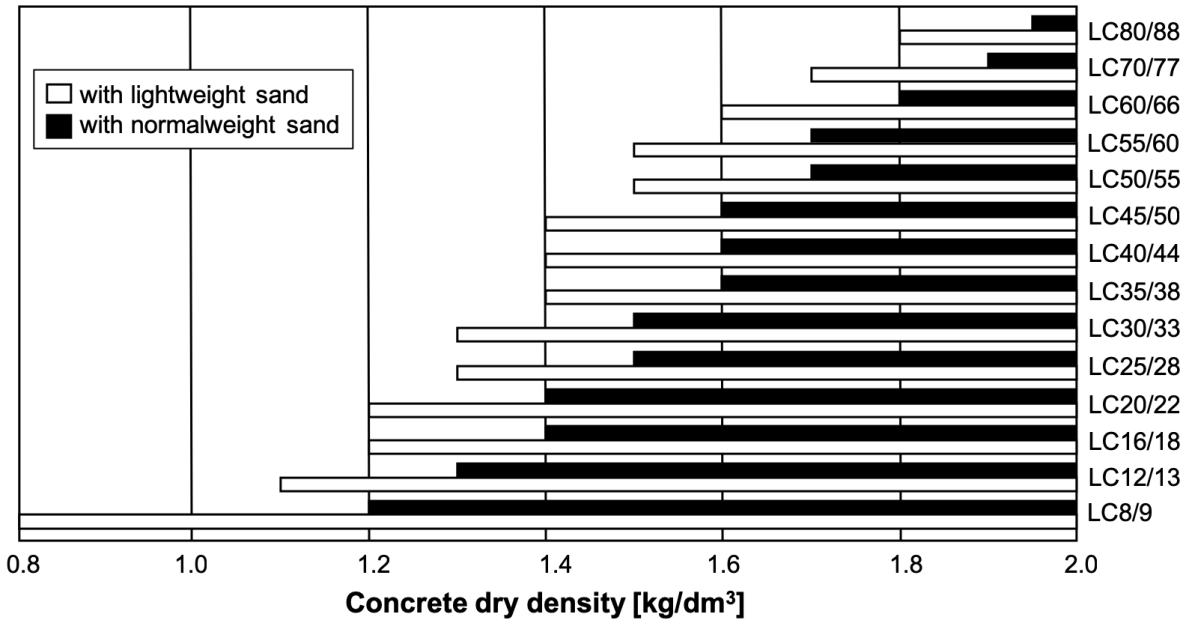

Figure 1 – Correlation between strength classes and necessary dry density for LC. Based on [2]

2 CLASSIFICATION OF APPLICATION AREAS FOR LIGHTWEIGHT CONCRETE

Lightweight concrete for structural applications is often made with normalweight sand. The density exceeds in most cases 1.4 kg/dm^3. Thus far only a few projects have been made with self-compacting lightweight concrete (SCLC). Three different application and synergetic areas exist for light and very light concrete made with lightweight sand. They depend mainly on the combination of required compressive strength and thermal conductivity needed in order to adapt to the building physics requirements [3].

- Highly stressed facades of office buildings with many and wide window and door openings demand a higher compressive strength and are realized in a concrete density range between 1.3 and 1.6 kg/dm^3.
- Less stressed facades, which either have thicker walls, less stories or less openings are executed in the density range between 1.0 and 1.3 kg/dm^3.
- Very light LC with the best thermal insulation are increasingly used for exclusive private houses. Their external walls are executed in densities ranging from 1.0 down to 0.80 kg/dm^3 and even less. Below 0.80 kg/dm^3 such lightweight concretes are no longer covered by existing standards for structural lightweight concrete in Europe. Since the thermal insulation requirements lead to rather thick walls, the achievable strength is usually high enough to provide sufficient load bearing capacity for single- or two-story houses. In some projects, the concrete strength is even below a strength class LC8/9, which is the lowest strength class that is covered by existing standards for LC [1]. These so-called infra-lightweight concretes (ILC) [4] range somewhere in between structural lightweight concrete (LC) and no-fines lightweight concrete with open porous structure (LAC). Special considerations are necessary regarding a suitable design concept and durability for ILC. Thus ILC require a technical approval or an approval on an individual basis [5].

3 EXEMPLARY PROJECTS

3.1 LC made with normalweight sand and in the density range above 1.5 kg/dm^3

A white LC35/38 D1.6 forms the curved roof that rests on individual columns and covers the bus and railway station in Korbach, Germany (Fig. 2 left). The pedestrian bridge crossing the river Vitava in České Budějovice (Budweis), Czech Republic, has a main span of 75 m and consists of 54 precast elements made with LC35/38 D1.8 (Fig. 2 right). The elements rest on two sets of cables and form the bridge deck.

Figure 2 – Left: Bus station roof, Korbach, Germany. Right: Pedestrian bridge Budweis, Czech Republic

3.2 Self-compacting lightweight concrete (SCLC)

SCLC was used for the first time in 2002 for the lower (Fig. 3 left) and upper end elements of the upper tribune in the football stadium “Volkswagen Arena” in Wolfsburg, Germany. The architects asked for a perfect fair faced concrete. This could only be accomplished through a

self-compacting LC25/28 D1.6 due to the complex shape of the precast elements. In 2005 the Emmaus Autobahn Chapel (Fig. 3 right) was built using a technical approval for a LC35/38 D1.3 named “LiSA”. Such technical approval is still needed as SCLC is not covered by European concrete standards.

Figure 3 – Left: lower end element of the upper tribune, Volkswagen Arena, Wolfsburg, Germany. Right: Emmaus Autobahn chapel, rest and service area Hegau-West, Germany.

3.3 LC made with lightweight sand and in the density range above 1.3 kg/dm³

Thermal conductivity is still too high for using LC with densities above 1.3 kg/dm³ as sole insulation material for external walls. Here, the excellent combination of strength and density is important. A black-colored LC16/18 D1.4 formed the outer shell of the external sandwich walls of the apartment and office building L40 (Fig. 4 left) and reduced the weight of the cantilevering facing. Even more severe were the requirements for the concrete hull of the heavy lifter [6] (Fig. 4 right). A LC35/38 D1.4 was chosen as a demolding density below 1600 kg/m³ was mandatory for the necessary buoyancy.

Figure 4 – Left: Linienstraße 40, Berlin, Germany. Right: Heavy lifter, Rotterdam, The Netherlands

3.4 LC made with lightweight sand and in the density range between 1.0 and 1.3 kg/dm³

Less stressed facades which either have thicker walls, less stories or less openings are executed in the density range between 1.0 and 1.3 kg/dm³. These LC are commonly used for office buildings and public structures like churches. The regional and district court in Frankfurt/Oder, Germany, was built using LC16/18 D1.2 for its fair faced concrete (Fig. 5 left). A LC12/13 D1.2 formed the external 60 cm thick monolithic walls of the new office building of Spenner GmbH & Co. KG in Erwitte, Germany (Fig. 5 right).


Figure 5 – Left: Regional and district court Frankfurt/Oder, Germany. Right: Office building, Erwitte, Germany

3.5 ILC made with lightweight sand and dry densities below 0.8 kg/dm^3

Currently the most prominent executed examples for ILC in Germany are two private houses. The first achieved a strength of 7,4 MPa at a density of 0.76 kg/dm^3 (Fig. 6 left) and a more recent building a record breaking LC8/9 D0.725 (Fig. 6 right).


Figure 6 – Left: Private house Schlaich, Berlin, Germany. Right: Private house Thalmair. Aiterbach, Germany

4 REFERENCES

[1] DIN EN 206. *Concrete - Specification, performance, production and conformity*. 2013, p. 96.

[2] Thienel, K.-C., *Besonderheiten bei Leichtbeton in DIN FB 100*, in *Heft 526 Erläuterungen zu den Normen DIN EN 206-1, DIN 1045-2, DIN EN 13670, DIN 1045-3, DIN 1045-4 und DIN EN 12620*, Deutscher Ausschuss für Stahlbeton, Editor. 2011, Deutscher Ausschuss für Stahlbeton: Berlin. pp. 80-84.

[3] Thienel, K.-C., *Structural lightweight concrete for external walls – A challenge between the poles of improved thermal insulation and fair faced concrete* ALITinform: Cement. Concrete. Dry Mixtures, 2018. 50(1): pp. 18-29.

[4] Schlaich, M.; Zareef, M.E., *Infraleichtbeton.* Beton- und Stahlbetonbau, 2008. 103(3): pp. 175-182.

[5] Callsen, B.; Thienel, K.-C., *Besondere Aspekte bei der Entwicklung und Ausführung eines hochwärmedämmenden Hochleistungs-Leichtbetons mit sehr niedriger Betonrohdichte.* Beton, 2017. 67(4): pp. 128-134.

[6] Thienel, K.-C., *Heavy Lifter – Konstruktion und Bautechnik.* Beton, 2011. 61(6): pp. 224-229.