COMPLEX TESTING OF AERATED CONCRETE

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Abstract

The mechanic, thermomechanic, deflection and moisture properties of aerated concrete wall elements (GM 500/2) that have been in production since 1986 were investigated. The main causes of cracks appearing shortly after construction were: the inhomogeneous strength and modulus of elasticity depending on moisture distribution, the inhomogeneous and not "custom designed" other structural elements (slabs, beams), the very high strength of the applied mortar and inaccuracy in the attachment of element rows.

1. Introduction

The MÁTRA Aerated Concrete Factory of KÖSZIG company has been producing aerated concrete blocks using Hebel's technology since 1986. The raw material is fly ash from a nearby lignit burning power station, the binders are lime and cement, the aerator agent is aluminium paste. The present article summarizes the findings of a test program of the GM 500/2 gas concrete element.

2. The tested properties

The dry body density is usually 30—70 kg/m^3 less than the nominal value of 500 kg/m^3. The internal density distribution of the element depends on its position during the manufacturing procedure. The elements in the middle of the vat usually have homogeneous density, while elements manufactured around the edges of the vat are more likely to be inhomogeneous. (See Figures 1 and 2).

The moisture content of the elements after manufacturing is about 40—45 m%, this gives around 650 kg/m^3 body density for calculations.

The compressive strength tested according to the appropriate Hungarian Standard (3 cubes, $100 \times 100 \times 100$ mm^3, dried at 105 °C, load direction — as if it was built in a wall structure) gave results above 2 MPa — the required strength according to the Hungarian Standard. If samples are taken out of one element strength results may differ as a result of inhomogeneous density and the faults of a porous system. Wet or soaked samples have 20—40% lower strength compared to dry ones.

It was stated after the complex strength tests of 150 × 150 × 600 mm^3 samples that flexure strength — loading at every third of the beam of 500 mm span — was 10—15% of the compressive strength, the compressed area was 150 × 150 mm^2. Splitting tests, using two 20 mm diameter steel bars, resulted in around 6—8% of the compressive strength. The strength loss caused by water content was significant in this case also.

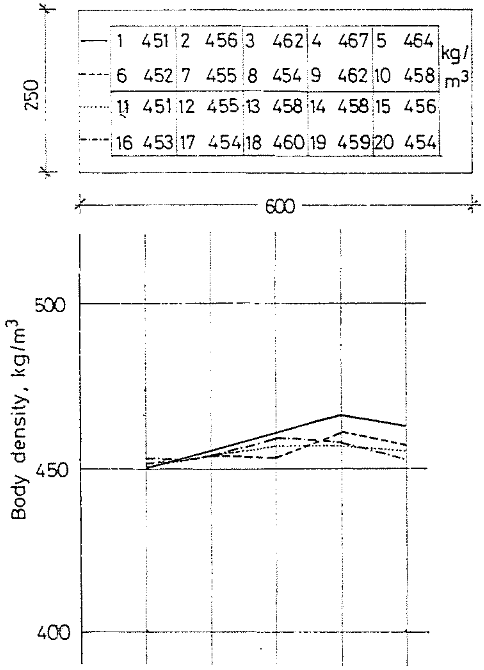

Fig. 1. The change in body density of element cast in the middle of the vat. (20 samples, 100 × 100 × 100 mm^3 cubes)

Testing the strength according to DIN showed that elements cracked under minor load as a result of drying and non-uniform deflection. Strengthening of aerated concrete is insignificant after manufacturing and strength basically depends on its body density.

The limit stress (0.7MPa) for design should be reconsidered to be 0.6 MPa, furthermore, for low density (420—430 kg/m^3) elements 0.5 MPa would be a wise stress limit.

Testing of chemical components and derivatograms showed that aerated concrete had very little free lime and that increases the corrosion danger.

Durability tests were carried out to find out the effects of climate (e.g. CO_2, SO_2, smoke and coal tar), water, oil stains and winter salting (chlorides). Possible structural changes or strength loss were investigated.

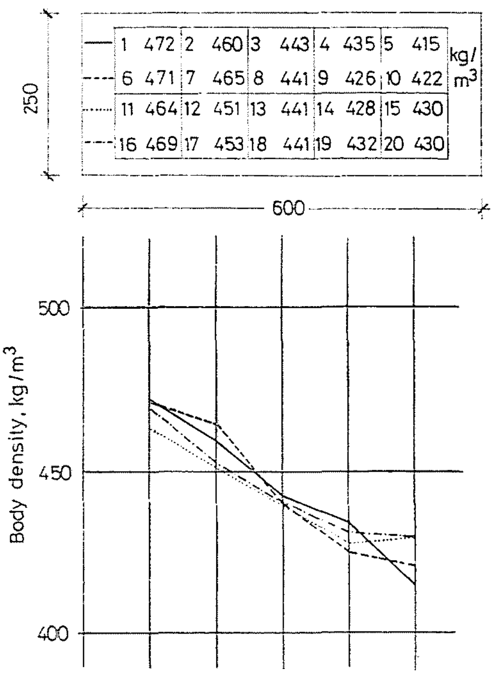

Fig. 2. The change in body density of element cast on the edge of the vat. (20 samples, $100 \times 100 \times 100$ mm³ cubes)

3—3.5 month long tests showed that CaO may leave the aerated concrete thus further reducing the small free lime content. Coal tar treated wet samples showed significant strength loss.

As a result of absorption and desorption tests the absorption saturation was found to be around 20—25% (depending on body density) and the equilibrium moisture content was around 5—8 m%. (Figure 3).

The drying of aerated concrete depended on the initial moisture content at 20 °C temperature achieved equilibrium during a one year period. (Figure 4). (Sample surfaces were free in all directions.) Built-in elements have only 37% of total surface free thus drying takes even longer. The mortar on walls plus the real temperature and moisture effects ensure that drying takes almost 5—6 years.

The absorption rate of water saturated elements was between 42—50 V% with high deviation.

Frost-thaw tests in 1986 showed 50% strength loss after 15 cycles.

The Young-modulus of aerated concrete is largely influenced by test methods and moisture content. The dry Young-modulus computed after the deflection of samples was marginally lower (520—938 MPa) than factory specifications (1250 MPa). Tests according to DIN 1048 resulted in 1226—1451 MPa.

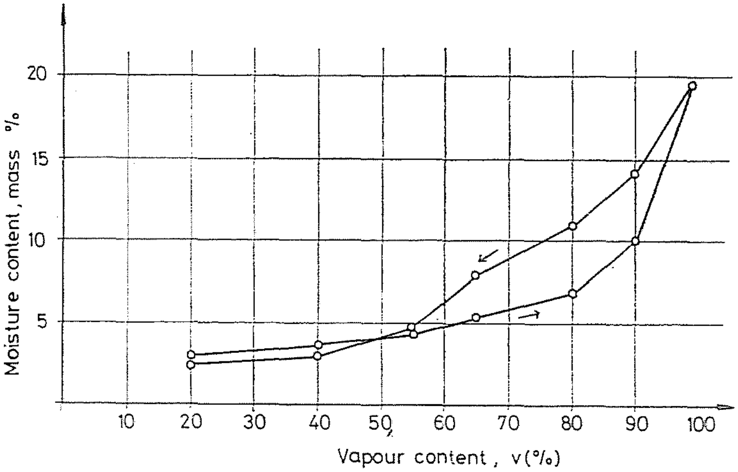

Fig. 3. The absorption and desorption isotherms of gas concrete

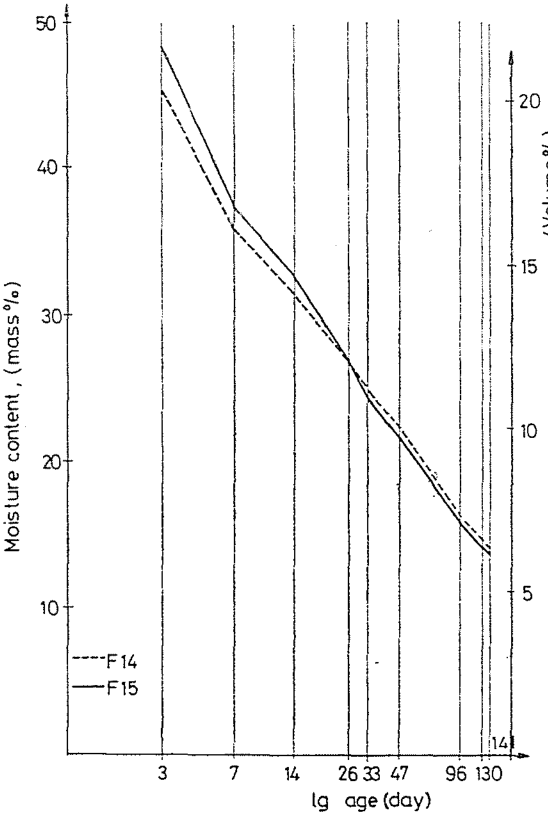

Fig. 4. Changing moisture content in a wall element

The deviation of results was very high. For moisture "softened" aerated concrete the Young-modulus was lower, although fully saturated samples showed increased Young-modulus.

Aerated concrete also has a significant shrinkage — 0.52—0.75% between 15—140 days measured along the direction of swelling after the natural drying procedure. (The moisture content was still around 14—15 m%, thus drying was not finished.) Until the 15th day the shrinkage was around 0.4% according to EMI (Construction Quality Control Institution). One of the consequences of shrinkage was the "curving" of the elements. Swelling of an air dry element after 42 days in a water bath was 1.15%.

The factor of thermal expansion of aerated concrete depends on casting. 1986 tests gave 7.9×10^{-6}1/°C for dry and 7.2×10^{-6} 1/°C for wet samples. 1987 tests gave 6.2×10^{-6} 1/°C longitudinally and $4—4.6 \times 10^{-6}$ 1/°C in the traverse direction. Thermal expansion was thus direction dependent and lower than factory parameters (8×10^{-6} 1/°C).

The vapour diffusion factors of samples made in 1986 were between $0.028 \times 10^{-9} — 0.038 \times 10^{-9}$ kg/s × Pa × m. This depended on body density and porous distribution.

The thermal conductivity of dry aerated concrete samples was around 0.13W/m K depending on the body density. Moisture increased thermal conductivity up to 0.25 W/m K.

Wall elements are rather big at $250 \times 300 \times 600$ mm^3 and their "fresh" mass is around 30 kg. Construction is fast and efficient although lifting heavy elements over higher levels is tiring work and elements are frequently damaged.

3. Cause of cracks in wall structures

Walls built from aerated concrete blocks are usually cracked in Hungary. The causes of cracks are listed below:

— Inhomogeneous body density and strength inside the elements.

— Inhomogeneous moisture content in the wall (dry edges, wet middle) also means strength difference and change of Young-modulus through the wall.

— Low flexure and split strength and moisture reduces them further.

— A significant 1% shrinkage during drying (or swelling when moisture content increases) and inhomogeneous moisture content causes internal stresses.

— Creep under permanent load and the inhomogeneous deflection because of non-uniform body density, moisture content and strength qualities.

— Some structural parts are not "custom made" for this technology, e.g. ring beams, slabs etc. (Inhomogeneous structure with different deformation properties plus additional moisture into aerated concrete, e.g. casting ring beam.)

— Deformation because of temperature change.

— Impeded deflections caused stresses from the very high strength of binding mortar.

— Large element size — high stresses from the previously mentioned impeded deflections.

— Inaccurate placement of elements especially when the top of each layer of elements was not properly flattened.

— Faulty construction practices.

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