Lightweight woodchip concrete in composite constructions

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ABSTRACT

The considering of dense lightweight woodchip concrete matrixes in load carrying structures is hardly investigated although its less density and adequate compression strength are well pre-conditions for application in composite constructions. In the context of a research project at the University of Luxembourg composites slaps with lightweight woodchip concrete are investigated. At the moment first small statics tests on small elements with various element heights and sheet thicknesses are carried out to analyze the load carrying behaviour, the deformations, the composite behaviour, the bond behaviour.

INTRODUCTION

With different mixtures but the same basic materials it is possible to create lightweight concrete for requirements related to dense and porous concrete. While the porous lightweight concrete can be used for heat insulating elements and sound absorbing constructions the dense lightweight concrete is principally adequate for use in constructive elements. A low density of the material reduce the self weight of the construction, thus an economical designing is possible. Woodchips aggregates decrease the elastic modulus and the bearing capacity; hence a composite partner for constructive elements becomes necessary. The following sections show the results of the first statics tests with small composite slabs.

1. TRIAL TESTS

Aim of the trial tests on small plate elements is to get first and fast information about the ability for the composite partner. Thereby the composite behaviour, deflection, bearing capacity are in the main focus. A chosen composite sheet is a profile with additional burling, corrugations and undercut profile geometry. Thus the mechanical composite can be increased. The sheet thickness and the high of the slabs get varied, while the width and the lengths kept constant. Therewith the results of the static tests can be evaluated in dependence of the geometric parameters.

Table 1- Dimensions of the small slabs and sheet thickness

sheet thickness [mm]	height [mm]	length [mm]	width [mm]	composite sheet
1.0	120	1100	450	SHR 51/150
1.25	160			
	200			

1.1. Experimental procedure and measuring instruments.

The experimental procedure took place on three point bending test, thereby a static loading occurred by displacement control. The measuring instruments are placed in a symmetric manner. The deflections are measured via displacement transducers in the middle of the slab and at the point of measuring the strains (third point of the slab). The strains are measured by strain gauges on the concrete and sheet surfaces. The relative displacements between the concrete and the sheet are measured at the section of the slab. In figure 1 the measuring plan is shown.

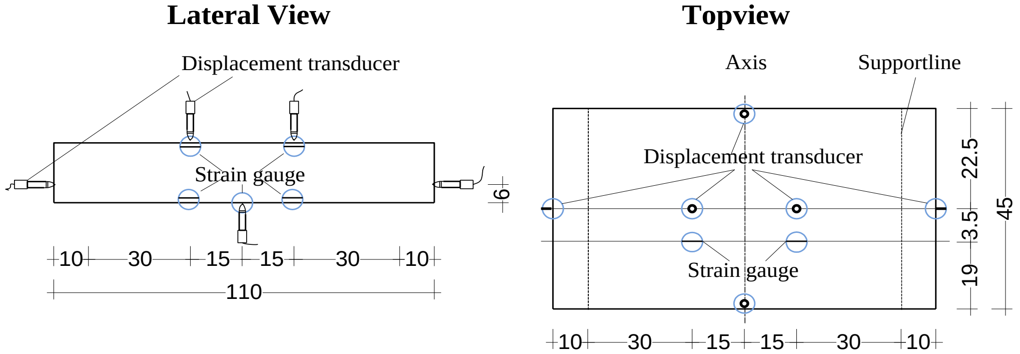


Figure 1- Plan of the measuring instruments

2. Material Parameters

The material parameters are destined by DIN 12390 and in order to obtain the compression strength at the day of testing the slabs, three cubes are tested. In table 2 the most important material parameters for the analytical analysis are listed.

Table 2- Material parameters

Compression strength , cubes	16.9 [N/mm²]	Elasticity Module	5200 [N/mm²]
Compression strength, cylinder	13.1 [N/mm²]	Averaged compression strength of all cubes	16.5 [N/mm²]
Splitting tensile strength	1.55 [N/mm²]	Density class	1,2

3. COMPOSITE ACTION

The composite action is activated after concretes hardening. The geometry of the composite sheet is the essential point for the load bearing behaviour. While the burling increase the mechanical composite the internal friction occurs by transverse strains. The composite actions occur combined and directly after loading.

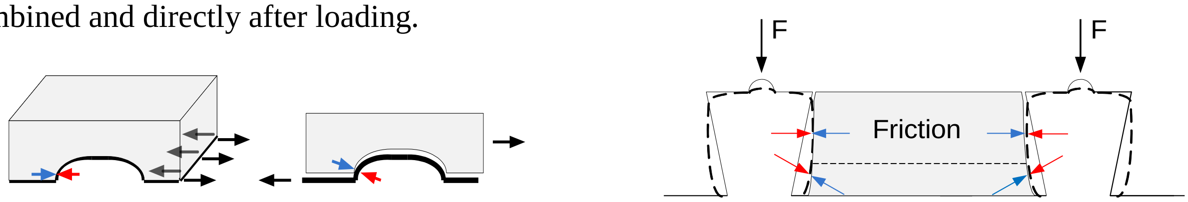


Figure 2- Mechanical composite and friction effects during loading

4. GRAPHICAL EVALUATION

In figure 3 are exemplary the quantitative results of the loading test of slabs with a height of 200mm and a sheet thickness of 1.25mm (black line) and 1.0mm (grey line) shown. In figure a) the y-axis represents the loading and the x-axis the deflection in the middle of the slab. In figure b) the y-axis represents also the forces and the x-axis represents the slippage related to the displacement between the concrete and the sheet. The ultimate load is higher by using a sheet with a thickness of 1.25mm, but the beginning of slippage is rather than by using a thickness of 1.0mm. The deflections in the middle of the slabs by reaching the bearing load are differing marginally.

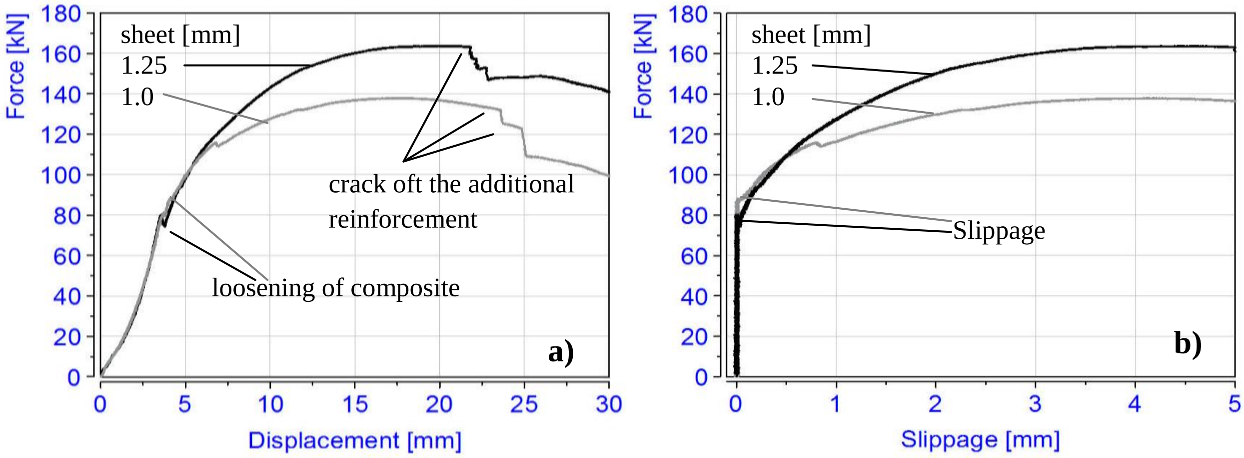


Figure 3- Load displacement-diagram and load-slippage-diagram

4.1. Results of the test series

This material behaviour can also be detected by the complete tested slabs. In figure 3 all results are shown. Independent of the high of the slabs the bearing load is higher with an increase of the sheet thickness, but the loosening of the composite begins earlier. That means for this used concrete in those realised tests that the mechanical composite is not the critical component, but the friction forces in due to transverse strains. For an increasing of the friction forces two points are necessary: A high E-module of the concrete as resistance and an adequate flexibility of the sheet. The first point is not given yet and in combination with a thicker sheet the composite behaviour in due to the thicker sheet is not able to develop.

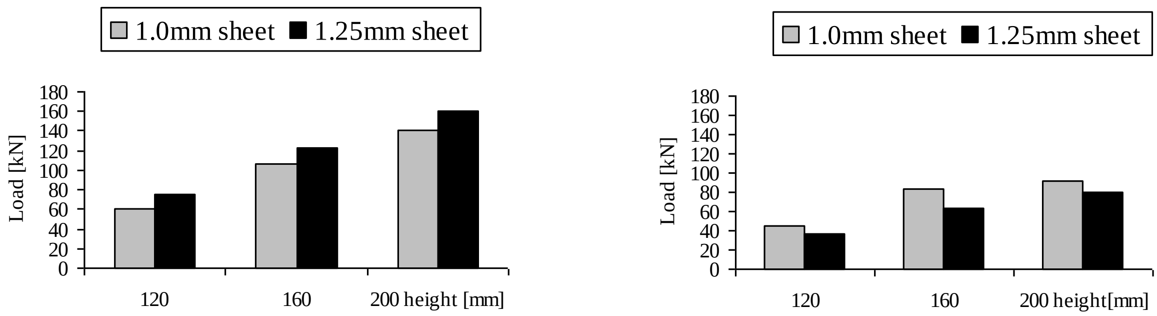
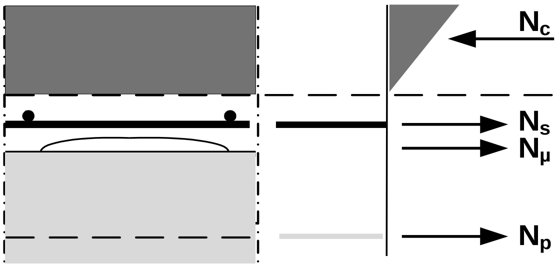


Figure 4- Load bearing behaviour and beginning of slippage in dependence to the slabs high

5. ANSATZ FOR CALCULATION OF THE INTERNAL FORCES

In this section the method of calculate the internal moment until loosening the composite and some exemplary results which include all variations are shown. For this method the tensile strain and the compression strain must be known. Furthermore the compressive strength for lightweight concrete under assumption of a linear stresses distribution /Faust 2003/ is assumed. The tensile strength of the concrete is neglected. With the requirement of equilibrium the unknown force Nµ can be calculated directly. Please note that with this ansatz the internal forces Nµ represented the combined composite behaviour. Nμ also includes effects related to the transverse strains. This circumstance can be avoided by rotating round Nμ.



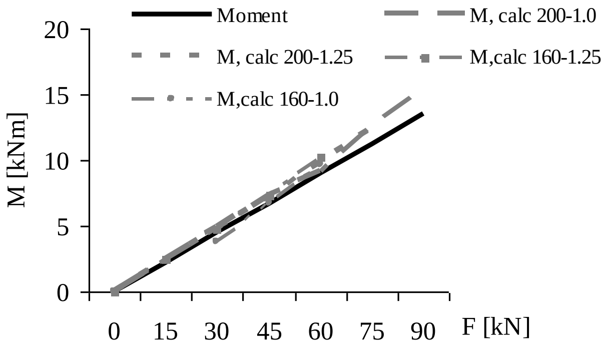


Figure 5- Internal forces and example of results

6. ANSATZ FOR CALCULATION OF THE DEFLECTIONS

In this section a simple ansatz for the calculation of the deflections until the bearing loading is presented. This model regards at every loading step after the loosening of composite a new composite slab with a reduced height of the concrete section related to the loading step before. The crack evaluation δ_{cr} [mm/kN] must be defined. For the present trial tests for δ_{cr} the ratio of the concrete section to the maximal load is chosen. The force and the high of the compression zone by losing the composite must be known. By an arbitrary loading step the difference between the chosen loading step and the point of losing the composite (Δ_F) can be calculated and multiplied with δ_{cr}. As a result the assumed length of the crack is known. Finally this length will be subtracted to the height of the compression zone and the effective depth at the actual loading step. With this procedure a new composite section is designed and the missing parameters for calculating the deflections can be, according to/Minnert & Wagenknecht 2008/, generated. Some results are shown in the following figure 6. Please note that the compression set is up to now neglected.

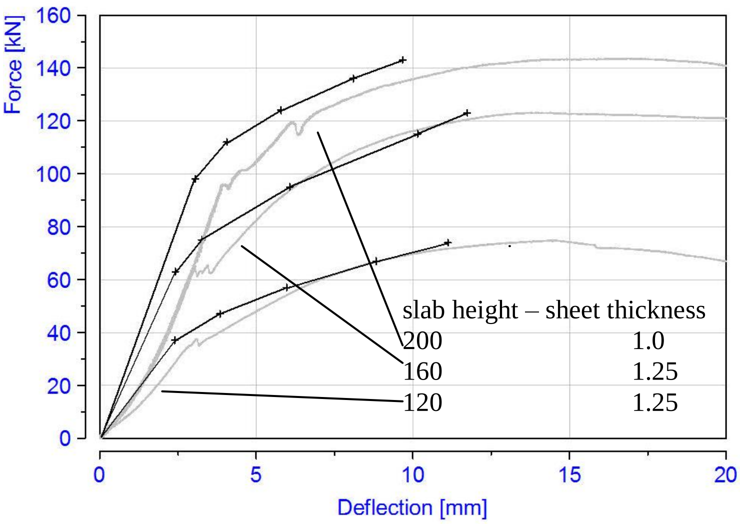


Figure 6- Results of the analytical calculations of the deflections

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