English Summary

The use of wood in different types of products has been assessed comparatively in a joint research project on new materials and materials development. The present project focussed on the development of new types of concrete with wood as an aggregate for a range of different applications. The compatibility of cement and different types of wood particles was to be significantly improved by tailoring binder composition which thus significantly simplifies the production process.

Three Portland cements, two Portland blast furnace cements, two rapid setting Portland cements, two rapid cements with 12CaO*7Al2O3 or 11CaO*7Al2O3*CaF2 and a special binder composition comprising ground granulated blast furnace slag, gypsum, Portland cement and fly ash were used in the investigations. In addition cements without Portland cement clinker were considered: a geopolymer cement with metakaolin, sulphate blast furnace cement, sodium silicate and binders based on calcium sulphate. The wood particles were in the form of coniferous wood shavings of different fineness, beech shavings, wood chips and shredded forestry wood residue.

The wood concrete mixes containing Portland and Portland blast furnace cement set very slowly and could only be demoulded after at least two days moist storage. Chemical and mineralogical investigations have shown that the soluble organic constituents of wood form complexes with calcium ions in the pore solution of wood concrete. This impedes the crystallisation of portlandite. The rapid cement containing 12/7 calcium aluminate and the special binder exhibited the best compatibility with wood. The setting and strength development of the 12/7 calcium aluminate cement occurs due to the hydration of calcium aluminate and the crystallisation and interlocking of long ettringite needles. The crystallisation of gypsum is responsible for the setting of the special binder. Both processes are scarcely delayed by the organic constituents of the wood.

A large quantity of air voids formed during the preparation of wood concrete of plastic consistency with coniferous wood shavings. This led to an increase in binder paste volume and improved workability. The resin in the wood promoted air void formation.

Intensive mixing enabled the production of conifer wood concrete containing as much as much as 58 vol.% air voids. By using a foaming agent, it was possible to reduce the w/c ratio of mixes with a high air content and increase strength moderately. No improvement in the properties of wood concrete was obtained by using superplasticizers.

Depending on the amount of wood (coniferous wood shavings: wood-to-cement ratio 0.18 to 0.33 kg/kg), it was possible to produce wood concretes mixes with a plastic consistency and densities between 480 and 850 kg/m3 which, when hardened, possessed 28 d compressive and flexural strengths ranging between 0.8 an 10 MPa and 0.4 to 3.8 MPa, respectively. The ratio of flexural to compressive strength increases as the shavings becomes coarser.

No intensive formation of air voids was apparent during mixing wood concrete with beech shavings. This is due to the lower resin content of beech wood compared with coniferous wood. Owing to this and the higher density of the beech shavings, this type of wood concrete has a higher density and strength than equivalent mixes made with coniferous wood shavings.

The strength of wood concrete made with wood residue is lower than concrete of equivalent composition made with saw dust. This is probably due to the

relatively large proportion of bark and needles in the forestry wood residue. Durability testing was carried out with wood concrete specimens made from the rapid 12/7 calcium aluminate cement (wood-to-cement ratio 0.26 kg/kg) and the special binder (wood-to-cement ratio 0.22). The fresh concrete was soft in consistency and the specimens were stored for 14 d at 20℃ and 95% RH prior to outdoor storage under natural climatic conditions. After two winters, the specimen made with the special binder showed clear signs of spalling. No surface damage was apparent for the specimen made with rapid cement. However, the edges and corners of the specimens were slightly rounded.

Fresh moist concretes with relatively high wood-to-cement ratios between 0.43 and 0.47 kg/kg were compacted by tamping. The properties of these concretes were mainly determined by the degree of compaction and the size of the shaving used. Higher strengths were achieved with the coarser F2 shavings. The density of these wood concrete mixes was between 590 and 850 kg/m3 and the corresponding compressive and flexural strengths between 1.0 and 5.5 MPa and 0.4 to 2.2 MPa, respectively

Investigations of shrinkage behaviour indicated a higher degree of shrinkage and swelling for specimens produced by pounding and with high wood-to-cement ratios. The shrinkage of poured concrete specimens of plastic consistency reached as much as 0.45 mm/mm during a reduction in relative humidity from 65 to 30%. The shrinkage of the specimens produced by tamping is, at 0.6 and 0.75 mm/m, somewhat higher. A higher degree of shrinkage was observed for wood concrete made with finer shaving as opposed to the coarser shavings.

It was possible to produce wood concrete with densities around 800 kg/m3 and compressive strength between 4.5 and 6 MPa using the non-Portland cement based binders calcium sulphate α-hemihydrate or the geopolymer cement with metakaolin. Good bonding of wood shavings was obtained with sodium silicate. Although the density of this material (320 kg/m3) was very low, the compressive and flexural strengths were also low, <0.8 and <0.4 MPa, respectively.

During the production of large wood concrete slabs for demonstration objects, it was found that inhomogeneous storage conditions can result in deformation and cracking. This is due to the shrinkage behaviour of the wood concrete slabs. In addition, the aging of rapid cement can have a disadvantageous effect on the hardening process at low temperatures.

Based the life cycle assessment of wood concrete, it was found that the use of wood particles as concrete aggregate in lightweight concrete contributes to environmental protection. For all environmental impact categories, the effect of wood concrete production on the environment is lower compared with the production of lightweight concrete with light expanded clay aggregate or perlite.

Suitable combinations of wood and binder for the production of wood concrete without the need of previous treatment of the wood have been successfully developed. Wood concrete can be produced using sawmill shavings and other wood residues. The first investigations on the effect of wood particle shape have been carried out. It concluded that further optimization of the concrete mixes is possible and worthwhile from a technical and economical point of view.