The use of Sludge Incinerator Ash in the production of concrete

Pernille Nyegaard,
M.Sc., consultant
Concrete Centre, Danish Technological Institute
Gregersensvej, DK-2630 Taastrup
E-mail: pernille.nyegaard@teknologisk.dk

Claus Pade,
M.Sc., consultant
Concrete Centre, Danish Technological Institute
Gregersensvej, DK-2630 Taastrup
E-mail: claus.pade@teknologisk.dk

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1. INTRODUCTION

Incineration of sludge from biological wastewater treatment plants (WWTP) leaves a fine granular waste material. Approximately 10,000 tons of sewage sludge incinerator ash is produced annually in the Copenhagen area by two incineration plants. The sludge incinerator ash (bio ash) represents an environmental problem as it is typically land-filled.

For the potential use of bio ash in concrete a number of barriers exist relating to the lack of documentation of the influence of the ash on concrete properties. To aid in establishing the required documentation of the use of bio ash in concrete a 2½ year project supported by the EU's LIFE programme was carried out.

The project has comprised documentation of variations in the chemical and physical properties of the bio ash over an extended production period, laboratory testing to document the influence of ash property variations on the properties of fresh and hardened concrete including evaluation of the leaching of heavy metals from bio ash concrete, and finally evaluation of full-scale daily production of bio ash concrete.

2. RESEARCH SIGNIFICANCE

In Denmark the use of bio ash is allowed in exposure classes X0 and XC1, if the chemical parameters, density and loss on ignition are declared using the test methods provided in EN 450-1. (Suitability is establish by national provisions) If the possible use of ash in concrete is increased to include more severe exposure classes, the amount of waste for disposal can be reduced. The results from this project can be used in the further work regarding the regulation of the use of bio ash in the standards.

3. METHOD

In order to provide the necessary documentation to overcome the barriers for extensive use of bio ash concrete, the project was executed in two major phases:

- Design, construction, implementation and use of systems required for full-scale production of bio ashes concrete – as these systems did not exist at the start of the project. Full scale production tests were made, consisting of activities relating to the design and delivery of bio ash concrete including extended testing and follow up on the execution experiences during casting of the concrete.
- Tests in the laboratory and in the field of the properties of the bio ash and bio ash concrete. The test included chemical and mineralogical analyses of the ashes, accelerated durability tests and leaching tests of concrete designed to meet the demands for all exposure classes (divided in 3 groups, as described in the Danish standard DS 2426).

4. RESULTS AND CONCLUSIONS

The results from the tests show that there is a significant difference in the particle size distribution from the two WWTPs due to their different types of incinerators. The ash from the fluid bed oven has approximately 40 weight-% particles larger than 125 μm, where the ash from the conventional multiple hearth furnace is much coarser; with approx. 65 weight-% larger than 125 μm. This ash could not readily be used as a powder in concrete, but was milled down in order to perform laboratory scale testing.

Bio ash is red resulting from the iron used to precipitate phosphorus during the wastewater treatment. Consequently, bio ash concrete also has a reddish gray colour that when used in visible constructions next to “normal gray concrete” results in a distinct undesirable difference in colour, which is one of the main barriers to more extended use of bio ash concrete. In concrete with as little as 7% red bio ash of cement weight, the colour of the concrete is still affected. However, when aluminium is used for precipitation of phosphorus instead of iron, the colour of the ash is lighter and less red. Preliminary results show that to avoid influence on colour only small amounts of bio ash can be used in concrete (300 kg of CEM I + coal fly ash pr. m^3), i.e. 20 – 40 kg/m^3 for light colour bio ash and only 5 – 10 kg/m^3 for red colour bio ash.

The results from establishing the ash handling facilities at the WTTPs and the ready mix plants show that the ash can be handled as any other powder material. The tests from full scale concrete production show that bio ash has a negative effect on the workability and setting time of fresh concrete. However, it was possible to replace 50% of the coal fly ash and obtain reasonable fresh concrete properties while sustaining the economy of the mixture.

With respect to the hardened concrete properties the accelerated durability and leaching tests showed little or no difference between the reference concretes and the bio ash concretes.

5. FINANCIAL SUPPORT AND PROJECT DATA

The project is partially funded by the EU LIFE-Environment programme. The project period was from June 2005 to December 2007. The partners involved in the project were: Avedøre Spildevandscenter I/S, Lynettefællesskabet I/S (wastewater treatment plants with sludge incineration) and rmc producer Unicon A/S with Danish Technological Institute as consultant.