TALLINNA TEHNIKAÜLIKOOL
EHITUSTEADUSKOND

Ehitustootluse instituut

AS EESTI ENERGIA ENEFIT-280 LENDTUHA SOBIVUS BETOONIS PORTLANDTSEMENDI OSALISEL ASENDAMISEL

THE SUITABILITY OF THE AS EESTI ENERGIA ENEFIT-280 FLY ASH IN PARTIAL SUBSTITUTION OF PORTLAND CEMENT

EPM 60 LT

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SISUKOKKUVÕTE EESTI KEELES:

Käesoleva lõputöö eesmärk oli uurida AS Eesti Energia tootmistegevuses kasutatava uue Enefit-280 tehnoloogial tekkiva lendtuha sobivust betoonis ja selle mõju betooni püsivusomadustele.

Lõputöö katseline osa viidi läbi TTÜ ehitusteaduskonna ehitusmaterjalide õppetooli õppelaboratooriumis. Lõputöö katseline osa nägi ette tsemendi osalist asendamist lendtuhaga ning leidmaks protsentuaalne kogus tsemendist, mil lendtuhal ei oleks betooni koosseisus betooni püsivusomadustele negatiivset mõju.
Betooni püsivusomadustelt katsetati survetugevust, külmakindlust, mahumuutust ning veeimavust.
Lendtuha omadustelt katsetati kivistunud lendtuha surve- ja paindetugevus näitajaid jahvatatud ja jahvatamata lendtuhal.
Täiendavalt viidi eksotermia, sideainepasta voolavuse katsed läbi Soome Consolis Technology Rusko laboris

Katsetulemused:

1. Tsemendi asendamisel lendtuhaga sideainepastas, alandab reaktsioonidest tingitud sisemisi temperatuure võrreldes tsemendipastaga.
2. Sideainepasta voolavus flow meetodil väheneb lendtuha sisalduse suurenemisel.
3. Survetugevus – betooni 28 päeva survetugevus ei muutu 10% lenduha sisaldusel oluliselt võrreldes lendtuhata betooniga. Jahvatatud lendtuhal on suurem survetugevus 28 päeval kui jahvatamata lendtuhal.
4. Paindetugevus – Jahvatatud lendtuhal on survetugevus 28 päeval suurem kui jahvatamata lendtuhal.
5. Veeimavus – lendtuha sisalduse suurenemisel suureneb kapillaarne veeimavus.
6. Mahukahanemine – lendtuha sisalduse suurenemisel betoonis väheneb mahukahanemine.
7. Külmakindlus – lendtuha sisalduse suurenemisel suureneb külmakindlus.

SUMMARY OF MASTER THESIS:

The aim of this research was to analyze the effect of burnt shale ash from fluidized bed firing (CFBC), which is more efficient than pulverized firing units and has a smaller impact on the environment. The importance of a research comes from lack of information on that type of fly ashes.

The research is separated into three parts:

1. Analyzing burnt shale ash properites on a X-ray diffraction analysis, specific surface area, cement paste heat generation, compressive and flexural strength.
2. Analyzing burnt shale ash effects on a concrete paste, such as workability.
3. Analyzing burnt shale ash effects on a concrete compressive strength, water absorption, shrinkage, freeze-thaw resistance.

1) XRD - Examination of specimen shows high content of $CaCO_3$ (34,7%), SiO_2 (21,5%) and low content of CaO_{free}, (0,9%)XRD showed also no content of alite (C_3S), since it is produced at higher level on temperature. The content of belite (C_2S) was 9,2%. The content ratio between C_3S and C_2S indicates the fact that the early strength of a concrete with a burnt shale ash is smaller since C_2S is not as active as C_3S.

   Specific surface area increased from 389 m^2/kg to 889 m^2/kg after an hour of grinding in a mill.

   Mixing cement mortar with burnt shale ash lowers the rise of a inner temperature caused by reaction of the particles. Heat of hydration with 5% ash content in cement paste showed faster temperature rise from 2,4h to 8,9h than the cement paste with no ash in it.

   Compressive and flexural strength was tested with burnt shale ash with and with out grinding the ash. The test was carried out with burnt shale ash and water with water-binding ratio of 0,5. The results showed higher compressive and flexural strength on first, second and 7 day old test specimen with burnt shale ash which was not grinded. Grinded burnt shale ash had averagely 14% higher compressive strength and flexural strength at 28 day old test specimen. It was concluded that

pozzolanic properties came out better with grinded burnt shale ash since it had specific surface area 228% higher than burnt shale ash without grinding.

2) Ashes which are produced at higher temperature $\geq$ 1300 ˚C has spherical particles covered with smooth glassy material which improves workability. Burnt shale ash from CFBC reduce workability of a concrete since it does not have indefinite geometric configuration.

3) Compressive strength was tested with concretes up to 30% fly ash in cement paste. The results showed that the strength was reduced in concretes containing higher than 15% burnt shale ash. It was concluded not to proceed tests with higher content than 15% of ash in concrete mixture. After tests with different ratio of water-binder and super plasticizing admixtures the results showed no significant difference on a 28 day compressive strenght. However, early strenght was reduced in early days of hardening.

   The greater was the content of burnt shale ash in concrete mixture the higher was water absorption. In mixtures, with out super plasticizing admixtures, the differences were bigger from mixtures without fly ash, since the workability was lower and tightening the mixture into mold was harder and therefore the porosity was bigger. Mixtures with super plasticizing admixtures and different water-binding (W/B) ratio had slightly bigger water absorption. In all case of the mixtures the content of 5% fly ash in a mixture showed lower water absorption upto 53 days in a mixtures with W/B – 0,5 and 41 days in a mixture with super plasticizing admixtures 0,9% and W/B – 0,5.

   The bigger was the content on fly ash in a mixture the lower was drying shrinkage. Shrinkage is affected by the amount of water in the mix, the W/B and the fractional volume of aggregate. By that mean, the fly ash tied excessing water.

   Freeze thaw was analyzed until 42 cycles and 56 cycle results was presented on the final presentation. Until 42 cycles the results showed that the greater the content of burnt shale ash in concrete mixture the higher is the freeze thaw resistance. Used concrete recipe showed that the concrete without and up to 10% burnt shale ash in mixture did not did not meet the criteria of XF1 by standard EVS 814:2003 ,,Frost

resistance of normal-weight concrete. Definitions, specifications and test method". From 15% of burnt shale ash in concrete is more likely to meet the criteria of XF1. Visual examination showed that the surface cracking started from lime stone.

In final part, it was analyzed if the fly ash would be economically rewarding. Analysis took into account only raw material, which showed 4,1% lower cost, if we use 10% fly ash in concrete.