Characterization of sewage sludge ash and its effect on moisture physics of mortar

A study was carried out to investigate the potential use of ash obtained as an incinerated by-product in sewage sludge treatment, as a possible supplementary cementitious material. Chemical parameters and granulometry of the sewage sludge ash and selected physical and hygroscopic properties of cement-ash-based mortar are presented and compared with results from previous studies. The effect of different ratios of cement substitution and two pre-treatment methods for ash, i.e. ash grinding and water washing, on the physical properties of mortar were investigated by using density, porosity, and compressive strength as elemental indicators of the mortar quality. The hygroscopic sorption properties of the individual constituents alone and the resulting mortar samples were described by sorption isotherms for water vapour and by a capillary water absorption test. Results showed that the SSAs typically consisted of larger particles compared to the cement particles. Incorporation of ash resulted in more porous mortar structures compared to cement-based mortar, which affected the material's mechanical properties such as the compressive strength. 28-day compressive strength decreased with increasing ash content and porosity. Cement conveyed the greatest ability to adsorb and react with water and there were clear differences between the different ashes. Despite the differences in sorption properties between the different constituents, the effect of ash content on mortar sorption isotherms was negligible.

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Determination of hygrothermal properties of cementitious mortar: The effect of partial replacement of cement by incinerated sewage sludge ash

Two sewage sludge ashes were used as substitutes for cement and their effect on the hygrothermal properties of mortar was examined. Different cement to ash ratios and two ash pre-treatment methods (water washing and grinding) were in focus. The impact of cement replacement by sewage sludge ashes on thermal conductivity, sorption isotherms, water vapour permeability and carbonation was described with standard cement-based mortar as the reference material. Measurement results showed that thermal conductivity decreased by 15% when 30% of the cement was replaced by sewage sludge ash. Water vapour permeability increased as the cement to ash ratio was reduced. Sorption was tested by two methods; although differences in the sorption isotherms of mortars were reported when a climatic chamber method was applied, no differences, or only minor differences, were observed with the desiccator method. Measurements revealed that cement-based mortar possessed a higher content of carbonate than cement-ash-based mortar, and it thus appears that the carbonation rate was higher when the cement content was high.

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The effects of cement-based and cement-ash-based mortar slabs on indoor air quality

The effects of emissions from cement-based and cement-ash-based mortar slabs were studied. In the latter, 30% of the cement content had been replaced by sewage sludge ash. They were tested singly and together with either carpet or linoleum. The air exhausted from the chambers was assessed by means of odour intensity and chemical characterization of emissions. Odour intensity increased with the increased exposed area of the slabs. It did not differ significantly between cement-based or cement-ash-based mortar and neither did the chemical composition of the exhaust air. A significant sink effect was observed when linoleum was added to any of the two slabs examined. The sink effect increased as the exposed area of the slabs was increased. The odour intensity of the mixture of the slab and linoleum was lower than the intensity of odour produced by any of the two materials when tested singly. A plausible explanation for this effect was that the mortar slabs adsorbed the organic acids that were emitted at a high rate from linoleum, mortar being strong base. The same sink effect was also observed when the mortar slabs were exposed together with carpet but it was much smaller because the carpet emitted smaller quantities of acids. The total concentration of organic compounds measured was not appreciably different when the slabs were tested alone or together with linoleum or carpet. Considerable differences in the concentration of organic compounds were however observed when the total concentration of each functional group was calculated and compared.

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Sensory ratings of emissions from nontraditional building materials
Twenty-five subjects assessed the emissions from building materials: linoleum, cement mortar with and without fly ash, gypsum board and tiles with air cleaning properties and natural organic sheep wool. The ratings were made at different material loadings and in combinations with linoleum. The results showed that except for natural organic product, increasing loading and combining materials with linoleum increased intensity of odor.

Waste-based materials; capability, application and impact on indoor environment – literature review
This paper reviews and discusses various sustainable materials utilizing waste products with the focus on their properties having an impact on the indoor environmental conditions and indoor air quality (IAQ). Materials included in the review are selected considering the following aspects: sustainability, cradle to cradle perspective, application, their impact on indoor environment and human well-being. The attempt of the paper is to cover a wide spectrum of information so to provide better understanding of waste utilization in construction industry.

ZeroWaste BYG: Hygro-thermal conditions and pollutant emissions from ZeroWaste materials and their effects on humans

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ZeroWaste BYG: Redesigning construction materials towards zero waste society

The ZeroWaste research group (www.zerowaste.byg.dtu.dk) at the Department of Civil Engineering was established in 2012 and covers the broad range of expertise required for turning waste materials into attractive, new materials. Members of the group have developed methods for removal of heavy metals and phosphorous from waste incineration, sewage sludge and other bio ashes [1], providing the basis to make these ash types an attractive, new material for the building sector. The amount of waste increases and it is both difficult and expensive to handle many waste types as e.g. different ashes. At the same time there are fewer natural resources and the general consumption increases. We wish to utilize alternative and new ash types as raw material in concrete, similarly to what was previously seen with fly ash from coal combustion and microsilica, which were both transformed from problematic waste to valuable raw material. The physical-chemical characteristics of fly ash, such as large uniformity coefficient, clay-sized particles and rich in some metal elements and salts, show the possibility of being a raw material also for bricks and lightweight aggregates. In the future we expect increasing political pressure to change the status of different ashes from waste to raw material and that export for disposal will be no longer be allowed. We wish to influence the consequences from this new situation. In principle some of the ashes can be used already, but the huge variation in ash characteristics and lack of knowledge in the construction industry on the qualities of some of the ashes can give the concrete and clay materials means that they are not used today.

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Human response to local convective and radiant cooling in a warm environment.

The response of 24 human subjects to local convective cooling, radiant cooling, and combined radiant and convective cooling was studied at 28°C and 50% relative humidity. The local cooling devices used were (1) a tabletop cooling fan, (2) personalized ventilation providing a stream of clean air, (3) radiant panels below and above the desk in front of the desk occupant, and (4) the same two radiant panels but with small fans blowing room air toward the upper panel to be cooled and redirected toward the person. A reference condition without cooling was also tested. The cooling devices significantly (p<0.05) improved subjects' thermal comfort compared to the condition without cooling. The acceptability of the thermal environment was similar for all cooling devices. The acceptability of air movement and perceived air quality increased when local cooling methods were used. The best results were achieved with personalized ventilation or the tabletop fan. Only minimal improvement in perceived air quality was reported when the radiant panel was used alone, indicating that in a warm environment, local convective cooling is superior to local radiant cooling as a means of improving perceived air quality. The intensity of the reported sick building syndrome symptoms increased during the exposure time, with or without cooling devices in operation. Air movement had very little effect on sick building syndrome symptoms, but they increased when the pollution level was high. The lowest prevalence of symptoms was reported with personalized ventilation and with the radiant panel with attached fans, which also caused subjects to report less fatigue. Sick building syndrome symptoms increased most when the tabletop fan, generating movement of polluted room air, was in operation. The temperature of the inhaled air rather than any local cooling of the head was associated with sick building syndrome symptoms, although this needs further study. The most preferred cooling method was personalized ventilation for six subjects, fan for eight subjects, and radiant panel (or radiant panel + fans) for nine subjects.

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Organisations: Department of Civil Engineering, Section for Indoor Environment, Section for Building Physics and Services, Silesian University of Technology, Technical University of Denmark, Shinshu University
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Incinerated sewage sludge ash as alternative binder in cement-based materials: effect on mortar characteristics

Sewage sludge ash is characterized by its pozzolanic properties, as cement is. This predetermines its use in a substitution of cement and cementitious materials. Utilization of sewage sludge ash does not only decrease the consumption of cement, one of the largest cause of CO2 emissions, but also it can minimize the need of ash landfill disposal. The objective of this study is to show potential use of incinerated sewage sludge ash (ISSA), an industrial byproduct, as possible binder in cement-based materials. Chemical and mechanical characteristics are presented and compared with results obtained from previous studies. The effect of different ash substitution ratio on mechanical properties of mortar is investigated my means of compressive strength results.

Use of local convective and radiant cooling at warm environment

The effect of four local cooling devices (convective, radiant and combined) on SBS symptoms reported by 24 subjects at 28 °C and 50% RH was studied. The devices studied were: (1) desk cooling fan, (2) personalized ventilation providing clean air, (3) two radiant panels and (4) two radiant panels with one panel equipped with small fans. A reference condition without cooling was tested as well. The response of the subjects to the exposed conditions was collected by computerized questionnaires. The cooling devices significantly (p<0,05) improved subjects’ thermal comfort compared to without cooling. The acceptability of the thermal environment was similar for all cooling devices. The acceptability of air movement and PAQ increased when the local cooling methods were used. The best results were achieved with personalized ventilation and cooling fan. The minimal improvement in PAQ was reported when the radiant panel was used alone. The use of the local cooling devices led to increase of eye irritation. The reported SBS symptoms increased during the exposure time in all studied conditions, i.e. with and without cooling devices. The lowest prevalence of symptoms was with personalized ventilation and with radiant panel with attached fans, which also helped people to feel less fatigue. The SBS symptoms increased the most when the cooling fan, generating movement of polluted room air, was used.
Use of local convective and radiant cooling at warm environment: effect on thermal comfort and perceived air quality

The effect of four local cooling devices (convective, radiant and combined) on thermal comfort and perceived air quality reported by 24 subjects at 28 °C and 50% RH was studied. The devices studied were: (1) desk cooling fan, (2) personalized ventilation providing clean air, (3) two radiant panels and (4) two radiant panels with one panel equipped with small fans. A reference condition without cooling was tested as well. The response of the subjects to the exposed conditions was collected by computerized questionnaires. The cooling devices significantly (p<0.05) improved subjects’ thermal comfort compared to without cooling. The acceptability of the thermal environment was similar for all cooling devices. The acceptability of air movement and PAQ increased when the local cooling methods were used. The best results were achieved with personalized ventilation and cooling fan. The improvement in PAQ when the radiant panel was used alone was minimal.

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