Combining mineral fractions of recovered MSWI bottom ash: improvement for utilization in civil engineering structures

In real-life construction projects, the utilization of different types of waste derived aggregates can often be falsely considered as utilization, but in fact, it is merely dumping the potentially high value material from one site to another. For example, building highway noise barriers with waste derived aggregates cannot be considered as utilization. In this study, a more advanced approach was chosen in order to create aggregate like products from recovered municipal solid waste incineration (MSWI) bottom ash (BA) and thus potentially increase their value and image in civil engineering applications. MSWI BA from one waste incineration plant in Finland was first treated with a Dutch dry treatment technology called ADR (Advanced Dry Recovery). This process separates non-ferrous and ferrous metals from MSWI BA and generates mineral fractions of different grain sizes. These mineral fractions may not be used separately, for example, in the unbound structural layers of roads due to the strict grain size distribution requirements of these civil engineering structures. Hence, different combinations were designed from these BA mineral fractions using the mathematical proportioning of aggregates. The aim was to create aggregate like products from this waste material for different structural layers (filtration, sub-base and base) of, for example, road and field structures. Three mixtures were chosen based on their correspondence to the grain size distribution requirements of natural aggregates and further analyzed in the laboratory from their technical, mechanical and environmental point of view. The leaching of chrome (Cr) and chloride (Cl-) exceeded the Finnish emission boundary values for utilization of certain types of ashes in civil engineering. On the other hand, the technical and mechanical properties of these mixed bottom ash products were considered suitable to be used, for example, in the unbound structural layers of the interim storage field in a waste treatment center. In such location, also the leaching potential of harmful substances can be further studied and verified in a larger scale.
Deterioration mechanisms and life cycle of concrete monoblock railway sleepers in Finnish conditions

Thirty eight sleepers aged 30 to 40 years old were removed from Finnish railway lines and were loaded. Twelve new sleepers were also tested. The old sleepers fulfilled most of the requirements specified for the new ones. The old sleepers were also much more resistant to loading than predicted by structural calculations. The purpose of field tests was to establish the role of traffic loads in the life-cycle of sleepers: the actual stresses and moments in sleepers due to traffic loads; the distribution of the load through the underside of the sleeper to the ballast; and the variation in ballast-sleeper reaction on different sections of track in different seasons. Strain changes at the top surfaces of sleepers were measured on tracks while the rail was loaded by passing trains. Ballast-sleeper reactions tended to be concentrated under the rail along a length of sleeper of approximately 350 mm towards the centre of the track. The mean bending moments determined at the rail seat and centre of sleepers were about ±2.5 kNm, and the maximum moments were up to ±10 kNm. The purpose of fatigue loading tests was to analyse the long term properties of the sleepers and the effect of fatigue on the stiffness of sleepers. Several load levels were chosen in order to estimate the significance of the fatigue in a real operating situation. The fatigue limit determined based on the loading tests and the computational limit state of crack formation were clearly higher than the bending moments measured in the field tests.
Back-calculation of the Saint-Alban A test embankment with a new modelling approach in LEM
To facilitate the continued use of limit equilibrium method (LEM) in stability design of embankments on soft clays, the new calculation method “Hybrid su” (HSU) has been developed. It is used to derive undrained shear strength from effective strength parameters, or to predict the excess pore pressure at failure. The HSU method uses an anisotropic effective stress soil model with volumetric hardening, from which a closed form solution for the effective mean stress at failure $p'$ is derived. This in turn is used to derive the anisotropic undrained shear strength (for use in total stress analyses), or excess pore pressure (for use in undrained effective stress analyses). The model accounts for factors such as anisotropy, consolidation state, volumetric hardening and to some extent, rate effects. An advantage of the model over traditional undrained effective stress calculations is that the overestimation of shear strength at $F > 1$ is avoided.

Commercialising reclaimed materials in earthworks – guidelines for productization and the process of appending these materials in the Finnish national code of practice
To decrease the use of non-renewable natural resources as well as environmental effects of earth-works, natural aggregate materials can be replaced with recycled materials acquired from surplus soil, industrial by-products and waste, etc. When wishing to increase the usage of these reclaimed materials (=“UUMA”-material), the usage must be straightforward for developers, designers and constructors alike. To make this possible, the materials must have design guidelines for their appropriate applications. They must be productized and CE marked or otherwise authorized, and the construction guidelines for the materials must be included in the Finnish general specifications for infrastructural construction works (InfraRYL). As productization is especially important in increasing the usage of UUMA materials, guidelines for vendors are being drawn that present information on commercializing reclaimed materials to be used in earthworks. The guidelines for productization are being prepared in the Finnish national UUMA2 programme (2013-2017, www.uuma2.fi), which was created to promote the use of recycled materials in earthworks.
Arsenic in bedrock, soil and groundwater - The first arsenic guidelines for aggregate production established in Finland

Concern over arsenic (As)-rich drinking water has gained worldwide attention since the 1990s, when the problem was discovered in West Bengal in India and in Bangladesh. Since then, authorities and research institutes have focused on risk assessment and management for As in Finland. Nationwide geochemical mapping projects determined background levels and revealed regions with a higher than average As content in bedrock and soil. Approximately 10% of the citizens in Finland use drinking water from private wells. Groundwater, especially from drilled bedrock wells, may contain As concentrations higher than 10 μg/L, the European Union quality guideline for As in drinking water. Here, we present the outcome of two European Union projects, RAMAS and ASROCKS, which based their conclusions on nationwide databases and thousands of samples. Both RAMAS and ASROCKS focused on the Tampere-Häme region of Southern Finland, where bedrock and soil contain more As than in other parts of Finland on average. Over 1000 groundwater samples revealed that drilled bedrock wells may contain As-rich water in certain geological units. Naturally occurring As in bedrock and soil may also cause mobilization of As during rock aggregate production and construction activities, potentially impacting on groundwater aquifers, surface waters, and biota. Arsenic concentrations in aggregate production and construction exceeded the regional background levels in some bedrock and aggregate product samples, but during leaching tests As concentrations were found to be low. Based on the results, risk management tools were revised and guidelines for the rock aggregate industry were established in cooperation with authorities, companies, and other stakeholders. To our knowledge, the guidelines established were the first in the world. The guidelines for As for the aggregate and construction industries can be applied in other countries and adapted to local conditions.

General information
State: Published
Organisations: Department of Civil Engineering, Research group: Earth Constructions, Research group: Track Structures, Aalto University, Geologian tutkimuskeskus, Finnish Environment Institute
Keywords: (Arsenic, Bedrock, Construction, Groundwater, Risk management, Rock aggregates, Soil, Surface water)
Number of pages: 15
Pages: 709-723
Publication date: 1 Nov 2015
Peer-reviewed: Yes
ASJC Scopus subject areas: Earth and Planetary Sciences(all)
Kapillaaristen vedenimuominaisuuksien määrittämiseen sopivan vapaan vedenimukoelaitteiston kehittäminen

**General information**

State: Published

Ministry of Education publication type: B3 Non-refereed article in conference proceedings

Organisations: Department of Civil Engineering, Research group: Building Physics and Acoustics

Authors: Tuominen, E., Vinha, J.

Keywords: (Double skin facade, Energy efficiency, New renovation consepts, Innovative HVAC, Earth to air heat exchanger)

Number of pages: 6

Pages: 233-238

Publication date: 20 Oct 2015

**Host publication information**

Title of host publication: Rakennusfysiikka 2015. Uusimmat tutkimustulokset ja hyvät käytännön ratkaisut. 20.-22.10.2015, Tampere

Place of publication: Tampere

Publisher: Tampereen teknillinen yliopisto, rakennustekniikan laitos, rakennetekniikka

Editors: Vinha, J., Ruuska, T.

In fatigue load tests, unused Finnish concrete railway sleepers B97 and BP99 were loaded. The purpose of the loading tests was to analyse the fatigue properties of the sleepers and the effect of the fatigue on the stiffness of the sleeper. Furthermore, the significance of cracks was estimated in the study. The load levels were chosen so that it was possible to estimate the significance of the fatigue in a real operating situation. The fatigue limit that has been determined based on the loading tests and the calculatory limit state of crack formation are distinctly higher than the bending moments that have been measured in the field tests. Consequently, the deterioration of the railway sleepers under the traffic load and due to the fatigue is very unlikely.
This study deals with total track stiffness measurement and modification. The main focus are the properties and measurement results of the ‘Stiffmaster’ rolling track stiffness measurement vehicle developed as part of this project and modification of track stiffness. An interim report titled ‘Vertical track stiffness and measurement techniques’ on the project was published earlier in the Research Reports of the Finnish Transport Agency 6/2013.

The load-carrying capacity of a railway track is affected by many factors, but total track stiffness is one of the most obvious indicators of it. A new rolling stiffness measurement vehicle named ‘Stiffmaster’ was developed to measure load-carrying capacity. The vehicle is coupled to a track maintenance locomotive to make continuous rail deflection measurements as it is pulled over the track. The vehicle measures both loaded and unloaded vertical track geometry, and deflection is determined as the difference between these two values measured during the same run. The loading consists of one axle of a Tka7 railway truck that weighs 140 kN. Three light axles are used as measurement references.

Based on the measurement results, track type affects the magnitude of deflection the most. Deflection of wooden-sleepered tracks is considerably greater than that of concrete-sleepered tracks. Moreover, the thin structural layers of low volume tracks increase deflection caused by subsoil. Many discontinuities, such as fish-plate joints and bridge approaches, can often be discerned from measurement results. On the other hand, on the main lines, where the structural layers are thicker, soft soil deposits do not stand out clearly in measurements, but shallow rock cuttings may show. Deflection varies also on the main lines, but it is usually caused by individual points of discontinuity. Sudden stiffness variations result in hanging sleepers that can be found, for example, at bridge approaches and at the points where frost insulation slabs start. Weak sleeper support and geometric problems are most likely caused by a change in track stiffness that increases the dynamic loading from rolling stock. That is a self-accelerating problem.

Several methods of track stiffness modification are described in the latter part of the report. Structural components are analysed individually and evaluations of the effects of modifications are presented. Evaluations are based on a literature review, measurement results, and simple hand calculations. The clearly best method to increase track stiffness is to add new structural layers to the substructure of low volume tracks. They reduce the loading on weak subsoil which decreases deflection. Replacing fish-plate jointed rails by continuously welded rails decreases variation in track stiffness significantly. On the main lines, the focus of modification should be on stiffness transition zones such as bridge approaches. The literature review revealed that composite materials can be used successfully to reduce deformations and maintenance need. Under sleeper pads (USP) have also been used to reduce stiffness variation. They can also be used to reduce noise and vibration in rock cuttings and tunnels.
A proposal for some modifications of EN 1997-1 design approaches

All Eurocodes are currently under a critical review, while the work for a second generation of codes are about to start in 2015. For the geotechnical design EN 1997-1 is facing high demands for harmonization and simplification of the present code.

The paper presents some proposals for improving the code regarding ultimate limit state (ULS) design. The goal is to make the code better in accounting for uncertainties involved in the design and possible consequences of an ultimate limit state.

When applying a material factor approach (MFA), the partial safety factors are suggested to depend on both the uncertainty of the material and the consequence of failure. Such an approach is well suited for slope stability analysis. However, the authors suggest that also the uncertainties involved with loads should be placed on the material factors. For retaining wall design a load factor approach (LFA) is suggested in addition to MFA similar to present Design Approach (DA) 1 in the Eurocode. This approach gave the most consistent design for all cases in a comprehensive study performed. Some modifications are though suggested also for DA1 to make the design simpler and even more consistent.

Full-scale embankment failure test under simulated train loading

A full-scale embankment failure experiment was conducted in 2009 in Perniö, Finland. A small, extensively instrumented railway embankment on a soft clay foundation was brought to failure by loading over a period of 30 h. Instrumentation consisted of over 300 different measurement points, including 37 piezometers and nine automatically monitored inclinometer tubes. The relatively rapid loading simulated a heavy train coming to a standstill on the embankment. The primary purpose of the experiment was to gather field data of a failure caused by a rapidly applied load, with an emphasis on the pore pressure response in the clay foundation layer. The test was also used to assess the suitability of various instruments for real-time stability monitoring. The embankment failure was an asymmetric bearing capacity mechanism that is hypothesised to have been triggered by an undrained creep rupture. During the last 2 h of the experiment, pore
pressure and displacements increased at an accelerating rate while the external load was kept constant. The time-
dependency of the pore pressure and displacement responses was a key factor in the experiment. With regards to
monitoring of similar in-service train embankments, proper placement of instruments according to predicted failure mechanisms was found to be important.

**General information**

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Civil Engineering, Research group: Foundation Structures, Life Cycle Effectiveness of the Built Environment (LCE@BE)
Authors: Lehtonen, V., Länsivaara, T., Mansikkamäki, J., Meehan, C.
Number of pages: 14
Pages: 961-974
Publication date: 2015
Peer-reviewed: Yes

**Publication information**

Journal: Geotechnique
Volume: 65
Issue number: 12
ISSN (Print): 0016-8505
Ratings:
  - Publication Forum (2017): 1
  - Scopus rating (2016): 3.489 2.927
  - Publication Forum (2016): 1
  - Scopus rating (2015): 2.757 2.744
  - Web of Science (2015): 2.0 2.496 >10.0 0.262 0.00776 1.105
  - Publication Forum (2015): 1
  - Scopus rating (2014): 3.201 2.762
  - Web of Science (2014): 1.868 2.242 >10.0 0.379 0.00747 1.034
  - Publication Forum (2014): 2
  - Scopus rating (2013): 3.326 3.047
  - Publication Forum (2013): 2
  - Scopus rating (2012): 2.652 2.803
  - Publication Forum (2012): 2
  - Scopus rating (2011): 2.633 2.848
  - Scopus rating (2010): 2.58 2.589
  - Scopus rating (2009): 2.2 2.34
  - Scopus rating (2008): 2.655 2.583
  - Scopus rating (2007): 1.5 2.094
  - Scopus rating (2005): 1.501 2.681
  - Scopus rating (2004): 2.043 2.367
  - Scopus rating (2003): 1.777 1.836
  - Scopus rating (2002): 1.313 1.894
  - Scopus rating (2001): 1.89 2.372
  - Scopus rating (2000): 2.752 2.569
  - Scopus rating (1999): 1.178 2.103
Original language: English
Electronic versions:
Full-scale embankment failure test under simulated train loading DOIs:
10.1680/jgeot.14.P.100
Links:
http://urn.fi/URN:NBN:fi tty-201701091032
Research output: Scientific - peer-review › Article
Hiekkatekonurmpintaisten pesäpallokenttien ominaisuuksien muuttuminen ja elinkaari


Kenttä on kuitenkin käytännössä yhtenäinen ja neljän neljäkertaiset kerrosten kenttä on nopeasti käytettävissä. Kentän kaukana tehtyyn kylki- ja etävälitykseksi saatiin pelaajilta kuitenkin kyselyyn vastauksia. General information

State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Civil Engineering, Research group: Earth Constructions
Authors: Jäniskangas, T.
Number of pages: 45
Publication date: 2015

Publication information
Publisher: Tampereen teknillinen yliopisto. Rakennustekniikan laitos
Original language: Finnish

Publication series
Name: Tampereen teknillinen yliopisto. Rakennustekniikan laitos
Volume: 80
ISSN (Print): 1799-1684
Electronic versions: janiskangas_hiekkatekonurmpintaisten_pesapallokenttien_ominaisuuksien_muuttuminen_ja_elinkaari
Modern track evenness demands are high which is why frost heave causes considerable problems in Finland. Nowadays railway ballast and sub-ballast are often of crushed rock whose thermal performance differs from that of the traditional gravel. Many studies around the world have found that convective heat transfer may occur in very coarse crushed rock aggregate. This can lead to increased heat transfer from the embankment which allows frost to penetrate deeper than normal calculation methods predict.

Many studies have been conducted on free convection internationally, and there is a calculation model for estimating its probability. However, the calculation involves problems because the calculation model considers intrinsic permeability, which is difficult to define for coarse materials. Intrinsic permeability can be calculated from water permeability. Unfortunately, water permeability is difficult to determine for coarse materials. The results of research conducted abroad are not as such applicable in determining convection in Finnish railway embankments because of different grain sizes. Therefore, new laboratory test apparatus was built. Three materials of different gradation were tested in the lab: 31.5/63 mm ballast aggregate, 5/16 mm crushed rock aggregate, and 0/63 mm sub-ballast material.

Strong natural convective heat transfer via air occurred in the railway ballast tested in the lab. If the medium was moist air or water, convection could occur at smaller temperature differences. No significant convection occurred in the crushed rock and sub-ballast material via convection, but when water was added to the sample, thermal conductivity of the material increased significantly due to convection. The same phenomenon was observed in the case of 5/16 mm crushed rock aggregate, but adding of water did not increase thermal conductivity significantly.

Two actual railway embankments on which temperature data was available were also tested. The data allowed estimating the temperature differences in the embankments. Based on the results from the test embankments in Seinäjoki, Finland, the thermal performance of the gravel embankment and crushed rock embankment differed, but the possibility of natural convection could not be proved nor completely excluded.

The study showed that crushed rock ballast and sub-ballast material may allow natural convection to occur if its grain size distribution is close to the most coarse and...
even-grained materials allowed by the current guidelines Sorting of the material in the building phase can increase this susceptibility to convection.

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Civil Engineering
Authors: Latvala, J.
Keywords: (Convective heat transfer, Frost depth, Railway track structures)
Number of pages: 115
Publication date: 2015

Publication information
Publisher: Liikennevirasto
Volume: 20/2015
ISBN (Print): 78-952-317-081-0
ISBN (Electronic): 78-952-317-081-0
Original language: Finnish

Publication series
Name: Liikenneviraston tutkimuksia ja selvityksiä
Publisher: Liikennevirasto
Links:
Research output: Professional › Commissioned report

Shear bands in soft clays: strain-softening behavior in finite element method
Strain-softening behavior of soft sensitive clays is very often neglected in geotechnical design. During undrained loading, such materials show a dramatic loss of strength after the peak stress, until residual strength is reached at large strain. As a consequence, local failure occurs and plastic strains localize in a shear band. Shear band modeling in Finite Element Method requires a regularization technique to overcome mesh dependency. NGI-ADPSof2 model is able to simulate the post-peak softening behavior of sensitive clays. In this study, the influence of strain softening on the stability of sensitive clay slopes is studied using the NGI-ADPSof2 model. The analyses are conducted using the finite element software PLAXIS 2D AE. The advantages of using a strain-softening soil model are discussed.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Civil Engineering, Research group: Foundation Structures
Authors: D'Ignazio, M., Länsivaara, T.
Number of pages: 16
Pages: 83-98
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Rakenteiden mekaniikka
Volume: 48
Issue number: 1
ISSN (Print): 0783-6104
Ratings:
Publication Forum (2017): 1
Publication Forum (2016): 1
Publication Forum (2015): 1
Publication Forum (2014): 1
Publication Forum (2013): 1
Publication Forum (2012): 1
Original language: English
Electronic versions:
RakMek_48_1_2015_6
Links:
http://urn.fi/URN:NBN:fi:ttv-201605033915
Finnish mine waste disposal areas
In 2013, a total of forty-six mines and quarries were operating in Finland, and several new mining projects were in progress. Both mining and environmental legislation and dam safety regulations have been developed and renewed during recent years, and the mining and permitting authorities have changed. Due to problems at the Talvivaara Mine in 2013, the Finnish government decided to implement a voluntary stress test for Finnish mines. The method was developed based on the stress test designed for nuclear power plants by the European Nuclear Safety Regulators Group (ENSREG). Altogether twenty-one mines or concentrating plants were chosen to be tested, and twenty responded. In the stress test questionnaire there were fifteen questions on seven risk scenarios that the nominated expert group assessed to be both potential and significant. There are sixty-seven tailings dams in Finland. Nine of them have been classified as Class 1 ("consequence class"), that is, dams which could cause loss of life in the event of dam failure. The study showed that the hydrological design of tailings dams has to be reconsidered. One finding of the stress test was that the dam safety legislation and the guidelines do not define criteria for the closure of tailings dams. Based on the results, mining companies are monitoring their dams quite well and are aware of dam safety risks, probably thanks to the detailed dam safety legislation. However, the base of the waste areas is typically ignored. Old mining waste areas are mainly built on natural soil layer without any liners. New mining waste areas require an environmental permit, which contains requirements for the bottom liners as well.
Liikkuvan kaluston aiheuttama vaakavärähtely rautatievaihteessa ja sen vaikutus kääntöavustimen toimintaan

Liitteen 6: Yleistä kaivannaisjätealueista ja patoturvallisuudesta

Liite 7: Yleistä kaivannaisjätealueista ja patoturvallisuudesta
Raskaiden ajoneuvokuormitusten rasitusvaikutukset ohutrakenteisilla teillä

General information
State: Published
Ministry of Education publication type: D3 Professional conference proceedings
Organisations: Department of Civil Engineering
Authors: Kolisoja, P., Haakana, V., Kalliainen, A.
Number of pages: 7
Pages: 267-273
Publication date: 2014

Host publication information
Publisher: Suomen Tieyhdistys
Links:
http://issuu.com/tieyhdistys/docs/esitelma__julkaisu02092014_pieni

Bibliographical note
Contribution: organisation=rak, FACT1=1
Portfolio EDEND: 2014-09-09
Source: researchoutputwizard
Source-ID: 753
Research output: Professional » Conference contribution

Stiffmaster - A continuous track stiffness measurement device

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Civil Engineering
Authors: Luomala, H., Peltokangas, O., Nurmikolu, A.
Number of pages: 10
Pages: 109-118
Publication date: 2014

Host publication information
Title of host publication: GEORAIL 2014 : 2nd International symposium - Railway geotechnical engineering, 6-7 November 2014, France
Publisher: IFSTTAR
ISBN (Print): 978-2-7208-2621-4

Bibliographical note
Contribution: organisation=rak, FACT1=1
Portfolio EDEND: 2014-12-30
Publisher name: IFSTTAR
Source: researchoutputwizard
Source-ID: 980
Research output: Scientific - peer-review » Conference contribution

Back analysis of a case history using finite element method: the Kansai International Airport, Japan

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Civil Engineering, Research group: Foundation Structures
Authors: D'Ignazio, M., Länsivaara, T.
Keywords: (settlement, creep, soft clay)
Number of pages: 4
Pages: 249-252
Publication date: 2013

Host publication information
Full scale landfill bottom liner test structures at Ämmässuo landfill, Espoo, Finland

Full scale test structures were constructed in summer 1996 to the Ämmässuo landfill to gather experience on quality control during the construction and long term behaviour of mineral liner and combination liners. Actual leachate was used to create the chemical loading and a hydraulic pressure of one meter. The leachate was implemented in October 1996, and the structures were monitored for two years. The structures were continuously monitored by temperature and soil moisture sensors installed into the liner. The leachate seeping through the liner structure was collected to the lysimeter basins and further to the lysimeter wells, in which the amount of the water was measured automatically by pressure sensors. In addition, frost penetration and infiltrometer measurements were performed and samples were taken for laboratory tests during the two-year period. The structures were pulled down under control in November 1998.