Report of activities in Recycled Materials Resource Center, The University of New Hampshire

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Abstract

The author visited Recycled Materials Resource Center of the University of New Hampshire (UNH) from 28th August to 26th October in 2008. UNH is located in Durham, New Hampshire, the United States. The author conducted two research topics. One was risk assessment of abraded fragments derived from melted waste slag used as aggregates for asphalt concrete pavement. Although the enrichment of fine slag-derived fragments in abrasion dust was expected owing to their less hardness than that of natural aggregates, the enrichment was estimated to be insignificant from two approaches on the basis of chemical and mineralogical characteristics of melted waste slag. The other was the evaluation of two methods to measure carbonate content of MSWI residues on the basis of thermogravimetry and evaporation/adsorption separation. Themogravimetric method tended to yield larger values than evaporation/adsorption separation method. In addition, this difference was not non-negligible. Although visit period was short, the author could enjoy the stay including sight seeing to Boston, Portsmouth, and White Mountains as well as foreign experiences such as English communications. The author would like to appreciate greatly for kind cooperative support of prof. Shiamoka, prof. Sasaki, Dr. Gardner, Mr. Greenwood, and financial support by Japan Society for the Promotion of Science (JSPS).

1. Introduction

1.1 The University of New Hampshire

The University of New Hampshire is located in Durham, which is a small town in northern part of New Hampshire, the United States. It takes 20 to 30 minutes by car from Portsmouth, which is famous for Japanese as the location of Portsmouth treaty between Japan and Russia, to Durham. The location of Durham is illustrated in Figure 1 and 2.

- To visit Durham from Japan, you leave for Boston via Chicago, Detroit, New York, or other transit cities. From Boston to Durham, we can have two transportation ways. One is using Amtrack trains, which connect Boston South station and Durham. If you want to go to Durham directly, Amtrack is better. The other is using highway buses connecting Boston Logan Airport and "Park and Ride" station near Portsmouth. After you arrive at "Park and Ride" station, you go to Durham by Taxi that you can ask staff in the station to call for you.

- General consulate of Japan government is located in Boston. If you have any troubles including the loss of your passport, you can ask advices and receive administrative services there.
- Durham has been developed since second half of 15th century and has long history. This town is surrounded with many forests and lakes. Therefore, you can enjoy beautiful landscape in the way from Portsmouth to Durham. The author watched wild dear in backyard of the hotel.
- Durham is small town with only one supermarket and about 6 restaurants. However, you can buy all necessary daily goods without car in this town. If you want to go to shopping malls located in suburb near Portsmouth, you can rent a car in Durham.
- The most of undergraduate and graduate students of UNH stay in dormitories inside University campus. Because entertainments are limited in Durham, many UNH students go to Boston, especially on a weekend. Therefore, Amtrack seat reservation on a weekend is competitive. You can also enjoy movie in a theater in UNH campus.
- You can enjoy lunch and dinner in food stands and restaurants inside and near UNH campus. If you want to eat foods other than hamburger, pizza, pasta, or wrap, you can enjoy Chinese in a restraint near supermarket. You can also enjoy Japanese in two restaurants in Portsmouth.
- Durham is located near Canada. Therefore, the climate is cool as well as Hokkaido in Japan. From second half of October, temperature decreases so much that you have the frost in every morning.

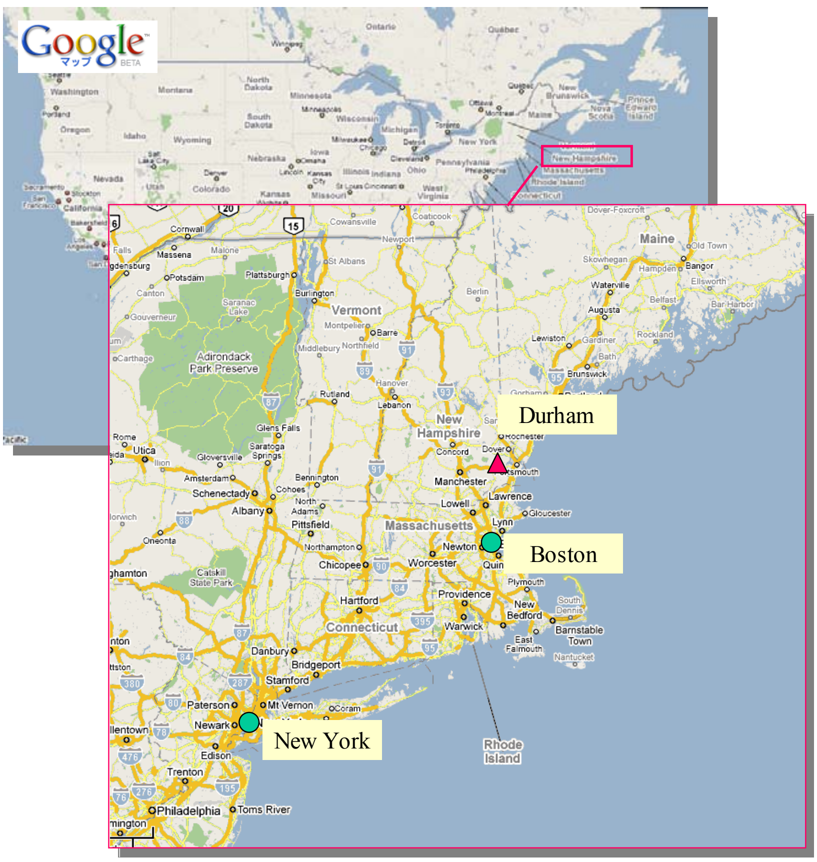

Figure 1. The location of Durham

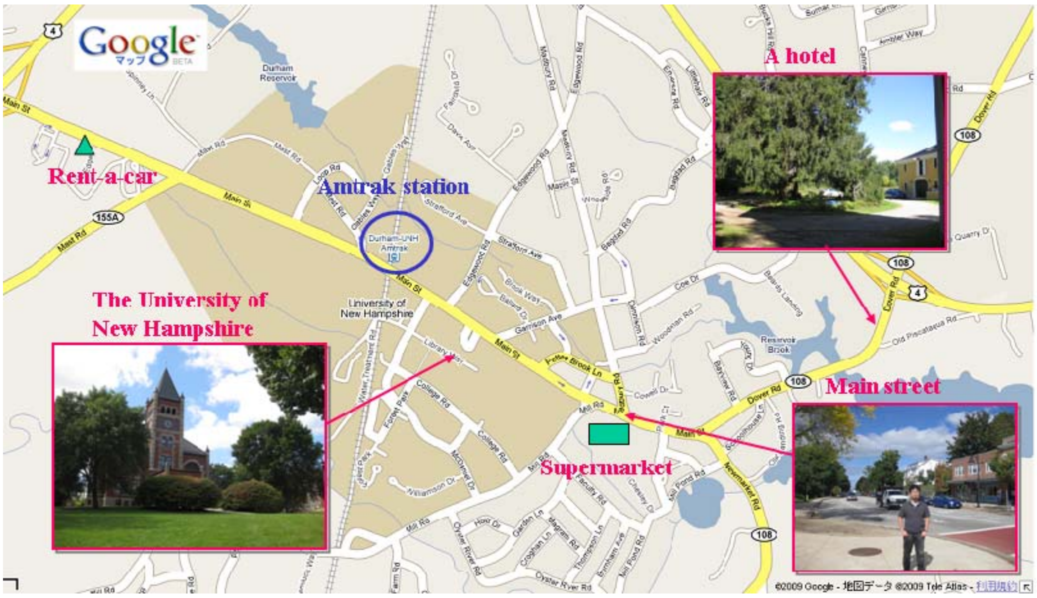

Figure 2. Town map of Durham

1.2 Staffs of Recycled Materials Resources Center, The University of New Hampshire

- Kevin H Gardner, Dr., Associate professor

  He works as the president of Recycled Materials Resources Center. Prof. Shimaoka has had cooperative joint researches and relationship with him and prof. Eighmy. The author received a lot of support from him during the stay.

- Jeffery Melton, Dr., Assistant professor

  He was absent during the first half of the stay because he visited Ireland. The author received a lot of support, especially reservation and management of experimental apparatus. His advices were very helpful for my study.

- Scott Greenwood, Mr., Technical staff

  The author could not conduct most of experimental activities if his support was not available. He serves the management of experiment rooms including managerial control of toxic reagents. Because he was often out of the campus for his research trips, it was important for the author to prepare experimental plans considering his schedule.

- Madeleine Wasiewski, Ms., office staff

  Everyone calls here Maddy. The author received her support, especially the reservation of hotel and preparation of UNH account as a visitor. If you have any trouble, you had better to ask her an advice.

2. Activity plans before the visit

Before the visit, the author had several discussions with prof. Shimaoka and Dr. Gardner about research plan including experiments. In Recycled Materials Resources Center, recycles of wastes and their environmental assessment have been investigated actively. Therefore, the author suggested risk assessment of melted waste slag as aggregates for asphalt concrete pavement as a research topic in UNH. Because risk assessment of recycled resources in highways had been investigated in Recycled Materials Resources Center, the author could find an advantage of this study topic in cooperative joint research.

Mr.Fukui, who was a graduate student of Kyushu University, would visit UNH one month after the author’s visit. Because his research topic was CO_2 sequestration capacity of a landfill site disposed mainly by municipal solid waste incineration residues, preliminary discussion with a manager of a landfill site before his arrival was also expected for the author. In addition, academic exchange agreement between Kyushu University and the University of New Hampshire was being concluded during the stay, the author was expected to be a contact window of Kyushu University side in UNH.

3. Research activities in UNH

3.1 Risk assessment of melted waste slag used as aggregates for asphalt concrete pavement

3.1.1 Introduction

Vitrification treatment of municipal solid wastes (MSW) and their incineration residues has been promoted in Japan. Although about 60% of melted waste slag has been recycled to some applications such as backfilling material, the rest 40% was landfilled without any applications. Therefore, recycles of melted waste slag have been requested from the viewpoint of waste management. An application of melted waste slag as aggregate for asphalt concrete pavement is attractive because it can utilize certain amount of melted waste slag constantly. However, environmental risk of this application is still uncertain. In particular, fine dust abraded from melted waste slag aggregates contained in asphalt concrete pavement is concerned in this study. Because melted waste slag is glassy material and has less hardness than that of natural aggregates, melted waste slag might be abraded to finer fragments than natural aggregates. This means that the enrichment of melted waste slag fragments in fine abrasion dust, which are more inhalable to human bodies, might occur. Because melted waste slag contains toxic heavy metals to some extent, the enrichment of melted waste slag fragments in fine abrasion dust should be concerned. Therefore, the objective of this study is to evaluate the enrichment of slag-derived fragments in abrasion dust.

3.1.2 Experimental

3 types of Water-granulated slag (slag A, B, and C) were tested as aggregates for asphalt concrete pavement. Specimen of asphalt concrete was prepared for abrasion test. Cumulative size distribution of aggregates was adjusted to keep comparable hardness for all specimens. Waste melted slag was used instead of coarse sand. The content of waste melted waste slag aggregates was 30 wt%. All specimens were mechanically abraded at -10 ºC and all abrasion dust were recovered. After size distribution of abrasion dust was measured, the enrichment of slag-derived fragments in abrasion dust was analyzed by two

methods, which were on the basis of quartz (SiO_2) peak of X-ray Diffraction (XRD) analysis and the difference of heavy metal concentrations between natural aggregates and waste melted slag.

3.1.3 Results and discussion

Although it was expected that waste melted slag aggregates was abraded preferentially than natural aggregates, experimental results was quite different. The relative share of slag-derived fragments in abrasion dust whose diameter was less than 150 μm was estimated to be less than 30%, which was initial share of waste melted slag aggregates, on the basis of quartz peak of XRD analysis (see Figure 3). In the case of 150-1000μm abrasion dust, the relative share of slag-derived fragments was more than 30%. The same result was estimated by a method on the basis of the difference of heavy metal concentrations (see Figure 4). There was good agreement between the results estimated by quartz peak-based approach and heavy metal concentration-based approach (see Figure 5). Although estimated relative share of slag-derived fragments for slag C specimen has relatively large errors, different results estimated from Fe, Pb, and Zn concentration data seems to contribute to this uncertainty. Bad substance balances of Fe, Pb, and Zn before and after abrasion dust indicated that content analysis including acid-digestion pretreatment of these elements has non-negligible level of errors. The enrichment of slag-derived fragments in inhalable fine abrasion dust, which the diameter was less than 75 μm, was estimated to be negligible.

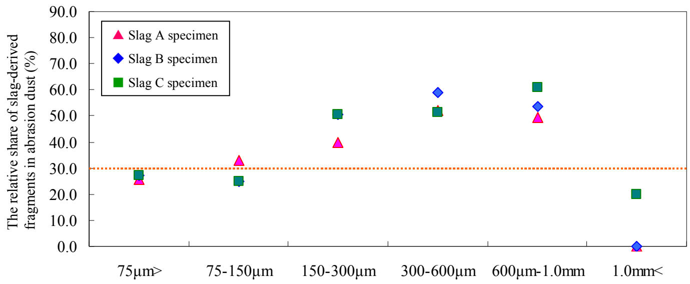

Figure 3. The relative shares of slag-derived fragments in abrasion dust estimated by quartz peak of XRD

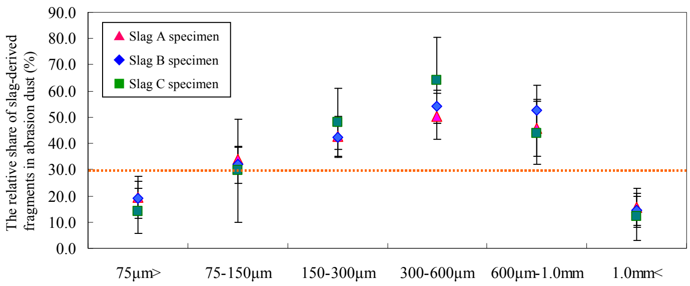

Figure 4. The relative shares of slag-derived fragments in abrasion dust estimated by the difference of heavy metal concentrations

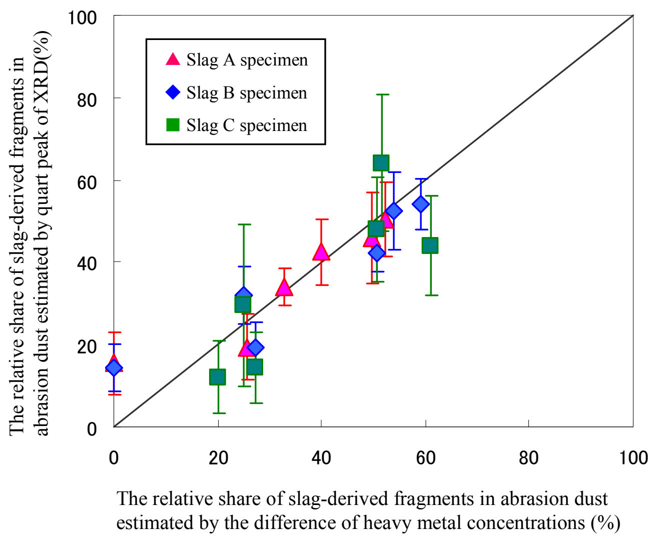

Figure 5. Comparison of estimation results for the relative share of slag-derived fragments in abrasion dust

3.1.4 Conclusion

Significant enrichment of slag-derived fragments in inhalable fine abrasion dust generated from asphalt concrete pavement is not needed to be considered when environmental risk of waste melted slag aggregates used for asphalt concrete pavement is assessed.

3.2 Evaluation of two measurement methods for carbonate content in municipal solid waste incineration residues

3.2.1 Introduction

From the viewpoint of global warming, emission reduction and sequestration of carbon dioxide has been investigated and developed all over the world. During the latest 15 years studies, carbonate mineral formation in municipal solid waste incineration (MSWI) residues was reported. Although atmospheric carbon dioxide was sequestrated through the carbonation of MSWI residues, there are few reports focusing on carbon dioxide sequestration capacity of MSWI residues. To evaluate carbon dioxide sequestration capacity of MSWI residues, one of the most important analysis factors is carbonate content. Carbonate content of MSWI residues has been usually measured by differential thermal analysis. However, it is difficult to measure carbonate content of MSWI residues precisely because MSWI residues consist of various minerals and are very heterogeneous. Therefore, two measurement methods for carbonate content in MSWI residues are compared and evaluated in this study. One is differential thermal analysis methods. The other is evaporation/adsorption method using barium hydroxide solution. This study is the basis for further study of carbon dioxide sequestration capacity of landfill sites that MSWI residues are mainly disposed.

3.2.2 Experimental

MSWI residues were sampled from a landfill site in the US (see Figure 6). Landfill period of samples is 13 years. MSWI residue were taken from 0.5 to 4.5m depth of two sampling location (A-site and B-site) with 1 m interval. Fresh MSWI residues, which were not landfilled before sampling, were also taken. Afther all samples were dried at 105 ºC, they were milled and sieved to less than 105 μm. Carbonate content of these samples were measured by two methods, differential thermal analysis method and evaporation/adsorption method.

Figure 6. Sampling of MSWI residues

3.2.3 Results and discussion

Measurement results of thermal differential analysis method are shown in Figure 7. Because MSWI residues consist of heterogeneous minerals, dehydration and decarbonation occurs in wide temperature range. Therefore, it can be realistic to consider that both reactions can occur at the same time in certain range of temperature. Because measurement results can vary to some extent depending on temperature range that is considered as decarbonation-dominant temperature range, determination of decarbonation-dominant temperature range is significant for the accuracy of the measurement by thermal differential analysis method. Results of carbonate content measurements by thermal differential analysis method and evaporation/adsorption methods using barium hydroxide solution are shown in Figure 8. Measurement results of samples at A-site have good agreement. In contrast, measurement results of samples at B-site and fresh samples have significant differences. Thermal differential analysis method tends to produce large values than those of evaporation/adsorption method. Further study is necessary to explain these differences. Certainty assessment by the comparison to measurement data of evaporation/adsorption method is strongly recommended when measurement data of carbonate content in MSWI residues by thermal differential method.

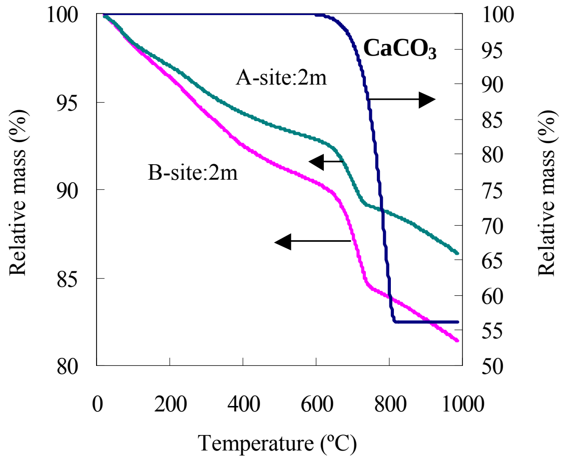

Figure 7. Measurement results of thermal differential analysis

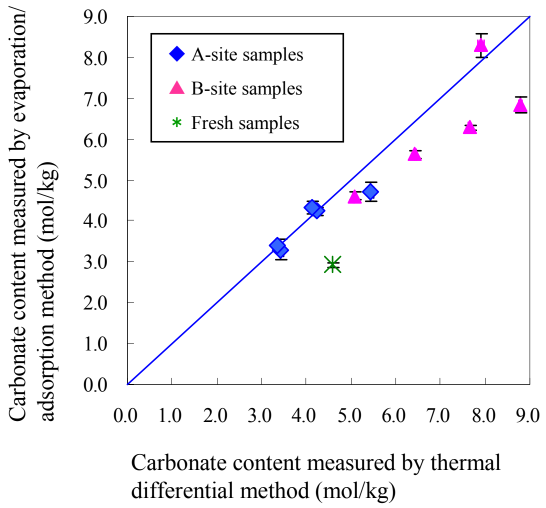

Figure 8. Comparison of the results measured by two methods

4. Acknowledgement

It was good experiences for the author to use only English in daily lives and study discussions during the stay in UNH. Although this requested a little bit difficulty, it was very effective to improve English communication skill. In addition, experiences of foreign cultures were very impressive. This will help the author understand deeply not only foreign cultures but also Japanese cultures. The author could concentrate research activity during this stay. This was very useful to consider research topics and the strategy for further studies.

The author appreciated greatly for cooperative support by Prof. Sasaki, Prof. Shimaoka, and other staff in Kyushu University as well as financial support by Japan Society for the Promotion of

Science (JSPS). In addition, the author also appreciated for kind and cooperative support by Dr. Gardner and other staffs in UNH. The author wishes other young researcher can get the chance to have excellent experiences.