International hybrid workshop

between

the Faculty of Civil and Geodetic Engineering of the University of Ljubljana

and

PHIS, The IDEC Institute, Hiroshima University

(12th Special seminar on The IDEC Institute, 5th PHIS Seminar)

"Interactions between physical parameters, chemical pollutants, and microbes in the built environment"

9th January 2023

Interactions between physical parameters, chemical pollutants, and microbes in the built environment. International hybrid workshop between the Faculty of Civil and Geodetic Engineering of the University of Ljubljana and PHIS, The IDEC Institute, Hiroshima University (12th Special seminar on The IDEC Institute, 5th PHIS Seminar). Book of peer-rewieved papers.

Bibliographic information support: Assist. Prof. Dr. Teja Koler Povh, Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Slovenia

Page layout cover page and photo:
Assist. Prof. Dr. So Fujiyoshi, PHIS, The IDEC Institute, Hiroshima University, Japan

Language: Romana Hudin, Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Slovenia

Publisher: Faculty of Civil and Geodetic Engineering of the University of Ljubljana, Slovenia; PHIS, The IDEC Institute, Hiroshima University, Japan

Place and year: Ljubljana and Hiroshima, 2023

The publication is free of charge.

E-format available at URL: https://mge.hiroshima-u.ac.jp/en/the-international-hybrid-workshop-entitled-interactions-between-physical-parameters-chemical-pollutants-and-microbes-in-the-built-environment-was-held-by-the-faculty-of-civil-and-geodetic-engine/

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Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID 143253763
ISBN 978-961-6884-81-5 (PDF)

URL: https://mge.hiroshima-u.ac.jp/en/the-international-hybrid-workshop-entitled-interactions-between-physical-parameters-chemical-pollutants-and-microbes-in-the-built-environment-was-held-by-the-faculty-of-civil-and-geodetic-engine/

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The Book of peer-reviewed abstracts was made as part of the International hybrid workshop between the Faculty of Civil and Geodetic Engineering of the University of Ljubljana and PHIS, The IDEC Institute, Hiroshima University.

Abstacts are peer reviewed.

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Program

8:00-8:05 (16:00-16:05)	***Opening*** **Dr. Mateja Dovjak**, Faculty of Civil and Geodetic Engineering of the University of Ljubljana **Dr. So Fujiyoshi**, PHIS, The IDEC Institute, Hiroshima University
8:05-8:20 (16:05-16:20)	***Welcome speech*** **Prof. Dr. Violeta Bokan Bosiljkov**, Dean of the Faculty of Civil and Geodetic Engineering of the University of Ljubljana **Assoc. Prof. Dr. Saori Kashima**, Director of PHIS, The IDEC Institute of Hiroshima University **Assist. Prof. Luka Culiberg**, President of the Alumni Association of Slovene Japanese Academic Exchanges
8:20-8:45 (16:20-16:45)	**Prof. Dr. Fumito Maruyama**, PHIS, The IDEC Institute, Hiroshima University ***Invited lecture titled: An infectious disease in Japanese built environment.***
8:45-9:00 (16:45-17:00)	**Li Yutong**, Graduate School of Advanced Science and Engineering, Hiroshima University ***Student presentation entitled: Improvement of indoor thermal environment with the insulation system evaluated by heat-flow sensor***
9:00-9:15 (17:00-17:15)	**China Kuratomi**, Graduate School of Advanced Science and Engineering, Hiroshima University ***Student presentation entitled: The diagnosis method for neutralization of concrete using microbiome***
9:15-9:35 (17:15-17:35)	***Discussion*** *Questions to speakers*
9:35-10:00 (17:35-18:00)	***Coffee break***
10:00-10:25 (18:00-18:25)	**Assoc. Prof. Dr. Janez Mulec**, Research Centre of the Slovenian Academy of Sciences and Arts ***Invited lecture titled: Health in natural karst environments***

10:25-10:40 (18:25-18:40)	**Ožbej Vene**, Faculty of Civil and Geodetic Engineering of the University of Ljubljana ***Student presentation entitled: Transient modelling of carbon dioxide and radon levels in indoor air for analysis of ventilation efficiency***
10:40-10:55 (18:40-18:55)	**Tajda Božič**, Faculty of Civil and Geodetic Engineering of the University of Ljubljana ***Student presentation entitled: Can nanoparticles pass through the building envelope?***
10:55-11:25 (18:55-19:25)	***Discussion*** *Questions to speakers*
11:25-12:00 (19:25-20:00)	***Closing Remarks*** ***Best student presentation award***

"*Interactions between physical parameters, chemical pollutants, and microbes in the built environment*"

Assoc. Prof. Dr. Mateja Dovjak

Faculty of Civil Engineering and Geodesy, University of Ljubljana

PHIS, The IDEC Institute, Hiroshima University

and

Assis. Prof. Dr. So Fujiyoshi

PHIS, The IDEC Institute, Hiroshima University

Contents

Preface

The International hybrid workshop “Interaction between physical parameters, chemical pollutants, and microbes in the built environment”, held in Ljubljana on 9 January 2023, was organized by the Faculty of Civil and Geodetic Engineering of the University of Ljubljana and PHIS, the IDEC institute, Hiroshima University.

Japan and Slovenia are both small countries, but they share the common characteristic of having diverse climates in different regions. Based on the principles of bioclimatic design approach, the climate is reflected in the design and construction of the buildings. The comparison and study of the built environment in both countries will contribute to a wide range of fields, including architecture, public health, infectious diseases, microbiology, and ecology, as well as geophysics. The purpose of the workshop is to exchange interdisciplinary knowledge on physical parameters, chemical contaminants, and microorganisms in the built environment to understand these diverse and complex interactions that play a major role in creating a healthy and sustainable built environment.

We deeply appreciate that the Dean, Prof. Dr. Violeta Bokan Bosiljkov, the Director of PHIS, the IDEC Institute Assoc. Prof. Dr. Saori Kashima, distinguished representatives of the Embassy of Japan in Ljubljana and President of the Alumni Association of Slovenian–Japanese Academic Exchanges, Dr. Luka Culiberg, and Dr. Sayaka Yamashita, Cultural Attach of the Embassy of Japan in Ljubljana attended the workshop.

MATEJA DOVJAK, Univerza v Ljubljani

SO FUJIYOSHI, 広島大学

Invited talk

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An infectious disease in Japanese built environment

Fumito Maruyama

Microbial Genomics and Ecology, PHIS, The IDEC Institute, Hiroshima University.

Dr. Fumito Maruyama graduated from Osaka University (Japan) with formation in the fields of microbial ecology and environmental microbiology. Currently, Dr. Maruyama acts as a full professor at the section of Microbial Genomics and Ecology, PHIS, the IDEC institute, Hiroshima University, Japan, as well as an ad honorem professor in La Frontera University, Chile. The main objective of his work is to contribute to our knowledge on biotic-abiotic and biotic-biotic interaction, especially pathogen (microorganism carrying virulence factors to human and other animals, and antibiotic resistance genes) present in air ecosystems and water environment (drinking water, river, marine, etc.). The research activities are mainly focused i) to elucidate the role of microbial communities in built environments, ii) to decipher the genomic and metagenomics diversity and dynamics of microorganisms in air ecosystems affected by climate and anthropogenic-induced changes, iii) to characterize the genetic- and biochemical mechanisms involved in the microbial interactions and their living environments, and iv) to develop identification of the pathogen, prevention and prediction to manage sustainable built environment based on genetic and metabolic potential of microorganisms in their natural habitat. The projects and research are characterized by using a wide variety of omics techniques, such as real-time (digital) PCR, microfluidic devices, high throughput sequencing (Illumina and Oxford Nanopore platforms), microfluidic devices and machine learning (AI).

Pulmonary NTM (Non-tuberculous mycobacteria, NTM), an intractable chronic respiratory infection, has been rapidly increasing in the number of patients, especially in developed countries, and is urgently needed to be addressed in public health because of the highest incidence rate in Japan in the world. However, research on NTM has not progressed due to its slow growth and difficulty in genetic modification. My research group has focused on Mycobacterium avium, one of the causative organisms of NTM, and has accumulated knowledge from both environmental genomics and hygiene science to discover i) SNPs (single nucleotide polymorphisms) specific to the advanced form, which are not found in the chronic form, ii) new genome groups specific to Japan and nucleotide sequences that can identify each group, iii)) The discovery of a new ecology in which the species adheres to erythrocytes and proliferates on them. However, the genetic factors of this organism, which inhabits diverse environments and exhibits diverse genome groups, including exogenous factors specific to clinical strains, refractoriness including antibiotic resistance, and viability in aerosol conditions related to infection, remain unknown. To clarify these important themes, I would like to propose that we focused on the aerosol and biofilm states of the bacteria, and in addition to the transposon sequencing, a combination of CRISPRi, which is capable of specific gene silencing, and oligonucleotide-mediated recombineering followed by Bxb1 integrase targeting (ORBIT), will experimentally demonstrate the function of genetic polymorphisms involved in environmental adaptation found by informatics. Furthermore, the establishment of a simplified microbial evaluation platform using the resulting polymorphisms will be necessary to determine the genome type of the isolate. These approaches will clarify the open question of why Japanese and Korean isolates from human isolates are genetically different from US and EU isolates, and why only much fewer Mycobacterium spp. were found in Japanese bathrooms compared to US and EU while the frequency of infection in Japan is the highest in

the world. I believe this will the one good example of a research topic for Japanese and Slovenian researchers to start new collaborations related to issues to be solved in the built environment in the field of planetary health.

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Health in natural karst environments

Janez Mulec

Karst Research Institute, Research Centre of the Slovenian Academy of Sciences and Arts, Titov trg 2, SI-6230 Postojna, Slovenia

Dr. Janez Mulec received his PhD in Biology from the University of Ljubljana, Slovenia, and works at the Research Centre of the Slovenian Academy of Sciences and Arts, Karst Research Institute. His research includes various topics in microbial ecology, cave microbiology, and nature conservation. Dr. Mulec studies all three types of subsurface microbial habitats, water, air, and sediments. Of particular interest is the aspect of the subsurface as a potential source of microbial pathogens. He participates in research projects in Slovenia and abroad. He is an associate professor at the University of Nova Gorica and Postgraduate School ZRC SAZU, Slovenia.

"One Health" is defined by the World Health Organization as an integrated, unifying approach to balance and optimize human, animal, and environmental health. This initiative is particularly important for water and food safety, disease control, preventing the spread of antibiotic resistance among microorganisms, and pollution control. Karst, with its surface and underground habitats, highly reflects and accumulates the consequences of human activities. In this regard, all major underground microbial habitats are affected, air, water, and sediments. Remedial actions to restore natural conditions and reduce negative impacts require a proper understanding of the original environmental conditions and community structure. Screening of the natural aerobiome in Slovenian caves indicates potential hazards and impacts of mass visits to show caves on human health. The direct effects of human presence in show caves are also related to direct interactions with contact surfaces. Water, through seeps or river flows, is an excellent medium for connecting surface and subsurface karst and for transporting potentially hazardous microbes, including those carrying antimicrobial resistance genes. A proper understanding of the interactions between the environment and animals in karst caves should not exclude bats. The health status of bats is generally important in assessing overall environmental health. They can be a source of potentially dangerous microorganisms to humans, but their health also depends on interactions with microbial pathogens in the environment. Future studies of karst habitats, especially those that have been little studied, must not ignore a hazardous aspect for humans and animals.

Student presentation

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The diagnosis method for neutralization of concrete using microbiome

China Kuratomi

Department of Architecture, Graduate School of Advanced Science and Engineering, Hiroshima University

The risk of rebar corrosion in concrete structures is increased by pH neutralization due to carbonation. The progress of neutralization inside concrete is difficult to estimate through nondestructive conventional methods of neutralization diagnosis. In this study, we examine a new possible diagnostic method for neutralization by clarifying how the community of microorganisms living in concrete is affected by (1) environmental factors causing neutralization and (2) the concrete after neutralization has occurred.

First, specimens with different surface pore structures were prepared by changing the age of the demolding. Some of the specimens were coated with water-repellent or hydrophilic paint. Thereafter, the specimens were periodically moistened via two different supply methods: running water and spraying in an accelerated carbonation period. After the accelerated carbonation test, microbial samples were obtained from the surface and interior of the specimens to investigate the differences in microbial community characteristics between the neutralized and non-neutralized regions.

The results indicated that the pore structure of the surface layer was the most significant factor affecting the rate of progression of concrete neutralization. Although the coating had the effect of delaying the age at which neutralization began, it did not significantly affect the rate of subsequent neutralization progression, regardless of whether they were hydrophilic or hydrophobic materials.

To quantitatively evaluate the number of microorganisms present at each location, DNA concentrations were compared. More microorganisms were found to be present in the surface layer than in the interior, and the DNA concentration in the surface layer was greater for concrete with a shorter de-molded age. In addition, when water was supplied by running water, the DNA concentration in the surface layer decreased in this experiment, this indicates the effect of washing off microorganisms in the surface layer was greater than the effect of increasing the moisture content of the specimens.

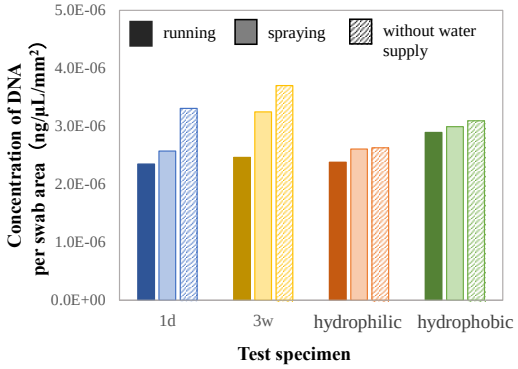

Fig. 1 Concentration of DNA per swab area

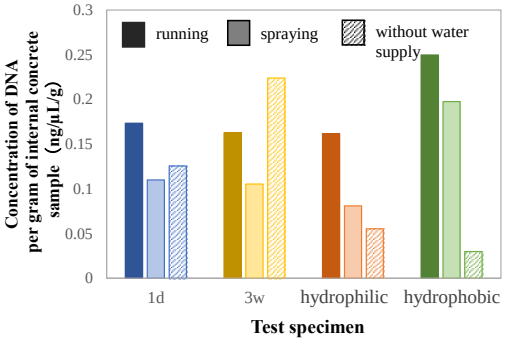

Fig. 2 Concentration of DNA per gram of internal concrete sample

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Improvement of indoor thermal environment with the insulation system evaluated by heat-flow sensor

Yutong Li

Department of Architecture, Graduate School of Advanced Science and Engineering, Hiroshima University.

Energy conservation and emission reduction are becoming increasingly important. Accordingly, to achieve these objectives, the building sector has strict requirements. Notably, improving the thermal insulation performance of buildings is crucial for saving energy. Currently, the insulation performance can be quantified based on the thermal resistance and thermal transmittance (U-value). However, for building owners, these data are not readily available for the verification of different insulation methods. To address this, a solution could involve establishing a connection between specialized evaluation indicators and temperature, a common physical quantity. In this study, we performed the following three main points: (1) Static and dynamic heat-transfer experiments were performed using an environmental simulation chamber and heat-flow sensors. The heat-flow sensor can simply and quickly measure the energy per unit area per unit of time passing through a surface. Once the temperature boundary conditions are consistent, the smaller the absolute value of heat-flow density, the better the insulation. The results show that heat-flow sensors can be used for the evaluation of the thermal insulation performance of multi-layered structural elements like the building envelope; (2) Based on the tests, a simplified equation for the variation in heat-flow density with time was established. This equation could be used to approximate the temperature increment in an indoor space. The simulation results agreed well with the experimental results. Notably, the temperature is a quantity easily understood by laymen; thus, it can improve the communication efficiency between owners, thereby aiding in the mitigation of environmental problems; (3) The performance of 14 experimental specimens, including self-developed and code-documented thermal insulation materials and construction methods, was evaluated. In our simulations of a full-scale building model, after turning off indoor cooling equipment for 6 h during hot summers, the average indoor temperature increase for a roof with insulation was only 52% of that without insulation.

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Can nanoparticles pass through the building envelope?

Tajda Božič[1], Mateja Dovjak[1,2], Janja Vaupotič[3]

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[2]Microbial Genomics and Ecology, PHIS, The IDEC Institute, Hiroshima University, Hiroshima, Japan
[3]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia

High concentrations of aerosol particles are one of the most pressing ambient air quality problems. They originate mainly from traffic and combustion and affect the quality of our outdoor environment. They are introduced into buildings by ventilation and (together with particles originating indoors) cause harmful effects on human health. The primary exposure of the general population to aerosol particles is inhalation. The deposition of particulates in human lungs depends strongly on their size, being higher for the smaller ones (<1000 nm, named nanoparticles in this study). Because of their extremely high surface versus volume ratio, they appear to have higher reactivity than bigger particles. Therefore, measuring their concentrations, preferably number concentrations and particle size distributions, is crucial.

It is assumed that some particle fractions of smaller size pass through the airtight building envelope, as checked in this study. In the semi-urban area in Slovenia, measurements of particle number concentration (CN/cm^{-3}) and particle size distribution were conducted in two buildings with similar characteristics (e.g., building type, size, purpose) but different building envelope airtightness. In each building, one room was selected for monitoring, where a week-long continuous measurement of CN in a particle size range of 10–1000 nm within 44 size channels, using Scanning Mobility Particle Sizer (SMPS+C, Grimm Aerosol Technik) was carried out in September 2021 (non-heating season). In addition, the meteorological parameters in outdoor and indoor air (temperature, relative humidity, pressure) have been continuously recorded. During the experiment, the same protocol of natural ventilation was used in both rooms, which were entered only to open or close the window; otherwise, the doors were closed, and nobody was present in the room to prevent the additional source of indoor particles. The obtained time series of the measured data in the periods of the opened and closed windows were analysed separately. The primary focus in data evaluation has been on periods of closed windows. The following size ranges of aerosol particles (in nm) were grouped from the 44 size channels: <100, 101–200, 201–500, >500 to analyse whether they pass the building envelope.

It was found that when the windows were closed for a longer time (around two days), there were some episodes of particle increase in the tested rooms. The total number of particles at the start (CN-s) and the end (CN-e) of the increasing periods were, on average, 670–1050 cm^{-3} in the room with lower airtightness of the building envelope (B1-LT) and 660–1320 cm^{-3} in the room with higher airtightness (B2-HT). The following average factors of increase (CN-e/CN-s) have been obtained for the particle size ranges (nm) <100, 101–200, 201–500 and >500: 2.37, 1.16, 1.09, 1.0 for the B1-LT and 2.93, 1.09, 1.11, 1.0 for the B2-HT, respectively. As seen, the first three fractions of particles passed through the building envelope, and the last did not. The time needed for particles <100 nm to pass through the building envelope was 2.6–4.6 h (average 3.8 h) in the B1-LT and 5.8–8.8 h (average 7.3 h) in the B2-HT. Although in the B2-HT, the infiltration of particles was higher, due to higher CN in outdoor air at the location of that building, it was almost two-fold slower. Unfortunately, we cannot wholly prevent the infiltration of aerosol particles through the building envelope. Still, we can ensure that the introduction of particles from the ambient air into the built environment is as small as possible by optimising ventilation, both in terms of duration and choice of hours (e.g., not during traffic rush hours, use of lawnmowers or grills).

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Transient modelling of carbon dioxide and radon levels in indoor air for analysis of ventilation efficiency

Ožbej Vene[1], Janja Vaupotič[2], Mateja Dovjak[1,3]

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[2]Department of Environmental Sciences, Jožef Stefan Institute, Ljubljana, Slovenia
[3]Microbial Genomics and Ecology, PHIS, The IDEC Institute, Hiroshima University, Hiroshima, Japan

Poor indoor air quality is a health and engineering problem. It is determined by various influencing factors, including location, building characteristics, ventilation efficiency, occupant activity and behaviour. Research findings have shown that renovated buildings with air-tightened building envelopes and insufficient ventilation are often related to deteriorated indoor air quality. Insufficient amount of fresh air, which leads to an increase in pollutant concentrations, has been tied to occupant discomfort, lower productivity and adverse health outcomes. The most commonly used indicator of ventilation efficiency is carbon dioxide (CO_2). As a metabolic product, its generation and concentration in indoor air mainly depend on occupants' activity and the occupant load. Also, radon (^{222}Rn) is an increasingly used indicator of ventilation efficiency. Its primary source is the ground, from where it enters buildings, and its indoor concentrations mainly depend on geology, climate and building characteristics. Additional sources, like building materials, tap water and natural gas, have a less evident effect on their indoor concentration. In general, CO_2 and ^{222}Rn are considered separately, mainly using a steady-state approach in studies when dealing with ventilation efficiency modelling. However, due to their different primary sources, the specifics of daily dynamics, relatively low outdoor concentrations and accumulation in poorly ventilated spaces, their simultaneous use represent a powerful and reliable tool for analysing ventilation efficiency. The benefits of such an approach were found mainly in transient simulations of DVRs (design ventilation rates).

The main purpose of our study was to analyse the ventilation efficiency of a small apartment in Ljubljana (ventilation zone 27 m^3) based on CO_2 and ^{222}Rn concentrations. Six sets of scenarios of required and recommended DVRs were defined to evaluate ventilation efficiency. The method includes continuous measurements of CO_2 and ^{222}Rn concentrations in the period 3–15 October 2021 by Radon Scout Professional portable monitors (Sarad, 2020), followed by transient simulation of various DVRs by CONTAM 3.4 program (National Institute of Standards and Technology, 2021) on measured data. Throughout the experiment, different ventilation scenarios were applied, and the occupancy schedule was recorded. In data analysis, legal requirements and recommendations on DVRs were considered to determine the optimal DVRs for CO_2 and ^{222}Rn concentrations.

A comparison of the measured and simulated datasets of CO2 and ^{222}Rn concentrations has shown similar trends. On the days of frequent ventilation, a moderate correlation was found between the measured and simulated concentrations (r=0.55 for CO_2, r=0.62 for ^{222}Rn). The simulation resulted in concentrations often exceeding the limit values (for CO_2: 1000 and 800 ppm, for ^{222}Rn: 100 Bq m^{-3}), indicated case scenario 1 as the worst one, with a DVR 15.0 m^3 h^{-1} (0.2 ACH). The best scenario was represented in case 5C_Cat I, with the DVR 46.9 m^3 h^{-1} (0.7 ACH), which is optimal and guarantees permanent ^{222}Rn and CO_2 concentrations below the limit values.

The results of our study confirm elevated concentrations of CO_2 and ^{222}Rn in the apartment with an air-tight building envelope and insufficient ventilation. However, this is not the only case; similar results can be expected in many apartments, especially during the heating season. We need to consider this

problem more broadly, and minimal DVRs have to be included in the design process in order to minimise health risks, which is especially important for protecting vulnerable occupants. Uncertain conditions in the field of energy with rising prices lead to a great concern that buildings will be even less ventilated, resulting in poor air quality.

The workshop information

The International hybrid workshop "Interaction between physical parameters, chemical pollutants, and microbes in the built environment", held in Ljubljana on 9 January 2023, was organized by the Faculty of Civil Engineering and Geodesy of the University of Ljubljana and PHIS, the IDEC institute, Hiroshima University.

There were 44 participants who pre-registered for the workshop. Of these, 70% were Slovenian and 30% Japanese (Fig. 3). The participants were from a wide range of positions, including students, young researchers, professors, and others such as the first secretary of the Japanese Embassy (Fig. 4). We would like to thank the many participants who attended the workshop on-site in Slovenia, even though it started as early as at 8:00 AM. The Japanese side participated online, but it seems that the lower number of participants than in Slovenia was due to the fact that January 9 is a national holiday in Japan rather than the time of 16:00 (ending at 20:00). The next time the event is to be held, even though the start of the event cannot be changed due to

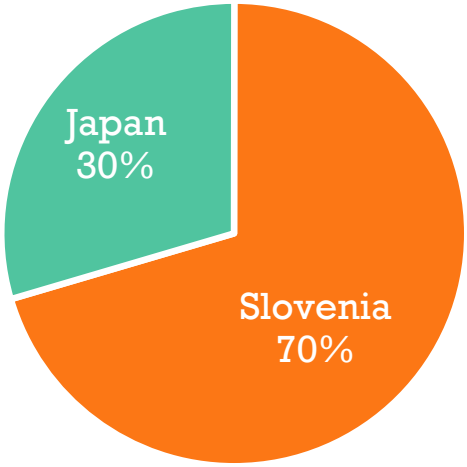


Fig. 3 Comparison of nationalities of pre-registrants

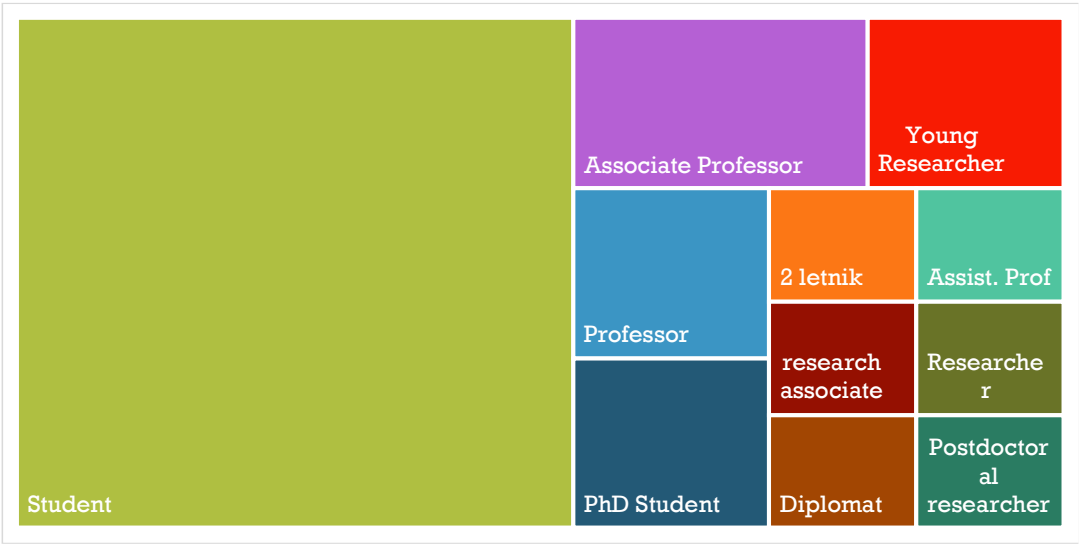


Fig. 4 positions in attendance

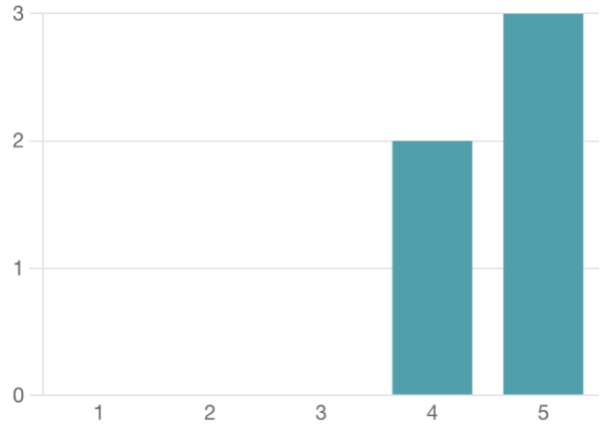
the 7- or 8-hour time difference between Slovenia and Japan, it would be better to hold the event outside the national holidays or vacation periods in both countries.

The decision to present the Best Student Presentation Award was made at the workshop. A total of 32 participants voted for the student they thought gave the best presentation, and the award was presented to the student with the most votes. This time, Ms. Yutong Li from the Hiroshima University, Japan, won the prize with her presentation entitled "Improvement of indoor thermal environment with the insulation system evaluated by heat-flow sensor".

Fig. 5. Trophy for the best student presentation award

After the workshop, participants were asked about their satisfaction with the meeting, and five responded.

1. Overall, how would you rate the event?



From 1 (bad) to 5 (good)

2. What did you like about the event?

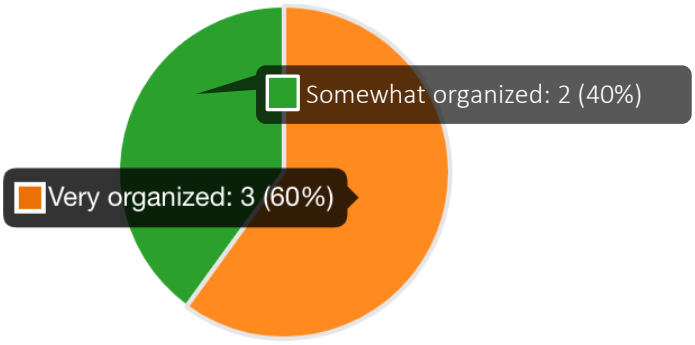
Coordination, Information, Information about Japan

3. What did you dislike about the event?

More sweets, Too quiet, Not following the schedule,
The speakers didn't speak loudly. It would need microphone

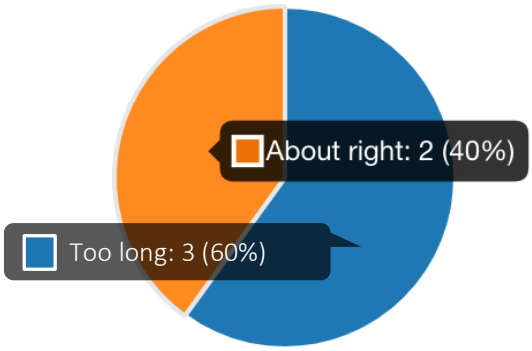
4. How organized was the event?

Options: Extremely organized; Very organized; Somewhat organized; Not very organized; Not at all organized



5. Was the event length too long or too short?

Options: Too long; About right; Too short



The results indicate that the respondents were satisfied with the workshop. In addition, the fact that the presenters from both the Slovenian and Japanese sides included each other's culture in their presentations shows that the workshop was not only about science but also about cultural exchange.

In addition, it must be reminded that the coffee break was shortened due to some program changes and the longer discussion time than planned. This probably contributed to the result that some respondents felt the meeting was too long. Online participants commented that they had no problems with the audio or video transmission. This was thanks to the preliminary work and on-site preparation by Ms. Lucija Lučka Hodnik, IT center of the Faculty of Civil and Geodetic Engineering of the University of Ljubljana. On the other hand, some participants who attended on-site stated that the audio was difficult to hear. When we hold the next event, it is important to use a microphone so that the audio can be heard clearly.

In this workshop, discussion time was divided into one session in the first half and one in the second half, rather than after each session. This allowed for cross-session discussions, but given that more than half of the participants were students, it would have been beneficial if there had been a little more exchange of ideas among the students. Since one

of the objectives of the workshop was to provide students with opportunities to speak at such international exchanges, we would like to explore ways to enable students to actively engage in academic exchanges (e.g., if they are not good at English, session directors can translate their comments into English; if they are not good at speaking in an open forum, they can use chat rooms, etc.).

Acknowledgement

The motivation for this workshop was the collaboration of Dr. Janja VAUPOTIČ and Dr. Ryoko FUJIYOSHI over a period of 20 years. We would like to express our deepest respect and appreciation for their work.

From left to right: So Fujiyoshi, Fumito Maruyama, Mateja Dovjak, Janja Vaupotič, Tajda Božič, Ožbej Vene, Janze Mulec, Sayaka Yamashita

Our sincere thanks also go to Luka Jurko, Tadej Pihler and Žan Mohorko for their help in managing the workshop.

This workshop was supported by Hiroshima University network support grant.

Hvala za udeležbo.

ご参加ありがとうございました.