# PDRG MEETING JRPUG 2021

## General Information

Date: October 21-22, 2021

Style: Virtual Event via Zoom

## Keynote

### Kazuyuki Kubo (久保 和幸)

Director, Pavement and Tunnel Group, Public Works Research Institute

(国立研究開発法人 土木研究所 道路技術研究グループ，グループ長)

Title: ***Pavement in Japan -Past, Present and Future-***

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## Technical Session

Theme: ***Ideas for Pavement Diagnosis in the Future***

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## ProVAL Workshop

### George Chang

Director of Research, The Transtec Group, Inc.

**Basic and Advanced Topics of ProVAL**: Fundamentals of Pavement Profiling, IRI Analysis, Power Spectral Density (PSD), Smoothness Assurance Module (SAM) & Grinding Simulation. (Windows PC & dual display recommended)

JRPUG website

**Conference web site: http://pdrg.org/workshop/jrpug2021**

**For further information, please contact PDRG meeting secretary by email at pdrg.jrpug@gmail.com**



As of October 18, 2021

# Agenda (day 1)

| **October 21, 2021** (JST, UTC+9) | |
|---|---|
| 8:30 AM — 8:40 AM | **Opening Session / President Speech** |
| 8:40 AM — 9:40 AM<br>**Keynote** | **Kazuyuki Kubo**<br>*Pavement in Japan -Past, Present and Future-* |
| 9:40 AM — 9:50 AM | Coffee Break |
| 9:50 AM — 10:50 AM<br>**Technical Session 1**<br>Moderator:<br>Kazuya Tomiyama,<br>Kitami Institute of Technology | ✓ Robert Otto Rasmussen: *Pavement Design and Construction at Automotive Test Tracks and Racetracks*<br>✓ Yafei Zhao , Yukihiro Kohata: *Deformation Characteristics of Artificial Lightweight Subbase Material on Cyclic Triaxial Test*<br>✓ Dang Quoc Thuyet, Masakazu Jomoto, Kazunari Hirakawa, and Yin Lei Lei Swe: *Development of an Autonomous Asphalt Pavement Damage Detection Program using a Deep Convolutional Neural Network* |
| 10:50 AM — 11:00 AM | Coffee Break |
| 11:00 AM — 12:00 PM<br>**Technical Session 2**<br>Moderator:<br>Hodaka Okajima,<br>Taisei Rotec Co., Ltd. | ✓ Yumi Hyogo, Yamamoto Minoru: *Approach to Transversal Shape Measurement for Multilane with Light-Section Method and IMU*<br>✓ Kazuya Tomiyama, Yuki Yamaguchi, Kazushi Moriishi, and Yuki Kotani: *Application of Wavelet Transform to Three-dimensional Pavement Surface Analysis*<br>✓ Kenichiro Sasaki, Yuki Kotani, Kazuya Tomiyama, Yuki Yamaguchi, and Kazushi Moriishi: *Measurement Characteristics of Road Surface Profiles Based on Point Clouds Acquired with ICT Devices* |
| 12:00 PM — 1:00 PM | Lunch |
| 1:00 PM — 1:50 PM<br>**Sponsor Presentation**<br>Moderator:<br>Akira Sakuraba,<br>Tairiku Kensetsu Co., Ltd. | ✓ AISAN TECHNOLOGY Co., Ltd.<br>✓ ASIA AIR SURVEY Co., Ltd.,<br>✓ KURABO INDUSTRIES Ltd.<br>✓ SAP Co. Ltd.<br>(in alphabetical order) |
| 1:50 PM — 2:00 PM | Coffee Break |
| 2:00 PM — 3:00 PM<br>**Technical Session 3**<br>Moderator:<br>Hiroyuki Mashito,<br>Toa Road Corporation | ✓ Keizo Kamiya, Yuki Ota: *Life Cycle Analysis of Road Pavement utilizing NEXCO-PMS*<br>✓ Hodaka Okajima, Masakazu Jomoto, Pham Hoang Kien, Dang Quoc Thuyet, and Nguyen Thi Thu Ha: *Investigation of the current state of asphalt pavement in Hanoi, Vietnam using STAMPER*<br>✓ Marei Inagi, Kazuya Tomiyama, Ryo Kohama, Masayuki Eguchi, and Msakazu Sato: *Quantitative Evaluation of the Road Roughness on an Expressway based on the Continuous IRI and Heart Rate Variability* |

# Agenda (day 2)

**October 22, 2021** (JST, UTC+9)

| | |
|---|---|
| 8:30 AM — 12:00 PM<br>**Workshop**<br>Instructor:<br>George Chang | **ProVAL Workshop**<br>George Chang<br><br>✓ Session 1 (8:30 AM – 10:00 AM): Basic Topics<br>• Fundamentals of Pavement Profiling<br>• IRI Analysis<br>• Hands-on exercise<br><br>✓ Session 2 (10:30AM – 12:00 PM): Advanced Topics<br>• Power Spectral Density (PSD)<br>• Smoothness Assurance Module (SAM) & Grinding Simulation<br>• Case Studies<br>• Hands-on exercise |
| 12:00 PM — 12:30 PM | **Closing Session / Chair Speech** |

# Sponsors

(in alphabetical order)

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|---|---|
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# Pavement Design and Construction at Automotive Test Tracks and Racetracks

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**ABSTRACT**

Automotive test tracks are unique places where tests are performed on vehicles to ensure they are safe, comfortable, and durable. Sometimes called proving grounds, these facilities typically contain dozens of special pavements. Each pavement is designed and constructed with a specific purpose, which is often to create a predictable and consistent vehicle or tire test response. Pavements at test tracks are engineered for many different purposes including testing brakes, steering, handling, noise and vibration, ride quality, durability, and fuel economy. In recent years, special pavement surfaces have been needed to test Connected and Autonomous Vehicle (CAV) sensors and systems.

Pavement engineering at racetracks has similarities to that of test tracks. Racetracks are primarily built for the exhibition of speed. Racetrack pavements must therefore be designed and constructed to withstand extreme forces. There are also stringent requirements for safety, evenness, tire wear, and durability. One challenge in pavement engineering for racetracks is to balance the desires and needs of the owners, the drivers, and the race fans.

Pavement performance on public roads are defined by their service to the traveling public as a means of safe and efficient transportation. Pavements are designed to carry heavy vehicles without excess damage or unevenness. Test tracks and racetracks rarely experience heavy vehicles, although some track pavements must resist extreme stresses from high-performance vehicles. But of particular importance to track pavement engineering is environmental and material durability. Degradation of a pavement surface such as cracking and raveling can adversely impact texture and friction. Successful track pavement engineering must include means to resist this damage.

Successful track pavement engineering requires materials, techniques, and measurements that are among the best known. What has been learned in designing and constructing track pavements can be used to improve overall pavement engineering practice.

*Keywords*: test tracks, racetracks, friction, evenness, texture.

# Deformation characteristics of artificial lightweight subbase material on cyclic triaxial test

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**ABSTRACT**

The objective of this study is to develop a new lightweight subbase course material to reduce the weight of the upper layer of the pavement. The deformation characteristics of the new lightweight subbase course material were discussed in this study. A series of cyclic triaxial tests under three confining pressures (29.4, 49.0 and 68.6 kPa) were performed for the specimens on dry and optimum moisture content. The influences of specimen condition, confining pressure and cyclic loading numbers on the deformation characteristics were investigated. From the test results, it was found that the equivalent Young's modulus in dry condition was greater than that in optimum moisture content condition under three confining pressures. With the increase of cyclic loading numbers, the equivalent Young's modulus of the specimen under the same condition basically remained unchanged, and the Poisson's ratio of the specimen also remained unchanged through the overall. It is found that the tendency of negative dilatancy for the cyclic triaxial test under almost conditions is indicated. However, the positive dilatancy is indicated in case of confining pressure, 29.4 kPa on the specimen of optimum moisture content.

From a general viewpoint, it is considered that the proposed artificial lightweight subbase material in this study is possible to be applicable as new subbase material.

*Keywords*: subbase course material, cyclic loading, deformation, stiffness, triaxial test

# Development of an autonomous asphalt pavement damage detection program using a deep convolutional neural network

Dang Quoc Thuyet[1], Masakazu Jomoto[2], Kazunari Hirakawa[3], and Yin Lei Lei Swe[4]

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**ABSTRACT**

Asphalt pavement inspection is one of the important issues for road construction industry to ensure traffic safety and preventing traffic accidents. In Japan, the increase of ageing paved roads together with the shortage of labors in road inspection and maintenance raises many burdens to public finances. The demand on automation in road inspection is high. This study presented the development and application of an autonomous asphalt pavement inspection program based on road surface image analysis. The program automatically detected road lane line marks and made grid mesh 50 cm × 50 cm of analyzed parts. It detected 100 % straight lane lines even though the lines were partly fading, peeling off or discontinued. The maximum detection error in the curved parts was 15 cm. The program utilized a customized deep convolutional neural network (CNN) based on VGG-16 network architecture to automatically detect crack, non-crack, and patch parts on each grid mesh. Transfer learning and fine-tuning parameters were employed during CNN model training for the image classification. The model accuracy for the classification of three classes was 98 %. The precision for each class, crack, non-crack and patch classes were 97.5%, 98.7% and 98.7 %, respectively. The study reveals the novelty of the application of customized CNN, and hyperparameter training in road surface image inspection. The program significantly improved asphalt pavement inspection efficiency. As compared to the inspection time of a professional engineer in 1-km road surface images in a national highway with a crack ratio of 20%, the program shortened inspection time by 98% for lane line detection and marking grid mesh, and by 82 % for road damage judgment. Total inspection time of 1-km road was shortened by 50%. This study shows a promising step for the application of AI on the asphalt pavement inspection research.

*Keywords*: asphalt pavement inspection, lane line, CNN, crack, patch

# Approach to transversal shape measurement for multilane with light-section method and IMU

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**ABSTRACT**

When deformed pavement to be repaired as road improvement work, measurement for pavement condition to be conducted in advance and cutting amount to be calculated. This pavement measurement is mainly conducted by positioning machine such as Total Station and the time and cost for the measurement are regarded as matters that we have to solve. Kurabo Industries Ltd has provided the compact pavement inspection system 'PG-4' which measures 1 lane width with using our original 3D photogrammetric system. We think the system can be used for measuring the volume by Cut and Fill calculation and tried to conduct the work as below.
We installed IMU to 'PG-4' and measured absolute transversal shape for multilane lanes by studying inclination of the vehicle. Road image is synchronized to IMU data with time and height information having inclination for Roll amount of IMU. We measured the shape based on these data. As a result of that, we acknowledged that there was no gap in comparison with fixed laser scanner data. The system makes the working time reduce dramatically and it will bring us the work efficiency and the cost reduction. Securing safety also will be improved since we can inspect lanes by driving cars without closing roads on site.

*Keywords*:

light-section method, inertial measurement unit, transverse shape figure、image analysis、Cut-and-Fill calculation

# Application of Wavelet Transform to Three-dimensional Pavement Surface Analysis

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**ABSTRACT**
The pavement industry in Japan actively improves quality and productivity by use of information and communication technologies (ICTs) measuring three-dimensional (3D) point cloud through construction, maintenance and rehabilitation activities of pavement surfaces. One of the most vital challenges by use of ICT devices is efficient and effective data treatment and analysis of point clouds. The pavement surface data composed of 3D point clouds contain much more information than conventional profile-based approaches. A question here is how to derive useful information fit for the purpose from point clouds in the 3D space. This study proposes a wavelet-based analysis method of point cloud-based pavement surfaces. The wavelet has so far been applied to multi-dimensional data analysis such as noise reduction, data compression, and feature identification for instance. The dual-tree complex wavelet transform (DTCWT) particularly allows highly efficient multiresolution analysis providing multi-dimensional filtering algorithm with directional selectivity such as vertical, horizontal, and diagonal orientations. The multiresolution function of DTCWT is capable of less redundant analytic data decomposition and feature detection with respect to the orientation of interest in pavement surface point clouds. It also identifies both specific wavelengths and corresponding locations simultaneously. This presentation demonstrates an application of DTCWT for the 3D point clouds of pavement surfaces. In particular, waveband analysis of a 3D pavement surface is conducted with the multiresolution analysis, which helps to consider the functional properties of a pavement surface. A novel approach to the analysis of surface deterioration, edge defects, and joint faults on various pavements is also presented on the basis of decomposition with the directional selectivity of DTCWT. This study contributes to the improvement of the quality and productivity for pavement surface evaluation based on point clouds acquired with widely used ICT devices.

*Keywords*: *pavement surface, point clouds, wavelet, 3D surface, ICT*

# Measurement Characteristics of Road Surface Profiles Based on Point Clouds Acquired with ICT Devices

Kenichiro SASAKI[1], Yuki KOTANI[2], Kazuya Tomiyama[3],
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**ABSTRACT**
In recent years, the pavement industry in Japan encourages a construction policy called "i-Construction" which intends to improve productivity and quality of pavement construction with saving working time and human recourses. The i-Construction encourages the broad use of ICTs measuring three-dimensional (3D) point clouds such as a Terrestrial Laser Scanners (TLS), TLS, a Mobile Mapping Systems (MMS), and an Unmanned Aerial Vehicle (UAV) across pavement construction and management activities including surface profile measurement. Therefore, the accuracy certification of a surface profile derived from point clouds is necessary to perform high-quality road surface management by use of various ICT devices. In this study, verification experiments are conducted to examine the measurement characteristics of road surface profiles acquired with various 3D measurement devices. As a result, this study suggests that the efficient application of ICTs need to use a right device according to the required measurement resolution and workability.

*Keywords*: *road surface profile, point cloud, TLS, MMS, UAV*

# Life Cycle Analysis of Road Pavement utilizing NEXCO-PMS

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**ABSTRACT**

Preventative maintenance is deemed an ideal strategy for managing road pavement because the concept of 'achieving early repair before leaving it heavily damaged' well matches on the roadway, which needs repeated maintenance and rehabilitation during its lifetime. However, preventative action is hard to achieve, because pavement performance varies even on the same design of projection; some portions show good condition for years, some others are heavily cracked and need to be rehabilitated earlier.

NEXCO-PMS collects comprehensive pavement data, including not just road surface monitoring data but also all contents of repair projects since decades long ago. For example, Chuo Expressway, a trunk beltway connecting Tokyo and Nagoya, has been in service over 50 years. Since the 1990s, all repair projects data have been compiled onto the PMS. Therefore by analyzing its repair history, it is possible to substantially grasp, for instance, past lifespan of pavements, identification of problematic areas and other repair specifics.

As a result of analysis, rehabilitation cycle of porous asphalt on the Hachioji section is around 9.3 years with standard deviation of three years. However, this cycle is highly dependent on the underlying binder layer's condition. This is because rainwater from the porosity runs slowly on the layer's surface while heavy vehicles passing on the pavement. Moreover, the importance of earlier rehabilitation is confirmed, as damages tend to proceed in depth as time goes by. These findings are considered crucial in achieving a preventative maintenance policy that weighs early action before it is too late. (248 words)

*Keywords*: life cycle analysis, PMS, preventative maintenance, repair history, porous asphalt

# Investigation of the current state of asphalt pavement in Hanoi, Vietnam using STAMPER

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**ABSTRACT**

Pleas Vietnam is experiencing remarkable economic development, and rapid growth of social capital including roads. However, economic activity is becoming more active at a faster rate, and traffic congestion is occurring on urban roads. In order to continue to develop the economy in the future, it is necessary to further improve social capital and at the same time to efficiently maintain and manage the existing social capital stock.
In collaboration with the University of Transport and Communications, we are working to build a pavement management system that is suitable for Vietnam, and to investigate the pavement service status in Vietnam. We use a simple IRI measuring device (STAMPER II) for the investigation in 3 years. This study presents the results of IRI measurements and the pavement service status in Hanoi. (130words)

*Keywords*:
*IRI, pavement management system, Vietnam, STAMPER*

# Quantitative Evaluation of the Road Roughness on an Expressway based on the Continuous IRI and Heart Rate Variability

Marei INAGI[1], Kazuya TOMIYAMA[2], Ryo KOHAMA[3],
Masayuki EGUCHI[4], and Msakazu SATO[5]

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**ABSTRACT**

In Japan, the International Roughness Index (IRI) is normally calculated for specific fixed intervals such as 10 m and 200 m. On the other hand, since vehicle vibration induced by road surface roughness changes momentarily, continuous IRI which indicates dynamic change of the roughness in each profile sampling point potentially corresponds to road users ride quality to be accurate. In this study, a field survey was conducted on a section of expressway where the poor ride quality might be claimed by road users, which acquired vehicle motion, surface roughness, and heart rate of a driver. A driving experiment using a driving simulator (DS) was then conducted by loading the data acquired in the field survey. In the experiment, we focused on the possibility of evaluating ride quality of expressways by physiological information of road users, and thus measured the heart rate variability with pulse waves of participants. The result shows that unconscious mental stress of road users against surface roughness can be detected by the heart rate variability analysis. According to this result, a cognitive threshold of IRI changes can be provided on the basis of the relationship between the continuous IRI and increase of mental stress level quantified by heart rate variability. This study indicates the feasibility of preventive maintenance of surface roughness based on the subconsciousness of road users against the ride quality.

*Keywords*: *continuous IRI, expressway, ride quality, heart rate variability, mental stress*

# ProVAL WORKSHOP

## *Pavement Profile Viewing and Analysis Software*

*2021/10/22*
*Online Workshop*
*JRPUG 2021*

### *OBJECTIVES*

- ❑ To familiarize attendees with the current version of ProVAL – the *Profile Viewing and Analysis* software *(www.RoadProfile.com).*
- ❑ To refresh some of the critical fundamentals of pavement profiling and analysis methods.
- ❑ To inform attendees of the advantages, limitations, and pitfalls related to analyzing and interpreting pavement profiles.
- ❑ To provide an interactive and hands-on approach throughout the workshop.

### *AGENDA*

***Time in JSP***

### Session 1 (8:30 AM – 10:00 AM): Basic Topics

- Fundamentals of Pavement Profiling
- IRI Analysis
- Hands-on exercise

### Break (10:00 AM – 10:30 AM)

### Session 2 (10:30AM – 12:00 PM): Advanced Topics

- Power Spectral Density (PSD)
- Smoothness Assurance Module (SAM) & Grinding Simulation
- Case Studies
- Hands-on exercise

### *Further Information*

www.RoadProfile.com www.SmoothPavements.com

## Appendix A: Bio of ProVAL Trainer

Dr. George K. Chang, P.E.
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Dr. George Chang is recognized as the world expert on pavement smoothness and intelligent compaction technologies. His research, teaching, specification development, and software tools have helped make significant technology advancements in the above fields. The websites he develops and maintains, Profile Viewing and Analysis - ProVAL (www.RoadProfile.com), Intelligent Compaction - IC (www.IntelligentCompaction.com), and Intelligent Construction Technologies - ICT (www.IICTG.org), have evolved into the one-stop-shop for pavement smoothness and intelligent compaction/construction. He led the US national deployment effort of the International Roughness Index (IRI) with ProVAL and intelligent compaction with Veta since 2001 and 2007, respectively.

Dr. Chang has been the Principal Investigator (PI) for numerous projects that enhance pavement materials/structure design and analysis, pavement surface characteristics (smoothness/texture/noise), intelligent compaction for soils and asphalt pavement construction, and intelligent construction technologies, etc. Examples of these projects include FHWA ProVAL Support, HIPERPAV, Concrete Mixture Optimization (COMPASS), Pavement Surface Enhancements, TPF/EDC Intelligent Compaction, and Veta software, and Intelligent Construction Systems and Technologies (ICST). Dr. Chang has also developed and edited many ASTM and AASHTO standards. The above software tools and standards have been adopted by industry around the world. Recognized for his energetic, lively teaching style, Dr. Chang delivers pavement smoothness and intelligent compaction/construction-related workshops worldwide. Dr. Chang has taught more than 150 ProVAL workshops in the US, Europe, and China since 2001

Dr. Chang has been the chairman of the International Intelligent Construction Technologies Group (IICTG), Road Profile Users' Group (RPUG), TRB AFD90 Pavement Surface Properties and Vehicle Interaction committee (an Emeritus Member), and ASTM E17.31 Profile Measurement subcommittee. He is a member of the TRB AFH60 Flexible Pavement Construction committee, AFH20 Pavement Rehabilitation committee, AAPT, etc. Dr. Chang received many industry awards such as ASTM Kummer Lecture Award, ASTM Meyer-Horne Outstanding Achievement Award, RAI Power List Award to rejuvenate the US infrastructure, NOVA award from Construction Innovation Forum (CIF), Founders' Award from RPUG, and ASTM Billiard-Stubstad Award. His research work has been featured in over 50 professional publications and 100+ reports.

## Appendix B: ProVAL Software Download and Installation

### *Download ProVAL*

The latest version of ProVAL can be freely downloaded from the ProVAL website.

http://www.roadprofile.com/proval-software/current-version/

All sample files used for the ProVAL workshops will be automatically installed with the ProVAL software installation (see the Hands-on Sample Files for further details)

### *Install ProVAL*

**System Requirements**

ProVAL 3.6x is supported on 32 or 64-bit versions of Windows 7 or later. Older operating systems are only supported through ProVAL 3.52.

ProVAL 3.6x requires Microsoft .NET 4.5.2. If you do not have the required version of .NET installed, the ProVAL installation will download and install it.

To uninstall the software, go to Programs and Features in the Windows Control Panel.

**Installation Guide**

Previous versions of the same family will be automatically uninstalled. For example, 3.6x will uninstall the last 3.6x versions but will not uninstall 3.5. The two versions can co-exist side-by-side.

You must have sufficient privileges (i.e., administrative rights) to install applications on your computer. If you receive an error message during the installation, ask your administrator to install the software for you. If your administrator is also unable to install the software, then please contact us (http://www.roadprofile.com/proval-support/).

## Appendix C: ProVAL Sample Files

### *Summary of Sample Files*

All sample files are installed in the following folder:
C:\Users\Public\Public Documents\ProVAL 3.6 Samples

**Sub-folder Names**

Data import – Contains sample profile data of the various sort
Template – Template files for ProVAL input settings

**Project File Names**

00_Data Import.pvp
01_Basic Sample.pvp
02_Profiler Comparison.pvp
03_Ride Statistics.pvp
04a_APSync-org.pvp
04b_APSync-test.pvp
05_PCM_Asphalt test.pvp
06_PCM_Concrete test.pvp
07_PCM_Not-so-good.pvp
08_PCM_with lead_in_out.pvp
09_PCM_vs_PB.pvp
10_PSD_Sample.pvp
11_PSD_ID Profile Features.pvp
12_SAM_Sample.pvp
13_AFM_Sample.pvp
14_OWL_Sample.pvp
15_Case Studies.pvp