KUUSJOKI BRIDGE (U-2306)

Condition Assessment of Surface Structures by using NDT and DT Inspection Techniques

Client:

ELY CENTER UUSIMAA
TRANSPORT AND INFRASTRUCTURE
PL 36, Opastinsilta 12 B
FIN-00521 Helsinki
Finland

Service provider:

RAMBOLL FINLAND OY
Espoo, Head Office
PL 25, Säterinkatu 6,
FIN-02601 Espoo
Finland

CONTENT

1.0 The Investigation Task – General Objectives and Information

Background information: the Kuusjoki bridge was included in The Finnish Transport Agency pilot project “Accelerated repair methods for bridge deck renovations” (report 39/2011). The Kuusjoki bridge surface structures have been renewed under tight condition control during summer 2009.

The objective of this investigation task is to access the condition / integrity of the recently renewed surface structures by Non Destructive Test methods (NDT). In addition, during the field work inspection task it has been decided to perform core sample taking form one location.

1.1 General Information Regarding the Investigated Structure

The investigated structure is Kuusjoki bridge (U-2306), which is located in the south-west part of Finland near the municipality of Ypäjä on road no. 2805 in road section 004-02171. The traffic volume in the bridge road section is the very low, 313 vehicles per day according to the year 2011 traffic counting (6% heavy-load traffic). The bridge crosses the Kuusjoki river.

Kuusjoki bridge was constructed in the year 1953 and has been repaired, as mentioned above, in the year 2009.

The bridge type is continuous reinforced concrete slab bridge and it is founded on concrete piles. The main dimensions of the bridge are:

Overall length:	18,70 m
Span length:	5,2 m + 6,5 m + 5,2 m
Horizontal clearance:	6,45 m

Part of the bridge longitudinal section and of its cross-section, taken from the bridge original drawing, is presented in figures 1 and 2.

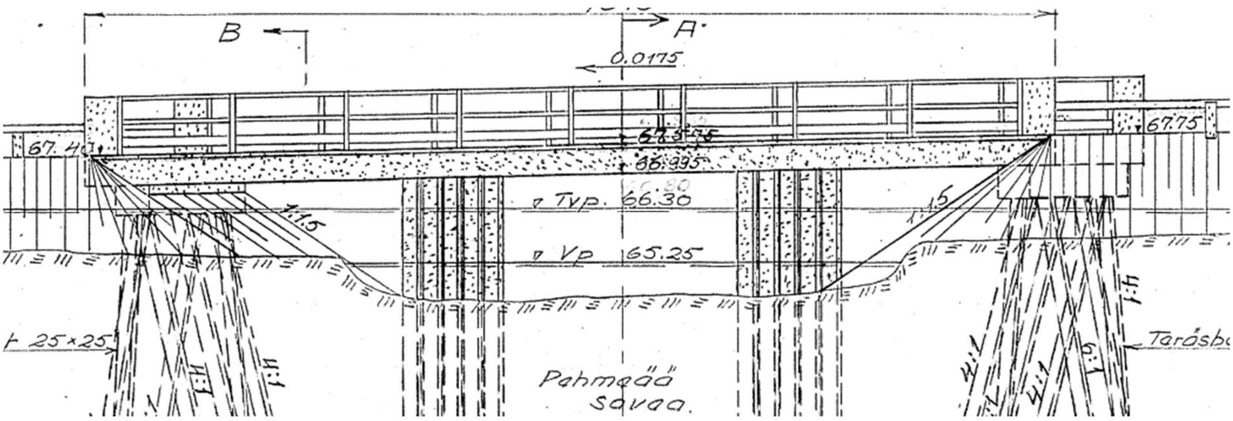


Figure no. 1 – Kuusjoki longitudinal section

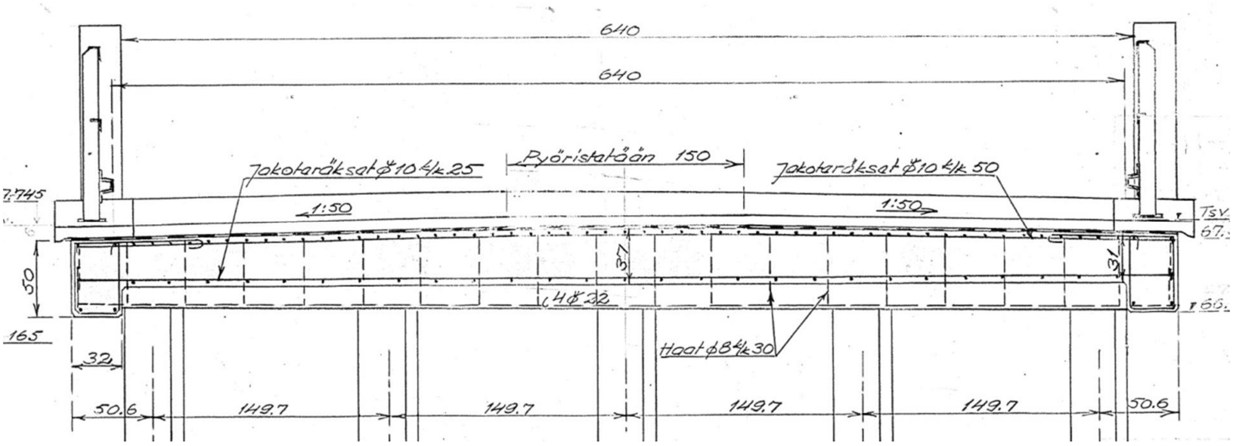


Figure no. 2 – Kuusjoki cross-section

1.2 Organization and Implemented Investigations

Ramboll Finland Oy Infrastructure & Transport carried out the above mentioned investigation task on 22.5.2012 and drafted this report.

The investigation task NDT experts are Eng. (Technical University) Guy Rapaport (guy.rapaport@ramboll.fi) and Eng. (MEng) Tuomo Koskela (Tuomo.koskela@ramboll.fi). Both are well experienced bridge planners, inspectors and NDT experts. Since the year 2009 the NDT experts have carried out dozens of NDT inspection tasks of pre-stressing systems in bridges as well as in other concrete structures.

Both NDT experts are certified bridge inspectors of the Finnish Transport Agency and they are holders of the FISE “A Class Certificate of Qualifications of Concrete Bridge Repairs” and the “A Class Certificate of Qualifications of Concrete Bridge Condition Inspection”. In addition Eng. Tuomo Koskela holds the “AA Class Certificate of Qualifications of Concrete Bridge planning”.

This investigation report was drafted by Eng. Guy Rapaport and checked by Eng. Tuomo Koskela.

1.3 Initial Information

Initial information necessary for performing the investigation task and for drafting this report is the information available from The Finnish Transport Agency Bridge Registry and pilot project report n. 39/2011.

1.4 The Inspection Methods and Process

This inspection task was carried out by using the Impulse – Response (IR) s’MASH and the Impact – Echo DOCter NDT systems (distributor: Germann Instruments, Denmark). Supportive NDT system for this purpose was the Surfer NDT system (GI). The NDT testing was performed from the surface of the asphalt pavement.

In addition diamond drilling equipment was used for purpose of opening the surface structures and for core sample taking from the bridge upper surface.

The testing techniques, principles and testing systems are presented in section 1.6 of this report.

The inspection process included the following actions:

1. Marking of the testing grid for the s'MASH NDT investigation.
2. Performing of the S'MASH testing.
3. Rapid in situ interpretation of the s'MASH testing results.
4. Marking of testing points for the Impact – Echo DOCter testing.
5. Performing of the DOCter testing.
6. Rapid in situ interpretation of the DOCter testing results.
7. Diamond drilling of the surface structures and taking of core sample from the bridge deck upper surface.
8. Patching of the deck concrete and of the surface structures.

1.5 The Guiding Logic of Using NDT Technology

The aim of using NDT technology is to find the most suspicious locations in a structure according to the NDT testing systems and to investigate them thoroughly, by using destructive / invasive testing techniques such as core drilling.

If destructive testing confirms that no substantial problems exist in locations determined suspicious by the NDT tests, one can logically assume that no substantial problems exist at the locations determined non-suspicious by the NDT testing. In other words it could be considered as a logical elimination method.

It is important to mention that one should not determine with absolute certainty the existence of a fault based merely on NDT testing results!

1.6 Description of the NDT Systems used in the Inspection Task

The evaluation of the surface structures condition was performed mainly by IR s'MASH screening (all the bridge deck area) and by using the IE DOCter for point-wise investigation in the most suspicious location according to the s'MASH investigation. Supportive NDT system for the DOCter has been the Surfer NDT system which was used for measuring the P-wave velocity in the asphalt pavement.

Hereunder the description of the above mentioned systems:

1.6.1 The Impulse – Response s'MASH System

The Impulse-Response s´MASH test system is suitable for quick NDT screening of a structure aiming to evaluate its integrity, to detect possibly existing flaws in it and to identify suspicious areas for subsequent detailed analysis for example by the NDT MIRA and Impact-Echo systems and/or by invasive inspection with drilled cores.

The Impulse-Response NDT testing system is introduced in ASTM C1740-10 “Standard Practice for Evaluating the Condition of Concrete Plates Using the Impulse-Response Method”.

The Impulse-Response system has been successfully implemented for the following applications:

- Evaluation of bridge deck surface structures
- Locating delaminations and honeycombing (casting defects) in bridge decks, slabs, walls and large structures such as dams, chimney stacks and silos
- Detecting the presence of damage due to freezing and thawing
- Detecting the presence of alkali-silica reaction (ASR)
- Evaluating the effectiveness of load transfer system in transmitting stresses across joints in concrete structures
- Detecting de-bonding of asphalt and concrete overlays and repair patches from concrete substrates
- Detecting the curling of slabs
- Evaluating anchoring systems of wall panels

One of the benefits of the Impulse-Response testing method is that it requires access to only one surface of the test object.

The Impulse-Response *system components and system operation:*

The components of the Impulse-Response system are presented in figure 3.
The Impulse-Response system (IE) comprises of:

- Hard rubber tipped hammer (tip d=50mm, weight 1 kg) with a built-in load cell capable of measuring dynamic forces up to 20 kN.
- Velocity transducer for 360^{o} testing (geophone) that responds to normal surface motion and with constant sensitivity over the range 15-1000 Hz
- Laptop with the s’MASH software, Windows®, and Excel®. The laptop and the s’MASH software are responsible for data acquisition, data storage and signal analysis. The Excel software is responsible for graphical presentation of the screening data (contour plots).

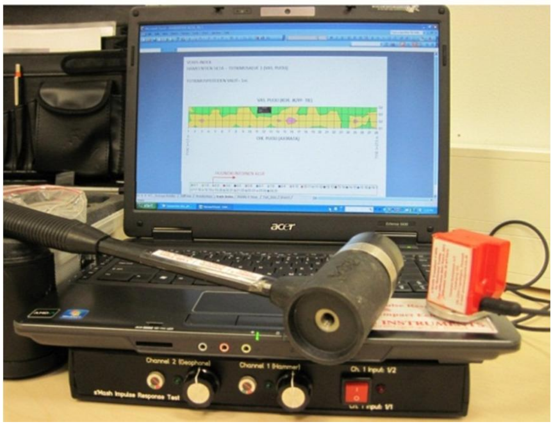


Figure 3 – The Impulse-Response s’MASH system

Principle of the Impulse - Response system technique and the system operation:

The s´MASH system uses a low-strain impact, produced by a load cell instrumented hard rubber tipped hammer, to send stress waves through the tested element. The impact causes the element to vibrate in a bending mode (flexural vibration) and a velocity transducer, placed adjacent to the impact point (about 100 mm), measures the resulting motion of the test element, i.e. the amplitude of the response. The hammer load cell and the velocity transducer are linked to a portable field computer with s'MASH software for data acquisition, signal processing and storage.

The time histories of the hammer force and the measured response velocity are transformed into the frequency domain using the fast Fourier transform (FFT) algorithm. The resultant velocity spectrum is divided by the force spectrum, to obtain the mobility as a function of frequency. The s'MASH calculates the mobility spectrum which is analyzed to obtain parameters representing the element's respond to the impact.

The screening by the Impulse – Response system is done in a grid form, usually of intervals between 500-1000 mm.

The parameters from the mobility plot that are used for integrity evaluation are:

The Average Mobility [(m/s)/N)]: average of the mobility values from the mobility spectrum in the frequency range 100-800 Hz.
Indication => compare differences in overall mobility among test points in the tested element and assist to determine problematic areas in the investigated object.

The Mobility Slope: the slope of the mobility spectrum obtained from the best-fit line to mobility values between 100-800 Hz.
Indication => location of poorly consolidated concrete / honeycombing and of poorly compressed asphalt layer.

The voids Index (peak-mean): the ration of the peak mobility value between 0-100 Hz to the Average Mobility between 100-800 Hz.
Indication => poor support conditions under the investigated layer, presence of internal defect.

The Dynamic Stiffness [N/m]: the inverse of the initial slope of the mobility spectrum from 0-40 Hz. Used mostly for relatively thin structures, usually not used for evaluation of surface structures.
Indication => relative quality of concrete, relative thickness, relative quality of support.

The Impulse – Response s'MASH data presentation:

Figure 4 shown the data presentation available during (and after) the testing time. The s'MASH presents for each testing point the Force Waveform (up left), the

Velocity Waveform (up right) and the Mobility Spectrum (down) as well as numerical values of the above mentioned parameters.

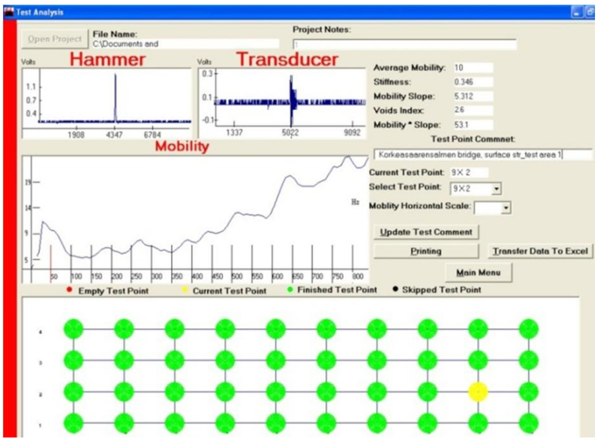


Figure 4 – The Impulse – Response data presentation of a test point (yellow dot)

In the end of screening a test area (in figure 4 the test area consist of 4x10 points) the data is the transferred to Excel for graphical presentation in shape of contour maps and numerical data for further analysis if needed. In figure 5 the counter map of the Average Mobility of the figure 4 test area is presented as an example.

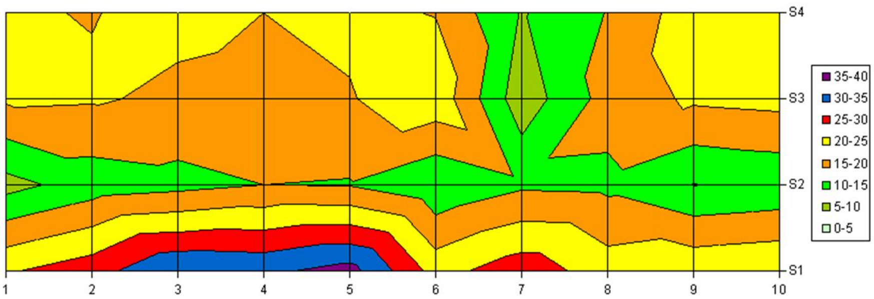


Figure 5 – example of Average Mobility counter map

Interpretation of scanning results:

The interpretation of Impulse response results is done according the threshold values mentioned in the ASTM C1740-10, from other published performed testing results and according to Ramboll NDT experts empirical experience with the Impulse – Response system.

Experience with the Impulse – Response *system:*

The Impulse – Response s'MASH system is frequently used by Ramboll engineers since the year 2011 (in Finland) for assessing the condition of the concert elements and condition evaluation of bridge decks surface structures. The system is almost regularly used in concrete structures special inspections.

1.6.2 The Impact – Echo DOCter System

The impact-echo method is based on monitoring the periodic arrival of reflected stress waves and is able to obtain information on the depth of the internal reflecting interface or the thickness of a solid member.

In the Impact – Echo system a short-duration (<100 µs) stress pulse is introduced into the member by mechanical impact. This impact generated three types of stress waves that propagate away from the impact point. A surface wave (R-wave) travels along the top surface, and a P-wave and an S-wave travel into the member. In Impact-Echo testing, the P-wave is used to obtain information about the test object.

The Impact - Echo system has been successfully implemented for the following applications:

- Measure the thickness of pavements, asphalt overlays, slabs-on-ground and walls (ASTM C1383) and detect possible flaws in those structures
- Detect the presence and depth of voids and honeycombing
- Detect voids below slabs-on-ground
- Evaluate the quality of grout injection in post-tensioning tendon ducts
- Integrity of a membrane below an asphalt overlay protecting structural concrete
- Delamination surveys of bridge decks, piers, cooling towers and chimneystacks
- Detect de-bonding of overlays and patches
- Detect ASR damages and freezing-and-thawing damages
- Measure the depth of surface-opening cracks

One of the benefits of the impact-echo testing method is that it requires access to only one surface of the test object.

The Impact – Echo system components and system operation:

The components of the DOCter system are presented in figure 6.
The impact-echo system (IE) comprises of:

- Mechanical spherical impactor source, i.e. the generator of the short duration pulses, normally in the range from 3 to 15 mm in diameter.
  The impactor contact time is a function of the impactor diameter and influencing the frequency domain. The impact point has to be close (approximately 50 mm) to the geophone
- High fidelity displacement transducer responsible to measure the surface displacement
- P-wave propagation speed measuring test set (the Longship in the GI DOCter system)
- Laptop with the Impact - Echo software (Viking software in the GI DOCter system). The laptop and the software are responsible for data acquisition, data storage and signal analysis.


Figure 6 – the Impact- Echo system

Principle of the Impact - Echo system technique and the system operation:

The impactor generates a short-duration pressure wave (P-wave), which travels into the concrete and is reflected from the backside of the test object or from an internal anomaly (for example a void) back to the surface. This P-wave is reflected several times and the arrival of the reflected P-wave are detected by the displacement transducer on the test object surface.

The time-displacement response (i.e. time domain waveform) is converted to a frequency response (i.e. amplitude spectrum) using a fast Fourier transform (FFT) algorithm. Figure 7 (taken from GI brochure) shows a sketch of the setup of the IE system and the operation principle.

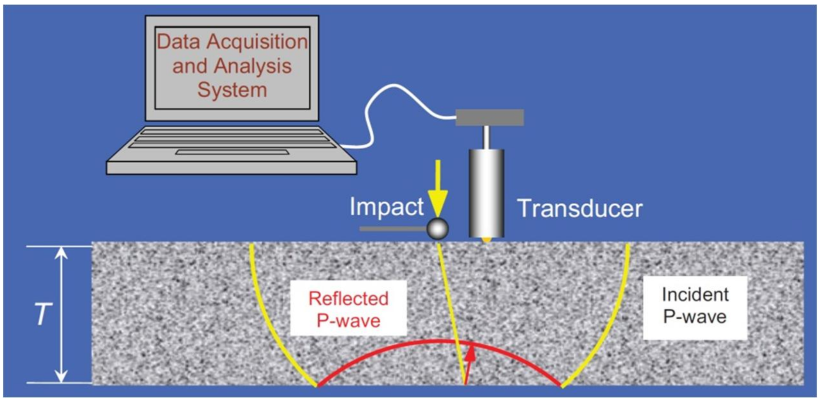


Figure 7 – sketch of the setup of the IE system

For a plate-like structure the IE system can be used to measure the thickness of the concrete or depth to the defect below the test-point as briefly explained here.

The time (Δt) taken for the reflected P-wave to reach the transducer depends on the P-wave velocity (Cp) in the concrete and the thickness (T) of the concrete, and is given by:
$\Delta t = (2*T) / Cp$ (1)

By using the FFT-algorithm the plate thickness or frequency (f) can be determined. It is the inverse of the travel time in equation (1). Thus the plate thickness is related to the thickness frequency as follows:

$T = Cp / (2*f)$ (2)

• The thickness, T, of the solid plate is either measured directly on the structures or is known from the structural drawings.
• The P-wave velocity Cp can be obtained by directly measurement on the surface by using two transducers at a known separation and measuring the P-wave travel time between the two transducers. This can be done by the IE equipment (the Longship) or for example by using the Surfer system.

The same principle applies to reflection from an internal defect (delamination or void for example in a tendon duct). Thus, the impact-echo method is able to determine the location of internal defects as well as measure the thickness of a solid member. The determination of flaw depth (t) is depended upon the diameter of the used impactor and flaw size (d). In general, when d/t>0,3 the depth of the flaw could be determined.

The Impact – Echo data presentation:

The Impact – Echo software presents the following plots as seen is figure 8:
The upper plot shows the surface displacement waveform obtained from the specific test point and the lower plot shows the amplitude spectrum obtained by transforming the waveform into the frequency domain. In the amplitude spectrum of the selected test point the dominant signal's frequency peak is marked. The system user can examine also the other "less dominant" signal peaks.

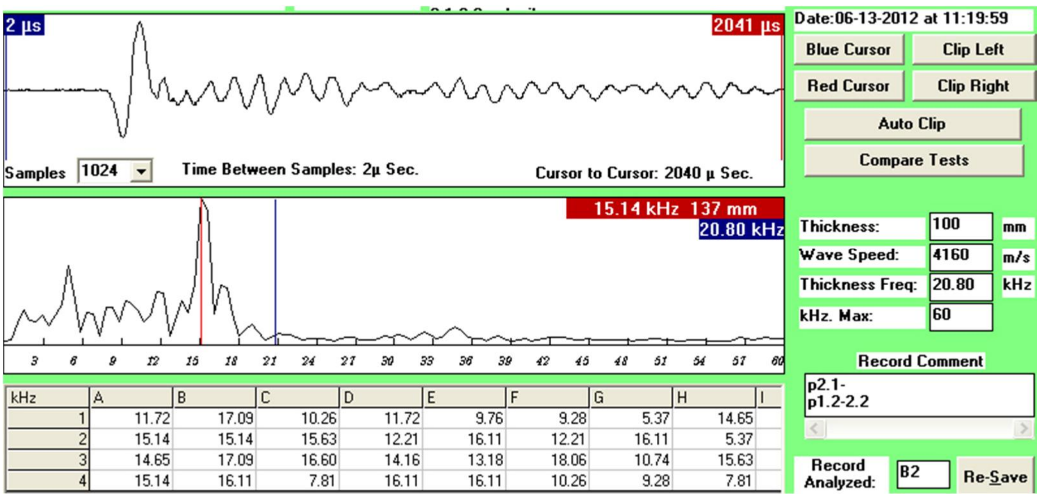


Figure 8 – Impact – Echo test point presentation

Interpretation of Scanning Results:

The interpretation of Impact – Echo testing results requires from the system user substantial technical understanding, understanding of principle of signal analysis including performing “forecasting” frequency calculations before actual testing, experience of using and “calibration” experience of I-E testing results by invasive means.

Experience with using the Impact – Echo *system:*

The Impact – Echo system is frequently used by Ramboll engineers since the year 2011 (in Finland) together with other NDT systems such as the MIRA tomographer and the IR s’MASH for verification of existing faults in concrete elements or pavements and for evaluating depths of faults in those.

1.6.3 The Surfer System

The Surfer system is a compact hand-held instrument for measuring the propagation speed of a pulse of ultrasonic longitudinal stress waves (P- wave) in a test object. The instrument incorporates two dry point contact (DPC) transducers that are brought into contact with the surface of the test object. Thus ultrasonic pulse velocity can be measured without having access to opposite sides of the test object. The surfer system is shown in figure 9.

Figure 9 – The Surfer system

The Surfer system is suitable for following applications:

- Measure the thickness of pavements, asphalt overlays, slabs-on-ground and walls
- Assessment of concrete uniformity
- Estimation of the extent and severity of deterioration of near-surface concrete
- Evaluate flexural strength of stone panels using correlations
- Evaluation of damage to test specimens during durability testing (freezing and thawing, sulfate attack, alkali-silica reaction)
- Estimation of depth of surface-opening cracks
- Estimation of early-age strength development (with correlation)

In this inspection task the Surfer system has been used for measuring the P-wave propagation speed through the test object. This figure is essential for the Impact – Echo testing (see section 2.2).

Principle of the Surfer system technique and the system operation:

The Surfer system is based on measuring the time it takes for a pulse of P-waves to travel from one transducer to another on the same surface. The nominal distance between the transducers is 150 mm. Because point transducers are used, the wave pulse travels away from the transmitting transducer along a spherical wave front. When the wave front arrives at the receiving transducer, a signal is generated.

The instrument measures the pulse transit time from transmitter to receiver, and computes the pulse velocity using the known distance between transducers.

The surfer system has two modes of operation:
1. Measurement of transit time and pulse velocity (used in this task)
2. Measurement of depths of surface-opening cracks

The device will self-activate and begin taking measurements after setting the necessary initial parameters and as pressing it moderately to the test object.
The Surfer data presentation:

The Surfer Impact system includes a liquid crystal display (LCD) that can be set up to display transit time or pulse velocity. The data is presented immediately when testing

Experience with the Surfer system:

The Surfer system is frequently used by Ramboll engineers for determination of P-wave propagation speed in test objects, together with using the MIRA and the Impact – Echo systems. In addition the system is used for depth measuring of surface cracks and for general concrete quality evaluation.

2.0 Investigation zones and investigation results

2.1 The Investigated Structure

The investigated structure is the bridge surface structures and the bridge deck upper surface.

The composition of the investigated structure is (from top to down):

-Asphalt layer AC 20/120; theoretical thickness= 50 mm
-Asphalt layer AC 16/100; theoretical thickness= 40 mm
-Protective layer AC 6/50; theoretical thickness= 20 mm
-Waterproofing + Tack coat primer layers, Eliminator; theoretical thickness= 2,5 mm
-Profiling concrete cast SLR/60/6/RH; theoretical thickness= 30-50 mm
-Remaining deck original concrete after weterjetting; theoretical thickness= about 260-280 mm near the edge beams, about 320-340 in the center of the deck

2.2 The Investigation Results

S'MASH testing was performed on the whole bridge deck area in a grid of 1/1 m as presented in figure 10 and in appendix no. 1. Alltogether 112 s'MASH tests (16 x 7) were performed. The total bridge deck surface area is about 120 m^2.

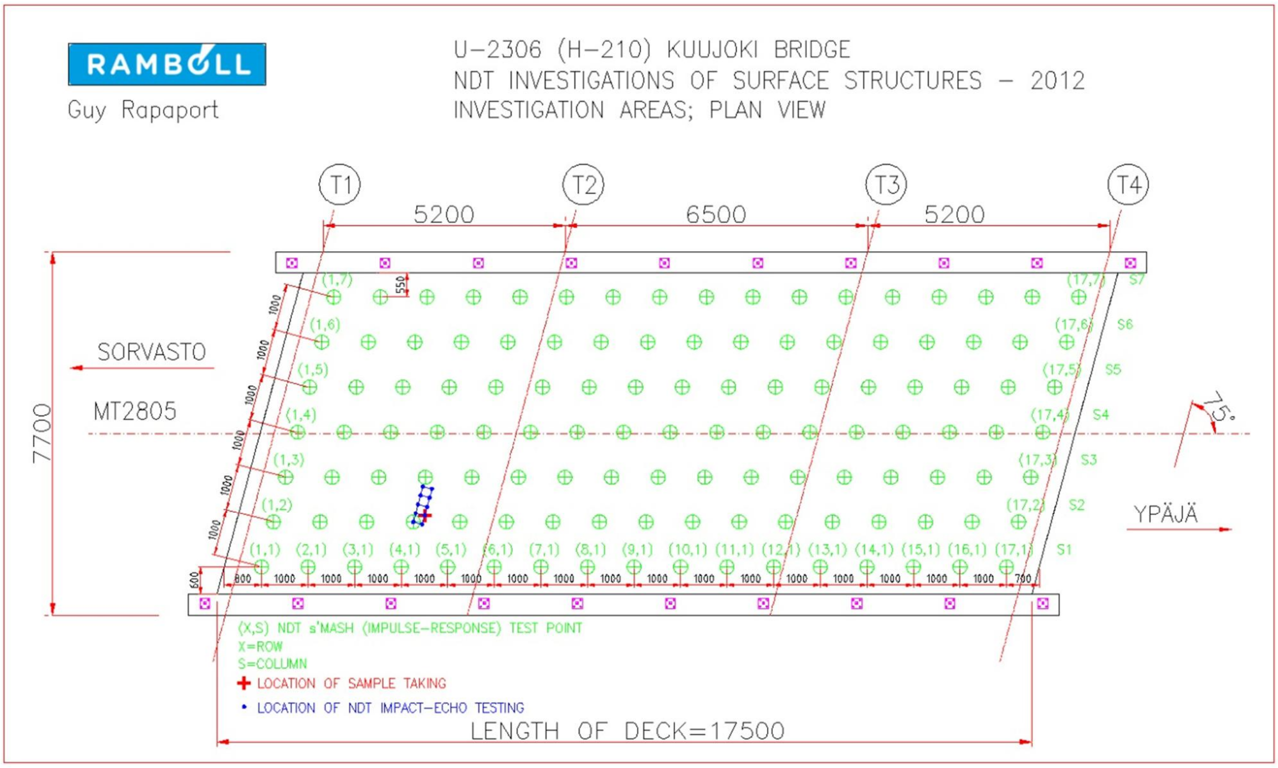


Figure 10 – The investigation zone

Figures 11a…11c show the contour plots processed by the s'MASH software.

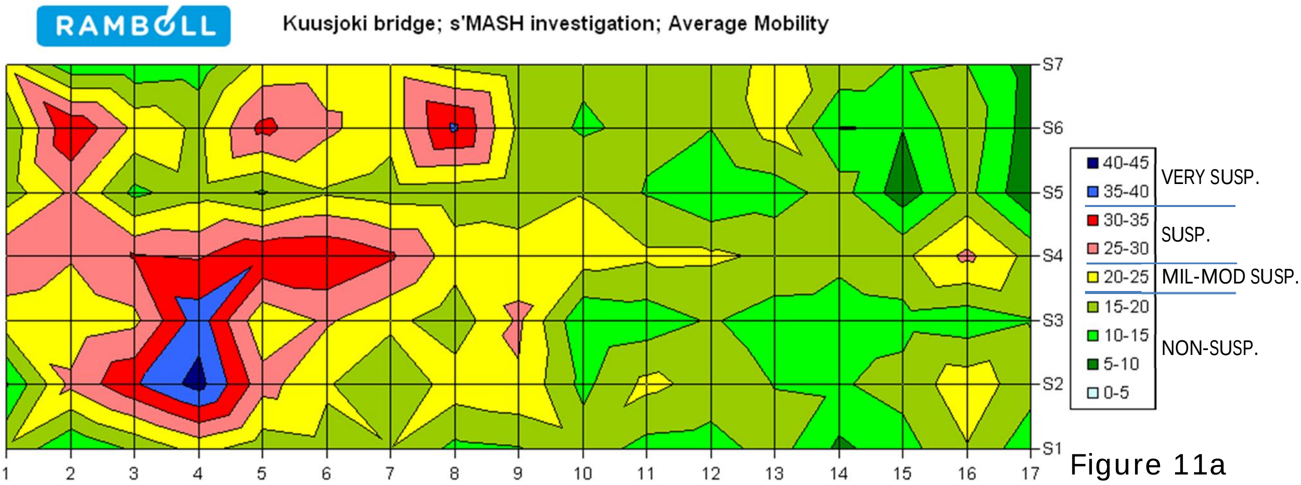


Figure 11a

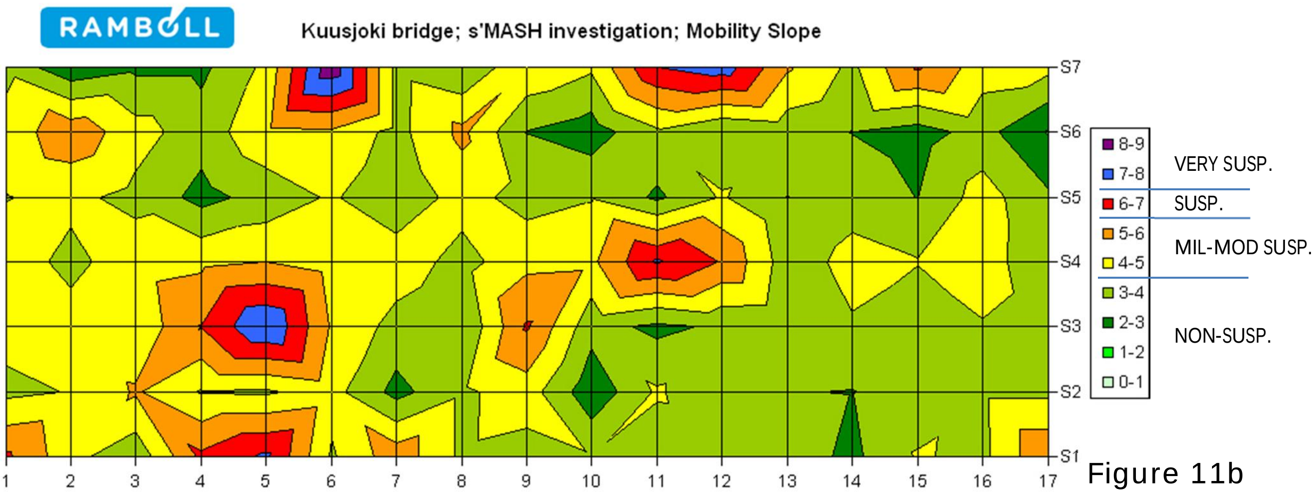


Figure 11b

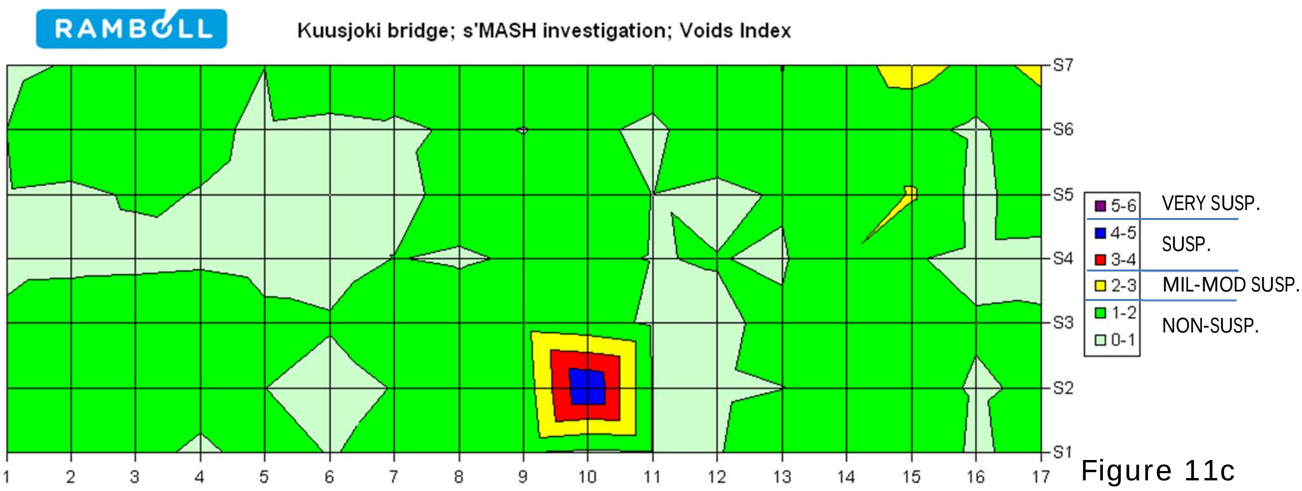


Figure 11c

Figures 11a…11c – s'MASH contour plots

SUSP. = SUSPICIOUS; MIL-MOD = MILDLY – MODERATELY;

Average Mobility:

When evaluating bridge deck surface structures the Average Mobility (AM) is the most important figure. High AM may indicate of debonding between layers for example between the asphalt pavement layers, between the waterproofing and the deck profiling concrete / asphalt or if those above mentioned are well bonded, between the profiling concrete and the original deck concrete.

According to the s'MASH result here, the colored light red – red – blue – purple areas (figure 11a) are estimated as "suspicious" or "very suspicious" area. These areas include 20 test points which are about are about 18% of the deck area (~22 m^2). See figure 12, the mobility spectrum graphical presentation in test point (4,2) - "very suspicious" location.

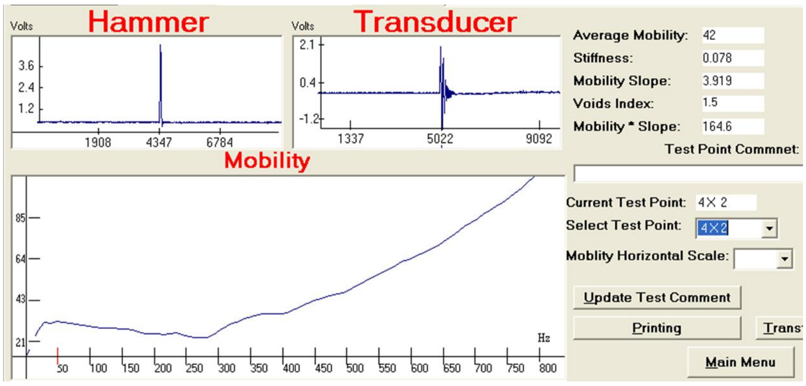


Figure 12 – the mobility spectrum in test point 4.2

In addition to the clearly suspicious areas, an overall significant area of the bridge deck is estimated to be "mildly-moderately suspicious". These areas include 27 test points which are about are about 24% of the deck area (~29 m^2).

Most of the deck area (about 58%) is estimated as "non-suspicious" in relation to the AM. See figure 13, the mobility spectrum graphical presentation in test point (15,3) - "non-suspicious" location.

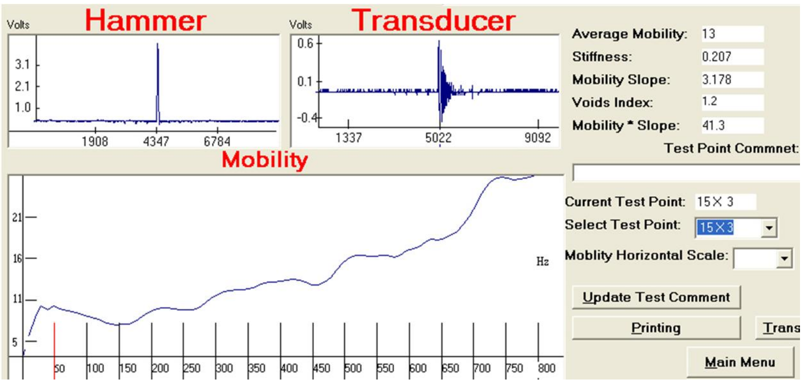


Figure 13 – the mobility spectrum in test point (15,3)

Mobility Slope:

Mobility slope (MS) in evaluation of bridge deck surface structures mostly refers to not well compacted asphalts pavement layers or to “casting defects” in the layers, for example pockets of air / aggregates. As these types of faults are not usually significant in condition evaluation of bridge deck surface structures we can estimate the actually problematic area are the “suspicious” ones.

According to the s’MASH result here, the colored red – blue – purple areas (figure 11b) are the “suspicious” or “very suspicious” areas. These areas include 11 test points which are about are about 10% of the deck area (~12 m^2). About half of the suspicious areas are suspicious to some degree according to the Average Mobility figures.

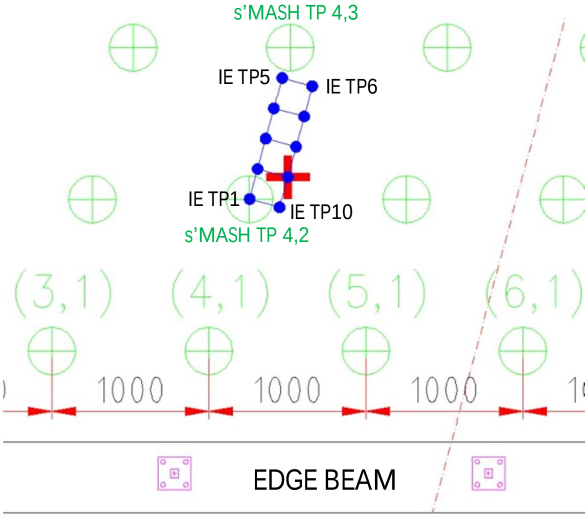
Voids Index:

Voids Index (VI) in evaluation of bridge deck surface structures mostly refers to unsupported /loosed pavement layer. In locations of high VI figures breakout of the pavement is likely to occur.

According to the s’MASH result here, only the colored red – blue small estimated as “suspicious” / “very suspicious”. As this area consists of only one test point we can assume it is a “false” test result probably due to a loosed stone / piece of pavement at that point.

In addition one suspicious area, 3 more test points of the bridge deck are estimated to be “mildly suspicious”. These points are about 3% of the deck area (~3 m^2).

Impact – Echo DOCter testing was performed at the most suspicious area according to the s’MASH testing, which is between s’MASH test points (4,2) and (4,3). All together performed 10 IE tests in a grid of 0,2 x 0,2 m. The location OF test points is presented in figures 10, 14 (a zoom of figure 10) and 16.



IE TP = Impact – Echo test point

Figure 14 – location of DOCter test points

The Impact – Echo theoretical frequency calculations for predicting good condition and problematic locations are based on composite calculation for concrete with asphalt over layer. For that purpose the P-wave velocity in the asphalt pavement and the bridge deck concrete (undersurface) were measured by using the Surfer NDT system.

The P- waves velocities were measured from several locations and the average velocities were taken into consideration.

The Average P- wave velocity in Concrete = 4900 m/s

The Average P- wave velocity in Asphalt pavement = 3500 m/s

According to the IE theoretical frequency calculations:

Ft = ˜ 5,3 kHz should indicate of a whole solid structure
Ft = ˜ 15,9 kHz should indicate of a problem in the depth of the waterproofing
Ft = ˜ 12,6 kHz should indicate of a problem in the bonding between the profiling cast and the old concrete.

The used impactor was 8 mm. The Impact – Echo testing results are presented in the following table:

TEST POINT NO.	DOMINANT PEAK FREQUENCY [KhZ]	SUSPICION LEVEL
1	14,16	SUSPICIOUS
2	15,63	VERY SUSPICIOUS
3	4,39	NON-SUSPICIOUS
4	15,63	SUSPICIOUS
5	16,6	SUSPICIOUS
6	4,39	NON-SUSPICIOUS
7	4,39	NON-SUSPICIOUS
8	4,39	NON-SUSPICIOUS
9	15,63	VERY SUSPICIOUS
10	4,39	NON-SUSPICIOUS

According to the Impact – Echo testing results in 50% of the test points there is a clear indication for a possible problem in the level of the waterproofing.

Figure 15a and 15b present the frequency spectrum at test points 2 and 9.

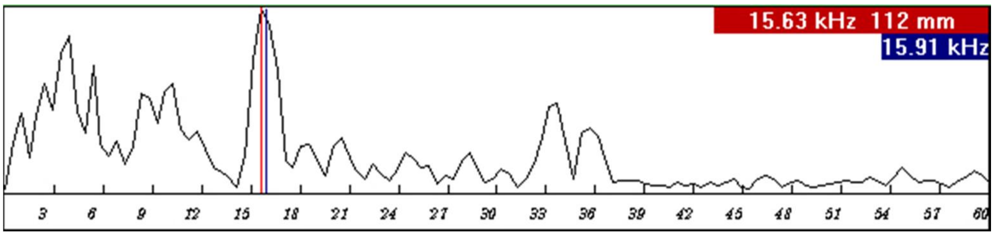


Figure 15a –IE frequency spectrum at test point no. 2

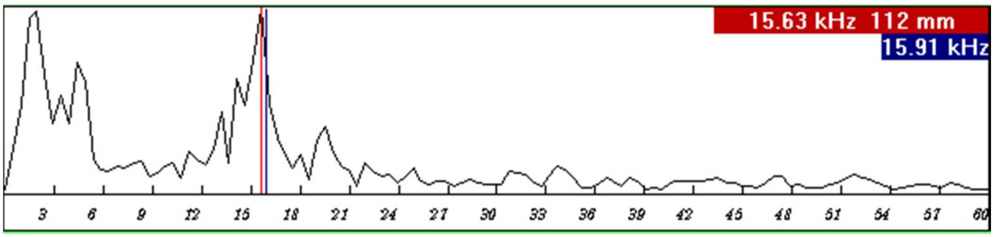


Figure 15b –IE frequency spectrum at test point no. 9

As the Impact – Echo testing is a point-wise testing finding of several suspicious points in the same relatively small test area may indicate of a possible problem in the waterproofing depth.

According to the s'MASH and DOCter testing results it was decided to perform additional testing to the agreed testing program – making of one opening of the surface structures and taking of a core sample from the deck upper surface concrete. The target was to evaluate the waterproofing bond to its substrate and to evaluate the bond between the profiling cast and the original deck concrete.

The location of the opening of the surface structures is presented in figure 14 (the red cross marking), in figure 10 and in figure 16.

Figure 16 – location of DOCter test points and of surface structures opening (red arrow)

The opening of the surface structure structures was performed by diamond drilling, see figure 17. The asphalt pavement layers were drilled by 150 mm core drill bit and the concrete by 50 mm core drill bit.

Figure 17 – diamond drilling of the surface structures

The results of the surface structures opening are summarized here:

Asphalt and protective layers:
Overall thickness ˜110 mm composed
˜50 mm (AC 20/120) + ˜40 mm (AC 16/100) + ˜20 mm (AC 6/50)

Waterproofing:
Eliminator, overall thickness ˜2,5 mm, upper layer (white color) ˜1 mm and base later ˜1,5 mm (yellow color).

Deck upper surface:
Sample overall length 112…120 mm;
Profiling cast 35…46 mm + deck original concrete.

Surface structures condition estimation:

The asphalt and protective layers seem to be well compacted, intact and well connected to each other (see figure 18). The protective layer bottom surface is relatively poorly bonded to the waterproofing upper surface. Small amount of the waterproofing Tack coat primer layer (red layer) is glued to the AC protective layer and it is almost not visible on the upper surface of the waterproofing (see figure 19).

The Eliminator waterproofing is partly loose and partly very poorly bonded to the bridge deck upper surface (profiling concrete), see figure 18, 20 and 21. Probably this is the reason for the suspicious indicates according to the NDT testing.

The profiling cast is well bonded to the original deck concrete according to visual observation and the contact plan seems to be well closed, see figure 20.

The original deck concrete seems to be of relatively poor quality. Small casting defects are visible and the some of the voids are filed with lime (evidence to high moisture stress).

Figure 18

Figure 19

Figure 20

Figure 21

3.0 Summary, Conclusions and Recommended Measures

3.1 Summary

The aim of this inspection task has been to evaluate the condition of Kuusjoki bridge surface structures by the Impulse – Response s'MASH NDT testing systems. In the bridge site, after performing the NDT investigation by using the s'MASH system it was decided to execute additional elaborated testing of the area found to be suspicious by using the Impact – Echo DOCter NDT system and by performing in the suspicious area an invasive sample taking by diamond drilling.

According to the s'MASH NDT testing results about 20% of the bridge deck surface structures appear to be clearly suspicious. The Impact – Echo testing in the most suspicious area has confirmed this suspicion.

In the most suspicious location opening of the surface structure and core taking from the deck upper surface was performed. According to this invasive investigation the Eliminator waterproofing is partly loose and partly very weakly bonded to the deck upper surface. In addition the bond between the asphalt protective layer and the waterproofing upper surface is relatively poor. The pavement layers are generally intact and the bonding plan between the profiling concrete cast and the original deck concrete seems to be good

3.2 Conclusions and Recommended Measures

According to the performed investigation task it is obvious that the waterproofing, at least in the most suspicious location, is poorly bonded to the deck upper surface and therefore does not fulfill the quality demands for waterproofing. However, it is not advisable to make conclusions regarding the whole waterproofing functionality based only upon one sample!

It is advisable to perform additional openings of the surface structures and sample taking in accordance to the already performed NDT investigations, for example in summer 2013.

Kuopio, 4.12.2012

The report drafter and NDT expert: *Guy Rapaport*
Guy Rapaport

Ylivieska, 4.12.2012

Quality assurer and NDT expert: *Tuomo Koskela*
Tuomo Koskela