# GLOBAL HEALTH MONITORING SYSTEM OF BRIDGES IN FINLAND

Ilkka Hakola[1], Matti Halonen[2] and Petr Hradil[3]

**ABSTRACT:** In Finland the bridge inspection information have been collected for many years into the Finnish Bridge Register. The Bridge Register includes data in electrical format, but unfortunately the bridge drawings are not in digital format. In recent year The Finnish Traffic Agency has published the guide of bridge information model, but it does not include detailed information about the data format. VTT, Technical Research Centre of Finland together with The Finnish Traffic Agency and Finnish monitoring companies has begun to develop in recent projects bridge global monitoring system and platform to combine monitoring, bridge register, load test, analysing, information model and management system. In recent years many bridges in Finland includes permanent monitoring system and several bridges have been loaded with heavy vehicles, analyzed by FE (Finite Element) method and the data have been saved in database using systematic structure and format. Most of bridges are old bridges and therefore no digital information model is available, but for these bridges a simplified and systematic way to generate the FE analysing model have been developed. The model is intended to use for old bridges to generate systematic and digital information to analyze strains of heavy vehicles, but also to mark detected failures into the digital 3D model. The model can also be used for concrete bridges while the deterioration of concrete and reinforcement will be analyzed. The report summarizes the global health monitoring system, which have been developed for the Bridge Monitoring Guide in Finland.

**KEYWORDS:** Monitoring, health, bridge, database, platform, analysis, Finite Element, strength

## 1. INTRODUCTION

Finland is a country in northern Europe with the total area of 340 000 km$^2$ and population of 5.4 million inhabitants [1]. We have quite many lakes and rivers, about 10% of the total area, due to Ice Age, which ended for 11 000 years ago. Therefore we have quite many bridges, most of them are crossing the rivers but mainly in cities and main roads bridges are junction bridges. In Finland the total amount of bridges is 15 000 and on an average the first basic preparing work will start at the age of 30 years. The bridges have been inspected regularly, but in spite of that we have 200 bridges which are in very bad condition and 800 bridges in bad condition. In addition in 2013 Finland together with European Union will allow increase the total mass of heavy vehicles, which causes limitation for maximum allowable loads for bridges also in main rods. Therefore the systematic management and monitoring system together with bridge register is a very important tool to maintain the condition of bridges. In Finland and in other countries in recent years many bridges have been monitored, some of them permanently. In recent years about 100 bridges have been tested by heavy vehicles and the measured results have been used for analyzing and for estimating the condition of bridges. The paper describes basic methods and guidelines to utilize the bridge monitoring, bridge load tests, analyzing methods and also tools for life cycle calculations.

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## 2. GLOBAL MANAGEMENT SYSTEM OF BRIDGES

The global management system of bridges is one part of the global infra management system, because information needed for bridges maintenance and analysis is also coming from common information of roads, transportation and travelling [2]. In Figure 1 is shown the basic description how people are living in their houses, in the morning are going to working places, then in the evening coming back and going for shopping and hobbies.

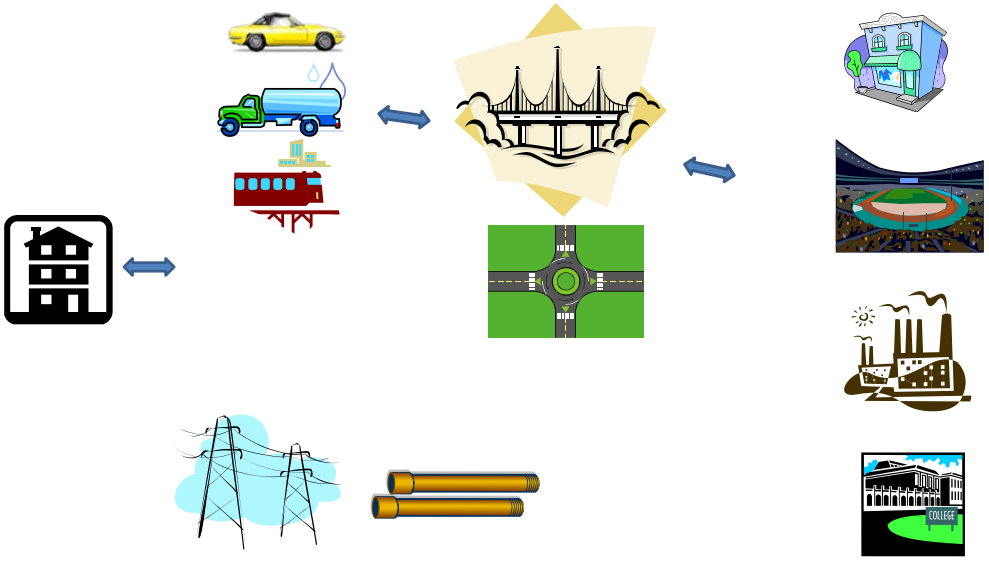

**Figure 1. People are using bridges and road while going to work, shopping and hobbies**

The bridges are important for people but also for goods and material, when they will be transported to and from factories and also for shops for selling. The bridges are part of the road or street and therefore the traffic information can be used for bridges, but also monitoring information from bridges can be used to design traffic planning. Especially in cities while preparing bridges the traffic density and re-routes should be planned.

The global bridge management system is not only a database including geometrical and material information about the bridges, but in the future it will also include the whole information model of bridges. Today it is not been defined, which information should be included in the bridge information model and which is saved in other databases. The bridge management system will, in the future, include deterioration and life cycle models and analyzing methods. In Finland most of the bridges are concrete bridges also steel beam bridges have concrete deck. Therefore the deterioration of concrete and rebars is important to develop and automate. The deterioration analysis needs information e.g. about the weather, air humidity and salting, which are not wise to copy to the bridge database. Figure 2 describes some basic information and analyzing tools needed for global bridge management system.

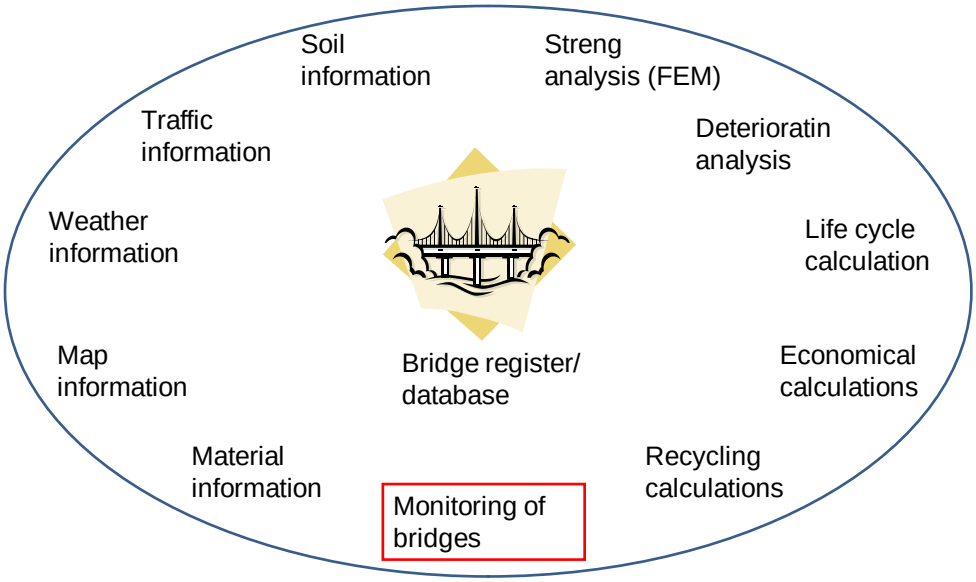


**Figure 2. Basic information and analyzing tools for global bridge management system**

## 3. MONITORING OF BRIDGES

Monitoring of bridges is a very effective tool to have continuously reliable information about the condition of bridges. Monitoring can be divided into three groups

- Short term monitoring for some days or some month
- Periodical monitoring, which will be repeated regularly or during inspections
- Permanent monitoring, which will continue for years or to the demolishing of bridge.

Short term monitoring will be performed, if there has been found failures from bridge or if the crossing traffic will be measured. The bridge load testing can be done during short monitoring. It should be noted the results do not include necessary the highest loads or the temperature changes, which may occur during one year.

Periodical monitoring will be repeated regularly at least once in a year, or at least several times. The results will most probably include also rare occasions and the reliability is higher. The periodical monitoring can be started during normal bridge inspection by connecting the measuring device to sensor wires. The monitoring is economical, because the equipment can work with battery and without permanent network, but the sensors should install beforehand to the bridge.

Permanent monitoring will last many years and will produce continuous data for analyzing, but also it can be able to send alarms from the failures of bridges, traffic accidents or fires. The condition of concrete can be monitored by permanent monitoring, because the variation weather during the whole year should be included. Especially the deterioration of concrete is depended mostly of the wet time in concrete. In Finland also the salting of rods has strong effect on the perforation of chlorides.

The monitoring is not only measuring of data from the structure, it should also include reporting and analyzing. The monitoring should plan carefully, because measured data will be later on analyzed and only the bridge designers and experts can define the proper locations for the sensors. The main reason to decide to begin the monitoring is earlier detected failure or overall low condition of bridge and therefore the monitoring equipments will be mostly installed in old bridges. The new bridge can also be monitored, if the mechanical structure is new or complicated or if the bridge represents a new type. Monitoring is quite expensive tool and therefore only a limited amount of bridges can be monitored.

The systematic way is to monitor only one or some exemplar of each type in various weather conditions. The rest bridges can be analyzed with these exemplars of monitored bridges. In Figure 3 is shown the phases of bridge monitoring. First the bridge will be inspected, analyzed and assessed and if the monitoring has been found necessary or valuable, the monitoring plan will be made. The monitoring should also include load tests, analyzing and reporting.

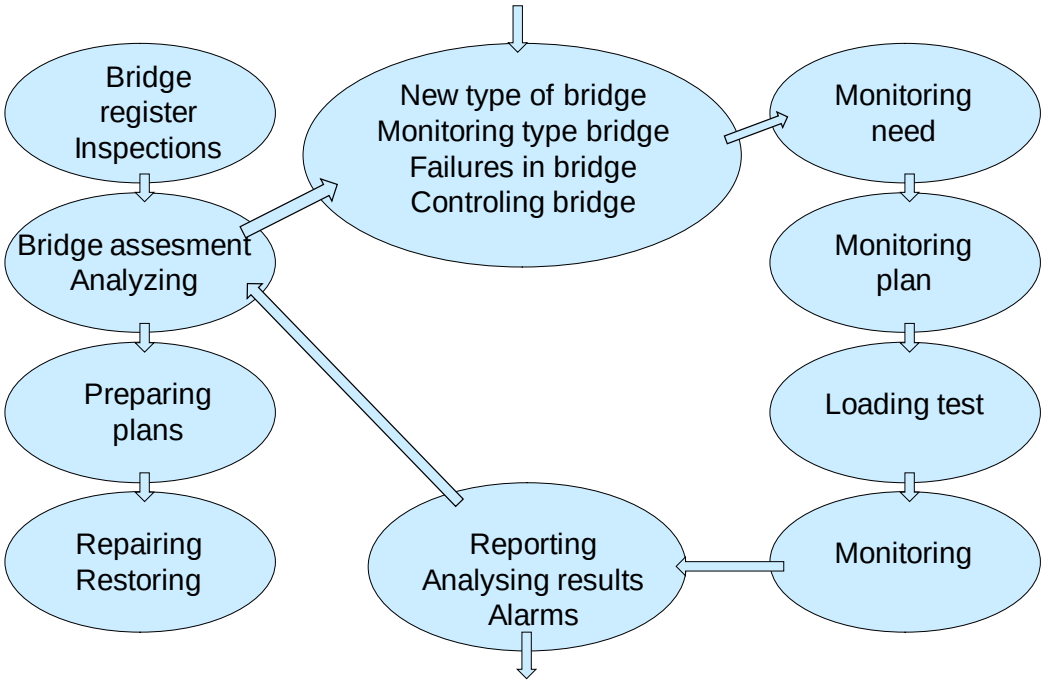


**Figure 3. Flow chart of bridge monitoring**

Monitoring of bridges will be, in the future, a systematic way to gather continuously information from many bridges and this is possible if information, strength (FE model) and deterioration models of bridges have been made and in addition the other analyzing tools and registers can be included in the platform. If all the data is saved according to guidelines and standards the analyzing, economical and life cycle calculations can be made easily and reliable for all bridges. The standards, guidelines, database structures, drivers and data transfer protocols are the tools, which will require much development and co-operation in the future.

In SITUEL project Simantics [3] was selected as the implementation tool for the common bridge platform. Simantics is a platform for modelling and simulation originally developed at VTT, but currently released and maintained as an open source tool by THTH (Association of Decentralized Information Management for Industry). Simantics has a semantic modelling kernel and an Eclipse framework based client software with plug-in interfaces. The idea is that a semantic approach to modelling enables users of the platform to connect and co-use a wide range of different simulation and engineering tools. Tools such as OpenModelica, BALAS, Apros, OpenFoam, Comos and SmartPlant have already been integrated to the environment. After the data model of the system is modelled in Simantics and the interfaces for transferring system data to the platform are implemented, mapping rules can be defined to keep the different models consistent and thus provide automated model integration.

## 4. BRIDGE REGISTER

Bridge register in Finland is a basic data base and it includes administrative, structural and geometric information, but only a few of newest drawings are in digital format. Almost all the old drawings have been scanned from micro films and are only in picture formats. Therefore no dimensions or material

information can automatically be performed, but only looking manually from drawings. The bridge register includes detailed inspection information about the condition of bridges. The inspection in Finland is systematic work and also the people performing the inspections (inspectors) are educated and their work will be supervised and therefore the evaluation of condition and failures are uniform. The bridge register also includes pictures and failures of bridges and the development of failure can also be estimated.

Today the information about the real loading capacity of bridges is confidential or secret, but for special heavy load vehicles the information can be asked. The bridge register includes also bridge information about bridge of some big cities.

The information model about the bridges is under development, the newest version has been published in 2013 [4], but more development is still needed if all the information could be build in the model. Especially the automatic generation of strength model from information model is under development in many design and FE (Finite Element) programs. The link of monitoring information has also been indented to include in the new version of bridge register. The main problem of bridge register is the old bridge information, which is not in digital format, because the work is huge. On the other hand the digital information of newest bridges will be utilized after ten or twenty years, because usually these bridges are in good condition for many years. It is not easy task to convince bridge owners and monitoring companies to develop bridge monitoring, analyzing tools and drivers.

## 5. INFORMATION MODELS OF BRIDGES

There are many types of information models for bridges. The building process of bridges begins with planning, designing and analyzing of bridge. The planning process includes the soil, traffic and architectonic research, but also economical calculations. The report discusses mainly the strength, deterioration and monitoring models of bridges.

The strength model of bridge is usually FE (Finite Element) model of the bridge it is simplified model of global information and geometrical model. Today there are some commercial bridge design programs, which can generate the input file for FE analyzing program, but the link is working only in one direction, usually if modifying the FE input model the information model cannot be changed automatically. On the other hand the commercial bridge design program cannot produce the input file for all commercial FE programs, because the input file varies for every programs. Some FE and design programs can produce UFF (Uniform File Format) files, but unfortunately FE programs include many other parameters to controll analysis and to define e.g. material parameter. The UFF file can only be used to transfer material and geometrical information like nodes, elements, boundary conditions and material information. The input/output files for design and FE programs have been clarified in Figure 4.

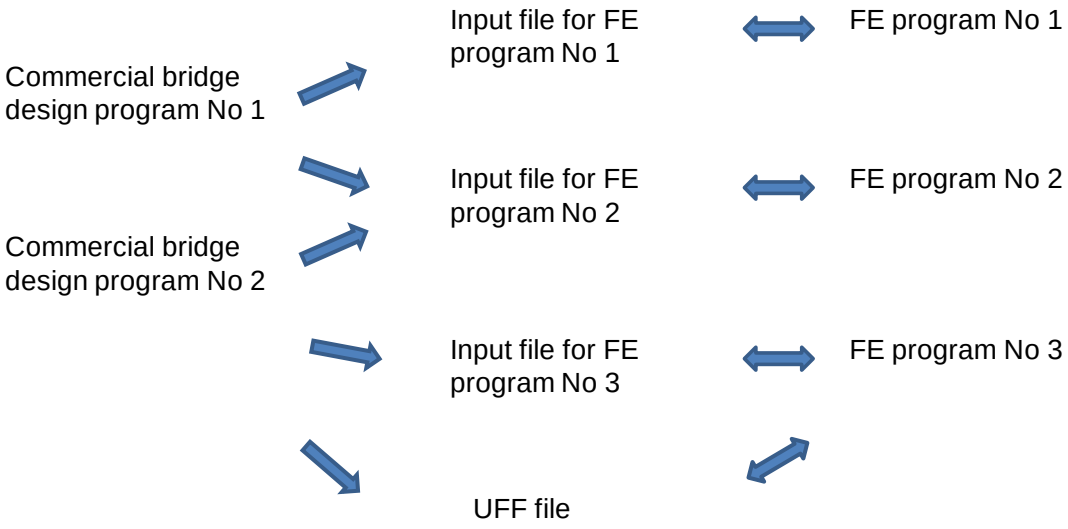


**Figure 4. File format and of commercial designing programs and analyzing FE programs**

As mention before, today there exists design programs, which can include the geometrical and material information of the bridges and they can produce input file for FE programs. One problem is, that the strength model of bridge is always a simplified model of bridge and does not includes all the details e.g. connection plates and bolts. This is because the FE programs have still size limitations for the model especially if shell or 3d elements have been used in the model. The FE models of bridge are still made using beam elements and the deck using shell or 3d elements to save time in modeling and analyzing work. The other problem is how to model reinforcement of concrete bridge, because traditionally concrete bridge will be divided in beams while calculating the bridge manually, but the information model does not necessary support this kind of structure. In Figure 5 is shown the FE model of I section using beam elements or shell elements. While using beams elements located in the neutral axis, the eccentricity to the other components should be included e.g. the main girder and bridge deck.

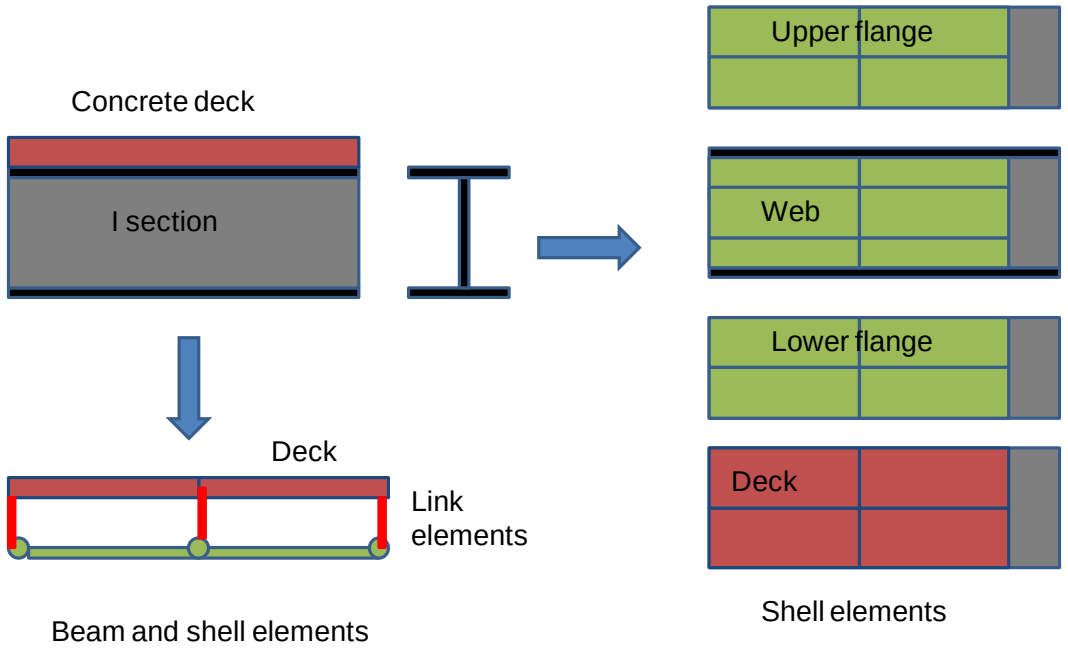


**Figure 5. FE model of I section using shell elements or beam elements with link elements**

The new bridges can be designed using commercial design programs and then the strength analysis can be done almost automatically using FE programs. The system will develop more in the future, but unfortunately the main problem of failures concerns old bridges, which does not include information or FE model. The model should be created almost manually using old calculations and paper drawings.

In VTT in Finland has been developed a method to create FE model using only few parameters taking from Bridge register and drawings. The model can be simplified or more complicated depending how many parameters and data values have been used in modeling. If the bridge model will be created always systematically and using same component definition and co-ordination system, the model will be uniform and same methods e.g. moving load method can be used. The FE mesh generator uses main bridge parameters and the code is open source XML file. At the moment generator creates Abacus code (FE program) using Python source code. The flow chart of FE generator is shown in Figure 6 and in Figure 7 is shown an example of generated code for the bridge with two spans and three main girders. The FE model is also shown in Figure 7 and it consists of beam elements (I section) and shell elements (deck). The idea of automatic generation is, that the generation part can be same and will be utilized by every analyzers. The end part to generate the individual code for FE programs should be modified individually.

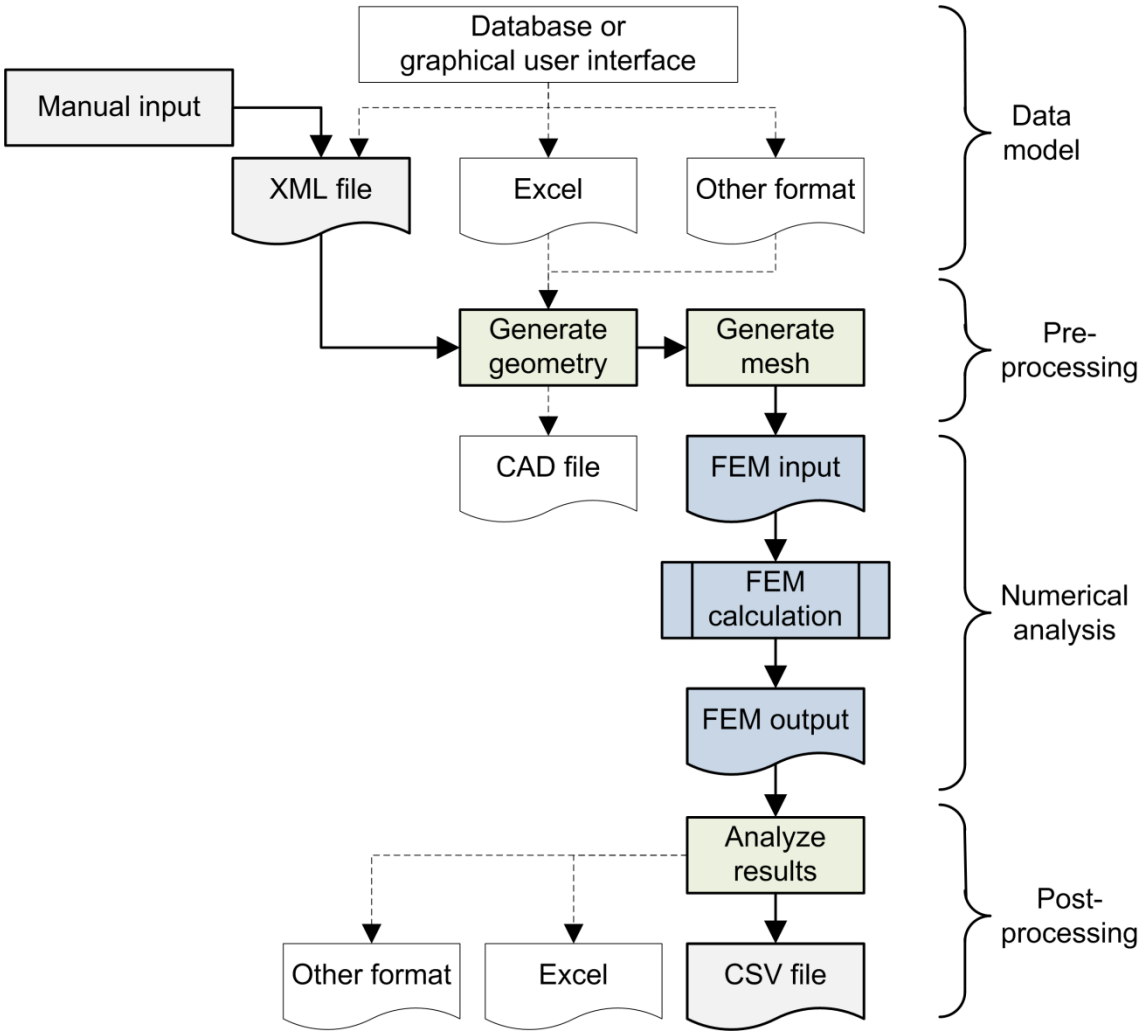


**Figure 6. Flow chart of automatic mesh generator**

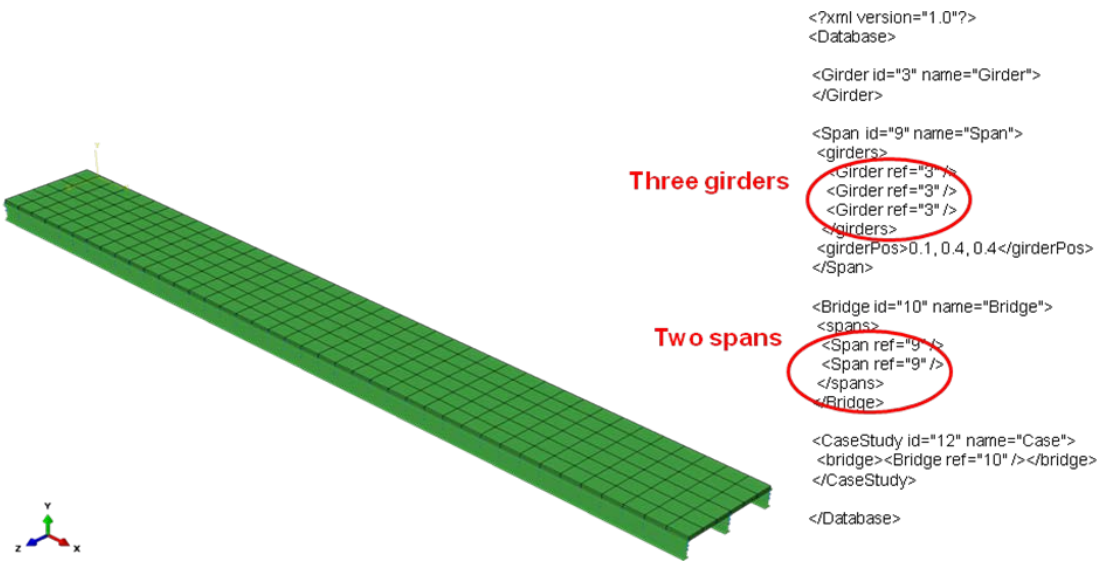


**Figure 7. An example of automatic mesh generator to create mesh for bridge with two spans and three main beams**

In Figure 8 and 9 is shown an example of automatically generated FE model of Makarla steel beam bridge in southern part of Finland. The model includes four main girders, cross beams and cross girders on supports.

The bridge has been tested with heavy vehicles and the FE model has been calibrated for the load test results. The analyzing also includes failure analyzing e.g. for the occasion, that the one of the main beams will break according to Figure 9. In this case the failure has not been very severe due to number of main beams, only the heavy vehicles cannot cross the bridge on the side having the failure. The failure analyzing will give valuable information while planning and designing locations for the sensors. To begin the monitoring for the bridge will be done after analyzing and reporting.

**Figure 8. An example of automatic mesh generator to create element mesh for Makarla bridge with six spans and three main beams**

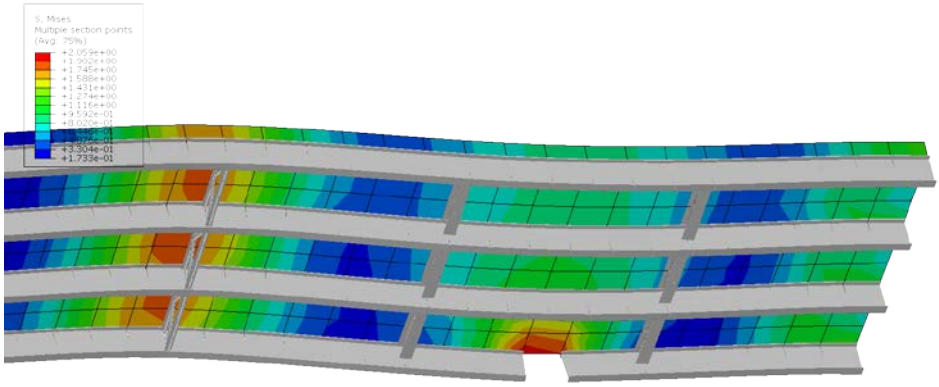

**Figure 9. An example of analyzing model of failure generated in one main beam in Makarla bridge**

## 6. BRIDGE LOAD TESTS

Monitoring of bridges should also include analyzing and reporting to have the full advantage of measurements. While analyzing and then comparing the calculation results with monitoring results it is important to know the loads crossing the bridge, which can be done by performing load testing.

The bridge load testing will be done with one or many heavy vehicle, which total and axis loads and axis spaces have been measured. In Figure 10 the weighing of axis loads have been shown. The vehicles will be driven cross the bridge using different lanes, but also using many vehicles close to each other. If the bridge begins to vibrate or if the stabilized strains of concrete have to measure the vehicles can be stopped for one minute on the defined location. The Figure 11 shows the different loading vehicles and driving lanes during load testing. The testing has been done by walking speed. The deflections, the strains, the vibrations and other will be measured during the test and will be saved for analysis. The deflection curves measured by laser equipment have been shown in Figure 12.

**Figure 10. Weighing of axle weights for bridge testing**

**Figure 11. An example of loading vehicles and driving lines in bridge loading test**

It should be observed, some bridge behave non-elastic e.g. suspension bridges and concrete bridges and therefore the load test should be done by increasing slowly the weight of vehicle. Also while continuing the monitoring many years, the load tests should be renewed e.g. once in 3 years to be able to calibrate the sensors. According to manufactures the sensors should be calibrated once in a year.

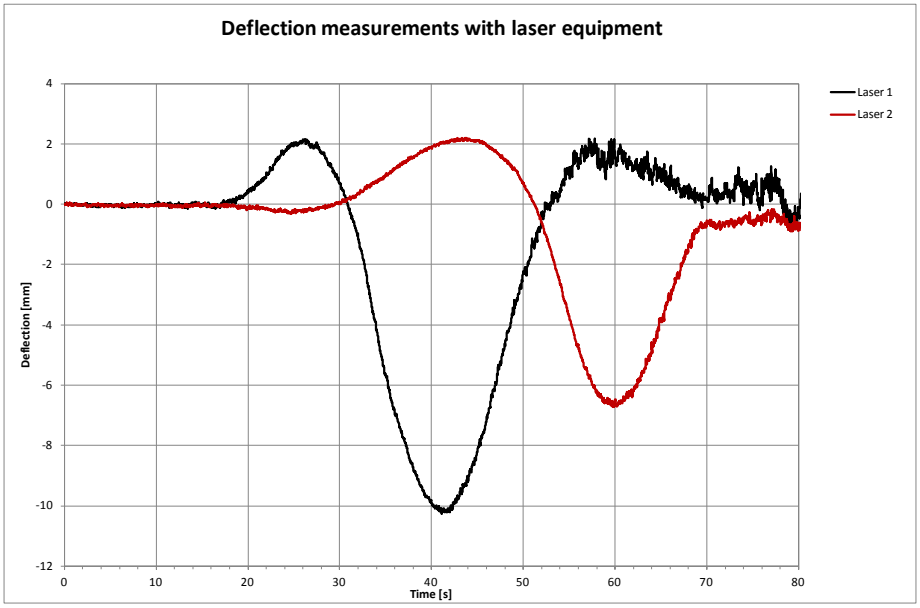


**Figure 12. An example bridge deflections while heavy vehicles crosses the bridge**

## 7. MONITORING GUIDE

The monitoring guide will give detailed information about how the monitoring should be performed. The detailed information of sensors and wires have been given in the report of [5]. It is important, that if after bridge design or inspection or other assessment monitoring has been selected to realize, it will be done systematically and according to guidelines and standards. In Finland the first version of Bridge Monitoring Guide [6] has been made to give detailed information for bridge owners, bridge designers and companies performing monitoring. The report is going to modify to the official guide of The Finnish Traffic Agency. In the future the guide could be applied while planning or designing monitoring for new or old bridges.

The guide is intended to provide basic information and guidelines for bridge owners, municipal and transport authorities engineers and experts, and companies carrying out bridge monitoring on bridge condition and carrying capacities, in order to facilitate the design and implementation of bridge or tunnel monitoring. The aim is to facilitate the carrying out of maintenance and repair work in a timely and economical manner and to help ensure that as comprehensive as possible benefits are achieved from monitoring activities. The guide primarily addresses road and railway bridges, but can also be applied, where appropriate, to the monitoring of tunnels and other special structures. The guide does not provide specific technical or operational instructions, but serves as a general guideline. The guide starts from the assumption that bridge monitoring is a service provided by companies to bridge owners. Monitoring provides owners and monitoring companies with useful and accurate information on bridge condition and functionality, on the basis of which appropriate and timely decisions on economic bridge repair and maintenance can be made.

Bridge internal and external stresses can be measured by monitoring. Typical loads monitored include traffic load, wind load, temperature change, and loads between structural elements. The most significant load, particularly in small and medium-sized bridges, is generated by road vehicle or train crossings. The most essential parameters for bridge structures are vehicle weight, speed, number of axles, and driving line.

The sensors, measuring devices and methods used are presented in detail in the monitoring plan in question. The plan specifies the amount and type of sensors, their location, the measuring device, the locations of cables, and the purpose of the monitoring. The main reasons for carrying out monitoring include a detected failure, the need to determine a bridge’s bearing capacity, evaluation of a new or complicated structure, to carry out a bridge strain analysis, or to determine structural quality. The number of sensors depends on the required level of accuracy of the analysis; if a detailed and complex strength calculation has already been performed, fewer sensors are needed. The most common sensors used in bridge monitoring are given in Table 1. In special cases also many other sensors can be used.

**Table 1. Common sensors used in bridge monitoring**

| Sensor type | Measured variable | Usage/structure |
|---|---|---|
| Theodolite, tacheometry | Deflection | Deflection of bridge component |
| Deflection transducer | Movement, deflection | Movement of component or deflection of bridge |
| Laser movement device | Movement, deflection | Movement in plane |
| Rotating laser device | Movement, deflection | Deflection of bridge |
| Laser scaling | Location | 3D figure of structure |
| Optical fibre | Movement, strain | Movement of component or deflection of bridge |
| Optical fibre | Strain, temperature | Stress, strain and temperature of component |
| Strain gauge | Strain (stress) | Strain or stress of component |
| Humidity sensor | Humidity | Humidity of air or material |
| Thermocouple | Temperature | Temperature of air or component |
| Accelerometer | Acceleration, vibration | Vibration of bridge or component |
| Weather station | Weather information | Air |
| Force transducer | Force | Force between components |
| Induction sensor | Induction | Vehicle and axle recognition |
| Camera, video camera | Image, video | Traffic; bridge condition |
| AE sensor | Acoustic emission | Growth of fracture |
| Ultrasonic sensor | Fracture, welding failures | Quality of welds and concrete casting |
| Corrosion sensor | Electric currency | Corrosion of rebars |

It is important, that the location of sensors have been given by systematic way to be able to perform automatic reporting and analyzing. In addition also the measuring device and servers should be given in systematic way. The systematic way is usually performed by object oriented programming and definition. In Figure 13 is given an example about the definition of sensor location on the lower flange of I section. Each structural part includes own local co-ordinate system, which can be used to define the exact location for the sensor. If object-oriented system and component definition has been used the sensor located e.g. in the left main girder in middle span and in lower flange can be automatically find for the group of bridges. In Table 2 is given an example of systematic way to define the location of sensor. The method above can also be used to define the failures detected from bridge during inspection. This is also useful, because it can be find, if same failures will be found in same locations of same type of bridges.

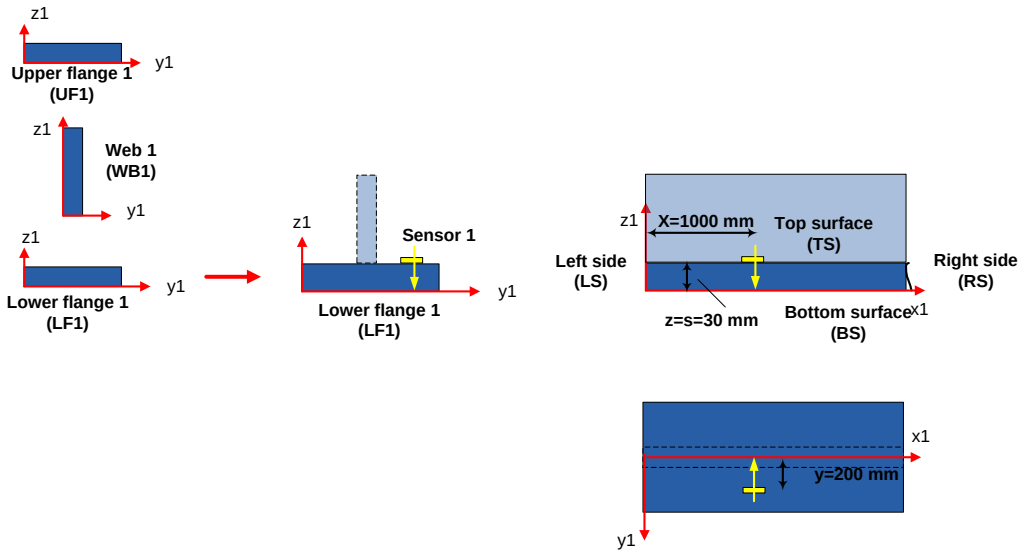


**Figure 13. Systematic way to define the location of sensor**

**Table 2. Example location description for a sensor located on the main girder**

| Name of bridge | Bridge no. | Basic component (span no.) | Structural element (main beam, cross beam ...) |
|---|---|---|---|
| River Bridge | 101 | SP2 | MG2 |
| Structural part (lower flange) | Surface (top surface) | Coordinates for the beginning part (centre point) | Additional parameters: Location/depth coordinates |
| LF1 | TS<br>x = 1000<br>y = 200 mm<br>z = 30 mm | LG 0 mm | DP = 0<br>(x, y and z, no needed) |
| Short entry: **BR101/SP2/MG2/LF1/TS1000,200,30/LG0/DP0,0,0**<br>(Bridge 101, Spacing 2, Main girder 2, Lower flange 1, Top surface x = 1000, y = 200 mm, z = 30 mm, LG 0 mm, DP x = 0, y = 0, z = 0) | | | |

## 8. DATA ANALYSIS AND REPORTING

The monitoring results have to analyze and simplify for reporting. The raw time series are too complicated for making assessment of bridge condition. In Table 3 is given an example of month report (January 2013) where the maximum, minimum and average values for each sensor have been given. In addition the table includes information how many events have been detected, when either the triggering limit or the alarm limit have been passed. Only by careful analysing the critical values and alarm values can be defined. The required filtering system should be used in data analysis to distinguish single events from oscillation. It is also important to verify and analyze, if measured values are reliable and are not coming from the broken sensor. The bridge cannot be closed only based to readings from one sensor.

**Table 3. Example of monthly report of monitoring results**

| Bridge | No 999 | Big bridge | Monitoring Time | January | 2013 | | |
|---|---|---|---|---|---|---|---|
| Sensor | Unit | Maximum<br>Minimum | Average | Triggering value | Events over Triggering | Alarm limit | Events over alarm limit |
| Deflection | mm | **50**<br>-2 | 5.6 | 25<br>-5 | 100<br>1 | 40<br>-25 | **1**<br>0 |
| | | | | | | | |
| Strain | µS | 120 | 80 | 100 | 80 | 200 | 0 |
| | | -20 | | -15 | 2 | -100 | 0 |
| Force | kN | 100 | 50 | 80 | 5 | 200 | 0 |
| | | 20 | | 0 | 0 | 0 | 0 |

The more advanced methods, which can be used in reporting and analysis are e.g. FE analysis, modal analysis and fatigue analysis. The bridge monitoring can be used to gather information about the traffic density, types of vehicles and weights of vehicle. If the analyzing model will be combined to monitoring results, the weight of the vehicle should be defined. Monitoring equipments can be utilized to automatically supervise the special heavy trucks, carriages and mobile cranes crossing the bridge. The carrier or other transport company can ask transport request for defined route, which can be automatically analyzed and permitted. While crossing the bridge, the heavy load and vehicle can be videotaped, monitored and gauged. The method will insure, the bridge will not be overloaded, but also it will give information to develop the analyzing models and methods. In Figure 14 is given the flowchart to monitor and supervise transportations of heavy trucks.

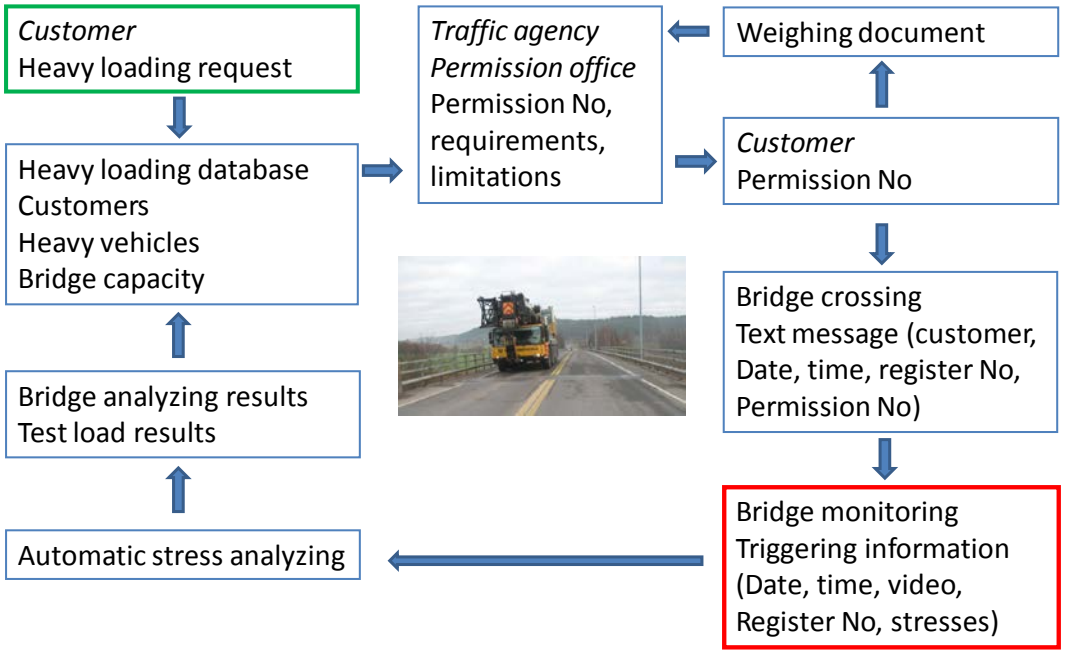


**Figure 14. Flow chart to supervise automatically heavy trucks and vehicles**

## 9. SYSTEMATIC DATA TRANSFER AND SAVING

The monitored data measured by monitoring equipments can be transferred from bridge to laboratory or other control room by wired internet connection, but usually the connection is not available especially in sparsely populated areas. The most common way today is to use GSM modems and mobile phone wireless connection, but the data transfer speed is limited and therefore all the data cannot be transferred. The data can be compressed and analyzed already on the bridge situ and then send the analyzed reports, alarms, and triggered time series. In SITUEL project in Finland, both wired and wireless connection was used, but also pre-analyzing was made with the PC on site. In the future the communication in the form of 3G and 4G will offer much more speed for data communication.

One of the goals of the SITUEL project was to achieve systematically handled data storage and data management. To achieve this goal, a data server was set up at VTT's central Espoo site. The server runs a Linux Fedora build 13 and it allows traffic only from the VTT office network or the addresses specified in its firewall. The measurement computers are set up with a routine that runs daily just before midnight. The routine transfers the measurement data and video clips to a home folder in the data server, compresses the files and stores them on a backup folder on the measurement computer's hard drive. This ensures that there is always a copy of each piece of data on both the measurement computer and the data server.

The global monitoring system requires, that the data and data format should be strictly and systematically defined to be able to include system a lot bridges. Usually the data have been transferred to one direction from bridge to database in control room, but in the future also there should be possibility to send commands to bridge. The reason for this can be traffic accident, when the bridge has to be closed or the control message to send data or change the measuring parameters. In Europe and in Finland the total weights of heavy trucks will increase to 78 tons in 2013, which is one example to command bridge monitoring systems to react for special type of vehicles with 9 axles.

Harmonized data storage and handling could lead to a centralized bridge management platform that could be implemented to include bridges from various monitoring service operators. The same data

processing and visualization routines could thus be used for all bridges. This harmonization could be achieved through use of a common data format, a common interface, or data plug-ins.

A common interface would leave the choice of data type and format to the individual making the measurements, as long as there is a standard way to access the information. These kinds of interfaces are in common use in the process and automation industry with the use of SCADA software. SCADA often utilizes interfaces such as ModBus, Siemens and OPC.

OPC has been widely used in the automation industry for process control. Its outdated Microsoft DCOM based protocol is slowly changing to the newer OPC UA protocol. OPC UA enables the use of OPC on all operating systems and with all programming languages. OPC UA is an IEC standardized (IEC 62541) protocol which is emerging from the automation industry towards a wider arena of applications. Figure 15 depicts possible uses of a common interface in the use of bridge monitoring with the example of OPC UA. The interface can be integrated directly into a measurement device, in which case no data storage or operating systems would be required at the measurement site. Another alternative is to use a data acquisition device of choice and implement the interface on the measurement PC or save the data on a private data server equipped with the common interface.

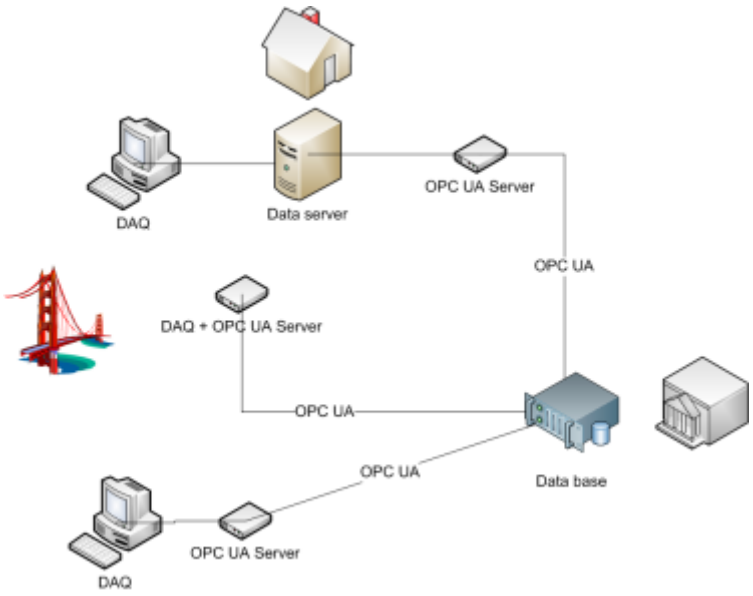


**Figure 15. A common interface in the use of bridge monitoring with the example of OPC UA**

## 10. SUMMARY

The report describes basic ideas of global monitoring systems of bridges in Finland, which have also been tested in the international project of SITUEL. The main partners have been Yamaguchi University, Technical University, München and many Finnish bridge monitoring and consulting companies.

The bridge monitoring is not only of collecting of data, but it also includes systematic way to select sensors, data analyzing in situ, data transfer and communication to server, detailed data analysis like FE calculations and database structure. In addition to calibrate monitoring equipments and analyzing models, the test loading has to be included in the monitoring wholeness. The report does not give detailed information about the structure or principles of sensors, but instead it gives requirements for measurements, communication systems, data analysis, transfer, and data base.

The global monitoring system consists of sensor and measuring device, which will be installed on the bridge. The selection will be done according to analyzing results, condition and failures of bridge. The global selection table is given in Table 1 and also in the research report of 'Bridge Monitoring Guide'. The report also includes guides about the calibration of sensors, communication protocol and database structure. The monitoring should also include load tests to verify analyzing and measuring results.

In addition global monitoring system requires many other information and data like weather, map, road and soil information, which can be collected using common platform. In SITUEL project Simantics platform has been tested. The platform has been used to combine 'Bridge life' program, FE calculation, map information and BIM information model.

## 11. CONCLUSIONS

The report presents principles of global monitoring system of Finland. The system has been tested using Simantics platform developed in VTT for process industry. Map information, monitoring and analyzing results have joined to Simantics paltform and also bridge deterioration program 'Bridge life'. The research shows, that global platform is needed for bridge management, but it can also be used for other Infra structures management like roads and tunnels.

One main challenge is information models, which also should be developed especially models should include information and parameter for strength analysis and also for deterioration and lice cycle calculation. The models should also be developed for old bridges, which do not have information model and digital drawings. These models can be simplified models, because they will not be used for building of bridges, but only for maintenance and preparing work.

## 12. REFERENCES


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