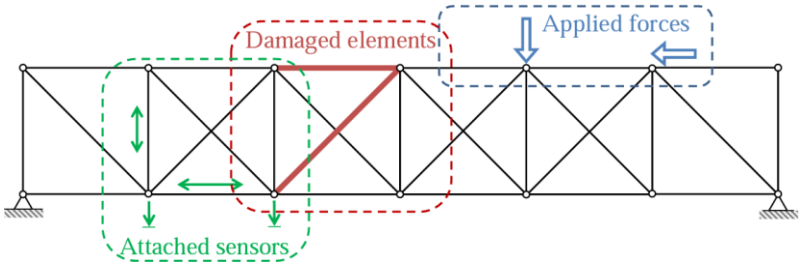
DEVELOPMENT AND VERIFICATION OF EFFECTIVE METHODS AND ALGORITHMS FOR OPTIMUM DESIGN OF SENSOR AND ACTUATOR SYSTEMS IN LOAD-AWARE STRUCTURAL HEALTH MONITORING

OBJECTIVES OF THE PROJECT AND THE RESEARCH TO BE CARRIED OUT

This project belongs to the field of structural health monitoring (SHM). It considers the design of systems that monitor various structures (mainly in civil and transport engineering) for the occurrence of dangerous damages and to infer the loads the structure is subjected to. We address two vital factors that affect the accuracy of any such a system, see Fig. 1:

- Placement, number and types of the sensors that record the mechanical response of the structure.
- Intentionally applied structural excitation, which (if used) should be designed to facilitate the detection, localization and assessment of damages.

*In any SHM system, the accuracy of damage identification depends on the **sensor system** and **actuation/excitation**. Optimum design of these systems is the aim of this project*



We will model the structure, including the damages, in terms of the excitations/loads. We intend to

1. Develop new methodologies and effective algorithms for determination of the **optimum placement of available sensors** in monitoring for the purpose of identification of structural loads.
2. Apply the developed load-oriented methods to determine the optimum placement of sensors for the purpose of monitoring and identification of structural damages.
3. Adapt the developed approaches for simultaneous determination of the **optimum testing excitation**, that is the one that facilitates detection and identification of damages of the monitored structure.

We will strive to

- account for various errors, uncertainties and insufficient knowledge about the monitored structure;
- develop computationally effective methods that yield accurate results in a reasonable time;
- promote simple setups with the minimum possible number of sensors and actuators

The developed methods will be thoroughly verified: first numerically, using specialized engineering software, and then experimentally, in the Laboratory of the Division of Safety Engineering at IPPT PAN.

REASONS FOR CHOOSING THE RESEARCH TOPIC

The project pursues original and relatively unexplored research problems and approaches, including:

- ***Optimum sensor placement*** for the purpose of *identification of structural loads*. We will
  - consider multi-type sensor placement problem, that is simultaneous application of sensors of various types (for example sensors that measure acceleration and strain);
  - support the assumption of load sparsity, because many operational loads are sparse, that is they are very localized in space and time (for example, consider a vehicle on a bridge),
  - investigate the effects of model error and structural uncertainty to account for all possible sources of inaccuracy,
  - account for specifics of wireless sensor networks, such as the distance between the sensors.
- Representation of damages in the form of certain pseudo-loads, which are of the same nature as the external structural excitations. It will allow a uniform load-oriented approach to be applied for analysis of damages and excitations, and to account for characteristics of the actual structural excitation.
- ***Optimization of testing excitations*** for experimental SHM, as well as the joint optimum design problem of the testing excitations and sensors (number, type and placement of sensors and actuators).

We believe that the optimum design approaches developed within the project will contribute to the progress in structural mechanics and structural health monitoring, as well as foster advancement of reliable and cost-effective monitoring systems for infrastructure engineering.