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How to avoid a new ”leaning tower of Pisa”?

The Kansai International Airport in Japan, opened in 1994, had to be partly reconstructed because the ground settled more than 8 meters. New long term tests and computer models, developed in the CREEP project, contribute to better predictions of creep and deformations over long time spans.

How do you predict future ground subsidence, in order to avoid that buildings, roads or other infrastructures end up like the leaning tower of Pisa? And what is the latest knowledge on creep and deformations in geomaterials?

These were essential questions at the *International Conference on Creep and Deformation Characteristics in Geomaterials,* held in Gothenburg 24th – 25th August 2015. Norwegian Geotechnical Institute, NGI, presented results of their new long term tests, designed to improve calculations and numerical models.

The conference marked the closing of a four-year international research project, financed by EU, aimed to exchange knowledge between academia and industry. The participants are NTNU and NGI, Norway; Chalmers University of Technology, Sweden; Deltares research institute, the Nederland; Shanghai Jiao Tong University, Cold and Arid Regions Environmental and Engineering Research Institute , China; and the University of Strathclyde,UK. The project is headed by professor Gustav Grimstad, NTNU.The creep project is organized as a Marie Curie Industry-Academia Pathways and Partnership (IAPP) project under EU's 7th Framework Programme.

All geomaterials, such as clay, silt, sand, and peat, are subject to creep and deformations over time. This must be taken into consideration when planning, designing and constructing infrastructure.

How to predict 100 years settlements?

– These creep deformations take place extremely slowly and over a lengthy time span. This makes it extremely difficult both to run representative laboratory tests and field studies, explains Hans Petter Jostad, head of numerical modeling at NGI.

– We have been running special long-term tests at NGI's Schmertmann Research Laboratory. We have looked into time dependent deformation properties of clays. The purpose is to develop methods to quantify and extrapolate deformations measured in the laboratory during a few days to deformations developing over time periods as long as 50 – 100 years.

In road construction projects, the minimum life span is normally 50 years, while railway and dam constructions typically have a much longer life cycle.

New knowledge incorporated

– We need to develop the right parameters and procedures, enabling us to estimate deformations for very long time spans. We are now developing a new computation tool for assessment of 3D creep deformations over extended time spans. New knowledge from the IAPP Marie Curie project will be embedded in the models. The goal is to offer the new modeling tool for

commercial use in 2016, explains Jostad.

At the Gothenburg conference, he talked about these new computation models and NGI's experiences with the laboratory tests and the international research project. He also pointed out that more research is needed in order to improve methods and models.

The researchers are not only looking into improvements in computation models. They also take interest in measures that can be undertaken to reduce creep and settlements all together, since a minimum level of creep and deformations is always first priority for developers and builders.In some cases, unstable masses are substituted with more stable materials. Other methods include the use of lime and cement stabilization, and also drainage, often combined with heavy loads designed to incur settlements before construction starts.

Road on quick clay

NGI recently delivered comprehensive geotechnical services to Aas-Jakobsen Trondheim AS, the consultancy planning the new, four-lane motorway stretch of E6 between Storler and Jaktøyen south of Trondheim. Large areas of quick clay represent the main challenge here. There have been several historical landslides in the area.

NGI performed extensive field investigations, including a large number of soil samples from borings, and cone penetration tests. Long term creep and stress changes have to be taken into consideration when constructing foundations for the next hundred years.

The main challenge in Norway is normally creep in clays. Other partners in the IAPP Marie Curie research project, such as the Dutch, are more often faced with deformations in peat, while the Chinese researchers together with NTNU deal with permafrost. Building on permafrost is also a challenge in Arctic regions, including the Norwegian Svalbard archipelago.

The target audience for the conference at Chalmers Conference Center in Gothenburg was made up of researchers, academics, engineers and consultants.

– The main purpose of the research project is to develop and disseminate new knowledge for the benefit of the building, construction and transportation industries. It will have a huge impact on the economy if we can avoid unfortunate scenarios, as was seen at the Kansai International

Airport, Japan, with settlements of more than 8 meters and the runways had to be reconstructed. Here in Oslo, there has been much media attention regarding subsiding ground at the construction sites in Bjørvika, near the Opera House, where my colleague Kjell Karlsrud has studied the mechanisms, says Hans Petter Jostad.

FACTS:
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The Norwegian Geotechnical Institute (NGI) is a leading international centre for research and consulting within the geosciences. NGI develops optimum solutions for society, and offers expertise on the behaviour of soil, rock and snow and their interaction with the natural and built environment.
NGI works within the markets Offshore energy; Building, construction and transportation; Natural hazards, and Environmental Engineering.
NGI is a private foundation with office and laboratory in Oslo, branch office in Trondheim, and daughter companies in Houston, Texas, USA, and Perth, Western Australia. NGI was established in 1953.

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