

## Fjóla Guðrún doktor á jarðtækni sviði

Þann 3. júní síðastliðinn varði Fjóla Guðrún Sigtryggsdóttir doktorsritgerð sína við verkfræðideild NTNU í Þrándheimi. Titill doktorsritgerðarinnar er á ensku „Monitoring of structural health and danger state for safety and sustainability of infrastructure systems“ („Ástands- og várvöktun mannvirkjakerfa samfélagsins til að treysta öryggi þeirra og sjálfbærni“).

Verkefnið er tvískipt og fjallar annar hluti þess um várvöktun (danger state monitoring) en hinn um ástandsvöktun mannvirkja (structural health monitoring) m.a. með tölfræðilegri greiningu mæligagna. Sérstaklega er fjallað um stíflur og lón. Úrdráttur úr verkefninu fylgir hér á ensku.

Andmælendur voru Colin Taylor prófessor, University of Bristol í Bretlandi, og Kaare Høeg prófessor emiritus, Universitet i Oslo, Noregi. Formaður doktorsnefndar var Dr. Steinar Nordal, prófessor við NTNU. Leiðbeinendur Fjólu voru Lars Grande, prófessor emiritus NTNU, Noregi og Ragnar Sigbjörnsson, prófessor emiritus, Háskóla Íslands og prófessor við NTNU. En að verkefninu kom einnig Jónas Þór Snæbjörnsson, prófessor Háskólanum í Reykjavík og Universitetet i Stavanger.

Sá háttur er hafður á við lok doktorsnáms við NTNU að fluttur er próffyrirlestur sama dag og doktorsvörnin fer fram. Efni próffyrirlestursins (e. Trial lecture) er gefið upp 10 vinnudögum fyrir doktorsvörnina. Efni próffyrirlesturs Fjólu var: „Safety aspects related to internal erosion in different types of embankment dams and its potential triggering and exacerbation by earthquake events“. (Atriði er varða öryggi vegna innra rofs í jarðstíflum og möguleg áhrif jarðskjálfta á slíkt ferli. )



Kaare Høeg, Fjóla Guðrún, Steinar Nordal, Colin Taylor, Jónas Þór Snæbjörnsson og Lars Grande.

Á myndinni tilkynnir fyrsti andmælandi Colin Taylor prófessor að doktorsritgerðin hafi verið samþykkt samhljóða og fór yfir umsögn doktorsnefndarinnar .

# **Monitoring of structural health and danger state for safety and sustainability of infrastructure systems**

Fjóla Guðrún Sigtryggsdóttir

## **ABSTRACT**

The dissertation is on monitoring of structural health and danger state for safety and sustainability of infrastructure systems. It consists of a synopsis, in addition to journal and conference papers and manuscripts.

The general considerations for structural health monitoring (SHM) of infrastructure systems are introduced, as well as the monitoring of dangers relevant to structural safety. Danger state monitoring (DSM) is defined along with related terms. The integration of these two monitoring systems with consideration of multi-hazards is described and termed as structural health and safety monitoring (SHSM). Next, the perspective of dams and reservoirs is discussed, with an outline of geohazards and definition of a dam SHM. The case in Iceland of Háslón Reservoir and its dams is introduced. This case discusses the aspects of concrete faced rockfill dams (CFRDs) in conjunction with the main dam. Finally, the synopsis is related to the main research, which encompasses two studies, referred to as Study A and Study B.

Study A relates to elements of a dam SHM. The study focuses on the settlement behaviour of Háslón Reservoir's main dam, a CFRD, statistical analysis of settlement data, and development of a statistical prediction model considering visco-elasto-plastic constitutive material models and unloading/reloading behaviour. The study brings forth the importance of scrutinizing and processing raw readings and data from full-scale monitoring instrumentation. It further shows that statistical analysis provides a means to compare responses from many instruments at different locations. This comparison aids in defining trends in a data set, seasonal components, changes in behaviour and/or outliers. Additionally, the analysis produces details for a comprehensive understanding of dam settlement behaviour.

Study B relates to elements of DSM as well as SHSM with regard to multi-hazards. The study focuses on geodangers that may threaten reservoirs and dams and the associated hazards (termed geohazards). The planning and organization of a danger-monitoring program is described and explained through the case of Háslón Reservoir. Subsequently, geohazards and their monitoring are defined in the general context of reservoirs and dams. A new methodology is set out for enhancing safety by linking multi-source monitoring to multi-hazards threatening infrastructure systems. An application of the methodology is demonstrated with a conceptual model of two systems. One system includes the infrastructure, a reservoir and its dams, along with settings for geohazards. The other system contains the associated monitoring. Interrelations between and within the two systems are quantitatively explored by applying an existing method of systems theory, extended to include multiple systems. This is used to investigate hazard-triggering potential, interaction intensity and dominance. It is further used to explore the reaction of monitoring components to geohazard action as well as safety values of the monitoring system and its components. The interrelations established have general relevance to reservoirs and dams. A case study illustrates these points. Moreover, the interrelations can be used for defining hazard chains in multi-hazard assessment, planning of monitoring programs and detecting precursory pathways within a monitoring system. The methodology constitutes the basis for comprehensive safety and risk management, embracing multi-hazard assessment as well as structural health monitoring.