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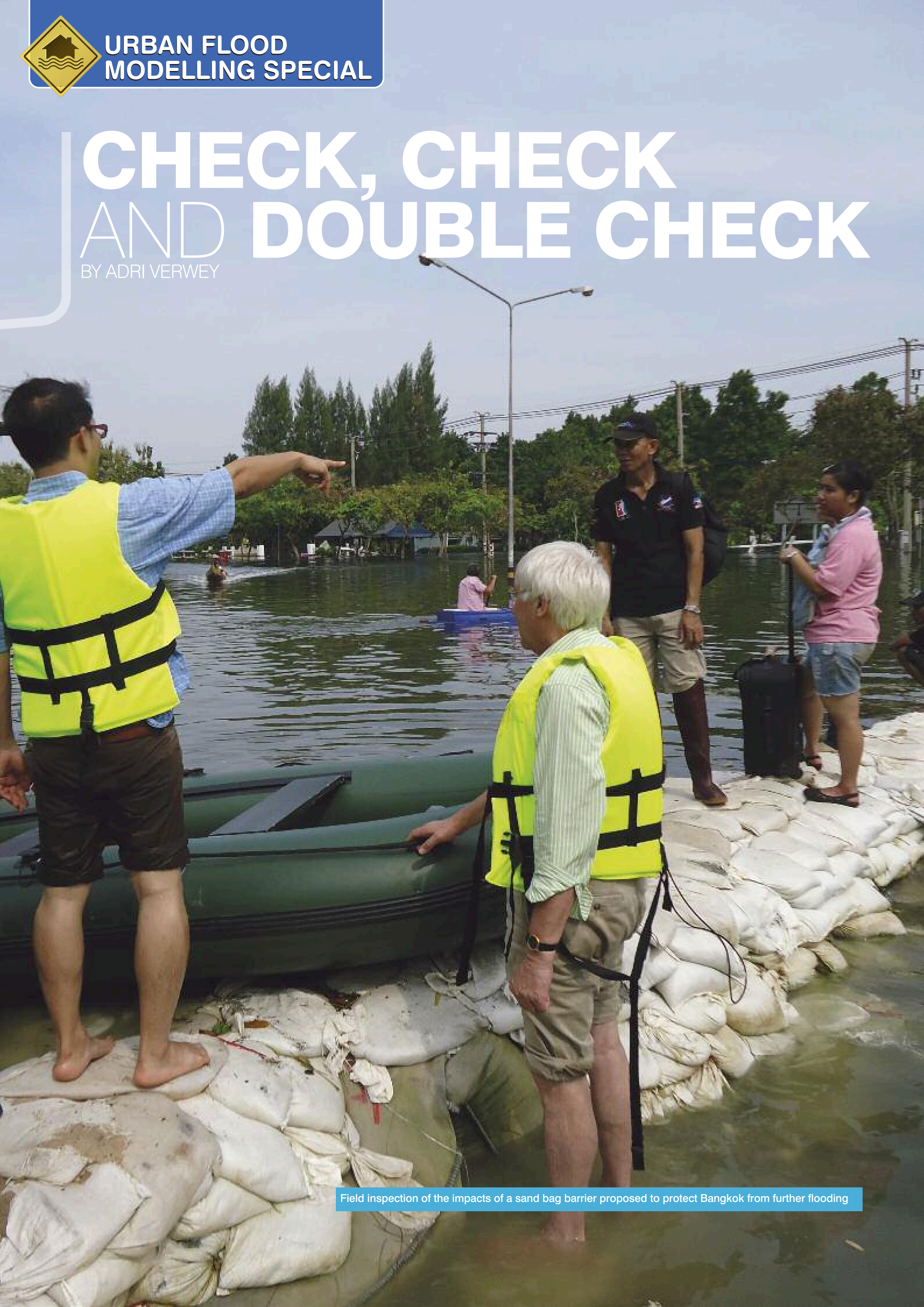
Check, check and double check

Hydrolink

CHECK, CHECK AND DOUBLE CHECK

BY ADRI VERWEY



Field inspection of the impacts of a sand bag barrier proposed to protect Bangkok from further flooding

When my retirement from Deltares in Delft approached, I had to prepare for my own presentation at the Urban Flood Modelling Farewell Seminar held on April 24 this year. The question came up: "What will be your most important message to be passed on to a new generation of engineers?" This led to the issue expressed by the title of the presentation: "Check, check and double check". Looking back at a career of more that 40 years as a hydraulic software developer, modeller of rivers and urban drainage systems and advisor on flood management, checking has become a guiding principle and lessons were learnt by eye openers while working on projects.

Software development

Working as a young engineer on the development of the MIKE 11 modelling system predecessor (System 11) at the Danish Hydraulic Institute, testing the codes was painstaking because of the long turn around times for compilations and test runs. Each mistake was punished heavily in terms of lack of progress. Jobs were submitted via a terminal connection from Hørsholm, Denmark to the new IBM 370 main frame computer at Lyngby University. One can imagine my joy when I was invited to spend the Sunday at the computer centre, right between all these blue boxes that processed my instructions. Turn around of jobs was immediate and I expected great progress. When I made up the balance at the end of the day I had a great disappointment. No more progress than on ordinary week days. My conclusion was that on weekdays I double-checked or even triple-checked my codes before submitting the jobs and I took no time for that on that particular Sunday. These days the main frame computer is on our desk, but the trap of immediate turn around time remains. I sometimes hear programmers using the expression: "I am going to "tap in" a code". The lesson I learnt is that thorough designs and thorough checks before submitting runs save a lot of time in code development and lead to more robust software products.

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Checking system performance after completion of works

Another lesson learnt about the need for double checking resulted from code development at EDF in France. The closure of one of the Phénix nuclear reactors at the end of the seventies led to the need to develop a numerical model to simulate the heat exchange process. Very exciting work and state-of-the-art at that time. However, the model did not lead to an immediate explanation of how temperature differences caused cracks in the mantle of the heat exchange vessel. As part of the checks, the pressure differences, set as boundary condition along the return chamber of the heat exchanger, were increased. This provided temperature differences high enough to explain the emergence of cracks. But what was the cause of such differences? The functioning of the return chamber had been tested thoroughly by simulations with a hydraulic scale model. The picture became clear when further checks were made. During the design process of the reactor the need had come up to reduce the height of its return chamber. Apparently no new model tests were made to check the new conditions, possibly based upon the jugdement that the changes were too insignificant to cause much impact. Maybe it also played that no information was available to calibrate the models used. Also this last aspect is very common in our engineering practice. In flood management, for example, it is more or less impossible to calibrate models for the purpose for which these are developed. One does not often monitor 1 in 100 year floods. Both model application areas show the need to check the performance of a system by monitoring and recalibration of models used, once the works have been completed. Check, check and double check. However, this is rarely planned. The job is considered to be finished, the consultant has gone and the authorities in charge find other focus areas.

Model development

At various stages the development of a mathematical model requires systematic checking. Most important is the check on the correct representation of the system behaviour. Such checks, partly done before the model is even constructed, vary from simple hand calculations to a complex model calibration and validation. The development of a pilot model can be extremely helpful as it provides a quick insight into data needs and system behaviour. This was clearly demonstrated during the 2011 floods in Thailand, where I advised the Thai Government on handling the floods. The first days after arrival at the flood centre the highest priority was the development of understanding of the flood behaviour. Slowly progressing from the north, the city of Bangkok was threatened by a progressive flood wave front. Simple calcula-

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tions on the basis of the Manning equation showed the unbalance between flood volumes coming down by gravity and the discharge capacity of Chao Phraya River and the large number of irrigation and drainage canals around Bangkok. As a result, the first conclusion drawn was that there was a high risk of further progressing overland flow. Within a few days, backed up by colleagues at Deltares, an integrated 1D2D pilot simulation model was developed based upon the SOBEK modelling system. Due to continuous time pressure, the model could only partly be refined. However, even so the model showed its tremendous value in understanding the flood mechanism. Systematic checking also showed its importance when combining model development with extensive field visits. On various occasions the model had to be corrected on the basis of own field observations. My former students know that I always stressed the importance of field visits in model development, but in this case its importance surprised even me. For example, as part of the hectic flow of information it was first told that at a crucial pumping station at Khlong Bang Sue 5 out of 8 pumps had failed, followed the next day by a message that all 10 pumps had failed, whereas a subsequent field visit to check conditions showed that all 15 pumps were functioning perfectly well. Once again, check, check and double check information while constructing a mathematical model.

Urban runoff monitoring site inspection at the NUS Campus, Singapore

The responsible role of education

The design and application of simulation models requires a good understanding of the underlying physical principles. The development of such understanding is a clear responsibility of university teaching staff. During many years of teaching at UNESCO-IHE in Delft, I had to spend quite some time to show my students, arriving from many different countries of the world, that much of the flow in rivers and canals is of unsteady nature. Their education had not gone beyond the point where steady flow principles were taught. On this basis, how can they understand the functioning of an urban drainage system? The design of a good urban drainage system is based on the art of reducing peak discharges and this requires orchestring the best system composed of storage and conveyance elements. Having only steady flow principles at hand, the urban drainage engineer is completely lost. Without a focussed university curriculum, the principle of check, check and double check is beyond reach.

Thinking out of the box

Thorough checking becomes even more important when leaving traditional paths. Concrete lining of urban drainage channels is the traditional way to enhance channel conveyance. With the current expansion of many large cities in the world, peak discharges in existing drainage channels tend to increase, resulting in new flood prone areas. The basic principle of reducing these peak flows again is delaying runoff from upstream and speeding up runoff at the downstream end of the system. Stretching the runoff hydrograph results in bringing its peak value down. Looking around in new urban developments, the use of glass lining of buildings is striking. So, why not apply this material as well in drainage canals? Glass instead of (weathered) concrete lining of channels brings Manning numbers down by nearly a factor two. The Manning equation shows that for the same cross-section the use of smooth material along the walls may increase the discharge capacity substantially. This is what I suggested to the Public Utility Board in Singapore in 2011 and it was taken up by covering walls of some of the existing drainage canal sections with epoxy-based material. However, such measure requires very thorough checking. Can downstream sections of the channel handle the increased flows? How is the energy of increased flow velocities handled? Nature has its ways of dissipating energy. In the first place wall friction takes care of it. However, if this is insufficient the flow will generate hydraulic jumps with localized production of turbulence and subsequent erosion capacity. Can the canals stand this? Checking of the adapted system design cannot just be based on standard simulation models and the use of common sense. Introducing new concepts in hydraulic design also provides a new challenge to research and education.

Concluding remarks

Many more examples could be given of cases where extensive checking appeared to be essential in my work as a practicing engineer. Checking becomes a second nature when applied systematically. This is a challenge for the new generation of engineers, disturbed by a continuous flow of short messages, e-mails and used to abbreviating texts to short hand forms. An era with managers expecting continuously that projects can be handled in shorter and shorter times. However, this last point may also be an extra impulse to the new generation of engineers to check, check and double check their work right from the beginning of a project, whether it is software development, model development, creative engineering, or other work. There is a good chance that this awareness avoids loss of own valuable time or that of other professionals at a later stage of a project or thereafter.