Risk and Safety in Civil Engineering

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To plan, develop and maintain the build environment is the main responsibility of civil engineers. In our daily lives most of us take the built environment more or less for granted. We have gotten used to a well functioning infra-structure. Furthermore, whereas some bridges and high rise buildings may be extremely spectacular most of the built environment is hardly noticed. This part includes sewage systems, tunnels and water supply systems; systems without which our modern society could not function. Civil engineers can be said to provide the basis for the existence and continued development of society.

When civil engineers make decisions in regard to the planning, design or maintenance of the built environment they take basis in the fundamental laws of nature, e.g. the results of fundamental research in physics, chemistry and biology. Well known examples of this is the law of gravity or the laws of thermodynamics which all play crucial roles in how we design and maintain buildings and structures. However, in most cases these laws of nature cannot be directly applied to a specific engineering problem. Engineering models have to be established by combining fundamental research with numerical computer simulations and the results of carefully planned experiments.

Figure 1: Sustainable decision making during construction and maintenance of infrastructure. (COWI)

Engineering models will always be subject to uncertainty. In many cases, such as e.g. the case when natural phenomena like the weather is considered the engineering models developed to predict such phenomena are indeed very uncertain. The same applies to the prediction of natural hazards such as e.g. earthquakes, rock-fall and tsunamis which all constitute important exposures for the built environment. Engineering models must, however, also take into account the uncertain performance of man. This concerns e.g. the case when models are developed to predict the strength of a structure which in turn strongly depends on the skills and dedication of the people involved in its manufacturing. Due to the effect of the different types of uncertainties there is no absolute certainty associated with the result of an engineering decision. For this reason there is also no absolute certainty about the safety of a structure.

The theoretical framework which constitutes the basis for engineering decision making is the decision theory which together with the Bayesian probability theory constitutes a consistent and rational basis for decision making subject to uncertainties. In daily language we refer to the application of the theoretical framework as risk based decision making. When engineering decisions are developed e.g. for the design of a bridge the design is chosen subject to a cost benefit assessment e.g. such that the life cycle benefits of the structure from it is planned and built till it is decommissioned are optimized, taking into account the income generated by the structure as well as the costs associated with it construction, future maintenance as well as costs implied by possible future failures (Figure 2). It is important to understand that due to the various uncertainties influencing engineering models failures cannot be avoided with certainty – however, the probability of failures and the associated risks may be controlled by engineering decisions such that these are acceptable to society; risk reduction is always possible at a cost – but as society only has limited resources societal risk acceptance is strongly related to the question of what society can really afford.

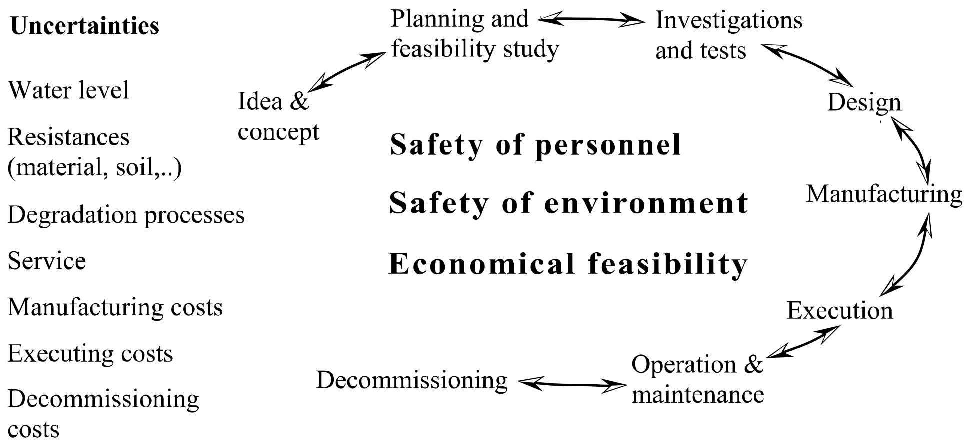

Figure 2: Risk contribution from different service life phases to be considered at the planning stage. (Faber).

When engineering decisions are made on behalf of society it is important that the preferences of society are consistently reflected in the decisions. Fundamentally seen the preferences of society define in which way society spends its resources for the purpose of enhancing the living conditions for the individuals living in society. Obviously this relates to how much money the society can spend on reducing the e.g. the risks associated with roadway traffic as opposed to spending money on education or public health. It has been found possible to formulate and verify a model which expresses societal preferences in regard to investments into life saving activities and this model is now widely applied as a basis for engineering decisions on investments into life saving.

Recently, with the famous Bruntland report, the common understanding of societal preferences gained yet another dimension – namely sustainability. In addition to life safety and economy also the environment is now considered to form a key attribute in societal decision making. In addition to this not only the preferences of our own but also future generations must be taken into account when we in our generation are making decisions with a possible impact on future generations. Society as well as the engineering community is still working hard to incorporate this new ethical rule setting in our daily lives. Difficult questions such as how society value the existence of individual animal species compared to improved living conditions for people must be answered before we can succeed in implementing sustainable decision making into our daily lives.