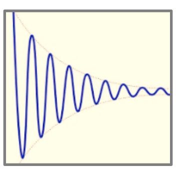
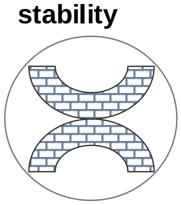
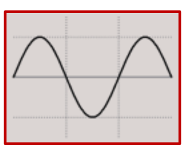
Engineering Design Principles

by Prof. dr. Jill H. Slinger

What is the essence of engineering design? What are the principles upon which it is based?

Answering these two questions enables the connection to ecological design, or nature-friendly design. If engineers can explain why they think and act in a particular way when designing, and if other professionals understand what motivates engineers, a multi-disciplinary negotiation space emerges. Therefore, this document attempts to answer the questions by expounding a set of eight Engineering Design Principles. Each of these principles describes an aspect that an engineer considers when design infrastructure.

1. Requisite standard 	A structure should withstand all conditions apart from those exceeding the design criteria. Examples include Dutch dikes which are built to withstand a 1 in 10000 year storm surge.
2. Control of (environmental) variability 	Control of environmental variability to ensure access, connection or supply. For instance, a lock is designed to connect two bodies of water in such a way that ships can move from one body of water to the other, by the control of the water level within the lock. A breakwater has a dual function - withstanding variability (to a requisite safety standard) and ensuring accessibility by controlling the variability of the wave conditions behind the breakwater. A major dam in a river is designed to control the variability in river flow by storing it to ensure supply. The more variable the river flow, the larger the dam needed to provide a particular assurance of supply.
3. Reasonable cost 	A pragmatic consideration of the costs and the benefits of certain infrastructure. While an unnecessarily expensive structure is not likely to be built, a cost-cutting version may not continue to meet the safety standard in the long term. A professional engineer is responsible for the trade-off between minimizing costs while maintaining standards.
4. Structural integrity, such as strength and stability 	A structure should be built of appropriate material and in an appropriate fashion to prevent unsteadiness or imbalance, yet retaining its resistance to loading. This requires the maintenance of structural integrity: strength, stabilityand stiffness. The structure should remain in position. For example, when large rocks or concrete blocks of a breakwater are placed directly on a sandy substrate, the structure can become unstable and subsides or slumps as time passes.

5. Reliability 	A structure should continue to function smoothly and well, and should not require many repairs. In general, the simpler the structure, the more likely it is to be reliable. This principle also incorporates the idea of maintenance: a structure can be maintained so that it remains reliable.
6. Implementibility 	Checking whether an infrastructure is feasible and reasonable to construct and operate. Tried and tested methods are generally preferred above entirely novel ones. An exception is the Eastern Scheldt storm surge barrier, for which many new design and construction methods had to be developed.
7. Adaptability 	Taking potential future changes in the function of an infrastructure into account in the design phase. Applying adaptability to the design of a quay, for instance, would consider the need to raise and/or re-use it at a later stage to accommodate the next generation of ships, with deeper draughts.
8. Resilience 	Capacity of an engineering structure to withstand a second shock, or sudden high load, of similar magnitude to the first and yet retain its structural integrity and continue to meet the functional requirements. An example is a flood protection barrier successfully withstanding first one flood without significant structural damage, then being subjected to another big flood, and successfully withstanding this.
9. Appropriate boundary conditions and loads 	When designing, each engineer seeks to reconcile the function required of the infrastructure with the hydraulic boundary conditions and load that it will experience. They do this to a required standard, and at reasonable cost.

Further reading

Voorendt, M.Z. (2015). The 'Delft design method' for hydraulic engineering. Technical report, Delft University of Technology. Delta Technology, Design & Governance Series. Bee's Books, Amsterdam. ISBN/EAN: 978-90-74767-19-4

Dym, C. L., & Little, P. (2004). Engineering design: A project-based introduction. Wiley.