Chapter 3: The design process

ct5308 Breakwaters and Closure Dams

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The design process

A design should combine:

- **Functionality**
- **Technology (what is feasible)**
- **Environment (what is allowed or accepted)**
- **Cost and Benefit (not only money)**
- **Paperwork (drawing board)**
  (could be replaced by virtual paperwork)
- **Matter (actual construction)**

abstraction level

- Macro level the system
- Meso level a component of the system
- Micro level an element of one of the components

	Macro level	Meso level	Micro level
1a	Harbour in global and regional transport chain	Harbour layout	Breakwater
1b	Harbour layout	Breakwater	Crest block
2a	Regional water management plan	Fresh water basin	Closure dam for fresh water basin
2b	Fresh water basin	Closure dam (location, cross section)	Closing method
2c	Decision to construct the Delta plan	Dam in the Brouwershavense Gat	Closing method north-gap
2d	Dam in the Brouwershavense Gat	Closing method north-gap	Design of a caisson

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Various levels of abstraction

- design a world or regional concept for transport of commodities
- design regional or national plans
- design a national or provincial zoning policy
- design an overall port with intermodal facilities
- design a breakwater for such a port
- design a quarry to provide stone (or find an alternative)
- design the workshop for maintenance of the equipment of the quarry

design phases

- initiative
- feasibility
- preliminary design
- final design
- detailed design

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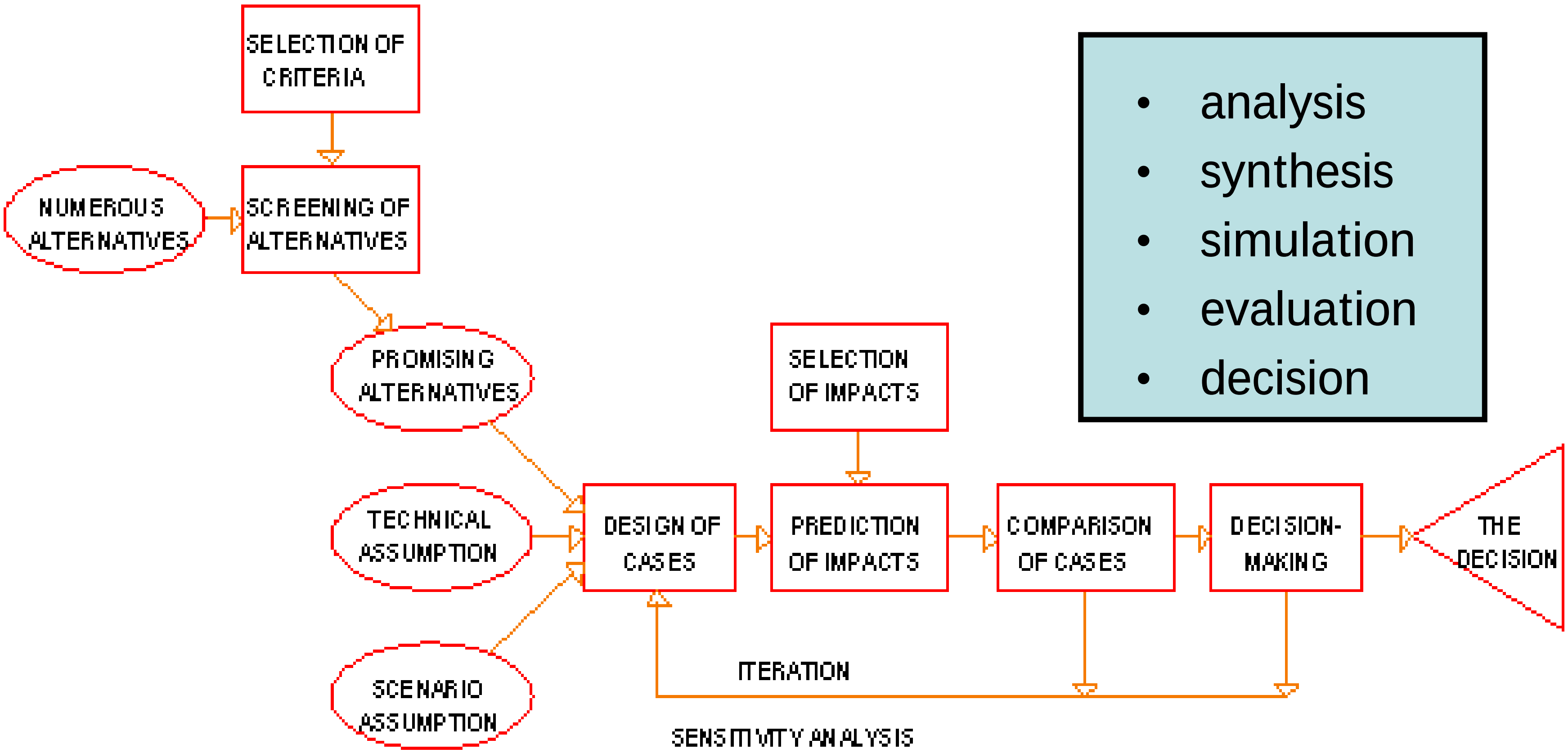
Cyclic design



- analysis
- synthesis
- simulation
- evaluation
- decision

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Structural design

New Text

- The structure should not fail:
  $Z = \text{strength} - \text{load} = R - S > 0$
- Simple case: cable in a crane
  strenght: $R = A\,\sigma$
  load: $S = M\,g$
  $Z = R - S = A\,\sigma - Mg$
  $A_{crit} = Mg/\,\sigma$

  Add safety factor:
  $A_{crit} = \gamma\,Mg/\,\sigma$
- Usually γ is given in professional codes and standards
- For Breakwaters PIANC has issued values of γ
- In case of high uncertainties a probabilistic approach can be followed

Problem !

- In coastal engineering we have a problem with the load.

$$M = \frac{\rho_s H_s^3}{K_D \Delta^3 \cot \alpha}$$

- Load parameter: H_s
- Strength parameters: ρ_s, Δ, M, K_D, α
- For strength parameters: Gauss distribution, small standard deviation
- But there is no “average” H_s
- We have to use a “design storm”

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Two cases

1. It is a pure economic problem
2. Also human lives and other non-monetary values are included, like protection of a museum or a religious site

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For breakwaters

- Usually a pure economic problem
- Balance between investments and maintenance has to be found (see appendix 7 in the book)
- But this is often not done, because:
  - available budget for initial work
  - various sources of money for investment and maintenance

Design storm and design life

- Economic lifetime of a breakwater is in the order of 50 years
- Decision makers therefore often suggest:
  "use for design a 1 in 50 years storm"
- Probability of serious damage is Poisson distributed:

$$p = -\exp(-fT_L)$$

  - p = probability of occurrence on an event in period T_L
  - T_L = lifetime of construction
  - f = average frequency of the event per year

$$p = 1 - \exp\left(-\frac{1}{50}50\right) = 1 - \exp(-1) = 0.632$$

- There is a probability of 63% that the construction will fail during lifetime

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Better values

- Life time 50 years
- Probability of failure during lifetime 10%
- Required storm frequency has to be:

$$f = -\frac{1}{T_L}\ln(1-p) = -\frac{1}{50}\ln(1-0.1) = 0.0021 = {}^{1}\!/_{474}$$

- So a 1/500 storm is a convenient value

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