The information in Sections 6.1.4 to 6.1.7 is really only adequate for preliminary design purposes, so the detailed design for major breakwater projects should ideally be checked in a hydraulic physical model (see Section 5.3.2), making use of state-of-the-art techniques. Alternatively, uncertainties in the design formulae may be translated into (increased) safety factors, but even for small breakwaters this generally leads to substantial cost increases. In most cases model tests are cost-effective and lead to optimisation of the preliminary design.

6.1.3.2 *Data collection and boundary conditions*

The main environmental conditions serving as input parameters for the design formulae and mathematical or physical models are given in Table 6.1 below.

Table 6.1 *Main environmental input parameters for design formulae and models*

Input parameters		Output	Tools
Environmental conditions	Water depth, tides and currents, long-term wave statistics	Design water levels, currents and wave statistics at the structure	Section 4.2.2: Marine water levels Section 4.2.3: Marine and estuarine currents Section 4.2.4: Wind waves and swell
	Seabed properties, bathymetry	Bearing capacity, geometry of the structure	Section 4.1.2: Bathymetry and morphology related to marine structures Section 4.4: Geotechnical investigations and data collection
Conditions during construction	Short-term wave statistics and seasonal variation, meteorological conditions	Construction methods and cost Design elevations	Section 4.2.4.8: Short-term or daily wave climate Section 9.3: Equipment
Environmental restrictions	Availability of construction material, infrastructure facilities Presence of protected fauna or flora	Construction costs Mitigation measures	Sections 3.2–3.11: Quarried rock Section 9.4: Transport
Present constraints	Availability of labour and equipment, local experience, safety of labour and public	Production costs and works duration	Sections 3.2–3.11: Quarried rock Section 9.5.2: Key hazards sources and their delivery
Future constraints	Facilities for future maintenance Durability of construction materials	Design details	Section 2.4.6: Maintenance and repair Section 2.4.7: Removal Chapter 10: Repair and replacement

6.1.3.3 *Materials availability*

The material for rock structures is supplied by quarries (see Section 3.9), the geological characteristics of which determine the maximum size and shape of the armour stones. Where a quarry is dedicated to a breakwater project, blasting to obtain the required design sizes of armourstone for a conventional rubble mound breakwater usually involves production of greater quantities of materials than are required by the design. This often results in an overproduction of certain gradations for which normally no other application can be found, even when that required for concrete aggregates has been used. This material is then effectively classified as waste. The design of a rock structure in this situation should therefore be tailored to the expected quarry yield as much as possible. This practice has been successfully adopted in Iceland and Norway.

Use of concrete armour units (see Sections 3.12 and 6.1.4) and berm breakwaters (see Section 6.1.6) are examples of design approaches that help achieve this kind of tailoring. Information