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Description of Fatigue Loading

6.1 The Nature of Fatigue Loading

Fatigue is defined as a process of cycle by cycle accumulation of damage in a material undergoing fluctuating stresses and strains (Almar-Naess, 1985). A significant feature of fatigue is that the load is not large enough to cause immediate failure. Instead, failure occurs after a certain number of load fluctuations have been experienced, i.e. after the accumulated damage has reached a critical level, see Fig. 6.1 for an illustration.

The service life of a component or a structure depends on both the load conditions and the fatigue strength. Hence, in order to obtain a proper fatigue design, it is important to consider the real structural loading history, \( P(t) \). From the definition of fatigue, one should know that different from monotonic loading which caused static failure, fatigue loading is basically of a cyclic nature. Furthermore, since it is a future event, the fatigue loading history for the designed structure can never be known \textit{a priori}. Many engineering methods are based on finding the worst case scenario, where “worst” should often be interpreted as a certain severe load condition.

From Chapter 1 we know that generally speaking there are two types of FLP methods. One is CFD analysis where fatigue loading is expressed as a spectrum. The other is FCP analysis where fatigue loading is expressed as a time history. In this chapter, technical problems related to fatigue loading description and determination are discussed.

In this book we distinguish the fatigue load history from the fatigue load spectrum while many other authors do not make this distinction, \textit{e.g.} Schijve (2009). In his book, the fatigue load on a structure in service is also referred to as the load spectrum. When we say a fatigue load history, it means a time-domain description, \( e.g. \ P(t) \). When we say a fatigue spectrum, it means a frequency-domain description, \textit{e.g.} a Weibull distribution. The fatigue load history is used in the FCP process while the fatigue load spectrum is used in CFD calculation, see Fig. 6.2 for the comparison.
6.2 Load Spectra for CFD Analysis

Current FLP of marine structures at the design stage is generally performed by calculating the damage on the basis of the structure’s dynamic load spectrum, the structure’s shape and material endurance using $S$-$N$ curves. The structure’s shape and material endurance are usually known, so only the structure’s dynamic load spectrum is needed to calculate the damage. The current fatigue strength assessment method for ship structures can be summarized as follows (adopted from Common Structural Rules for Tankers, 2006).

The following assumptions are made in the fatigue strength assessment:

1. A linear cumulative damage model, i.e. Palmgren-Miner’s Rule, has been