

Summary

Due to the high demand of energy and steel, new dry bulk terminals have to be build and existing terminals are being forced to expand. Conceptual design of dry bulk terminals is one of the main activities which is conducted at Heavy Industry and Logistics, an Advisory Group of the consultancy firm Royal HaskoningDHV (RHDHV). It would be beneficial if designers could gain a quick insight in the required characteristics of main terminal components based on demands and possibilities, without the need to perform many calculations or to develop a new calculation model for each new project. Furthermore, there are some design aspects which cannot be easily evaluated using conventional methods. Added insight could be achieved with the help of a design support tool. The objective of this thesis has been to develop a design support tool which can be used during the conceptual design of a dry bulk terminal. The tool should function as a guide during the early stages of the design of a terminal. It should give a better understanding in the different options which can be chosen and should be able to create a terminal model based on key parameters provided by user input.

Dry bulk terminals are worldwide used as a buffer between an incoming flow and an outgoing flow of bulk solids material. Each dry bulk terminal has a 'sea-side', a 'land-side' and an 'internal terminal' part. Depending on the flow direction of the bulk material, the terminal is called import terminal or export terminal. A terminal is characterised by its two functions: handling and storage. Handling can be divided in different sub-functions or processes. To these processes different terminal components and means of transport are related. To keep the model generic it is chosen to only implement functions and components which can be found on every terminal. The characteristics and common performances of all these components, processes and means of transport are investigated, which has led to empirical values and capacity ratios (EV&CR) which are used in the design support tool.

The design support tool is built in Microsoft Excel. This is preferred by RHDHV because during most of the conceptual design phases Excel is already used. Another advantage of Excel is that it is installed on all computers and most of the employees are used to work with it.

The developed model contains three calculation methods with increasing level of detail. The first method makes use of the EV&CR. The second method calculates in more detail taking into account the specific handling equipment and their numbers. The third method makes use of a simulation model and takes variations into account in inter-arrival time and service times.

The developed model consists of two parts: a terminal design (TD) part and a storage capacity determination (SCD) part. The TD part contains calculation methods 1 and 2 and the SCD part calculation method 3.

The terminal design part uses calculation method 2 to determine the required amounts and capacities of equipment and facilities of the four main processes (seaside handling, landside handling, storage handling and storage). As a result, some possible concepts are generated, which are checked by calculation method 1. Based on the EV&CR the tool selects a valid concept. The user of the tool may optionally select a different concept.

Case studies are performed to compare the results of the TD part with real data. Four existing terminals are used for comparison: two import terminals and two export terminals. The tool gives results which largely correspond with the characteristics of existing terminals. In particular the amount of equipment, number of berths and number of stockyard lanes suggested by the tool are mostly equal with the reality.

A large part of the calculations and assumptions is based on methods described in the Port Development handbook by UNCTAD. How to determine the required storage capacity is not described in this handbook. Therefore, this part of the design tool assumes that the required storage capacity is known. When the storage capacity is not known, or it is desired to check whether a given storage capacity is sufficient the SCD part of the design tool can be used.

The input of the SCD part of the design tool is both defined by the user and by the input and output of the TD part of the design tool. The in- and output of the TD part form the terminal characteristics which are used in the SCD part. During the simulation the stockyard is modelled as a black box. Material arrives with a particular rate and leaves the terminal at a certain rate. How, where and how long material is stored is not defined. The amount of stored material is determined by the differences in input rate and output rate. The throughput rate at landside is assumed to be constant. The throughput rate at seaside fluctuates and is determined by different parameters.

The storage capacity is determined by looking at the vessel waiting time depending on the storage capacity. It works in an iterative way. Simulations are run with different storage capacities each time. When the storage capacity is small, the situation will occur more often that vessels have to wait because the storage is full (or empty, depending on the type of terminal). The storage capacity which leads to the allowed waiting time will be the required storage capacity.

Experiments are performed to investigate the influence of the following four seaside parameters separately on the required storage capacity: annual throughput, average vessels' tonnage, vessels inter-arrival time distribution and the vessels' tonnage distribution.

Based on the performed experiments it appeared the four seaside parameters have (clearly observable) influence on the required storage capacity. The obtained storage capacities from the model are larger than the storage capacities of existing terminals. The cause of the larger required storage capacity by the model is probably the assumption that the throughput flow at landside is constant and evenly spread out over the year. To obtain more realistic results the model should be extended with a more detailed handling part at landside with specific transport units and landside handlers. However, extending the model will lead to longer simulation times. At the moment one simulation takes about 50 to 70 minutes. Because of this long calculation time and the limitations of Microsoft Excel it is recommended to optimise the model first in such a way that the simulation time becomes shorter, or to build the SCD part in a different programming environment.

The TD part of the design tool however gives realistic results and Excel is appropriate for it. The TD part functions as a guide during the early stage of the design of a terminal and gives a better understanding in the different options which can be chosen.