11 Summary

In the process of new designs of mechanical structures or systems and control strategy development, a great role for numerical modeling and simulation can evidently be identified. The most comprehensive verification provided by an experiment is naturally the best solution. It is however tedious and costly and in many cases difficult to perform. Offshore structures are often produced as single specimen for a specific order. Carrying out detailed empirical research would raise the final price of a device considerably. Therefore many design companies, including ones in the business of offshore engineering, are interested in access to appropriate calculation software. Such programmes have different purposes. Some of them are suited for strength analysis, others to simulate operation of a device or its control system. In addition to accurate calculations of precise values which are necessary when designing a given machine, companies also need quick and rough simulations, e.g. when preparing an offer (during initial negotiations with a counterparty). Calculations performed at the design stage are not significantly constrained by allowed duration of the simulation. On the other hand, control systems of devices must perform real-time calculations which requires using sufficiently numerically efficient models and methods. In many cases, to obtain satisfactory correspondence to reality flexibility of links must be taken into consideration by their discretisation. In some problems, nonlinear properties of the material or other specific conditions may be important. At present, different discretisation methods are used in calculations of machines' dynamics. The most widely known is the finite element method. The authors of this book have been involved for many years in the development of the rigid finite element method. Based on their experience, it is their position that this method allows developing models of structures adequately reflecting the actual features of the dynamics involved while keeping the number of generalized coordinates small. It is also fairly simple to implement on a computer. It furthermore enables quick and convenient changes of the number of rigid finite elements in the discretized links. This allows both the calculations in real time (for small numbers of RFEs) necessary for control and more time consuming ones which better reflect the flexibility of the system (assuming more RFEs) to be carried out.

In the book, the authors have discussed applications of the rigid finite element method in offshore technology. In addition to giving basic formulas and dependencies, a way has been presented to model added phenomena typical for operation of offshore structures. In particular, modelling of motion of the device's base caused by sea waves and interaction of the sea environment with the elements immersed in water (pipelines, cables) is of importance. Moreover,

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selected analyses concern nonlinear material characteristics, including deformations of elements in the plastic region. To describe the geometry of systems using the method of homogeneous transformations and joint coordinates is proposed. This method is characterized by conciseness of notation and simplicity of description of complex structures. Complex systems may be modelled with it, including ones in which rigid and flexible links are interleaved. The method also enables taking large deflections into consideration.

The models of offshore structures presented in this book vary in their complexity, therefore they reflect real objects in different ways. Some of them are suitable for quick calculations in real time, others enable more accurate analyses. Certain models have seen actual use in design practice (e.g. the model of an A-frame, the model of a device for unwinding pipes). Applications of the rigid finite element method are naturally not limited to offshore technology. The authors used this method before to model dynamics of spatial mechanisms and manipulators of robots with rigid and flexible links, passenger vehicles and lorries, power trains of vehicles and even satellite dishes. Contents of many of these works confirm the usefulness, effectiveness and correctness of the presented methods, documented by correspondence of the results of calculations and measurements on actual objects.

We hope that the readers will appreciate the two fundamental advantages of the rigid finite element method. First the simplicity of the physical interpretation of a system divided into rigid bodies connected by spring-damping elements, and secondly the ease both of the division into elements and combinations of the natural division into rfes and sdes with the virtual division, which is necessary for the discretisation of the flexible links of machines and mechanisms. We look forward to receiving feedback about the usefulness and applications of the methods presented.