

Introduction

The oil and gas industry around the world are continuously going into deeper and deeper waters. The technological challenges are increasing and new solutions must be found. A depth considered as deepwater 20 years ago, is not defined as deepwater now a days. The floating units used for these operations must be moored at the specified location. Several anchor concepts has been developed during the decades and a more recently developed concept is the dart/ torpedo anchor.

DPA- Deep Penetrating anchor

The Deep Penetrating Anchor (Figure 1) is a new anchor type built on the same principle as the arrow used in the game Dart. The anchor is developed by Deep Sea Anchors AS. They describe the anchor as:

"The Deep Penetrating Anchor (DPATM) is an alternative anchor concept to present day solutions that offers cost saving potential in offshore mooring where soft clay seabed sediments are present..."



Fig. 1: Illustration of Deep Penetrating Anchor

The anchor is released from a convenient height above seabed and penetrates into the soil by utilizing the large kinetic energy made available during free fall. The aerodynamic shape and large weight of the anchor results in a high anchor speed during free fall. Since kinetic energy is proportional to velocity squared, the high anchor speed generates a large amount of kinetic energy as the speed increases. No external forces are acting on the anchor. It is driven by the gravitational force.

The anchor is equipped with tail fins to provide good directional and non-rotational stability. This gives a precise horizontal landing and a vertical configuration of the anchor in the soil.

Anchor Model

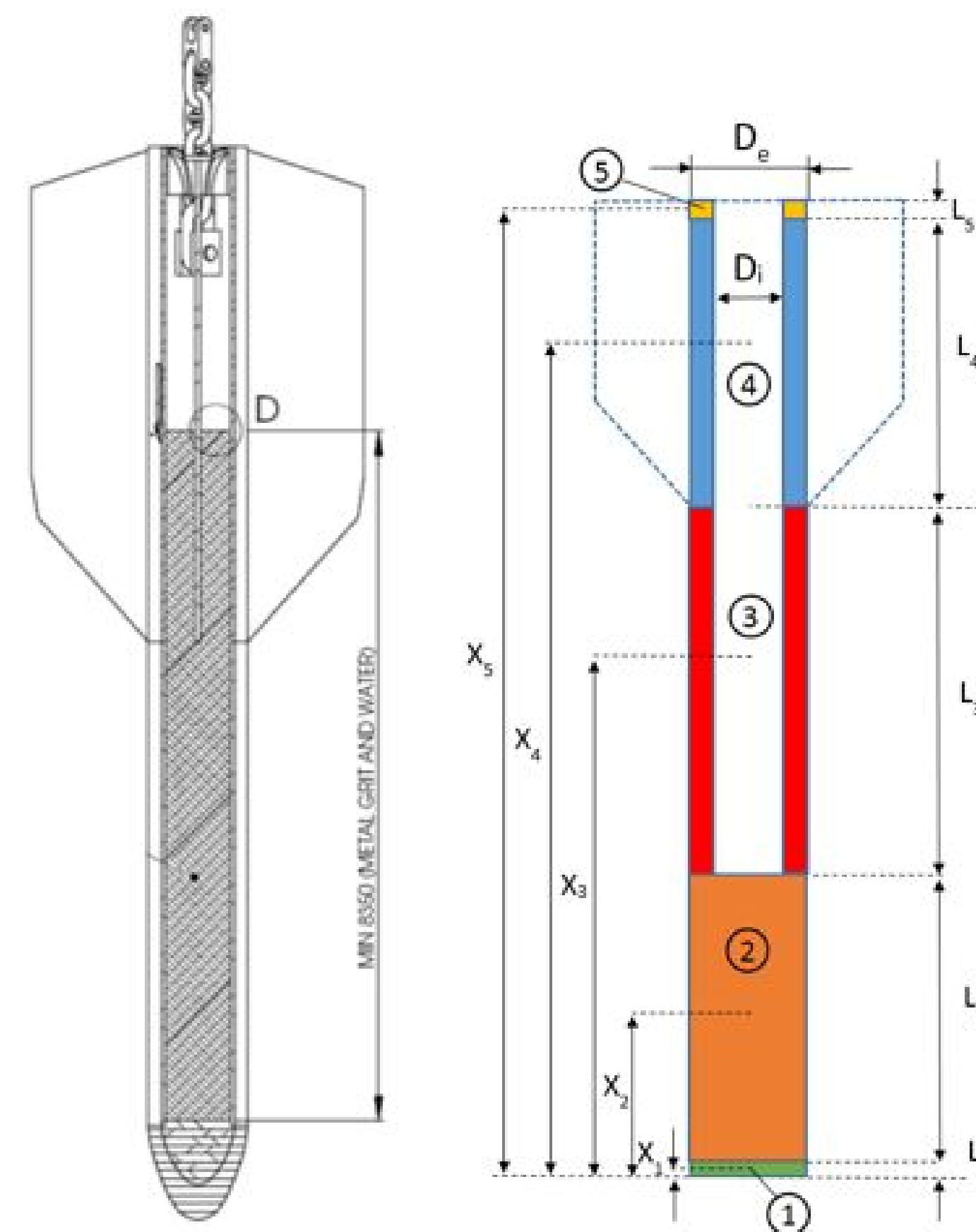


Fig. 2: Real vs. Modelled Cross-Section

The intention of the RIFLEX models is to describe the behavior of the anchor and mooring line in a realistic manner. The tilt angle and touchdown velocity of the anchor is of interest. It is hard to model the anchor in RIFLEX using the exact geometry shown in Figure 2 (left). Hence, a simplified model is utilized (right side in Figure 2). However, in order to get the most accurate and realistic anchor drop simulation, implementation of correct mass and is important. The anchor is modelled by 5 beam elements, Three main elements and two short front and back tip elements. Element 1 and 5 are dominated by pressure- and suction drag, while element 2, 3 and 4 are dominated by friction drag.

Model 1- Static Equilibrium

The horizontal and vertical anchor position is unknown prior to the static equilibrium analysis. The static analysis in Model 1 gives the coordinates of the connection point between the installation wire, mooring line and vertical chain segment that is holding the anchor. Two indexations are used to distinguish between the different supernodes and their locations. For a random coordinate x_{ij} , "i" represents the node number and "j" is the configuration. $j = 0$ corresponds to the "stressfree configuration" (start position) and $j = 1$ corresponds to the "static equilibrium configuration" (final position). In RIFLEX, the segments are modelled in a stressfree configuration (Figure 3). The elements are then not exposed to any strains or forces. Figure 4 shows the sequences when volume force and specified displacements are applied to the model.

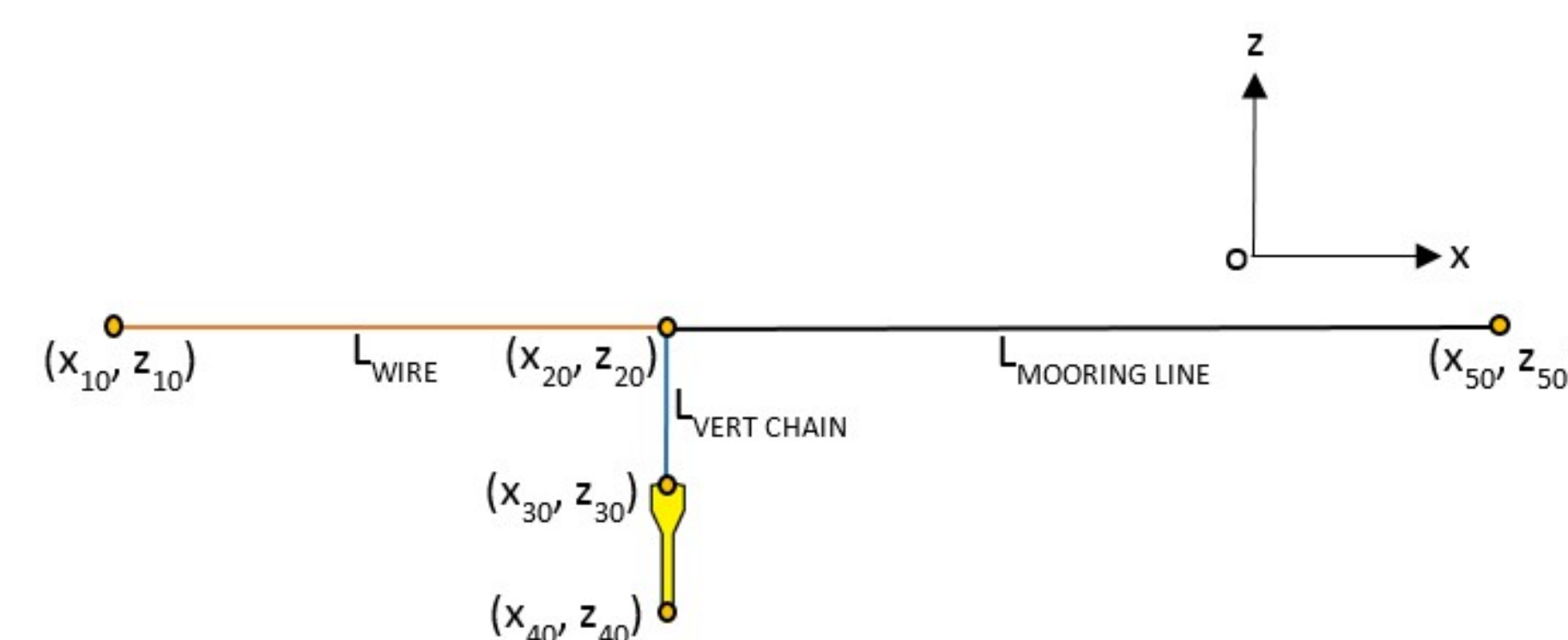


Fig. 3: Stressfree Condition - Model 1

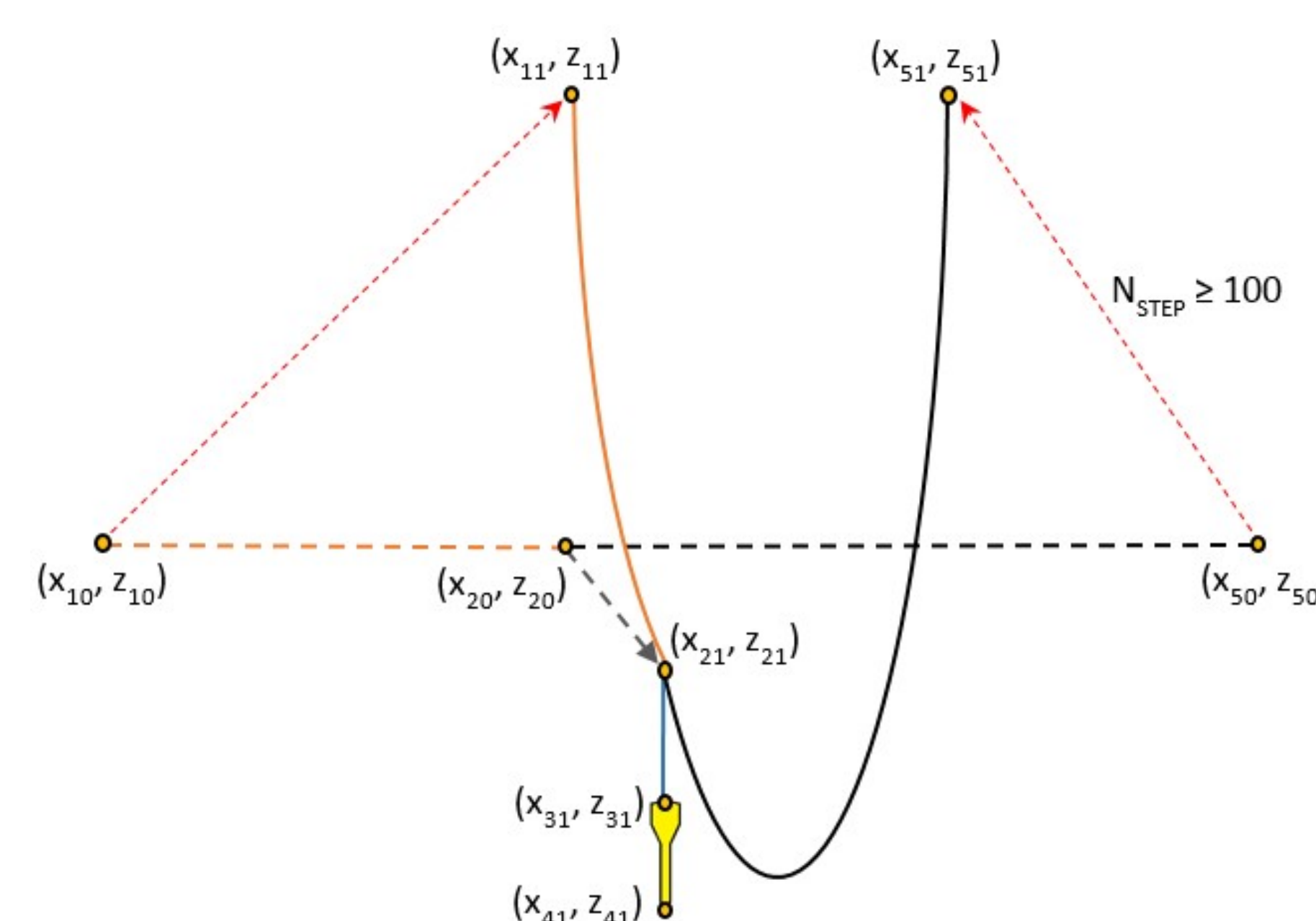


Fig. 4: Static equilibrium condition -Model 1

The coordinates (X_{21}, Z_{21}) of the connection point between the segments are given as input to Model 2 in order to get equal static equilibrium conditions.

Model 2 - Dynamic Simulation

This model is used for investigating the mooring line and anchor during freefall. The installation wire is excluded to save computational time.

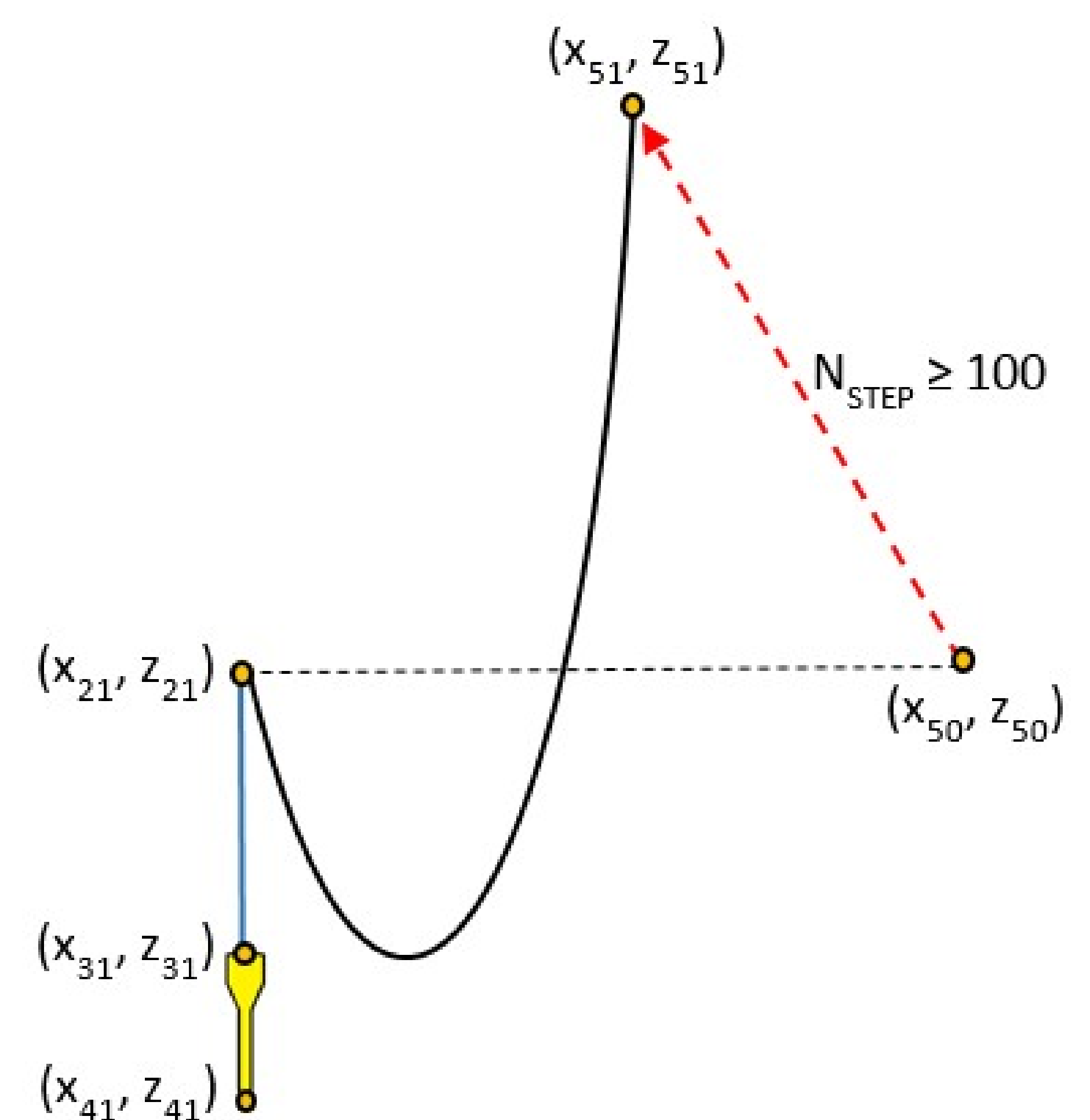


Fig. 5: Static equilibrium condition - Model 2

The anchor is released by changing the boundary condition of the supernode located at (X_{21}, Z_{21}) to "free". The anchor, vertical chain and permanent mooring line is then in freefall towards the sea bottom. In Figure 6 it is seen within the red circle how the axial tension is lost in parts of the chain after anchor drop. The snapshots are concentrated around supernode (X_{21}, Z_{21}) .

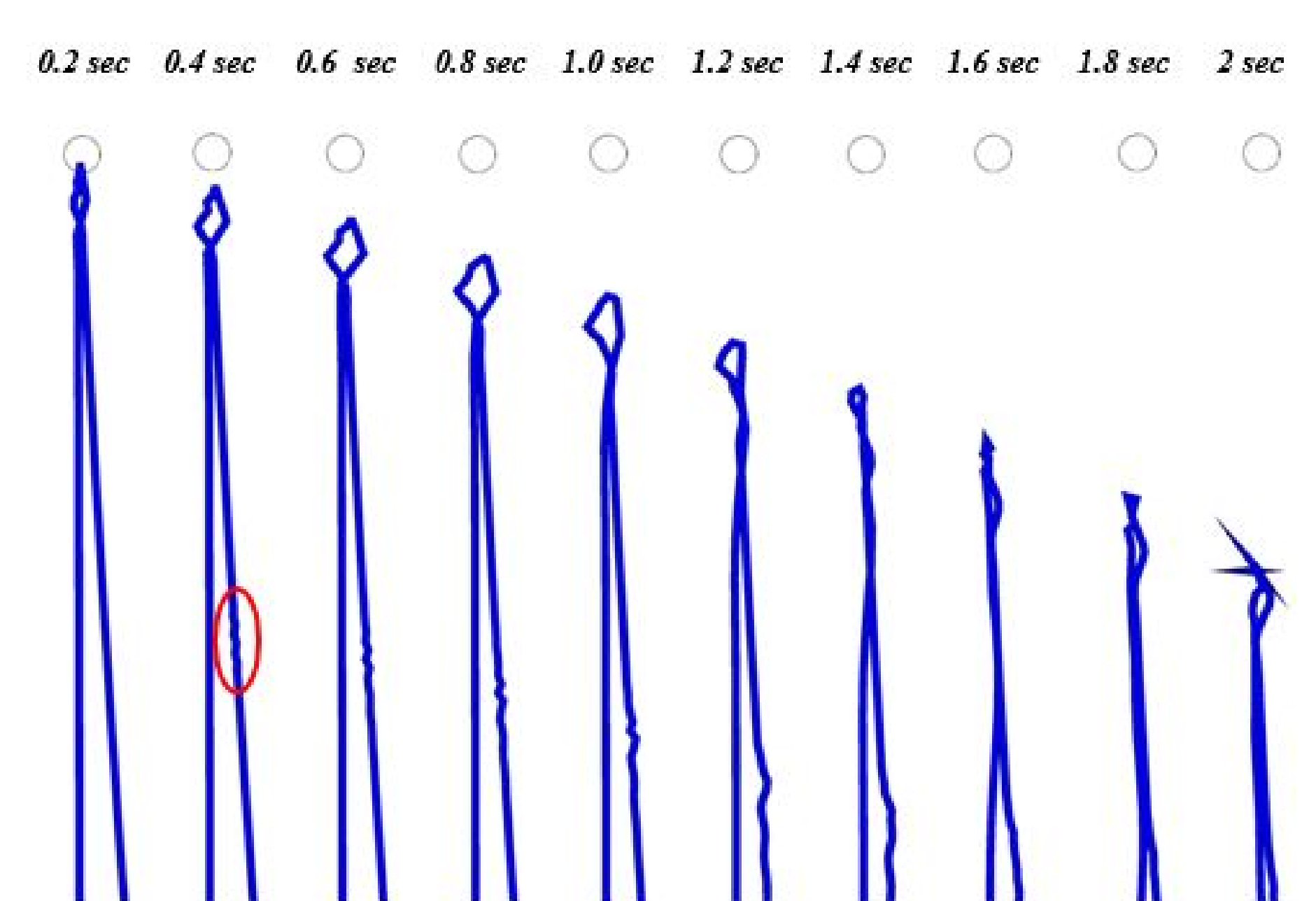


Fig. 6: Snapshots of the Chain After Anchor Release