

**SUPPORTING STABILITY OF CIVIL ENGINEERING MACHINE****TECHNICAL FIELD**

[0001] The present invention relates to using load capacity for supporting stability of a civil engineering machine.

**BACKGROUND**

5 [0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not  
10 prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] Solutions for operational safety of a civil engineering machine provide that injuries to personnel and damage to the civil engineering machine can be avoided. Operational safety of the civil engineering machine may be supported by limiting  
15 actuation of actuating units of the civil engineering machine. For example, tilting of a civil engineering machine can be avoided during use by limiting actuation of a leader to a distance from a carriage part of the civil engineering machine. However, available load capacity of the civil engineering machine may vary depending on inclination of the ground. Therefore, the available load capacity of the civil engineering machine may be  
20 higher at one inclination of the ground than at another inclination of the ground. The available load capacity can also be dependent on a slewing angle the civil engineering machine. The slewing angle indicates the angle of rotation of a structure, such as an upper carriage or a boom, installed to a lower carriage of the civil engineering machine to be rotatable with respect to the lower carriage. Limiting actuation of the actuation  
25 units can therefore leave a significant amount of available load capacity of the civil engineering machine unused.

**SUMMARY**

[0004] The scope of protection sought for various embodiments of the invention is set out by the independent claims. The embodiments, examples and features, if any,  
30 described in this specification that do not fall under the scope of the independent claims are to be interpreted as examples useful for understanding various embodiments of the invention.

[0005] Now, an improved method and technical equipment implementing the method has been invented, by which at least part of the above problems are alleviated. Various

aspects include a method, an apparatus, a computer program and a non-transitory computer readable medium, which are characterized by what is stated in the independent claims. Various details of the embodiments are disclosed in the dependent claims and in the corresponding images and description.

5 [0006] The scope of protection sought for various embodiments of the invention is set out by the independent claims. The embodiments and features, if any, described in this specification that do not fall under the scope of the independent claims are to be interpreted as examples useful for understanding various embodiments of the invention.

## 10 **BRIEF DESCRIPTION OF THE DRAWINGS**

[0007] For a more complete understanding of the example embodiments, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

FIG. 1 illustrates an example of a civil engineering machine in accordance with at least some embodiments;

FIG. 2 illustrates a block diagram of a civil engineering machine in accordance with at least some embodiments;

FIG. 3 illustrates an example of a method for a civil engineering machine in accordance with at least some embodiments;

20 Fig. 4 illustrates an example of a method for controlling a civil engineering machine in accordance with at least some embodiments;

Fig. 5 and Fig. 6 illustrate examples of available capacities of a civil engineering machine based on a distance of a center of gravity to load capacity limits;

25 Fig. 7 illustrates an example of a method for supporting continued use of a load capacity model between instances of use of a civil engineering machine in accordance with at least some embodiments;

Fig. 8 illustrates an example of a method for supporting an up-to-date load capacity model at a civil engineering machine in accordance with at least some embodiments;

30 Fig. 9 illustrates load measurements of a civil engineering machine in accordance with at least some embodiments;

Fig. 10 illustrates examples of configurations and corresponding load capacity models of the civil engineering machine in accordance with at least some embodiments;

Fig. 11 illustrates an example of determining available load capacity of a civil engineering machine;

Fig. 12 illustrates determining an available load capacity based on a plurality of load capacity limits in accordance with at least some embodiments;

5 Fig. 13 illustrates an example of controlling an operation of a civil engineering machine in accordance with at least some embodiments;

Fig. 14 illustrates an example of a user interface in accordance with at least some embodiments; and

10 Fig. 15 illustrates examples of control functions for controlling operations of the civil engineering machine in accordance with at least some embodiments.

#### **DETAILED DESCRIPTION OF SOME EXAMPLE EMBODIMENTS**

[0008] Use of ordinal terms such as “first,” “second,” “third,” etc., in the claims and description to modify a described feature does not by itself connote any priority, precedence, or order of one described feature over another or the temporal order in which acts of a method are performed, but are used merely as labels to distinguish one described feature having a certain name from another described feature having a same name (but for use of the ordinal term) to distinguish the described feature.

20 [0009] The verbs “to comprise” and “to include” are used in this document as open limitations that neither exclude nor require the existence of un-recited features. The features recited in dependent claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of “a” or “an”, i.e. a singular form, throughout this document does not exclude a plurality.

25 [0010] As used herein, “at least one of the following: ” and “at least one of ” and similar wording, where the list of two or more elements are joined by “and” or “or”, mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements.

30 [0011] A civil engineering machine comprises a work equipment for building foundations and a carriage, where the work equipment is operatively connected to. The carriage and the work equipment are operatively connected in at least one of the following ways: the carriage is operatively connected to the work equipment for carrying the work equipment to different work positions at a work site; or the carriage is operatively connected to the work equipment for powering operations of the work equipment; the carriage is operatively connected to the work equipment for positioning

the work equipment with respect to the carriage at a work position; the carriage is operatively connected to the work equipment for controlling operation of the work equipment. The connection between the carriage and the work equipment may be implemented by one or more devices that may comprise for example actuating units.

- 5 Examples of the actuating units comprise at least one of the following: a winch actuator; or a leader; or an actuating member. Examples of the actuating member comprise an actuating member for driving a leader such as a horizontal slide, forward inclination cylinder and lateral inclination cylinder.

- [0012] The civil engineering machine may be subject to loads that affect stability of the civil engineering machine. The loads may vary depending on a configuration of the civil engineering machine and a weight of a load carried by the civil engineering machine. Configuration of the civil engineering machine comprise at least one of the following: components of the civil engineering machine; properties of the components of the civil engineering machine; or positions of the components with respect to each other; or actuation states of the components; or one or more loads carried by the civil engineering machine; or position of the civil engineering machine on the ground; or inclination of the civil engineering machine. Examples of positions of the components of the civil engineering machine comprise positions in one or more directions, where the components are movable and may be driven by one or more actuating units. In an example a horizontal slide may be extended and retracted for moving a leader in a horizontal direction. Examples of the load carried by the civil engineering machine may comprise weight of work equipment, such as a piling hammer and/or a ram block. Examples of the components of the civil engineering machine comprise at least one of the following: a carriage; or an upper carriage; or a lower carriage; a counterweight of a carriage; or support legs attached to a carriage for supporting the civil engineering machine with respect to the ground; or a leader; or an actuating member; or a winch; or a work equipment; or one or more devices that connect the work equipment operatively with the (upper/lower) carriage to cause: driving the carriage carrying the work equipment to different work positions at a work site; or powering operations of the work equipment; positioning the work equipment with respect to the carriage at a work position; controlling operation of the work equipment. Examples of the work equipment comprise a piling hammer, ram block, drilling device and a gripper. Examples of the one or more devices that connect the work equipment operatively with the (upper/lower) carriage comprise at least one of the following: a winch, a leader; or an actuating
- 10
- 15
- 20
- 25
- 30

member. Examples of the actuating member comprise a horizontal slide, forward inclination cylinder and lateral inclination cylinder.

[0013] Examples of the civil engineering machine comprise devices for installing piles into the ground, or piling apparatuses. The piling apparatuses may be configured for different piling methods such as pre-cast pile driving and cast in-situ piling, examples of which comprise down-to-hole (DTH), continuous flight auger drilling (CFA), full displacement piling (FDP), Kelly-drilling, double rotary drilling, driven cast-in-situ. In an example, the piling apparatus may comprise a piling hammer. The piling hammer is a machine used in construction work for driving steel, concrete, or wood piling into the ground by a hammer block. The ram block is used to exert consecutive blows to a pile driven by the piling hammer. The consecutive blows may be caused by a reciprocating movement of the hammer block. Examples of loads that affect stability of the piling apparatus comprise at least one of the following: weight of ram block; or inclination of leader; or weight of a counter-weight; or weight of a pile supported to a leader; or height of ram block; or inclination of the ground; or inclination of carriage; or distance between carriage and leader. An example configuration for a piling apparatus comprises a position of a counterweight, mass of the counterweight, positions of support legs, rotation angle of an upper carriage with respect to a lower carriage, mass of a work equipment connected to a leader, position of the work equipment at the leader. An example of a situation, where stability of the piling apparatus is relevant is, when the piling apparatus has a work equipment that is attached to a leader of the piling apparatus. When the leader is standing on the ground, the work equipment is supported at a height above the ground. The mass of the work equipment can cause a shift a position of a center of gravity of the piling apparatus with respect to a position on the ground and if the center of gravity reaches a load capacity limit of the piling apparatus the piling apparatus may be tipped over. The effect of the work equipment to the position of the center of gravity is dependent for example on at least one of the following: the weight of the work equipment; height of the work equipment; or inclination of the leader. It should be noted that the effect of the work equipment to the position of the center of gravity may be reduced, or at least controlled, or by one or more components of the piling apparatus for example at least one of the following components for stabilizing the piling apparatus: position of counterweight of a carriage of the piling apparatus; or positions of support legs. Alternatively or additionally, the shift of a center of gravity of the piling apparatus can cause an increase of a pressure caused by the piling apparatus to the ground to a level at which the support of the

ground under the piling apparatus is not sufficient to support the piling apparatus, whereby the ground under the piling apparatus may give out. During use of the piling apparatus, at least one of the following may cause a change of the configuration, whereby the piling apparatus assumes a further configuration: the piling apparatus may  
5 be moved at a work site; or the leader may be moved with respect to a carriage; or the leader may be tilted with respect to the ground and/or the carriage; the piling hammer may be moved along the leader; the upper carriage and lower carriage may be rotated with respect to each other; or the support legs may be extended towards the ground or retracted from the ground.

10 [0014] The work equipment may subject the civil engineering machine to loads that affect stability of the civil engineering machine and can eventually cause the civil engineering machine to tip over. Examples of the loads caused by the work equipment to the civil engineering machine comprise at least weight of soil carried by the work equipment and a load caused by weight of the work equipment. Loads caused by work  
15 equipment may at least in some cases be a significantly large portion of the total weight of the civil engineering machine. For example, in a piling apparatus, a weight of a piling hammer may be large, compared with a weight of the piling apparatus, e.g. weight of the work equipment may be 15% to 30% of the weight of the piling apparatus. It should be noted that weight of a pile supported to the leader movable by an auxiliary rope can  
20 add load caused to the piling hammer. It should be noted that during operation of the work machine the load may vary at least because the work equipment is moved with respect to the carriage. Also, it should be noted that a total load of the work equipment may be significantly affected by conditions that are external to the work equipment and the civil engineering. Examples of the external factors comprise at least one of the  
25 following: inclination of the ground; or weather conditions such as wind.

[0015] An actuating unit preferably comprises at least one actuating drive. The operation of the actuating drive may be controlled based on one or more actuating parameters. Examples of the actuating unit comprise at least one of the following: an actuating unit for driving a work equipment; an actuating unit for driving a leader to at  
30 least one position from a plurality of positions that define different distances from a carriage of the civil engineering machine; or a winch actuator for reeling a rope connected to a piling hammer along a leader; or an winch actuator for an auxiliary rope of the civil engineering machine; or an actuating unit for tilting a leader relative to a vertical direction; or an actuating unit for driving a leader in a lateral direction with  
35 respect to a carriage; or a rotating device for rotating an upper carriage relative to a

lower carriage; or driving support legs. Examples of the one or more actuating parameters comprise at least one of the following: load of the civil engineering machine; or load of a part of the civil engineering machine; or winch forces; or hydraulic operating pressures; or operating positions of parts of the civil engineering machine; or operating speeds of the civil engineering machine; or operating speeds of parts of the civil engineering machine; or speed of one or more actuating units. Examples of the operating positions of the parts comprise at least one of the following: position of a leader; or position of a lower carriage; or position of an upper carriage; or inclination of a leader. Examples of the operating speeds of parts of the civil engineering machine comprise a rotational speed of a winch and a rotational speed of an upper carriage with respect to a lower carriage. A limit parameter may be used to limit one or more actuating parameters. In an example each actuating parameter may be associated with a limit parameter. Examples of the limit parameters comprise at least one of the following: a limit parameter for a load of the civil engineering machine; or a limit parameter for a load of a part of the civil engineering machine; or a limit parameter for winch force(s); or a limit parameter for hydraulic operating pressure(s); or a limit parameter for operating position(s) of part(s) of the civil engineering machine; or a limit parameter for operating speed(s) of the civil engineering machine; or a limit parameter for operating speed(s) of part(s) of the civil engineering machine; or a limit parameter for speed of one or more actuating unit(s).

[0016] Load capacity of a civil engineering machine defines one or more load values, e.g. in [N], at which the civil engineering machine may be used while satisfying stability requirements. The load values may be measured by one or more sensors and/or one or more actuating units that are deployed to the civil engineering machine that is carrying a load. Examples of the load values comprise at least weight of soil carried by a work equipment and a weight of a work equipment. Weight of work equipment may at least in some cases be a significantly large portion of a total weight of the civil engineering machine. Therefore, height of the work equipment is a significant factor, when load capacity of the civil engineering machine is determined and particularly for determining available load capacity of the civil engineering machine. In an example, the civil engineering machine may be a piling apparatus, whereby examples of load values that affect stability of the civil engineering machine comprise at least one of the following: weight of ram block; or inclination of leader; or weight of a counterweight; or weight of a pile supported to a leader; or height of ram block; or inclination of the ground; or

inclination of carriage; or distance between carriage and leader. Weight of the ram block may be e.g. 15% to 30% of the weight of the piling apparatus.

[0017] Load capacity model facilitates determining available load capacity of the civil engineering machine during use of the civil engineering machine. The load capacity model is a computerized model for controlling one or more operations of the civil engineering machine. The load capacity model may be stored in a computer-readable format in a memory of the civil engineering machine. In an example the load capacity model may be stored in a runtime memory of the civil engineering machine and/or to one or more files in a memory of the civil engineering machine. The load capacity model may be generated, or determined, and updated at the civil engineering machine based on measurements of inclination and load of the civil engineering machine during use of the civil engineering machine. During use of the civil engineering machine the civil engineering machine may be performing a work operation using a work equipment of the civil engineering machine. Examples of work operations of the civil engineering machine comprise at least one of the following: driving the civil engineering machine at a work site; or building foundations by the civil engineering machine; or driving a work equipment of the civil engineering machine; or driving a pile to the ground; or drilling the ground; or actuating an actuating unit for driving a part of the civil engineering machine; or actuating an actuating unit for rotating a carriage of the civil engineering machine; or actuating an actuating unit for driving a leader of the civil engineering machine; or elevating a piling hammer of the civil engineering machine. The load capacity model comprises load capacity limits that are determined based on first, or reference, inclination measurements and based on first, or reference, load measurements performed at a first, or a reference, configuration of the civil engineering machine. In this way load capacity limits may be obtained by measurements and referred to measured load capacity limits. The load capacity limits define limits for load values of the civil engineering machine. If the load capacity limits are exceeded, stabile operation of the civil engineering machine is compromised and the civil engineering machine may even tip over. The load capacity model may be calibrated at a first, or a reference, position, e.g. on a level ground, of the civil engineering machine. The calibration generates the load capacity model comprising load capacity limits that are positioned at distances from a center of gravity of the civil engineering machine at the reference position. The distances indicate available load capacities for the civil engineering machine. The center of gravity is defined with respect to the civil engineering machine, whereby the load capacity limits are defined in directions, where the civil engineering machine or a

part of the civil engineering machine may be moved. In an example, the civil engineering machine may be driven at a work site. The work site may be considered a horizontal plane, where the civil engineering machine is movable in all directions, e.g. in a 360 degree radius, on the plane. In another example, the civil engineering machine may comprise a leader and a piling hammer connected to the leader to be moved in a vertical direction, i.e. to different elevations from the ground. In an example, the load capacity limits may be defined in a three-dimensional space, e.g. based on cartesian coordinate system defined by X-, Y- and Z- axes. The center of the coordinate system may be at the center of gravity of the civil engineering machine at the reference position. The load capacity model may define a volume or a planar area limited by the load capacity limits. The shape of the volume or planar area may not be uniform, e.g. a sphere or a circle, but the shape may be determined based on the reference load measurements and the reference configuration and using interpolation to complete the load capacity model. In this way the load capacity model may comprise both measured load capacity limits and interpolated load capacity limits that adjoin the measured load capacity limits into a complete volume or planar area.

[0018] At least some embodiments comprise controlling at least one operation of the civil engineering machine based on a determined available load capacity. It should be noted that the determined available load capacity may be evaluated against one or more thresholds. If a threshold has been met, the at least operation may be controlled accordingly. Each threshold may be associated with a specific control, whereby the at least operation may be controlled differently depending on which threshold has been met. In an example, an actuation speed of one or more actuating units may be first limited after a first threshold has been exceeded and then if a further threshold has been exceeded, the one or more actuating units may be limited further, or even stopped. It should be noted that an acceleration of a change of an available load capacity may be used for facilitating pre-emptive control of one or more operations the civil engineering machine. The change of acceleration of an available load capacity may be determined for example based determining a center of gravity of the civil engineering machine and determining an acceleration of the center of gravity of the civil engineering machine. The determined acceleration may be monitored for one or more changes of the acceleration. Each change of the acceleration may have a direction and a magnitude which may be evaluated against one or more thresholds for the acceleration. Similar to the evaluation of the determined available load capacity, each threshold for the acceleration may be associated with a specific control, whereby the at least

operation may be controlled differently depending on which threshold for the acceleration has been met. In this way the acceleration may be used for controlling the one or more operations similar to the determined available load capacity.

[0019] FIG. 1 illustrates an example of a civil engineering machine in accordance with  
5 at least some embodiments. The civil engineering machine is illustrated with respect to Y-axis and X-axis that may be in accordance with a Cartesian coordinate system, where the Y-axis is a vertical direction at a right angle with respect to the ground and the X-axis a horizontal direction parallel to the ground. The civil engineering machine may be a piling apparatus 100. The piling apparatus may comprise a piling hammer 106  
10 installed to a carriage part. The carriage part is configured movable on the ground, parallel to the X-axis, whereby the piling hammer may be moved by driving the carriage part at a work site. The carriage part may comprise an upper carriage 102 and a lower carriage 101. The lower carriage may be configured movable on the ground. In an example, the lower part may comprise caterpillar bands for moving on the ground. The  
15 upper carriage 102 may be configured to be rotatable relative to the lower carriage 101 about a vertically directed axis, Y-axis, of rotation. In an example, the upper carriage 102 may be rotated relative to the lower carriage 101 by a rotation device. Accordingly, the upper carriage may have a slewing angle with respect to the lower carriage. The upper carriage may comprise a leader 104 and a piling hammer 106 connected to the  
20 leader. The leader is an elongated part of the piling apparatus, having the function of enabling a movement of the piling hammer in a direction that is transverse or inclined with respect to the ground 108 during driving a pile 110 into the ground. The leader may be tilted for driving the pile in a vertical or an inclined position and for tilting the leader to a horizontal position for the time of transport of the pile driving machine. The piling  
25 apparatus may comprise at least one actuating member 112. The at least actuating member may be driven by one or more actuating units. In an example, the at least actuating member may be configured to drive the leader to different distances from the carriage part. Accordingly, the actuating member may drive the leader towards the carriage part, whereby a distance between the carriage part and the leader is  
30 decreased. On the other hand, the actuating member may drive the leader away from the carriage part, whereby the distance between the carriage part and the leader is increased. The distance between the carriage part and the leader may be measured in a direction that is parallel to the horizontal direction, i.e. a direction parallel to a direction of level ground. Further examples of the at least one actuating member comprise a  
35 horizontal slide, forward inclination cylinder and lateral inclination cylinder. The

horizontal slide may be configured to drive the leader in the direction of the X-axis. The forward inclination cylinder may be configured to incline the leader with respect to the Y-axis. The lateral inclination cylinder may be configured to drive the leader laterally with respect to civil engineering machine, e.g. in a direction perpendicular to the X-axis and the Y-axis, e.g. in a direction into the Fig. 1 or out of the Fig. 1. The upper carriage 102 may comprise a counterweight 103 arranged on an opposite side of the piling apparatus with respect to the leader 104 for stabilizing the piling apparatus with respect to load caused to the piling apparatus from the leader 104 and a piling hammer 106 connected to the leader.

[0020] FIG. 2 illustrates a block diagram of a civil engineering machine in accordance with at least some embodiments. The civil engineering machine 206 comprises at least one processor 208 and at least one memory 210 connected to the processor. The civil engineering machine comprises one or more actuating units 202 and one or more sensors 204. The one or more actuating units 202 are configured to drive at least one of the following: a work equipment; or a winch actuator for reeling a rope connected to a piling hammer along a leader, or an winch actuator for reeling an auxiliary rope of the civil engineering machine, or tilting a leader relative to a vertical direction, or rotating an upper carriage relative to a lower carriage; or a leader to at least one position from a plurality of positions that define different distances from a carriage of the civil engineering machine. The one or more sensors 204 are configured to measure at least one of the following: load of the civil engineering machine, or load of a component of the civil engineering machine, or winch forces, or hydraulic operating pressures, or operating states of components of the civil engineering machine, or operating speeds of the civil engineering machine, or operating speeds of components of the civil engineering machine. Examples of the operating states of the components comprise positions of the leader, positions of a lower carriage, positions of an upper carriage of the civil engineering machine. Examples of the operating speeds of parts of the civil engineering machine comprise a rotational speed of a winch and a rotational speed of an upper carriage with respect to a lower carriage. In an example, one or more sensors 204e may be connected to the civil engineering machine by dedicated connections corresponding to each sensor. In an example, one or more sensors 204a, 204b, 204c, 204d may be connected to the civil engineering machine by electric connections, e.g. a data bus or electrical wiring. The data buses may follow e.g. CANopen, SAE J1939 or Ethernet technology. The data bus can be shared between sensors for communications of data to the civil engineering machine. In an example, one or more actuating units

202d may be connected to the civil engineering machine by dedicated connections corresponding to each actuating unit. In an example, one or more actuating units 202a, 202b, 202c may be connected to the civil engineering machine by electric connections, e.g. a data bus or electrical wiring. Communications over the electrical wiring may be performed by Pulse Width Modulation (PWM) or an on/off -type signal. The data buses may follow e.g. CANopen, SAE J1939 or Ethernet technology. In an example, one or more sensors may be deployed in connection with each actuating unit for measuring the actuating units. It should be noted that the sensors 204 and actuating units may be connected to the same data bus. Examples of the dedicated connections for the actuating units and the sensors comprise data connections that may follow Bluetooth, RS-232 or Universal Serial Bus (USB) technology, for example. A central control entity of the civil engineering machine may comprise the at least one processor 208, the at least one memory 210 connected to the processor and one or more interfaces for connecting to the one or more actuating units and the one or more sensors for receiving load measurements and inclination measurements. The interfaces may be in accordance with the electric connections for the sensors and the actuating units.

[0021] In an example in accordance with at least some embodiments, the civil engineering machine comprises one or more user interfaces of the civil engineering machine. A user interface may be provided by an on-board user interface device 212a connected to a data bus of the civil engineering machine, or an external user interface device 212b connected to the civil engineering machine by a data network connection that may be provided by data connection component 209. Therefore, the external user interface device may be remote with respect to the location of the civil engineering machine. Accordingly, the civil engineering machine may be at a work site and the external user interface device may be located outside of the work site. Additionally, the external user interface device may be moved independently from the civil engineering machine. Therefore, it is viable that the external user interface device is on one occasion at the work site of the civil engineering and at another occasion at one or more locations outside of the work site, and the external user interface device may be moved between locations without the civil engineering machine being moved at the device and/or out of the work site. The data connection component may be configured to connect to a communications network, e.g. a 3G, 4G or 5G mobile communications network, that supports data connections. Therefore, both kinds of user interfaces should be regarded as user interfaces of the civil engineering machine. Examples of the external user interface devices comprise a computer provided with a user interface

device, a smart phone and a tablet computer. The user interface at the on-board user interface device and the external user interface device may provide output of information to a user and/or input of information from the user. The output may be audio and/or visual information. The input may be voice input and/or touch input. A touch  
5 screen may provide both input and output functionality. Further examples of devices for input of information comprise buttons, keyboards and joysticks. Further examples of devices for output of information comprise speakers and display devices.

[0022] It should be noted that a user interface device 212a, 212b may be configured to communicate with the civil engineering machine based on data signals that may be  
10 digital signals or analogue signals. The data signals received from the user interface device may indicate the civil engineering machine one or more user interface actions. In an example, the civil engineering machine may be configured to interpret, or process, the data signals received from the user interface device into user interface actions.

[0023] In an example in accordance with at least some embodiments, the civil  
15 engineering machine comprises at least one processor and at least one memory storing a computer program comprising instructions that when executed by the processor cause one or more functionalities according to an example described herein. In an example, the one or more functionalities comprise that one or more of the actuating units 202 of the civil engineering machine are configured to drive a work equipment of  
20 the civil engineering machine to at least one position from a plurality of positions that define different distances from a carriage of the civil engineering machine.

[0024] FIG. 3 is illustrating an example of a method for a civil engineering machine in accordance with at least some embodiments. The method may be performed by the civil engineering machine described with Fig. 1 and Fig. 2. The method provides determining  
25 an available load capacity of the civil engineering machine dynamically according to different configurations assumed by the civil engineering machine during use of the civil engineering machine, when performing at least one operation, e.g. work operation. The method may start, when the civil engineering machine is switched on for receiving load measurements and inclination measurements, whereby controlling, e.g. positioning, a  
30 work equipment of the civil engineering machine for working the ground may commence.

[0025] Phase 302 comprises receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine. In an example, the first configuration may be  
35 determined based on at least one of the following ways: receiving information indicating

the configuration from one or more sensors; or receiving information indicating the configuration from one or more actuating units. In an example, the configuration of the civil engineering machine comprise at least one of the following: components of the civil engineering machine; properties of the components of the civil engineering machine; or positions of the components with respect to each other; or actuation states of the components; or one or more loads carried by the civil engineering machine; or position of the civil engineering machine on the ground; or inclination of the civil engineering machine. It should be noted that the information indicating the configuration of the civil engineering machine provides information for determining a center of gravity of the civil engineering machine and one or more load capacity limits of the load capacity model. In an example, the first configuration may be received at generating a load capacity model and calibrating the load capacity model, whereby the civil engineering machine may assume more than one configuration and inclination measurements may be made at each configuration. In an example, the actuation state may indicate a level of actuation such as a full, partial or zero actuation. Actuating unit of an actuating member may be configured to drive the actuating member between the actuation states. In an example, the actuating unit extends or retracts the actuating member, whereby the actuation state may be fully extended, partially extended or not extended, i.e. extension is zero.

[0026] Phase 304 comprises receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors. In an example, the first load measurements may be received based on at least one of the following ways: receiving load measurements from one or more sensors; or receiving load measurements from one or more actuating units. In an example, the first load measurements may comprise at least one of the following: weight of soil carried by a work equipment; or a weight of a work equipment; or weight of ram block; or inclination of leader; or weight of a counterweight; or weight of a pile supported to a leader; or height of ram block; or inclination of the ground; or inclination of carriage; or distance between carriage and leader.

[0027] Phase 306 comprises determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements. In an example, a load capacity model facilitates determining available load capacity of the civil engineering machine during use of the civil engineering machine. During use of the civil engineering machine the civil engineering machine may be performing a work operation using a work equipment

of the civil engineering machine. In an example, the load capacity model comprises load capacity limits that are determined based on first, or reference, inclination measurements and based on first, or reference, load measurements performed at a first, or a reference, configuration of the civil engineering machine. The load capacity limits define limits for load values of the civil engineering machine. If the load capacity limits are exceeded, stable operation of the civil engineering machine is compromised, and the civil engineering machine may even tip over. It should be noted that the load capacity model is stored in a memory that is accessible to the civil engineering machine. The memory may be provided at the civil engineering machine or the memory may be provided at a computing service accessible to the civil engineering machine over a data network connection, e.g. at a cloud computing service. It should be noted that since the load capacity model is based on the measurements in phases 304 and 304, load capacity limits of the load capacity model are determined dynamically by calculations performed at the civil engineering machine when performing the work operation.

[0028] In an example in accordance with at least some embodiments, phase 306 comprises storing context information associated with the load capacity model. The context information may comprise at least one of the following: a time; or a position of the civil engineering machine at a work site; or information indicating a configuration of the civil engineering machine at the time. The information indicating a configuration of the civil engineering machine may comprise at least one of the following: components of the civil engineering machine; properties of the components of the civil engineering machine; or positions of the components with respect to each other; or actuation states of the components; or one or more loads carried by the civil engineering machine; or position of the civil engineering machine on the ground; or inclination of the civil engineering machine.

[0029] In an example, the load capacity model comprises load capacity limits that are positioned at distances from a center of gravity of the civil engineering machine at a reference position. The distances indicate available load capacities for the civil engineering machine. The center of gravity is defined with respect to the civil engineering machine, whereby the load capacity limits are defined in directions, where the civil engineering machine or a part of the civil engineering machine may be moved.

[0030] In an example, the load capacity limits may be defined in a three-dimensional space, e.g. based on cartesian coordinate system defined by X-, Y- and Z- axes. The center of the coordinate system may be at the center of gravity of the civil engineering machine at the reference position. The load capacity model may define a volume or a

planar area limited by the load capacity limits. Shape of the load capacity model may be determined based on the first load measurements and the first configuration and using interpolation to adjoin the measured load capacity limits into a complete volume or planar area to complete the load capacity model.

5 [0031] Phase 308 comprises receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine. In an example, the second configuration may be determined during use of the civil engineering machine after the load capacity model has been determined. The second configuration may be  
10 determined based on at least one of the following ways: receiving information indicating the configuration from one or more sensors; or receiving information indicating the configuration from one or more actuating units.

[0032] Phase 310 comprises receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil  
15 engineering machine from the at least one of the following: one or more actuating units; or one or more sensors. In an example, the second load measurements may be received based on at least one of the following ways: receiving load measurements from one or more sensors; or receiving load measurements from one or more actuating units. In an example, the second load measurements may comprise at least one of the  
20 following: weight of soil carried by a work equipment; or a weight of a work equipment; or weight of ram block; or inclination of leader; or weight of a counterweight; or weight of a pile supported to a leader; or height of ram block; or inclination of the ground; or inclination of carriage; or distance between carriage and leader.

[0033] Phase 312 comprises applying a compensation to the received second load  
25 measurements, or the determined load capacity model, based on the second inclination measurements. In this way the effect of inclination may be taken into account and the second load measurements may be adapted to the determined load capacity model, or the determined load capacity model may be adapted to the second inclination measurements.

30 [0034] Phase 314 comprises determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or based on the second load measurements and the compensated determined load capacity model. Since the second load measurements or the load capacity model have been compensated the second load  
35 measurements and the load capacity model may be evaluated for determining the

available load capacity according to the second inclination. In an example, the load capacity model comprises load capacity limits defined in a three-dimensional space, e.g. based on cartesian coordinate system defined by X-, Y- and Z- axes. The center of the coordinate system may be at the center of gravity of the civil engineering machine at the reference position. The load values of the second load measurements, e.g. compensated second load measurements, may be positioned into the load capacity model and the available load capacity may be determined based on a distance from the second load measurements to load capacity limits of the load capacity model in the 3D space. Similar evaluation may be performed if the load capacity limits defined in a two-dimensional space of a cartesian coordinate system. It should be noted that the load capacity model may defined in directions, where the civil engineering machine or a part of the civil engineering machine may be moved. In some examples the load capacity model may be three dimensional, but in some cases a two-dimensional model is sufficient. The two-dimensional model may be sufficient for example in a situation, where elevation from the ground is substantially maintained for components of the civil engineering machine. In an example, when a piling hammer is driven to a desired elevation from the ground, the load capacity model may be determined for the elevation of the piling hammer and the load capacity model may be maintained until the elevation of the piling hammer or elevation of any other component of the civil engineering machine is changed, when being driven by one or more actuating units. The load capacity model may be e.g. a volume or a planar area limited by the load capacity limits. Accordingly, the available load capacity may be defined in all directions, where the civil engineering machine or a part of the civil engineering machine may be moved, and with respect to all load capacity limits of the load capacity model. Therefore, even if the civil engineering machine or a part of the civil engineering machine would be moving in one direction, the available load capacity may be defined in other directions as well, and even all possible directions. This is particularly beneficial for a user of the civil engineering machine, since information indicating an available load capacity or information derived from the available load capacity model for moving the civil engineering machine or a part of the civil engineering machine in alternative direction may be provided to the user e.g. by displaying the information to the user, while the user is driving the civil engineering machine or a part of the civil engineering machine. In this way a lack of available load capacity in the other directions may be foreseen by the user and the user may take necessary pre-emptive action(s) for preventing moving the civil engineering machine or a part of the civil engineering machine to a direction,

where outage of the available load capacity can be expected to take place. A pre-emptive action of the user may cause pre-emptive control of one or more operations the civil engineering machine. In an example, the user may control movement of the civil engineering machine based on one or more user interface actions on a user interface of the civil engineering machine.

[0035] Phase 316 comprises controlling at least one operation of the civil engineering machine based on the determined available load capacity. Controlling the at least one operation of the civil engineering machine provides that the civil engineering machine may be operated based on the determined available load capacity may be in a manner that supports stability.

[0036] In an example in accordance with at least some embodiments, phase 316 comprises determining an acceleration of a change of the determined available load capacity and controlling the at least one operation of the civil engineering machine based on the acceleration meeting at least one threshold for the acceleration. In this way the controlling of the at least one operation may be dependent on whether the acceleration has met the threshold or not. In an example, the acceleration of a change of the determined available load capacity may be determined based on monitoring a position of a center of gravity of the civil engineering machine and a change of the position of the center of gravity, e.g. speed of the center of gravity. The determined acceleration indicates a direction and a magnitude of the change of the determined available load capacity, whereby pre-emptive control of the at least one operation of the civil engineering machine is facilitated. In an example, if the threshold for the acceleration has been met, the at least one operation may be limited e.g. in terms of speed of the operation such as speed of reeling a rope. If the threshold for the acceleration has not been met, the speed of the operation may be as controlled by a user of the civil engineering machine. Therefore, the speed of the operation set by the user may be maintained and the determined acceleration is not used for controlling the speed of the operation. The speed of the operation may be set by the user based on a user interface action on the user interface of the civil engineering machine. If the acceleration exceeds a further threshold, the speed of the at least one operation may be limited further and even set to zero, whereby the at least one operation is stopped. In an example, the controlling the at least one operation may comprise:

- limiting or stopping the one or more actuating units of the civil engineering machine based on the acceleration of the determined available load capacity; or

- limiting or stopping driving the civil engineering machine at a work site based on the acceleration of the determined available load capacity; or
  - limiting or stopping a rotation of an upper carriage (102) of the civil engineering machine with respect to a lower carriage of the civil engineering machine based on the acceleration of the determined available load capacity; or
  - limiting or stopping driving at least one leader of the civil engineering machine at a distance from a carriage part of the civil engineering machine based on the acceleration of the determined available load capacity; or
  - limiting or stopping driving at least one leader of the civil engineering machine laterally with respect to a carriage part of the civil engineering machine based on the acceleration of the determined available load capacity; or
  - limiting or stopping reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine based on the acceleration of the determined available load capacity.
- [0037] In an example phase 316 may comprise controlling one or more actuating units. Controlling the one or more actuating units may cause at least one of the following: driving a horizontal slide; or driving a forward inclination cylinder; or driving a lateral inclination cylinder; or driving a counterweight; or driving one or more support legs. In an example, the horizontal drive may be driven to move a leader closer to a carriage. In an example, the forward inclination cylinder may be driven to adjust an inclination of a leader forwards or backwards with respect to a carriage of the civil engineering machine. In an example, the counterweight may be driven to extend the counterweight in a horizontal direction or to retract the counterweight in a horizontal direction. In an example, the lateral inclination cylinder may be driven to adjust an inclination of a leader in a lateral direction with respect to a carriage of the civil engineering machine. In an example, the counterweight may be extended or retracted with respect to a carriage. In an example, the one or more support legs may be extended or retracted with respect to a carriage.
- [0038] In an example in accordance with at least some embodiments, phase 316 comprises receiving at least one user interface action via a user interface of the civil engineering machine; and controlling a response of the civil engineering machine, or a part of the civil engineering machine, to the at least one user interface action based on the determined available load capacity. In an example, the user interface action may be an input by a user to the user interface of the civil engineering machine. In an example, the response of the civil engineering machine may be determined to the received user

interface action based on evaluating the determined available load capacity with one or more load capacity limits of the load capacity model. In an example an acceleration of a change of the determined available load capacity may be determined and the response of the civil engineering machine, or a part of the civil engineering machine, to the user interface action is controlled based on the determined acceleration. The determined acceleration may be compared with at least one threshold for the acceleration and the response can be dependent on whether the acceleration has met the threshold or not. In an example, the response to the user interface action is a control of at least one operation of the civil engineering machine. If a threshold for the acceleration has been met, the at least one operation may be limited e.g. in terms of speed of the at least one operation such as speed of reeling a rope. If the threshold has not been met, the speed may be as controlled by a user of the civil engineering machine e.g. by means of the user interface action. If the acceleration exceeds a further threshold, the speed of the at least one operation may be limited further and even set to zero, whereby the at least one operation is stopped.

[0039] In an example in accordance with at least some embodiments, phase 316 comprises that the at least one user interface action is configured to control at least one work operation of the civil engineering machine. Examples of work operations of the civil engineering machine comprise at least one of the following: driving the civil engineering machine at a work site; or building foundations by the civil engineering machine; or driving a work equipment of the civil engineering machine; or driving a pile to the ground; or drilling the ground; or actuating an actuating unit for driving a part of the civil engineering machine; or actuating an actuating unit for rotating a carriage of the civil engineering machine; or actuating an actuating unit for driving a leader of the civil engineering machine; or elevating a piling hammer of the civil engineering machine.

[0040] In an example in accordance with at least some embodiments, phase 316 may comprise giving feedback via a user interface of the civil engineering machine based on at least one of the following: the determined available load capacity; or an estimated available load capacity, or a likelihood of meeting one or more load capacity limits. In an example, the feedback may be based on a threshold for the load capacity. The threshold for the load capacity may be a load capacity limit for at least one of the following: the determined available load capacity; or the estimated available load capacity, or the likelihood of meeting one or more load capacity limits. In an example, the feedback may comprise information indicating that at least one load capacity limit has been met or that at least one load capacity limit has not been met. The feedback

may be received by the user of the civil engineering machine, whereby the user may be notified regarding operational safety of the civil engineering machine. In an example, the feedback may indicate to the user a level of operational safety of the civil engineering machine. The level of operational safety facilitates the user to understand a reason for controlling one or more operations of the civil engineering machine based on the determined available load capacity. In an example, one or more operations of the civil engineering machine may be stopped or limited based on the determined available load capacity, whereby the feedback may indicate the user that the reason for the stopping or limiting of the one or more operations is operational safety of the civil engineering machine. Therefore, the feedback enables the user to differentiate changes in the operation of the civil engineering machine caused by supporting operational safety from other causes such as malfunctioning of the civil engineering machine.

[0041] The level of operational safety may be determined based on at least one of the following: the determined available load capacity; or an estimated available load capacity, or a likelihood of meeting one or more load capacity limits. The level of operational safety may be used to control the at least one operation of the civil engineering machine. Examples of

[0042] In an example in accordance with at least some embodiments, 316 may comprise giving first feedback via the user interface of the civil engineering machine, if a load capacity limit has been met. In an example, the first feedback may indicate that the load capacity limit has been and that there is insufficient load capacity for at least one work operation of the civil engineering machine. The first feedback may comprise for example at least one of the following: a load value; or the load capacity limit that has been met; or a percentage value of used load capacity.

[0043] In an example in accordance with at least some embodiments, phase 316 may comprise giving second feedback via the user interface of the civil engineering machine, if a load capacity limit has not been met. In an example, the second feedback may indicate that the load capacity limit has been and that there is sufficient load capacity for at least one work operation of the civil engineering machine. The second feedback may comprise for example at least one of the following: a load value; or the load capacity limit that has not been met; or a percentage value of used load capacity.

[0044] In an example in accordance with at least some embodiments, phase 316 may comprise that the feedback is at least one of the following: audio feedback; or tactile feedback; or visual feedback. Examples of tactile feedback comprise at least vibration feedback. The vibration feedback may be output by a user interface of the civil

engineering machine. For example, the user interface of the civil engineering machine may comprise a joystick or other device that is capable to be grabbed by the user and is configured to cause one or more work operations of the civil engineering machine, when moved and/or touched by the user. Then, the civil engineering machine may be configured to cause vibration of the joystick in response to the determined available load capacity meeting a load capacity limit and/or in response to the determined available load capacity not meeting a load capacity limit. Giving tactile feedback has the advantage that the feedback may be received by the user while the user's gaze would not be focused on the user interface. Examples of audio feedback comprise a sound signal, e.g. a buzz. Examples of visual feedback comprise textual information, graphical objects and application of a highlighting on displayed information, e.g. textual information or graphical objects.

[0045] In an example in accordance with at least some embodiments, phase 316 may comprise that the feedback is given in response to, or during, at least one user interface action. In this way information regarding sufficiency of the available load capacity may be communicated to the user in connection with the at least one user interface action. The user interface action may be configured to control at least one work operation of the civil engineering machine, whereby the user may immediately utilize the displayed information and/or the tactile feedback for continued controlling of the civil engineering machine, e.g. by continuing or discontinuing the at least one work operation. In an example, the user interface action may be at least one of the following: a touch command; or a voice command; or a displacement of a user interface device. An example of a displacement of a user interface device is a vertical displacement, a horizontal displacement or a multidimensional displacement of the user interface device. An example of the touch command is a touch of a user received on a touch screen. Examples of the horizontal and vertical displacements comprise a displacement of a user interface device in a direction of a single axis of movement, e.g. a push of a button or a key of a keyboard. Examples of the multidimensional displacement of the user interface device comprise displacement of a joystick. In general, a joystick is a device having an elongated form that may be grabbed by a palm of a hand. Base of the joystick may be fixed to a position whereby an opposite end of the joystick is free. The joystick is displaced by displacing the free end from a center position that is directly above the base. The free end may be moved directly between different positions that are displaced from the center position.

[0046] In an example, phase 316 comprises determining if the determined available load capacity has met a load capacity limit of the determined load capacity model, and if yes, controlling the user interface to display information indicating that the load capacity limit has been met and/or or controlling the user interface to give first tactile feedback to the user. It should be noted that, the information indicating that the load capacity limit has been met may comprise in general information that is capable of communicating to the user that there is insufficient load capacity for at least one work operation of the civil engineering machine. The information indicating that the load capacity limit has been met may comprise for example at least one of the following: a load value; or the load capacity limit that has been met; or a percentage value of used load capacity. Alternatively or additionally, phase 316 may comprise determining if the determined available load capacity has not met a load capacity limit of the determined load capacity model, and if yes, controlling to display information indicating that the load capacity limit has not been met and/or controlling give second tactile feedback to the user. It should be noted that, the information indicating that the load capacity limit has not been met may comprise in general information that is capable of communicating to the user that there is sufficient load capacity for at least one work operation of the civil engineering machine. The information indicating that the load capacity limit has not been met may comprise for example at least one of the following: a load value; or the load capacity limit that has not been met; or a percentage value of used load capacity. In this way the user may be communicated that the determined available load capacity is insufficient.

[0047] In an example in accordance with at least some embodiments, phase 314 comprises that the determined available load capacity is a function of a distance of a center of gravity to a load capacity limit of the determined load capacity model.

[0048] In an example in accordance with at least some embodiments, phase 314 comprises determining reference positions of a center of gravity of the civil engineering machine at load capacity limits of the determined load capacity model; determining a current position of a center of gravity based on the compensated second load measurements; and determining the available load capacity of the civil engineering machine based on a distance between the determined current position of a center of gravity based on the compensated second load measurements, or the compensated determined load capacity model, and the determined reference positions of a center of gravity of the civil engineering machine.

[0049] In an example in accordance with at least some embodiments, phase 316 comprises that the at least one operation of the civil engineering machine is controlled based on at least one of the following one or more limit parameters:

- 5       - one or more limit parameters for actuating the one or more actuating units of the civil engineering machine; or
- one or more limit parameters for driving the civil engineering machine at a work site; or
- one or more limit parameters for rotating a lower carriage of the civil engineering machine with respect to an upper carriage of the civil engineering machine; or
- 10       - one or more limit parameters for driving at least one leader of the civil engineering machine laterally with respect to a carriage part of the civil engineering machine; or
- one or more limit parameters for driving at least one leader of the civil engineering machine towards a carriage part of the civil engineering machine or
- 15       away from the carriage part of the civil engineering machine; or
- one or more limit parameters for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine.

20       The limit parameters may be used to control one or more actuating units. In an example, the one or more limit parameters may be determined based on the available load capacity and the one or more limit parameters may be fed to the one or more actuating units or one or more control units that are configured to control the one or more actuating units. The one or more limit parameters may be at least used to stop or limit operation of the one or more actuating units. In an

25       example, an actuating unit, or a control unit of the actuating unit, may receive the one or more limit parameters, which causes to stop or limit operation of the actuating unit. The actuating unit may be caused to stop or limit operation at least when it is determined at the actuating unit or the controller of the actuating unit, that a limit parameter has been met. On the other hand, if the limit parameter has

30       not been met, the operation of the actuating unit may be continued without limiting or stopping its operation. Accordingly, the one or more limit parameters enable at least two operation modes for the actuating units depending on the available load capacity. Determining whether a load capacity limit has been met or not may serve for triggering a change between the operation modes.

35       [0050] In an embodiment phase 316 comprises at least one of the following:

- limiting or stopping the one or more actuating units of the civil engineering machine based on the determined available load capacity; or
  - limiting or stopping driving the civil engineering machine at a work site based on the determined available load capacity; or
  - 5 - limiting or stopping a rotation of an upper carriage of the civil engineering machine with respect to a lower carriage of the civil engineering machine based on the determined available load capacity; or
  - limiting or stopping driving at least one leader of the civil engineering machine at a distance from a carriage part of the civil engineering machine based on the
  - 10 determined available load capacity; or
  - limiting or stopping driving at least one leader of the civil engineering machine laterally with respect to a carriage part of the civil engineering machine based on the determined available load capacity; or
  - limiting or stopping reeling at least one of a rope connected to a work
  - 15 equipment, or an auxiliary rope of the civil engineering machine based on the determined available load capacity. In this way operation of individual components may be controlled to facilitate stabile operation of the civil engineering machine. The limiting or stopping may be caused based on one or more limit parameters for controlling one or more actuating units. It should be
  - 20 noted that the limiting or stopping may be caused based on one or more limit parameters as described above.
- [0051] In an embodiment, phase 316 comprises at least one of the following:
- determining an actuation speed of the one or more actuating units of the civil engineering machine; or
  - 25 - determining a ground speed for driving the civil engineering machine; or
  - determining a rotational speed for rotating a lower carriage of the civil engineering machine with respect to an upper carriage of the civil engineering machine ; or
  - determining a speed for driving at least one leader of the civil engineering
  - 30 machine at a distance from a carriage part of the civil engineering machine based on the determined available load capacity; or
  - determining speed for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine based on the determined available load capacity. In an example, the actuation speed, the
  - 35 ground speed, the rotational speed, and the speed for driving at least one

leader the speed for reeling may be controlled based on corresponding one or more actuating parameters of the civil engineering machine. In an example, the actuation speed, the ground speed, the rotational speed, and the speed for driving at least one leader the speed for reeling may be controlled based on the determined available load capacity and/or whether one or more load capacity limits have been met by the determined available load capacity. Alternatively or additionally, the actuation speed, the ground speed, the rotational speed, the speed for driving at least one leader the speed for reeling may be used for estimating an available load capacity and/or a likelihood of meeting one or more load capacity limits. The estimated available load capacity and/or the likelihood of meeting one or more load capacity limits may be evaluated, e.g. based on comparing them with at least one corresponding threshold value, e.g. a load capacity limit. Then, a result of the evaluation may be used to control at least one work operation of the civil engineering machine.

[0052] In an example in accordance with at least some embodiments, phase 316 comprises displaying on a user interface of the civil engineering machine information indicating at least one of the following: the determined available load capacity; or an estimated available load capacity, or a likelihood of meeting one or more load capacity limits. In this way information regarding sufficiency of the available load capacity may be communicated to the user of the civil engineering machine. The information may be displayed in connection with at least one user interface action on a user interface of the civil engineering machine. The user interface action may be configured to control at least one work operation of the civil engineering machine, whereby the user may immediately utilize the displayed information for continued controlling of the civil engineering machine, e.g. by continuing or discontinuing the at least one work operation.

[0053] In an example, phase 316 comprises:

- giving tactile feedback via a user interface of the civil engineering machine based on at least one of the following: the determined available load capacity; or an estimated available load capacity, or a likelihood of meeting one or more load capacity limits. The tactile feedback may serve for providing the user information of at least one of the following: determined available load capacity; or estimated available load capacity; or and/or likelihood of meeting one or more load capacity limits. An example of the tactile feedback vibration feedback. In this way information regarding sufficiency of the available load

capacity may be communicated to the user of the civil engineering machine.

The tactile feedback may be given in connection with at least one user interface action on a user interface of the civil engineering machine. The user interface action may be configured to control at least one work operation of the civil engineering machine, whereby the user may immediately utilize the tactile feedback for continued controlling of the civil engineering machine, e.g. by continuing or discontinuing the at least one work operation.

[0054] Fig. 4 illustrates an example of a method for controlling a civil engineering machine in accordance with at least some embodiments. One or more control configurations may be used for pre-emptive control of one or more operations of the civil engineering machine for ensuring that the civil engineering machine is operated within limits of operational safety. Examples of the operations of the civil engineering machine may comprise at least one of the following: one or more work operations of the civil engineering machine; or one or more user interface actions of the civil engineering machine. The operations may be performed by one or more components of the civil engineering machine. An example of the control configuration comprises at least one of the following: a set of operations of the civil engineering machine; or a set of limit parameters; or stopping a work operation of the civil engineering machine; or changing a work operation of the civil engineering machine from one work operation not another work operation; powering off the civil engineering machine; or powering off at least a part of the civil engineering machine; or alarm operations. The set of operations may define one or more operations of the civil engineering machine that are permitted to be performed by the civil engineering machine. The set of limit parameters may be applied at the civil engineering machine for controlling one or more actuating units. The alarm operations may define which alarm(s) is performed in response to determining that a load capacity limit has been met. Examples of the alarm operations comprise audible alarms, visual alarms and tactile alarms. The alarms may be provided to a user by a user interface of the civil engineering machine. The control configuration may be associated with a load capacity limit of a load capacity model, whereby the control configuration may be applied based on determining that the associated load capacity limit has been met. It should be note that there may be a plurality of load capacity limits, whereby each of the load capacity limits may have a control configuration. In an example scenario of the load capacity model comprises two load capacity limits TH1 and TH2. TH2 may be a limit that is not allowed to be exceeded, i.e. a "hard" limit, in order to ensure that the civil engineering machine is operated within the limits of

operational safety. TH1 may be a limit that is allowed to be exceeded, i.e. i.e. a “soft” limit. For example, TH1 and TH2 may be defined for load of rope connected to work equipment or load of an auxiliary rope and TH2 may be e.g. 100 tons and TH1 may be e.g. 90 tons. Since TH2 and TH1 both have an associated control configuration pre-  
5 preemptive control of one or more operations of the civil engineering machine is facilitated.

[0055] Phase 402 comprises controlling at least one operation of the civil engineering machine. The controlling may be performed in accordance to described with phase 316 of Fig. 3. In an example, phase 402 comprises receiving at least one user interface action via a user interface of the civil engineering machine. The at least one user  
10 interface action may cause controlling of the at least one operation of the civil engineering machine. In an example, the user interface action may be at least one of the following: a touch command; or a voice command; or a displacement of a user interface device. An example of a displacement of a user interface device is a vertical displacement, a horizontal displacement or a multidimensional displacement of the user  
15 interface device. An example of the touch command is a touch of a user received on a touch screen. Examples of the horizontal and vertical displacements comprise a displacement of a user interface device in a direction of a single axis of movement, e.g. a push of a button or a key of a keyboard. Examples of the multidimensional displacement of the user interface device comprise displacement of a joystick. In  
20 general, a joystick is a device having an elongated form that may be grabbed by a palm of a hand. Base of the joystick may be fixed to a position whereby an opposite end of the joystick is free. The joystick is displaced by displacing the free end from a center position that is directly above the base. The free end may be moved directly between different positions that are displaced from the center position.

[0056] Phase 404 comprises determining if an available load capacity has met a load capacity limit of the determined load capacity model. The available load capacity may be determined in accordance to described with phase 314. If the determined available load capacity has met the load capacity limit of the determined load capacity model, the method proceeds to phase 406 comprising controlling the civil engineering machine  
25 based on a first control configuration. The first control configuration may be associated with the load capacity limit that has been met. If the determined available load capacity has not met the load capacity limit of the determined load capacity model, the method proceeds to phase 408 comprising controlling the civil engineering machine based on a second control configuration. The second control configuration may be associated with  
30 another load capacity limit that than the load capacity limit evaluated in phase 404 or  
35

the second control configuration may be a default control configuration, where full load capacity of the civil engineering machine may be utilized.

[0057] In an example in accordance with at least some embodiments, phase 406 comprises giving first feedback via the user interface of the civil engineering machine indicating that the load capacity limit has been met. In this way the user may obtain feedback for continued controlling of the civil engineering machine, e.g. by continuing or discontinuing the at least one work operation via one or more user interface actions on the user interface. The feedback facilitates the user to know, when the load capacity limit has been met and use of the civil engineering machine is approaching its safety limits.

[0058] In an example in accordance with at least some embodiments, phase 408 comprises giving second feedback via the user interface of the civil engineering machine indicating that the load capacity limit has not been met. In this way the user may obtain feedback for continued controlling of the civil engineering machine, e.g. by continuing or discontinuing the at least one work operation via one or more user interface actions on the user interface. The feedback facilitates the user to know, that the load capacity limit has not been met. In this way the user may continue to control the at least one operation of the civil engineering machine and he/she knows the civil engineering is used within safety limits.

[0059] In an example phase 406 comprises, if the determined available load capacity has met a load capacity limit of the determined load capacity model, performing at least one of the following:

- displaying first information indicating that the load capacity limit has been met;  
or

- giving first tactile feedback. In this way the user may be communicated that the determined available load capacity is insufficient. It should be noted that, the information indicating that the load capacity limit has been met may comprise in general information that is capable of communicating to the user that there is insufficient load capacity for at least one work operation of the civil engineering machine. Giving tactile feedback has the advantage that the feedback may be received by the user while the user's gaze does not have to be focused on the user interface.

[0060] In an example, phase 408 comprises, if the determined available load capacity has not met a load capacity limit of the determined load capacity model, performing at least one of the following:

- displaying second information indicating that the load capacity limit has not been met; or
- giving second tactile feedback. In this way the user may be communicated that the determined available load capacity is sufficient. It should be noted that, the information indicating that the load capacity limit has not been met may comprise in general information that is capable of communicating to the user that there is sufficient load capacity for at least one work operation of the civil engineering machine. Giving tactile feedback has the advantage that the feedback may be received by the user while the user's gaze does not have to be focused on the user interface.

[0061] Fig. 5 and Fig. 6 illustrate examples of available capacities of a civil engineering machine based on a distance of a center of gravity to load capacity limits. Figs 5 and 6 are described with reference to the civil engineering machine described with Fig. 1 and at least part of the items described with Fig. 1. Load capacity model of the civil engineering machine may be determined in accordance with phase 306. Fig. 5 and Fig. 6 show the civil engineering machine at different configurations. In Fig. 5 the lower carriage 101 and the upper carriage 102 have their longitudinal dimensions aligned in a direction that is parallel to the X-axis. In Fig. 6 the lower carriage 101 has its longitudinal dimension aligned in a direction that is parallel to the X-axis and the upper carriage 102 has its longitudinal dimension aligned in a direction that is parallel to the Y-axis. Due to the different alignments of the upper and lower carriages in Fig. 5 and Fig. 6, the available load capacity of the civil engineering machine is different in Figs 5 and 6. According to the alignment of the upper carriage and lower carriage shown of Fig. 5, the upper carriage is supported by the lower carriage in its longitudinal dimension. However, according to the alignment of the upper carriage and lower carriage shown of Fig. 6, the longitudinal dimension of the upper carriage is supported by a lateral direction of the lower carriage. Therefore, a center of gravity of the civil engineering machine is different for the different alignments of the upper carriage and lower carriage in Fig. 5 and Fig. 6. In Fig. 5, the center of gravity 506 is within a perimeter of the upper carriage and at a distance D1 from a load capacity limit of the load capacity model 502. In Fig. 6, the center of gravity 606 is outside of a perimeter of the upper carriage and at a distance D2 from a load capacity limit of the load capacity model 602. It should be noted that alternatively or additionally to the illustrated different configurations of the civil engineering machine at least one of the following may affect a value of the available load capacity: weight of ram block; or inclination of leader; or weight of a counterweight;

or weight of a pile supported to a leader; or height of ram block; or inclination of the ground; or inclination of carriage; or distance between carriage and leader. In an example, since  $D2 < D1$ , the available load capacity of the civil engineering machine in Fig. 6 is lower than the available load capacity of the civil engineering machine in Fig. 5.

5 [0062] Fig. 7 illustrates an example of a method for supporting continued use of a load capacity model between instances of use of a civil engineering machine in accordance with at least some embodiments. The method may be performed by the civil engineering machine described with Fig. 1 and Fig. 2. The method may start, when the civil engineering machine is powered on and measurements of inclination and load may  
10 be performed. The measurements may be performed before one or more work operations of the civil engineering machine and during one or more work operations of the civil engineering machine.

[0063] Phase 702 comprises determining a load capacity model during use of the civil engineering machine in accordance to described in connection with phase 306 of Fig. 3.  
15 In accordance with at least some embodiments, the load capacity model may be compensated in accordance with phase 312 of Fig. 3.

[0064] Phase 704 comprises determining that use of the civil engineering machine is interrupted. In an example, the interruption may be caused by at least one of the following: stopping a work operation of the civil engineering machine; or changing a  
20 work operation of the civil engineering machine from one work operation not another work operation; powering off the civil engineering machine; or powering off at least a part of the civil engineering machine. In an example, the interruption may be caused by a user of the civil engineering machine. The interruption may be determined based on a receiving a user interface cation caused by the user via a user interface of the civil  
25 engineering machine. The user interface action may indicate an interruption, e.g. a standby state or a power off of the civil engineering machine. It should be noted that at a standby state or a power off of the civil engineering machine work operations of the civil engineering machine are disabled and a load capacity model in accordance with phase 306 is not calculated/updated. Therefore, it should be noted that the civil  
30 engineering machine may be at standby state or power off, when a central control entity of the civil engineering machine is at standby state or power off. In an example, the interruption may be determined based on a movement, or a lack of movement, of the civil engineering machine and/or one or more components of the civil engineering machine based on at least one of the following measurements: measurement of position  
35 of one or more actuating units; measurement of position of one or more components; or

load measurements; or position measurements of the civil engineering machine. In an example, the civil engineering machine may be at a standby state or powered off, when a consumption of electricity by the civil engineering machine or the central control entity is reduced. The consumption of electricity may be reduced at least because a voltage supply to the central control entity is switched off or the central control entity is switched to a standby state, where a power consumption of the central control entity is reduced.

[0065] Phase 706 comprises storing the load capacity model, if the interruption is determined in phase 704. In this way, when use of the civil engineering machine is continued, the stored load capacity model may be used for determining available load capacity of the civil engineering machine in accordance to described with phase 314 of Fig. 3.

[0066] In an example in accordance with at least some embodiments, phase 706 comprises storing context information associated with the load capacity model. The context information may comprise at least one of the following: a time of the interruption; or a position of the civil engineering machine at a work site; or information indicating a configuration of the civil engineering machine at the time of the interruption with the load capacity model. The information indicating a configuration of the civil engineering machine may comprise at least one of the following: components of the civil engineering machine; properties of the components of the civil engineering machine; or positions of the components with respect to each other; or actuation states of the components; or one or more loads carried by the civil engineering machine; or position of the civil engineering machine on the ground; or inclination of the civil engineering machine. It should be noted that the one or more loads carried by the civil engineering machine may be determined based on load measurements in accordance to described with at least one of phases 304 and 310 in Fig. 3.

[0067] If the interruption is not determined in phase 706, the method proceeds to phase 708 comprising using the current load capacity model and awaiting/monitoring for the interruption in phase 704. The current load capacity model may be used in phase 708 in accordance to described with phase 314 for determining available load capacity.

[0068] In an example, phase 704 comprises determining the interruption, e.g. a standby state or a power off, based on a user interface action received via a user interface of the civil engineering machine. Examples of the user interface action comprise a selection of a switch for a standby state or power off, by a user of the civil engineering machine.

[0069] Fig. 8 illustrates an example of a method for supporting an up-to-date load capacity model at a civil engineering machine in accordance with at least some embodiments. The method may be performed by the civil engineering machine described with Fig. 1 and Fig. 2. The method may start 802, when the civil engineering machine may have an existing load capacity model that may have been determined e.g. as described in connection with phase 306 of Fig. 3. The load capacity model may comprise context information associated with the load capacity model. The context information may comprise at least one of the following: a time; or a position of the civil engineering machine at a work site; or information indicating a configuration of the civil engineering machine at the time. In an example, the method may start at power up of the civil engineering machine, or a central control entity of the civil engineering machine. At start, a memory of the civil engineering machine may be checked for a stored load capacity model. The existing load capacity model may have been stored to the civil engineering machine, for example in connection with an interruption, e.g. at power off, as described in connection with phase 706 in Fig. 7, or during use of the civil engineering machine as described in connection with phase 306 in Fig. 3.

[0070] Phase 804 comprises determining, if the stored, or current, load capacity model is valid. If the current load capacity model is valid, the method proceeds to phase 806. If the current load capacity model is not valid, the method proceeds to phase 812.

[0071] In an example, phase 804 comprises determining the validity of the current load capacity model based on at least one of: a movement information; or time. If the civil engineering machine and/or one or more components of the civil engineering machine have been moved since storing the current load capacity model and/or if the current load capacity model has been outdated, the current load capacity model may be determined to be invalid in phase 804. The movement information may comprise information indicating at least one of the following: a position of the civil engineering machine; or movement of the civil engineering machine; or a position of one or more actuating units of the civil engineering machine; or a movement of one or more actuating units of the civil engineering machine; or position of one or more components of the civil engineering machine; or movement of one or more components of the civil engineering machine. The time may comprise at least one of the following: lapsed time since determining the load capacity model; or lapsed time since storing the load capacity model; or lapsed time since interruption of use of the civil engineering machine. The lapsed time may be determined based on time information stored associated with the load capacity model. The time information may comprise a time value representing

absolute time or relative time. The time information may be for example a counter value, a date value or a time of day. Movement of the civil engineering machine may be determined based on at least one of the following measurements: measurement of position of the civil engineering machine; or measurement of position of one or more actuating units; measurement of position of one or more components; or a position of one or more actuating units of the civil engineering machine; or a movement of one or more actuating units of the civil engineering machine; or position measurements of the civil engineering machine.

[0072] In an example, phase 804 comprises determining whether the current load capacity model is valid based on context information associated with the current load capacity model. The context information associated with the current load capacity model may be compared with one or more current, e.g. most recent, measurements of the civil engineering machine. The most recent measurements may be measurements that are measured at the civil engineering machine for determining at least one of the following for controlling at least one operation of the civil engineering machine: load; or inclination; or stability. In this way the validity, or relevance, of the load capacity model to the present time and status of the civil engineering machine may be determined. The context information may comprise at least one of the following information that may be obtained from measurements performed at the civil engineering machine: a movement information; or time. For example, the context information associated with the current load capacity model may comprise at least one of the following: a time (of the interruption); or a position of the civil engineering machine at a work site; or information indicating a configuration of the civil engineering machine (at the time of the interruption with the load capacity model). The time may indicate at least one of the following: lapsed time since determining the load capacity model; or lapsed time since interruption of use of the civil engineering; or lapsed time since storing the load capacity model. The context information may be compared with at least one of the following information: position of the civil engineering machine; or movement of the civil engineering machine; or movement of one or more components of the civil engineering machine; or position of one or more components of the civil engineering machine; lapsed time since determining the load capacity model; or lapsed time since storing the load capacity model; or lapsed time since interruption of use of the civil engineering machine.

[0073] In an example, phase 804 is performed after an interruption of a use of the civil engineering machine e.g. in accordance with phase 704 in Fig. 7. For example, when the interruption is determined in phase 704, a variable time period may elapse,

before use of the civil engineering machine is resumed. Time between the interruption of the user of the civil engineering machine and resuming the use of the civil engineering machine may vary, whereby the load capacity model used at the time of the interruption may be outdated at the time of resuming the use of the civil engineering machine. Therefore, validity of the load capacity model should be determined after the interruption before the load capacity model may be used, when use of the civil engineering machine is resumed. For example, environmental conditions prevailing at a work site of the civil engineering machine may change during the time between the interruption and resumption of the use of the civil engineering machine. The environmental conditions may comprise e.g. a wind speed and ground conditions. The ground may be for example frozen which may affect stability of the civil engineering machine. The environmental conditions may cause an increased load of the civil engineering machine, which may cause load of the civil engineering machine to exceed limits of operational safety. In an example, referring to the wind speed, at the time of an interruption a wind speed at the work site of the civil engineering machine may be 5 m/s and wind direction at the work site may be from southwest. However, at the time of resumption of the use of the civil engineering machine wind speed at the work site of the civil engineering machine may be 15 m/s and wind direction at the work site may be from northeast. Since both direction of the wind and wind speed have significantly changed, the load capacity model may be outdated and use of the load capacity model could falsely indicate that available load capacity remains, whereby stable operation of the civil engineering machine would be at risk and the civil engineering machine could tip over or the ground could give away under the civil engineering machine.

[0074] Phase 806 comprises displaying at a user interface of the civil engineering machine information indicating the load capacity model. The information indicating the load capacity model may comprise at least one of the following: information indicating that the current load capacity model is valid; or context information associated with the current load capacity model; or an available load capacity of the civil engineering machine determined based on the load capacity model. In this way the user of the civil engineering machine can be assisted in obtaining knowledge on the current load capacity model. The available load capacity of the civil engineering machine may be determined based on the load capacity model in accordance to described with phases 312 and 314 in Fig. 3.

[0075] Phase 808 comprises determining if an acknowledgement of a user for validating the load capacity model has been received. The acknowledgement may be

received in response to the displayed information indicating the load capacity model. In an example the acknowledgement may be a user interface action from a user of the civil engineering machine. The acknowledgement may indicate that the user accepts use of the current load capacity model. The user interface action may be received via a user interface of the civil engineering machine. The acknowledgement from the user provides that the load capacity model is validated by the user and that the user may control the load capacity model that is applied by the civil engineering machine. If the acknowledgement is received from the user, the method may proceed to phase 810 comprising applying the current load capacity model. In this way the user is informed of the load capacity model in phase 806 and also validated by the user in phase 810. Therefore, the current load capacity model may be applied for determining an available load capacity of the civil engineering machine whereby the available load capacity of the civil engineering may be determined based on an up-to-date load capacity model that is validated by the user. The method may then proceed to phase 820 and end. If the acknowledgement is not received from the user, the method may proceed to phase 812.

[0076] Phase 812 comprises determining a new load capacity model or updating the current load capacity model. The new/updated load capacity model may be determined in accordance to described with phases 302 to 306. The updated load capacity model may be determined by adapting one or more load capacity limits of the current load capacity model. In an example, a load capacity limit may be adapted by setting the load capacity limit to a pre-determined default value. One or more pre-determined default values may be stored at the civil engineering machine. In an example, the pre-determined default value may be selected from pre-determined default values based on inclination measurements, e.g. in accordance with phase 308, and/or load measurements, e.g. in accordance with phase 310.

[0077] Phases 814 comprises displaying by a user interface of the civil engineering machine information indicating the new/updated load capacity model similar to described in phase 806 for the earlier/non-updated load capacity model.

[0078] Phase 816 comprises determining if an acknowledgement of a user for validating the new/updated load capacity model has been received, similar to described with phase 808. The acknowledgement may be received in response to the displayed information indicating the new/updated load capacity model. If the acknowledgement is received from the user, the method may proceed to phase 818 comprising applying the current load capacity model similar to described with phase 810. If the acknowledgement is not received from the user in phase 816, the method may proceed

to phase 812. In this way, the available load capacity of the civil engineering may be determined at the civil engineering machine based on an up-to-date load capacity model that is validated by the user. The method may then proceed to phase 820 and end, where available load capacity of the civil engineering may be determined at the civil engineering machine based on an up-to-date load capacity model that is validated by the user.

[0079] Fig. 9 illustrates load measurements of a civil engineering machine in accordance with at least some embodiments. The load measurements are performed with respect to four locations P1, P2, P3, P4 of a lower carriage 902 of a civil engineering machine 904. The civil engineering machine is illustrated by a schematical representation as seen from above in a cartesian coordinate system comprising an X-axis and a Y-axis. The load measurements may be performed by one or more sensors and/or one or more actuating units that are deployed to the civil engineering machine. In an example, the civil engineering machine comprises tracks 906 and the lower carriage is supported to the tracks by beams 908. In an example, load, or force, at each of the four locations may be measured based on a load measurement of a load carried by the civil engineering machine and an inclination sensor for measuring an inclination of the civil engineering machine, whereby the load at each of the four locations may be determined based on geometry of the lower carriage, the load measurement and an inclination measured by the inclination sensor. Sensors for the load measurement may be configured to measure force of the carriage and any equipment supported by the carriage. The sensors may be installed to positions between the beams and the carriage. Position of a center of gravity 901 of the civil engineering machine may be determined based on the forces at each of the four locations. The center of gravity may be determined based on x,y of the coordinates of the coordinate system:

$$x = \frac{\sum_{i=1}^n F_i x_i}{\sum_{i=1}^n F_i} \quad (1)$$

$$y = \frac{\sum_{i=1}^n F_i y_i}{\sum_{i=1}^n F_i} \quad (2),$$

where x and y define a position of the center of gravity of the civil engineering machine or the lower carriage in the coordinate system spanned by the X-axis and Y- axis;  $x_i$  is x coordinate for location  $i$ ;  $y_i$  is y coordinate for location  $i$ ;  $F_i$  is a measured force; the numerators are sums of moments at locations  $i$ ;  $n$  is 4 according to the number of the locations P1, P2, P3 and P4; the denominators are sums of the forces, or loads, measured at each location  $i$ .

[0080] Fig. 10 illustrates examples of configurations and corresponding load capacity models of the civil engineering machine in accordance with at least some embodiments. The civil engineering machine may be controlled to perform one or more operations at each of the configurations. The configurations are illustrated by a schematical representation of the civil engineering machine as seen from above in a cartesian coordinate system comprising an X-axis and a Y-axis. Load measurements of the civil engineering machine may be performed in accordance to described with Fig. 9 for determining a center of gravity of the civil engineering machine. Tipping lines are illustrated dashed lines for each configuration. The tipping lines are examples of load capacity limits of a load capacity model corresponding to each configuration. The tipping lines may be connected to each other and configured to outline an area around a center of gravity of the civil engineering machine. Distance of each tipping line from the center of gravity may vary depending on at least one of a configuration of the civil engineering machine and an inclination of the civil engineering machine.

[0081] In a first configuration 1002 of Fig. 10, the civil engineering machine comprises two support legs that have been extended to the ground for providing stability to the civil engineering machine. The support legs provide corresponding support locations, e.g. on the ground, P6, P7 at which load measurements may be performed similar to described with points P1, P2, P3 and P4 with Fig. 9. The support locations of the support legs are connected by a tipping line with each other. Each of the locations of the support legs is connected by a tipping line to a tipping line extending longitudinally at one of the tracks. On an opposite side of the civil engineering machine with respect to the support

locations P6 and P7, the tipping lines at the tracks are connected by a tipping line that extends between the tracks.

[0082] In a second configuration 1004, the civil engineering machine is supported to the ground by the tracks 1014. Otherwise, this configuration corresponds to the first configuration but without the support legs providing additional stability to the civil engineering machine. In the second configuration the tipping lines extend longitudinally at the tracks and between the tracks.

[0083] In a third configuration 1006, the civil engineering machine is supported to the ground by a leader foot 1007, i.e. foot of a leader. The leader foot provides a corresponding support location, e.g. on the ground, at which load measurements may be performed similar to described with points P1, P2, P3 and P4 with Fig. 9. Otherwise, this configuration corresponds to the first configuration but without the support legs providing additional stability to the civil engineering machine. In the third configuration the support location of the leader foot is connected by a tipping line to tipping lines extending longitudinally at the tracks. On an opposite side of the civil engineering machine with respect to the support location P8 of the leader foot, the tipping lines at the tracks are connected by a tipping line that extends between the tracks.

[0084] In a fourth configuration 1008, the civil engineering machine is supported to the ground by the tracks similar to the second configuration and the civil engineering machine is additionally supported by an elevated, or risen, leader foot 1007. Accordingly, the leader foot is above the ground. In this position the weight of the leader foot is carried by the tracks. The load at the leader foot may be measured for determining the tipping lines. In the fourth configuration tipping lines extend from the leader foot 1007 to ends of both tracks 1014 on an opposite side of the civil engineering machine with respect to the leader foot, and a tipping line may extend between the ends of the tracks

[0085] In a fifth configuration 1010, the civil engineering machine is supported to the ground similar to the first configuration and additionally the civil engineering machine is supported by an elevated, or risen, leader foot 1007 similar to described with the fourth configuration. The load at the leader foot and at the support legs may be measured for determining the tipping lines. In this configuration the tipping lines extend between the support locations at the support legs and between each support location at the support legs and the leader foot 1007.

[0086] Fig. 11 illustrates an example of determining available load capacity of a civil engineering machine. The available load capacity, or amount of available load capacity,

may be used for controlling one or more operations of the civil engineering machine for example as described with phases 316, 406 and 408. The civil engineering machine may be in accordance with the first configuration 1002 described with Fig. 10. A center of gravity 1111 of the civil engineering machine may be determined based on load measurements with respect to one or more locations. Examples of the locations are described with reference to Fig. 9 and Fig. 10, e.g. tracks, P1, P2, P3, P4, P6 and P7. The available load capacity may be determined based on one or more moment values. The moment values may be calculated based on a distance of each tipping line, i.e. a load capacity limit, from the center of gravity 1111. Preferably the distance of each tipping line from the center of gravity is the shortest distance, or perpendicular distance. The moment may be calculated based on the perpendicular distance of the tipping line and a total load of the civil engineering machine as follows:

$$M_{\text{tipping\_line}} = \sum(F_j; j=1 \text{ to } m) \times d_{\text{tipping\_line}} \quad (3),$$

where  $M_{\text{tipping\_line}}$  is the moment for tipping line;  $F_i$  is a force acting on the tipping line;  $i$  is source of load or force;  $m$  is the number of source of loads that contribute to the moment;  $d_{\text{tipping\_line}}$  is a perpendicular distance of the center of gravity from the tipping line.

[0087] The perpendicular distance of the center of gravity from a tipping line, e.g.  $d_{\text{tipping\_line}}$ , may be obtained by:

$$d = \frac{|Ax_0 + By_0 + C|}{\sqrt{A^2 + B^2}} \quad (4),$$

where  $x_0$  is x coordinate of center of gravity;  $y_0$  is y coordinate of center of gravity; A, B, and C are auxiliary coefficients. The A, B and C are auxiliary coefficients, which are formed by equations of the tipping lines support points. The equations can be formed based on support point coordinates, e.g. from Fig. 10, where the dashed lines connect. Solving the slope of the tipping line enables calculating the distance of the center gravity distance to the tipping line.

[0088] Provided the moment calculated based on (3) is more than 0, the civil engineering machine may be determined to have available load capacity. If the moment becomes negative, the civil engineering machine tips over.

[0089] Fig. 12 illustrates determining an available load capacity based on a plurality of load capacity limits in accordance with at least some embodiments. The load capacity model may comprise load capacity limits, for example tipping lines. The plurality of load capacity limits may be connected to each other and configured to outline an area around a center of gravity of the civil engineering machine in accordance to described with Fig. 11. Additionally or alternatively, the load capacity model may comprise a plurality of load capacity limits 1204, 1206, 1208 in a given direction or a range of directions from the center of gravity 1202. Accordingly, in a given direction or a range of directions from the center of gravity, the load capacity model may comprise one or more load capacity limits. Each load capacity limit may be associated with a control configuration, whereby one or more operations of the civil engineering machine may be controlled according to the load capacity limit that has been met, in accordance to described with phase 404. The plurality of load capacity limits may be arranged at increasing distances  $d_6$ ,  $d_7$  and  $d_8$  from the center of gravity 1202. Whether any of the load capacity limits has been met may be determined based on the moment (3) indicating that one of the load capacity limits has been met. It should be noted that a number of the load capacity limits in each direction may vary.

[0090] Fig. 13 illustrates an example of controlling an operation of a civil engineering machine in accordance with at least some embodiments. The operation may comprise one or more components of the civil engineering machine and the operation may be controlled based on one or more limit parameters that limit one or more actuating parameters. In the example of Fig. 13 the civil engineering machine is a piling apparatus comprising a leader and that may be inclined towards and away, or in a forward direction, with respect to a carriage of the piling apparatus and sideways, or in a lateral direction, with respect to the carriage. The inclination of the leader is limited by limit parameters which in the illustrated example comprise a load stability compensation coefficient for forward inclination (LSCF) of the leader and a load stability compensation coefficient for side inclination (LSCS) of the leader. The LSCF and LSCS may be used for controlling the inclination of the leader based on the determined available load capacity in phase 316 of Fig. 3. In an example, forward inclination speed of the leader may be determined by multiplying, or adjusting, a speed for the forward inclination of the leader by the LSCF. In an example, side inclination speed of the leader may be determined by multiplying, or adjusting, a speed for the side inclination of the leader by the LSCS.

[0091] It should be note that the values of LSCS and LSCF may be determined based on the determined available load capacity. The determined available load capacity may be determined for side inclination and forward inclination respectively, whereby the LSCS may be determined based on the determined available load capacity for side inclination and the LSCF may be determined based on the determined available load capacity for forward inclination.

[0092] It should be noted that the LSCS and LSCF may be applied to one or more components of the civil engineering machine for controlling the inclination. For example, the LSCS may be applied to a lateral inclination cylinder for controlling a sideways movement of the leader. For example, the LSCF may be applied to a forward inclination cylinder for controlling movement of the leader in the forward direction.

[0093] In an example in accordance with at least some embodiments, the LSCF may limit or stop driving the leader at a distance from the carriage, or part of the carriage, of the civil engineering machine based on the determined available load capacity. For example, the value of LSCF may be set to '0' at a given forward inclination of the leader, whereby driving of the leader forward may be stopped at the given forward inclination. For example, a speed for the forward inclination may be set to '0' by multiplying the speed for the forward inclination by the LSCF, whereby driving the leader may be stopped. In an example, an LSCF is determined based on a value of a control function for forward inclination corresponding to a current forward inclination, 'F.Incl.', of the leader. In the example illustrated in Fig. 13, the control function for forward inclination may indicate a value, '0.95', of the LSCF based on the current forward inclination, 'F.Incl.', of the leader.

[0094] In an example in accordance with at least some embodiments, the LSCS may limit or stop driving the leader laterally with respect to the carriage, or part of the carriage, based on the determined available load capacity. For example, the value of LSCS may be set to '0' at a given side inclination of the leader, whereby driving of the leader laterally may be stopped at the given side inclination. For example, a speed for the side inclination may be set to '0' by multiplying the speed for the side inclination by the LSCS, whereby driving the leader may be stopped. In an example, an LSCS is determined based on a value of a control function for side inclination corresponding to a current side inclination, 'S.Incl.' of the leader and. In the example illustrated in Fig. 13, the control function for side inclination indicates a value, '1.0', of the LSCS based on the current side inclination, 'S.Incl.', of the leader.

[0095] It should be noted that the control function for forward inclination and control function for side inclination may be determined based on stability and capacity calculations. In an example, the control function for forward inclination and control function for side inclination may be set to reference values, e.g. '0', based on the determined available load capacity, e.g. determined in accordance to described with phase 314 of Fig.3. In an example, the control function for forward inclination may be set to have '0' value for a forward inclination that is not allowed to be exceeded. In an example, the control function for side inclination may be set to have '0' value for a lateral inclination that is not allowed to be exceeded. Accordingly, when the control function for side inclination is at value '0', i.e. the LSCS is '0', a speed for the side inclination is set to '0'. Consequently, the center of gravity of the piling apparatus cannot be moved by side inclination of the leader. Thus the center of gravity cannot exceed a tipping line or a load capacity limit of load capacity model by side inclination of the leader. Similarly, when the control function for forward inclination is at value '0', i.e. the LSCF is '0', a speed for the forward inclination is set to '0'. Consequently, the center of gravity of the piling apparatus cannot be moved by forward inclination of the leader. Thus the center of gravity cannot exceed a tipping line or a load capacity limit of load capacity model by forward inclination of the leader. In this way the exceeding of the available load capacity and tipping of the piling apparatus may be prevented.

[0096] In an example, the LSCF may be used to limit or stop a speed of the inclination of the leader towards or away from the carriage. For example, a speed of a side, or lateral, inclination may be determined by 
$$\text{forward\_inclination\_speed} = \text{LSCF} \times \text{forward\_speed\_control\_command} \quad (1),$$
 where the *LSCF* may be an LSCF value determined based on a control function for forward inclination and the *forward\_speed\_control\_command* may be determined e.g. by a user interface action such as tilting of a joystick. The LSCF may have values from '0' to '1.0'. In an example, the LSCF may be used to stop inclination of the leader towards or away from the carriage. In such case the LSCF may be set to '0' based on the control function for forward inclination. In an example, the LSCF may be used to limit a speed of the inclination of the leader towards or away from the carriage. In such case the LSCF may be such that, '0' <= LSCF <= '1.0', based on the control function for forward inclination.

[0097] In an example, the LSCS may be used to limit or stop a speed of the inclination of the leader towards or away from the carriage. For example, a speed of a side inclination may be determined by

$side\_inclination\_speed = LSCS \times lateral\_speed\_control\_command\_$  (2),  
where the *LSCS* may be an *LSCS* value determined based on a control function for side inclination and the *lateral\_speed\_control\_command* may be determined e.g. by a user interface action such as tilting of a joystick. The *LSCS* may have values from '0' to '1.0'.

- 5 In an example, the *LSCS* may be used to stop inclination of the leader in a lateral direction with respect to the carriage. In such case the *LSCS* may be set to '0' based on the control function for side inclination. In an example, the *LSCS* may be used to limit a speed of the inclination of the leader in a lateral direction with respect to the carriage. In such case the *LSCS* may be such that, '0' <= *LSCS* <= '1.0', based on the control  
10 function for forward inclination.

[0098] It should be noted that one or more other limit parameters may be used in a similar manner to the *LSCF* and *LSCS* described above for limiting or stopping at least one of the following: actuating units of the civil engineering machine based on the determined available load capacity; or driving the civil engineering machine at a work  
15 site based on the determined available load capacity; or a rotation of an upper carriage of the civil engineering machine with respect to a lower carriage of the civil engineering machine based on the determined available load capacity; or reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine based on the determined available load capacity.

20 [0099] Fig. 14 illustrates an example of a user interface in accordance with at least some embodiments. The user interface 1402 may be a user interface of a civil engineering machine described with Fig. 2. The user interface may be provided by an on-board user interface device connected to a data bus of the civil engineering machine, or an external user interface device connected to the civil engineering  
25 machine by a data network connection that may be provided by data connection component. The user interface may comprise at least one portion 1404 for displaying information indicating an available load capacity and at least one portion 1406 for displaying information indicating load measurements. The available load capacity and the load measurements may be determined as described with Fig. 3. The least one  
30 portion for displaying information indicating load measurements may comprise one or more measured load values 1412, 1414, 1416. The least one portion for displaying information indicating an available load capacity may comprise information indicating the available load capacity corresponding to the measured load values. The information indicating the available load capacity is enriched with directional information 1410 of at  
35 least one load capacity limit, or a tipping line. The directional information may comprise

one or more load capacity limits 1410, 1420 that are displayed on top of a top view of the civil engineering machine 1422. Preferably, the directional information highlights a load capacity limit that is closest to a center of gravity 1408 of the civil engineering machine. The directional information provides that, when the user is controlling an operation of the civil engineering machine by the user interface device, the user is provided with information on a direction at which the load capacity limit is the closest to the center of gravity during controlling of the operation, whereby the user may continue controlling of the operation of the civil engineering machine by keeping the center of gravity at the same distance to the load capacity limit, increasing the distance to the load capacity limit or decreasing the distance to the load capacity limit. Provided that one or more further load capacity limits are displayed in addition to the load capacity limit that is closest to a center of gravity 1408 of the civil engineering machine, the user is provided information indicating alternative directions and corresponding available load capacities for controlling operation of the civil engineering machine. It should be noted that provided the center of gravity is moved the load capacity limit that is closest to the center of gravity may be changed, whereby the highlighted load capacity limit is changed. The load capacity limit may be highlighted on the user interface 1402 by one or more properties of a user interface element representing the load capacity limit. The one or more properties may comprise a color, a shape and/or dimension of the user interface element. Examples of the colors are red, yellow and cyan. When more than one load capacity limits are displayed on the user interface 1402, the highlighted load capacity limit may be selected one or more different properties, e.g. a color, a shape and/or dimensions, from the other load capacity limits.

[00100] Fig. 15 illustrates examples of control functions for controlling operations of the civil engineering machine in accordance with at least some embodiments. The control functions 1502, 1504 facilitate controlling limit parameters for controlling operations 1506 of the civil engineering machine. The control functions may implement one or more functionalities described with phase 316 in Fig. 6. The civil engineering machine may comprise a memory stored with computer program code thereon, wherein the at least one memory and the computer program code are configured, with at least one processor of the civil engineering machine, to cause one or more functionalities of the control functions. Examples of the limit parameters comprise at least one of:

- a. one or more limit parameters for actuating the one or more actuating units of the civil engineering machine; or

- b. one or more limit parameters for driving the civil engineering machine at a work site; or
- c. one or more limit parameters for rotating a lower carriage of the civil engineering machine with respect to an upper carriage of the civil engineering machine; or
- d. one or more limit parameters for driving at least one leader of the civil engineering machine laterally with respect to a carriage part of the civil engineering machine; or
- e. one or more limit parameters for driving at least one leader of the civil engineering machine towards a carriage part of the civil engineering machine or away from the carriage part of the civil engineering machine; or
- f. one or more limit parameters for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine.

[00101] In an example, the one or more limit parameters for driving at least one leader of the civil engineering machine laterally with respect to a carriage part of the civil engineering machine comprise a *lateral\_speed\_control\_command* of the leader described with Fig. 13. In an example, the one or more limit parameters for driving at least one leader of the civil engineering machine towards a carriage part of the civil engineering machine or away from the carriage part of the civil engineering machine comprise a *forward\_speed\_control\_command* of the leader described with Fig. 13.

[00102] The one or more control functions 1502, 1504, e.g. CF<sub>j</sub>...CF<sub>j</sub>, where j={1, 2, 3, ...M}, are described with reference to commands that are limit parameters for controlling the civil engineering machine. The commands may be for example data signals received from a user interface device at the civil engineering machine. Each control function may be configured to control, or adjust, one or more commands, e.g. CMD<sub>ij</sub>...CMD<sub>ij</sub>, where i is an index for commands and j is the index for control functions such that i={1, 2, 3, ...N} and j={1, 2, 3, ...M}. For this purpose, each of the control functions may be configured to receive one or more values of the available load capacity, AVAIL\_LC<sub>j</sub> where j={1, 2, 3, ...M}, that may be determined in accordance to described with phase 314 of Fig. 3. It should be noted that the available load capacity received by each control function may be determined according to the commands CMD<sub>ij</sub> controlled by the control function. For example, the determined available load capacity, AVAIL\_LC<sub>j</sub>, may comprise a (shortest) distance of a center of gravity to a tipping line, or a load capacity limit. Each control function may output one or more values, ADJ\_CMD<sub>jj</sub>, i={1, 2, 3, ...N}, j={1, 2, 3, ...M} based on input CMD<sub>ij</sub>.

Accordingly, each CMD<sub>ij</sub> may be adjusted by the control function CF<sub>j</sub> to obtain adjusted commands, ADJ\_CMD<sub>ij</sub>. The output value, or ADJ\_CMD<sub>ij</sub>, is controlled by the control functions based on the available load capacity that is determined in accordance with phase 314. Output values of the control functions may be used for

5 controlling operations 1506 of the civil engineering machine in accordance with phase 316. In an example, one or more of the output values may be fed to one or more actuation units of the civil engineering machine for controlling at least one operation of the civil engineering machine. Examples of the output values comprise *forward\_inclination\_speed* and *side\_inclination\_speed*. It should be noted that the

10 output values of the control functions may be variably dependent on the available load capacity. The control functions may be determined for example based on stability and capacity calculations. For example, an output value of the control function may be determined differently depending on whether one or more load capacity limits have been reached. The control function may comprise sub-functions that are selectively

15 applied to the input value(s) depending on the available load capacity. Therefore, the available load capacity, e.g. load capacity limit that has been met, may determine which sub-function is applied for determining the output value of the control function based on the input value. Examples of the control functions and sub-functions comprise at least a stepped curve having a variable step size and a non-linear curve or their combination.

20 In a rough example of the sub-functions, an output value may be determined to be the input value, thus 100% of the input value, provided there is sufficient available load capacity. On the other hand, if a first load capacity limit has been reached, the output value may be determined to be 75% of the input value provided there is sufficient available load capacity. On the other hand, if a second load capacity limit has been

25 reached, the output value may be determined to be 50% of the input value provided there is sufficient available load capacity. In a further example, an output value may be determined based on input value(s) based on a non-linear function that has a decreasing slope based on a decreasing available load capacity, whereby output value(s) are increasingly decreased with decreasing available load capacity. It should

30 be noted that the available load capacity is determined dynamically according to different configurations assumed by the civil engineering machine. Therefore, operations of the civil engineering machine may use the dynamically determined available load capacity for controlling operations of the civil engineering machine.

[00103] In an example, where a control function 1502, 1504 receives a

35 *lateral\_speed\_control\_command* as input or a control function receives a

*forward\_speed\_control\_command*, i.e. *CMD\_ij*, as input. The respective control function, i.e. control function for lateral speed or control function for forward speed, may receive an available load capacity, *AVAIL\_LC\_j*, that is a function of the (shortest) distance of a center of gravity of the civil engineering machine to a tipping line, or load capacity limit. In this way, the control function for lateral speed may determine a value of the LSCS based on the available load capacity and further determine the *side\_inclination\_speed*, *ADJ\_CMD\_ij*, based on the LSCS, for example according to (2). On the other hand, the control function for forward speed may determine a value of the LSCF based on the available load capacity and further determine the *forward\_inclination\_speed*, *ADJ\_CMD\_ij*, based on the LSCF, for example according to (1).

[00104] It should be noted that the distance of a center of gravity to a tipping line may be a projection to a dimension according to the input, *CMD\_ij*, controlled by the control function 1502, 1504. In an example, where the control function receives a *lateral\_speed\_control\_command* as input the available load capacity received by the control function may be a function of the projection of a (shortest) distance of a center of gravity of the civil engineering machine to a tipping line, or load capacity limit, in a lateral direction of a leader. Similarly, in an example, where the control function receives a *forward\_speed\_control\_command* as input the available load capacity received by the control function may be a function of the projection of a (shortest) distance of a center of gravity of the civil engineering machine to the tipping line, or load capacity limit, in a forward direction of a leader.

[00105] According to an embodiment, there is provided a civil engineering machine comprising means for performing one or more functionalities according to one or more embodiments. The civil engineering machine may comprise:

means for receiving at a first configuration of the civil engineering machine first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine;

means for receiving at the first configuration of the civil engineering machine first load measurements indicating a load of the civil engineering machine from at least one of the following: one or more actuating units, or one or more sensors;

means for determining a load capacity model of the civil engineering machine based on the received first inclination measurements and based on the received first load measurements;

means for receiving at a second configuration of the civil engineering machine second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine;

5 means for receiving at the second configuration of the civil engineering machine second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors;

means for applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements;

10 means for determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model;

means for controlling at least one operation of the civil engineering machine based on the determined available load capacity.

15 [00106] The civil engineering machine may comprise a memory stored with computer program code thereon, wherein the at least one memory and the computer program code are configured, with at least one processor of the civil engineering machine, to cause the civil engineering machine at least to perform on a method or at least part of functionalities of a method. The memory may be a non-transitory computer readable  
20 medium.

[00107] It is to be understood that the embodiments disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the  
25 purpose of describing particular embodiments only and is not intended to be limiting.

[00108] Reference throughout this specification to one embodiment or an embodiment means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in/according to one embodiment" or "in/according to an embodiment" in  
30 various places throughout this specification are not necessarily all referring to the same embodiment. Where reference is made to a numerical value using a term such as, for example, about or substantially, the exact numerical value is also disclosed.

[00109] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience.  
35 However, these lists should be construed as though each member of the list is

individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and examples may be referred to herein  
5 along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations.

[00110] The foregoing description has provided by way of exemplary and non-limiting  
10 examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended examples. However, all such and similar modifications of the teachings of this invention will still fall within the  
15 scope of this invention.

**CLAIMS**

1. A method for a civil engineering machine (100), comprising:
  - receiving at a first configuration of the civil engineering machine (100) first inclination measurements from one or more sensors for measuring inclination  
5 of the civil engineering machine (100);
  - receiving at the first configuration of the civil engineering machine (100) first load measurements indicating a load of the civil engineering machine (100) from at least one of the following: one or more actuating units, or one or more sensors;
  - 10 - determining a load capacity model of the civil engineering machine (100) based on the received first inclination measurements and based on the received first load measurements;
  - receiving at a second configuration of the civil engineering machine (100) second inclination measurements from the one or more sensors for  
15 measuring inclination of the civil engineering machine (100);
  - receiving at the second configuration of the civil engineering machine (100) second load measurements indicating a load of the civil engineering machine from the at least one of the following: one or more actuating units; or one or more sensors;
  - 20 - applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements;
  - determining an available load capacity of the civil engineering machine based on the determined load capacity model and the compensated second load  
25 measurements, or the second load measurements and the compensated determined load capacity model;
  - controlling at least one operation of the civil engineering machine (100) based on the determined available load capacity.
2. The method of claim 1, comprising:
  - 30 - storing the load capacity model, if use of the civil engineering machine is interrupted.
3. The method of claim 1 or 2, comprising:
  - determining, if the load capacity model is valid;
  - displaying by a user interface of the civil engineering machine information  
35 indicating the load capacity model; and

- if an acknowledgement of a user for validating the load capacity model is received, applying the load capacity model for determining the available load capacity of the civil engineering machine.
- 4. The method of any of claims 1 to 3, comprising:
  - 5 - determining a new load capacity model or updating the load capacity model, if an acknowledgement of a user for validating the load capacity model is not received.
- 5. The method of any of claims 1 to 4, wherein the determined available load capacity is a function of a distance of a center of gravity to a load capacity limit of the determined load capacity model.
- 10 6. The method of claim 5, wherein the distance of a center of gravity to a tipping line is a projection to a dimension according to an input controlled by control function for controlling the at least one operation of the civil engineering machine (100).
- 7. The method of any of claims 1 to 6, comprising:
  - 15 - determining reference positions of a center of gravity of the civil engineering machine (100) at load capacity limits of the determined load capacity model;
  - determining a current position of a center of gravity based on the compensated second load measurements; and
  - determining the available load capacity of the civil engineering machine (100) based on a distance between the determined current position of a center of gravity based on the compensated second load measurements, or the compensated determined load capacity model, and the determined reference positions of a center of gravity of the civil engineering machine (100).
- 20 8. The method of any of claims 1 to 7, wherein the at least one work operation of the civil engineering machine is controlled based on at least one of the following one or more limit parameters:
  - 25 - one or more limit parameters for actuating the one or more actuating units of the civil engineering machine (100); or
  - one or more limit parameters for driving the civil engineering machine (100) at a work site; or
  - 30 - one or more limit parameters for rotating a lower carriage (101) of the civil engineering machine (100) with respect to an upper carriage (102) of the civil engineering machine; or

- one or more limit parameters for driving at least one leader of the civil engineering machine (100) laterally with respect to a carriage part of the civil engineering machine; or
  - one or more limit parameters for driving at least one leader of the civil engineering machine towards a carriage part of the civil engineering machine or away from the carriage part of the civil engineering machine; or
  - one or more limit parameters for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine (100).
9. The method of any of claims 1 to 8, comprising at least one of the following:
- limiting or stopping the one or more actuating units of the civil engineering machine (100) based on the determined available load capacity; or
  - limiting or stopping driving the civil engineering machine at a work site based on the determined available load capacity; or
  - limiting or stopping a rotation of an upper carriage (102) of the civil engineering machine (100) with respect to a lower carriage (101) of the civil engineering machine (100) based on the determined available load capacity; or
  - limiting or stopping driving at least one leader of the civil engineering machine (100) at a distance from a carriage part of the civil engineering machine (100) based on the determined available load capacity; or
  - limiting or stopping driving at least one leader of the civil engineering machine (100) laterally with respect to a carriage part of the civil engineering machine based on the determined available load capacity; or
  - limiting or stopping reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine (100) based on the determined available load capacity.
10. The method of claim any of claims 1 to 9, comprising:
- determining an acceleration of a change of the determined available load capacity; and
  - controlling the at least one operation of the civil engineering machine based on the acceleration meeting at least one threshold for the acceleration.
11. The method of any of claims 1 to 10, comprising:
- receiving at least one user interface action via a user interface of the civil engineering machine; and

- controlling a response of the civil engineering machine (100), or a part of the civil engineering machine (100), to the at least one user interface action based on the determined available load capacity.

12. The method of claim 11, wherein the at least one user interface action is

5 configured to control at least one work operation of the civil engineering machine (100).

13. The method of any of claims 1 to 12, comprising at least one of the following:

- determining an actuation speed of the one or more actuating units of the civil engineering machine (100); or
- 10 - determining a ground speed for driving the civil engineering machine (100); or
- determining a rotational speed for rotating an upper carriage (102) of the civil engineering machine (100) with respect to a lower carriage (101) (102) of the civil engineering machine (100); or
- determining a speed for driving at least one leader of the civil engineering machine (100) at a distance from a carriage part of the civil engineering machine (100) based on the determined available load capacity; or
- 15 - determining speed for reeling at least one of a rope connected to a work equipment, or an auxiliary rope of the civil engineering machine (100) based on the determined available load capacity.

20 14. The method of any of claims 1 to 13, comprising:

- displaying on a user interface of the civil engineering machine (100) information indicating at least one of the following: the determined available load capacity; or an estimated available load capacity, or a likelihood of meeting one or more load capacity limits.

25 15. The method of any of claims 1 to 14, comprising:

- highlighting on a user interface of the civil engineering machine a load capacity limit that is closest to a center of gravity of the civil engineering machine.

16. The method of any of claims 1 to 15, comprising:

- 30 - giving feedback via a user interface of the civil engineering machine (100) based on at least one of the following: the determined available load capacity; or an estimated available load capacity, or a likelihood of meeting one or more load capacity limits.

17. The method of claim 16, comprising:

- giving first feedback via the user interface of the civil engineering machine (100), if a load capacity limit has been met.

18. The method of claim 16 or 17, comprising:

- giving second feedback via the user interface of the civil engineering machine (100), if a load capacity limit has not been met.

19. The method of any of claims 16 to 18, wherein the feedback is at least one of the following: audio feedback; or tactile feedback; or visual feedback.

20. The method of any of claims 16 to 19, wherein the feedback is given in response to, or during, at least one user interface action.

21. A civil engineering machine (100) comprising:

- means for receiving at a first configuration of the civil engineering machine (100) first inclination measurements from one or more sensors for measuring inclination of the civil engineering machine (100);
- means for receiving at the first configuration of the civil engineering machine (100) first load measurements indicating a load of the civil engineering machine (100) from at least one of the following: one or more actuating units, or one or more sensors;
- means for determining a load capacity model of the civil engineering machine (100) based on the received first inclination measurements and based on the received first load measurements;
- means for receiving at a second configuration of the civil engineering machine (100) second inclination measurements from the one or more sensors for measuring inclination of the civil engineering machine (100);
- means for receiving at the second configuration of the civil engineering machine (100) second load measurements indicating a load of the civil engineering machine (100) from the at least one of the following: one or more actuating units; or one or more sensors;
- means for applying a compensation to the received second load measurements, or the determined load capacity model, based on the second inclination measurements;
- means for determining an available load capacity of the civil engineering machine (100) based on the determined load capacity model and the compensated second load measurements, or the second load measurements and the compensated determined load capacity model;

- means for controlling at least one operation of the civil engineering machine (100) based on the determined available load capacity.

22. A civil engineering machine (100) comprising a memory stored with computer program code thereon, wherein the at least one memory and the computer program code are configured, with at least one processor of the civil engineering machine (100), to cause the civil engineering machine (100) to perform any of the methods of claims 1 to 20.

23. A computer program product comprising computer program code that when executed by processors of a civil engineering machine (100) causes the civil engineering machine (100) to perform any of the methods of claims 1 to 20.