

# DEVICE AND METHOD FOR TURNING AN ELEVATED STRUCTURE

## FIELD OF INVENTION

[0001] The present invention relates broadly, but not exclusively, to a device and method for turning an elevated structure or a heavy load.

## BACKGROUND

[0002] As metropolitan cities expand, traffic congestion increases and elevated roads are needed to reduce congestion and improve traffic infrastructure when it is not possible or practical to widen existing roads or open new roads. An elevated road may be required to be constructed over an existing road and it is vital that the road below would still be open to traffic during construction of the upper structures to minimize disruption to traffic.

[0003] Construction of an elevated road typically involves placing vertical pier shafts or columns along the centre of the existing road (sub structures). Concrete pier heads are then built on-site on top of the pier shafts and perpendicular to the road axis to act as support for the upper structures. With conventional construction techniques, due to the width of the pier heads, using scaffolding supports below the pier heads during the on-site construction of the pier heads can lead to closure of the existing road. An alternative option is to have segmental pier heads with post tensioning system but that would greatly increase the costs of construction. In either option, disruption to the traffic below is evident as the pier heads are perpendicular to the direction of the road.

[0004] In an existing approach using the "Sosrobahu" technique, a pier head is constructed parallel to the direction of the road and once ready, is rotated by 90 degrees into position using a turning device made of two flat discs and installed between the pier shaft and pier head. However, friction is still encountered when turning the pier head. Moreover, significant efforts are required to ensure flatness

of the device during installation. A cavity of a specific geometry on the pier shaft is also required to accommodate the device to be installed.

**[0005]** Thus, there is a need to provide a device and method for turning an elevated structure that seek to address some of the above problems or provide a useful alternative.

## **SUMMARY**

**[0006]** According to a first aspect of the present invention, there is provided a device for turning an elevated structure about a support structure, the device comprising:

- an upper plate member configured to be attached to the elevated heavy-load structure; and

- a lower plate member configured to be attached to the support structure,

- wherein the upper plate member is rotatable with respect to the lower plate member for turning the elevated heavy-load structure about the support structure; and

- wherein the lower plate member comprises a raised central portion extending from an upper surface, the central portion configured to abut a lower surface of the upper plate member such that a contact area between the upper plate member and the lower plate member is equal to a fraction of a surface area of the lower plate member.

**[0007]**

**[0008]** The lower plate member further may comprise a flat lower surface, the lower surface having a recessed central portion opposite the raised central portion.

**[0009]** The lower plate member may further comprise a raised peripheral portion extending from the upper surface, the raised peripheral portion configured to abut the lower surface of the upper plate member.

**[0010]** The lower surface of the upper plate member and the upper surface of the lower plate member excluding the raised central and peripheral portions may define a fluid-tight chamber there between, the chamber configured to receive a hydraulic fluid.

**[0011]** The hydraulic fluid may comprise a lubricating oil.

**[0012]** A pressure of the hydraulic fluid may be determined based on the weight of the elevated heavy-load structure such that the device hydraulically supports the elevated heavy-load structure.

**[0013]** The upper plate member may comprise a fluid inlet for introducing the hydraulic fluid into the chamber, and a fluid outlet for removing the hydraulic fluid from the chamber.

**[0014]** The lower plate member may further comprise a plurality of attachment brackets extending outwardly from a peripheral wall of the lower plate member, for setting a horizontal position and attaching the lower plate member to the support structure.

**[0015]** The support structure may comprise a pier shaft and the elevated heavy-load structure comprises a pier head.

**[0016]** According to a second aspect of the present invention, there is provided a method of constructing an elevated heavy-load structure, the method comprising the steps of:

forming the elevated heavy-load structure at a first position relative to a support structure, comprising securing the lower plate member of the device as defined in the first aspect to the support structure and securing the upper plate member of the device to the elevated heavy-load structure, the upper plate member being received by the lower plate member;

turning the elevated heavy-load structure about the support structure from the first position to a second position, wherein turning the elevated heavy-load structure comprises providing a hydraulic fluid through a fluid inlet disposed in the upper plate member into a chamber of the device and rotating the upper plate member with respect to the lower plate member;

removing the hydraulic fluid from the chamber through a fluid outlet disposed in the upper plate member of the device at the second position; and

securing the elevated heavy-load structure to the support structure at the second position.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0017]** Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

**[0018]** Figure 1a is a top perspective view of a device for turning an elevated structure or a heavy load before assembly according to an example embodiment.

**[0019]** Figure 1b is a bottom perspective view of the device of Figure 1a.

**[0020]** Figure 1c is a cross-sectional view of the device of Figure 1a.

[0021] Figure 2a is a top perspective view of the device of Figure 1a after assembly.

[0022] Figure 2b is a cross-sectional view of the device of Figure 1a after assembly.

[0023] Figure 3a is a top plan view of the lower plate member of the device of Figure 1a.

[0024] Figure 3b is a cross-sectional view of the lower plate member of Figure 3a.

[0025] Figure 4a is a top plan view of the upper plate member of the device of Figure 1a.

[0026] Figure 4b is a cross-sectional view of the upper plate member of Figure 4a.

[0027] Figure 5 is a flow chart illustrating a method for constructing an elevated structure according to an example embodiment.

## DETAILED DESCRIPTION

[0028] Figure 1a shows a top perspective view of a device 100 for turning an elevated structure according to an example embodiment. Figure 1b shows a bottom perspective view of the device 100 of Figure 1a. Figure 1c shows a cross-sectional view of the device 100 of Figure 1a. The device 100 comprises an upper plate member 102 and a lower plate member 104. The upper plate member 102 is generally circular and comprises a plurality of bolt holes 106 configured to receive respective fastening means, e.g. in the form of bolts (not shown), to attach the upper plate member 102 to the elevated structure. For example, the bolt holes 106 are disposed on a cross-shaped rib 107 on the upper plate member 102. In alternate embodiments, the bolt holes 106 can be arranged such that an equal number of bolt holes 106 are on the opposite ends to balance the load of the pier head. The upper plate member 102 further comprises a fluid inlet 108 for introducing a hydraulic fluid, such as hydraulic oil, into the device 100, and a fluid outlet 110 to drain the hydraulic fluid after the elevated structure is in position, as will be described in more detail below.

[0029] The lower plate member 104 is also generally circular and dimensioned to snugly receive the upper plate member 102 while allowing rotation of the upper plate member 102 during operation. The lower plate member 104 comprises a raised central portion 112 extending from an upper surface 113 of the lower plate member 104. The lower plate member 104 further comprises a raised peripheral portion 114 extending from the upper surface 113. The lower plate member 104 also includes a plurality of

attachment brackets 116 extending outwardly from a peripheral wall 117 of the lower plate member 104. Each of the plurality of attachment brackets 116 comprises attachment means, e.g. in the form of at least one bolt hole 118, to attach the lower plate member 104 to the support structure.

[0030] As can be seen from Figures 1b and 1c, the upper plate member 102 may comprise a hydraulic fluid seal 120 to prevent hydraulic fluid leakage from the device 100 during operation. It will be appreciated that the hydraulic fluid seal 120 can be affixed to the lower plate member 104 in alternate embodiments. The lower plate member 104 comprises a generally flat lower surface 122, the lower surface 122 having a recessed central portion 124 opposite the raised central portion 112 (Figure 1b). In other words, when the lower plate member 104 is placed on a horizontal surface, the recessed central portion 124 is directly below the raised central portion 112.

[0031] Figure 2a shows a top perspective view of the device 100 of Figure 1a after assembly. Figure 2b shows a cross-sectional view of the device 100 of Figure 1a after assembly. The upper plate member 102 is configured to be attached to an elevated structure and the lower plate member 104 is configured to be attached to a support structure. As described above, in an example embodiment, the upper plate member 102 comprises a plurality of bolt holes 106 to mount bolts to the elevated structure and the lower plate member 104 comprises a plurality of attachment brackets 116 each having corresponding bolt hole 118 to mount at least one bolt for each bracket to the support structure. In an example embodiment, the support structure comprises a pier shaft or pylon and the elevated structure comprises a pier head. Other types of structures are possible. For example, the elevated structure can be a rotatable bridge section, and the support structure can be a support pillar of the bridge.

[0032] Referring to Figure 2b, when assembled, a contact area between the upper plate member 102 and the lower plate member 104 is equal to a fraction of a surface area of the lower plate member 104. Here, the raised central portion 112 and the raised peripheral portion 114 of the lower plate member 104 are configured to abut a flat lower surface 125 of the upper plate member 104. In addition, the peripheral wall 117 of the lower plate member 104 prevents any lateral movement by the upper plate member 102.

[0033] Further, the device 100 has a fluid-tight chamber 126 defined between the lower surface 125 of the upper plate member 102 and the upper surface 113 of the lower plate member 104 excluding the raised central and peripheral portions (112, 114), wherein the chamber 126 is configured to receive a hydraulic fluid. In an example embodiment, the hydraulic fluid comprises a lubricating oil. The seal 120 prevents leakage of the hydraulic fluid, but allows relative rotational movement between the upper plate member 102 and lower plate member 104.

[0034] During operation of the device 100, the hydraulic fluid is introduced into the fluid-tight chamber 126 through the fluid inlet 108 (Figure 1a) on the upper plate member 102 until the fluid in the chamber 126 is at a predetermined pressure. The predetermined pressure is calculated from factors such as the weight of the elevated structure, oil properties, etc., and is able to at least partially offset the weight of the elevated structure. In some embodiments, the hydraulic fluid acts like a jack to lift the elevated structure slightly. Subsequently, the elevated structure is rotated from a first position to a second position using the device 100 wherein the upper plate member 102 is rotated with respect to the lower plate member 104. For example, a crane and a connecting line can be used to tug the elevated structure. After the elevated structure is turned to the second position, the hydraulic fluid is removed from the chamber 126 through the fluid outlet 110 (Figure 1a) on the upper plate member 102. In some embodiments, the elevated structure is lowered slightly as a result of the withdrawal of the hydraulic fluid. The elevated structure is then secured to the support structure.

[0035] The hydraulic fluid in the fluid-tight chamber 126 reduces friction between the upper plate member 102 and the lower plate member 104 during rotation. The raised central support 112 also reduces friction by reducing the effective contact area between the lower surface 125 of the upper plate member 102 and the upper surface 113 of the lower plate member 104. Furthermore, the recessed central portion 124 allows the raised central portion 112 to deflect downward under the weight of the elevated structure, thereby reducing the normal force acting on the raised central portion 112 and further reducing friction. In alternate embodiments, a raised central portion may be positioned on the lower surface 125 of the upper plate member 102 and configured to abut the upper surface 113 of the lower plate member 104 to achieve similar friction reduction.

[0036] Figure 3a shows the top plan view of the lower plate member 104 of the device of Figure 1a and Figure 3b shows the cross-sectional view of the lower plate member 104. Typically, the lower plate member 104 is made of ductile iron casting (FCD). To

attach the lower plate member 104 to the support structure, the lower plate member 104 is first placed into a corresponding circular recess formed on a top surface of the support structure. Checks are then conducted to ensure that the upper surface 113 of the lower plate member 104 is horizontal. Next, the lower plate member 104 is secured to the support structure by filling any gap between the lower plate member 104 and the recess with concrete to prevent lateral movements, and by mounting bolts through bolt holes 118 provided on the respective attachment brackets 116.

[0037] Figure 4a shows the top plan view of the upper plate member 102 of the device 100 of Figure 1a and Figure 4b shows the cross-sectional view of the upper plate member 102. The upper plate member is also normally made of cast iron. To attach the upper plate member 102 to the elevated structure, in one embodiment, the upper plate member 102 is assembled to the lower plate member 104 while the lower plate member 104 is attached to the support structure. Bolts are then mounted to bolt holes 106 provided on the rib 107. Next, a mould for the elevated structure is formed having the upper plate member 102 at the bottom surface, and the elevated structure is formed, e.g. by pouring concrete into the mould. To ensure that part of the bottom surface of the elevated structure and the top surface of the support structure around the outside of the assembled plate members 102 and 104 (e.g. outside of the peripheral wall 117 (Figure 1a)) does not hamper further rotation, a thin gap is typically provided in between the support structure and the elevated structure. For example, the upper plate member 102 and with the elevated structure are supported by a removable mould (not shown) such that the gap is maintained between the elevated structure and support structure while ensuring alignment between the plate members 102 and 104. The hydraulic fluid is subsequently introduced into the chamber 126 (Figure 2b) until the pressure of the hydraulic fluid is sufficient to hydraulically support the weight of the elevated structure. The supporting mould is then removed and the upper plate member 102 is rotated to move the elevated structure to the second position. The hydraulic fluid is removed from the device 100 after the position of the elevated structure is confirmed and the gap is grouted using non-shrinkage concrete.

[0038] Figure 5 shows a flowchart 1000 illustrating a method for constructing an elevated structure according to an example embodiment. At step 1002, an elevated structure is formed at a first position relative to a support structure. At step 1004, the elevated structure is turned about the support structure from the first position to a second position using the device 100, wherein turning the elevated structure comprises providing a hydraulic fluid into a chamber 126 of the device 100. At step 1006, the

hydraulic fluid is removed from the chamber 126 at the second position. At step 1008, the elevated structure is secured to the support structure at the second position.

**[0039]** Embodiments of the present invention provide a device and method of turning an elevated structure that may overcome the problems of previous systems. As described above, the example embodiments also provide a method of construction of elevated roads with minimum disruption of the traffic below. The pier head is formed parallel to the traffic below over the pier shaft. Advantageously, forming the pier head in parallel may have minimum disruption to the existing traffic below as bulky supports are not required to hold the pier head in position. The raised central portion of the lower plate member of the device can reduce friction by reducing the contact area between the upper plate member and the lower plate member during rotation of the device. Further, the lower plate member can be installed easily on the pier shaft using the plurality of attachment brackets on the lower plate member. The flat surface of the lower plate member can enable installation onto the pier shaft without the need of creating a specific cavity on the pier shaft to install the lower plate member. The raised peripheral portion of the lower plate member can enable stability of the device during assembly and rotation. This can reduce the risk of wobbling of the pier head which may induce stress on the structure and the device.

**[0040]** During rotation of the pier head, the use of hydraulic fluid at a predetermined pressure may reduce friction which may damage the lower plate member or the pier shaft. Pressurized hydraulic fluid, such as a lubricating oil, may also withstand the weight of the pier head of approximately 450 tons. In addition, using lubricating oil is a simple and cost effective method and can be reused extensively. Thus, construction costs of the elevated road may be greatly reduced because of the simplicity of the design of the device and method used to turn the pier head. In addition, the device in embodiments of the present invention can be used not only for construction of elevated roads but also for other concrete structures, such as bridges and buildings, or other heavy load structures as well.

**[0041]** It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

**CLAIMS**

1. A device for turning an elevated heavy-load structure about a support structure, the device comprising:

an upper plate member configured to be attached to the elevated heavy-load structure; and

a lower plate member configured to be attached to the support structure,

wherein the upper plate member is rotatable with respect to the lower plate member for turning the elevated heavy-load structure about the support structure; and

wherein the lower plate member comprises a raised central portion extending from an upper surface, the central portion configured to abut a lower surface of the upper plate member such that a contact area between the upper plate member and the lower plate member is equal to a fraction of a surface area of the lower plate member.

2. The device as claimed in claim 1, wherein the lower plate member further comprises a flat lower surface, the lower surface having a recessed central portion opposite the raised central portion.

3. The device as claimed in claim 1 or 2, wherein the lower plate member further comprises a raised peripheral portion extending from the upper surface, the raised peripheral portion configured to abut the lower surface of the upper plate member.

4. The device as claimed in claim 3, wherein the lower surface of the upper plate member and the upper surface of the lower plate member excluding the raised central and peripheral portions define a fluid-tight chamber therebetween, the chamber configured to receive a hydraulic fluid.

5. The device as claimed in claim 4, wherein the hydraulic fluid comprises a lubricating oil.

6. The device as claimed in claim 4 or 5, wherein a pressure of the hydraulic fluid is determined based on the weight of the elevated heavy-load structure such that the device hydraulically supports the elevated heavy-load structure.

7. The device as claimed in any one of claims 4 to 6, wherein the upper plate member comprises a fluid inlet for introducing the hydraulic fluid into the chamber, and a fluid outlet for removing the hydraulic fluid from the chamber.

8. The device as claimed in any one of the preceding claims, wherein the lower plate member further comprises a plurality of attachment brackets extending outwardly from a peripheral wall of the lower plate member, for setting a horizontal position and attaching the lower plate member to the support structure.

9. The device as claimed in any one of the preceding claims, wherein the support structure comprises a pier shaft and the elevated heavy-load structure comprises a pier head.

10. The device as claimed in any one of the preceding claims, wherein the upper plate member further comprises a cross-shaped rib having a plurality of bolt holes disposed thereon, and wherein the upper plate member is configured to be attached to the elevated heavy-load structure using bolts installed into said bolt holes.

11. A method of constructing an elevated heavy-load structure, the method comprising the steps of:

forming the elevated heavy-load structure at a first position relative to a support structure, comprising securing the lower plate member of the device as claimed in any one of claims 1 to 10 to the support structure and securing the upper plate member of the device to the elevated heavy-load structure, the upper plate member being received by the lower plate member;

turning the elevated heavy-load structure about the support structure from the first position to a second position, wherein turning the elevated heavy-load structure comprises providing a hydraulic fluid through a fluid inlet disposed in the upper plate member into a chamber of the device and rotating the upper plate member with respect to the lower plate member;

removing the hydraulic fluid from the chamber through a fluid outlet disposed in the upper plate member of the device at the second position; and

securing the elevated heavy-load structure to the support structure at the second position.