ABSTRACT: Successively raisable shuttering for the casting of upwardly or downwardly tapering concrete structures, comprising two mutually opposed and horizontally displaceable form portions for forming the tapering surfaces of the structure, which are interconnected by a mechanism coupled to a raising system for the shuttering so that the form portions are displaced inwardly or outwardly by a predetermined amount during each raising step of the raising system.
CONCRETE CASTING SHUTTERING

BACKGROUND OF THE INVENTION

The invention relates to successively raisable shuttering for the casting of concrete structures. In the production of essentially vertical concrete structures, especially bridge piers, bridge abutments, and retaining walls, it is known to employ a modularly configured shuttering of relatively low height, in particular steel shuttering, which is raised successively step-by-step, with the growth of the concrete structure, each raising step being after the setting or solidification of the lower concrete layers. The raising of these shuttering elements is preferably performed by means of hydraulically or pneumatically operated climbing hoists or the like which are fastened to the top of the shuttering and climb upwardly on vertical steel rods set into and projecting from the concrete structure.

It is a principal object of the invention to provide a successively raisable form of shuttering of the kind referred to above, for the construction of upwardly narrowing or widening concrete structures.

SUMMARY

According to the invention successively raisable shuttering for use in the casting of a tapering concrete structure is provided characterized by two mutually opposed form portions which are horizontally displaceable relative to each other, at least one displacing mechanism interconnecting the form portions, and a raising system to which the displacing mechanism is coupled, the displacing mechanism being arranged for simultaneous operation with the raising system to displace both form portions inwardly or outwardly by a predetermined amount during each raising step of the raising system.

In the preferred embodiment of the successively raisable shuttering, the shuttering is also narrowed or widened at the same time in the horizontal direction during each raising step owing to the reciprocal outwardly or inwardly directed displacement of the two opposed form portions, the ratio between the raising step and the corresponding horizontal displacement step of the form portions being chosen in such a manner as to produce the required constant narrowing or widening of the concrete structure.

The two form portions which are reciprocally displaceable in the horizontal direction may be directly interconnected by means of the displacing mechanism.

According to another feature of the invention however, the shuttering comprises an interposed raisable connecting part on which the two form portions are displaceably guided, and synchronously driven displacing mechanisms connecting the form portions to the connecting part, which displacing mechanisms act in opposite directions for reciprocal horizontal displacement of the form portions.

This construction is advantageous for shuttering of greater width in particular, and ensures more precise displacement of the displaceable form portions. Moreover, a given maximum distance of travel of each separate displacing mechanism secures an approximately doubled reciprocal maximum displacement of the two form portions, thereby extending the range of application of the formwork and at least reducing the onerous setting-up and resetting procedures.

In the case of shuttering comprising a hydraulic or pneumatic raising system, the raising mechanism and the displacing mechanism are fluid-operated, a common pressurized fluid supply is provided, and a shared control device connects the fluid feed supply to the raising mechanism and the displacing mechanism. In this construction, the simultaneous actuation of the raising system and of the displacing mechanisms and consequently also the required simultaneity of the raising movement and of the horizontal displacement of the form portions, is assured by simple means.

Further according to the invention, each displacing mechanism consists of a mechanical feed mechanism which is connected to a fluid-operated actuating device. In this construction, the ratio between the raising step and the corresponding horizontal displacement step of the form portions may be varied by modification of the transmission ratio in the mechanical feed mechanism and may be adapted to the narrowing or widening of the concrete structure as required in each case, whereas the corresponding hydraulic or pneumatic actuating device still has the same pressure acting upon it, and fluctuations of this pressure do not exercise any influence on the displacement of the shuttering.

The shuttering according to the invention may be employed for production of concrete structures which are formed by a single vertical concrete unit comprising two opposed, upwardly converging or diverging sloping areas, and two vertical lateral surfaces. For such cases, the invention makes provision for a closed shuttering assembly, in which the two form portions which are displaceable in horizontal direction are made U-shaped, and embrace the concrete unit in the region of the oblique surfaces of the unit, and have correspondingly sloping end walls and overlap each other with their lateral branches in the area of the vertical lateral surfaces of the concrete unit, in longitudinally displaceable manner. If a connecting portion is interposed in this construction between the two displaceable U-shaped form portions, this connecting portion is formed, to complement the shuttering at both vertical sides of the concrete unit, by auxiliary shuttering plates which overlap the lateral branches of the displaceable U-shaped form portions.

The shuttering according to the invention may moreover be employed in advantageous manner for the production of concrete structures which consist of two individual upwardly converging or diverging piers, columns or the like of constant cross section. In this case, according to the invention, the two horizontally displaceable form portions are individual forms closed on themselves annularly, and each encircling one of the piers and correspondingly inclined, while the connecting portion preferably interposed between these individual form portions consists of a horizontal bearer arranged at one side of the pair of piers, on which the two individual forms are guided in longitudinally displaceable manner by means of saddles or carriages. This construction allows the simultaneous production of two convergent or divergent concrete piers, concrete columns or the like, by means of the raisable formwork elements which were not applicable to this purpose until now.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows in elevation raisable shuttering according to the invention for the production of a concrete unit which constantly diminishes in width upwardly,

FIG. 2 shows the shuttering of FIG. 1 in diagrammatic plan view,

FIG. 3 shows a part of the shuttering of FIG. 1, in elevation and to larger scale,

FIGS. 4 and 5 are cross sections along the lines IV-IV and V-V of FIG. 3, to larger scale, p FIG. 6 shows in elevation shuttering according to the invention for the simultaneous production of two upwardly converging concrete piers,

FIG. 7 shows the shuttering of FIG. 6, in diagrammatic plan view,

FIG. 8 shows a part of the shuttering of FIG. 6, in elevation and to larger scale,

FIG. 9 shows the shuttering part of FIG. 8, in plan view, and

FIG. 10 is a cross section along the line X-X of FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The raisable steel shuttering illustrated in FIGS. 1 to 5 is intended for the production of a concrete unit 1, for example a bridge pier or the like, which has a rectangular base area and a width which constantly diminishes upwards, that is, the unit 1 is delimited on two opposite sides by upwardly converging sloping surfaces 101 and on the other two sides by vertical lateral surfaces 201. The shuttering employed for producing this concrete unit 1, possesses a corresponding rectangular
cross section and is of closed form, consisting of two opposed U-shaped form portions 2 which enflank the oblique surfaces 101 of the concrete unit 1 and have correspondingly inclined end walls 102, and two plane form plates 3 constituting the shattering at either side of the concrete unit 1 in the area of the vertical lateral surfaces 201 of the same. The U-shaped form portions 2 overlap the associated lateral form plates 3 with the lateral branches 202 of the form plates 3, and the form portions 2 are displaceably guided in these lateral branches 202 in the horizontal direction. To this end, each lateral form plate 3 has an outwardly open section which is approximately U-shaped in vertical section, at least in the area of its two terminal portions 203. The branches 202 of the U-shaped form portions 2, which are also of U-shaped section, are displaceably guided in the profiled terminal portions 203 of the lateral form plates 3.

The lateral branches 202 of each U-shaped form portion 2 has a vertical crosspiece 7 (FIG. 3) at its free end, with which the form portions are displaceably guided on two horizontal guide rods 4 situated one above the other in the corresponding terminal portions 203 of the lateral form plates 3. The guide rods 4 are fastened at one end on a vertical crosspiece 5 of the form plate 3 and at the other end to an upright 6 by means of inwardly projecting brackets (FIG. 5), this upright 6 being situated on the corresponding outer extremity of the form plate 3 at the outer side of the branch 202 of the U-shaped form portion 2.

The branches 202 of each U-shaped form portion 2 are each connected to the lateral form plates 3 by means of a displacing mechanism indicated generally at 8. The displacing mechanisms 8 interposed between a U-shaped form portion 2 and the lateral form plates 3 then have a reversed sense of operation relative to the displacing mechanisms 8 interposed between the other U-shaped form portion 2 and the lateral form plates 3. All displacing mechanisms 8 have the same structure and are so constructed and synchronously driven, that in each case, they simultaneously displace the U-shaped form portions 2 inwardly, i.e. towards each other relative to the lateral form plates 3.

In particular, each displacing mechanism 8 consists of two horizontal screw spindles 9 arranged one above the other, for rotation without displacement in the axial direction, and are mounted in the crosspiece 5 of the lateral form plate 3 and in the inwardly projecting brackets 106 of the upright 6 on the outer extremity of the form plate 3. Each screw spindle 9 is threaded through an associated spindle nut 10 which is fastened in the crosspiece 7 of the corresponding lateral branch 202 of the U-shaped form portion 2. The two screw spindles 9 are positively coupled to each other by means of a chain drive 11, 12, so that they turn in the same direction. The screw spindles 9 are driven by means of a stepping mechanism 13, known per se, which is coupled through the chain drive 11, 12 to a spindle, and is actuated by means of a rocking lever 14. The rocking lever 14 is driven by means of a hydraulically operating cylinder 15 mounted on the form plate 3 and by retraction springs 16.

The shattering composed of the lateral form plates 3 and the displaceable U-shaped form portions 2 has a relatively small height compared to the overall height of the concrete unit 1 to be produced, and is raised successively in steps after the setting or solidification of the lower concrete layers. The raising system employed for this purpose consists of hydraulic climbing hoists 17, known per se, which are secured at the top to the lateral form plates 3 as well as to the U-shaped form portions 2, and climb upwardly on vertical steel rods 18 set into the concrete unit 1 and projecting upwardly therefrom.

The climb of the raising mechanism and the driving cylinders 15 of all the displacing mechanisms 8 interposed between the form plates 3 and the displaceable U-shaped form portions 2 are connected to the same hydraulic system 19 and may be connected simultaneously to the pressurized fluid infeed 120 by means of a shared control device 20. Consequently, during actuation of the control device 20, the climbing hoists 17 as well as the cylinders 15 of the displacing mechanisms 8 receive a driving thrust, so that the whole shattering 23 is raised by a step, and both U-shaped form portions 2 are displaced inwardly simultaneously, i.e. towards each other in horizontal direction relative to the lateral form plates 3. The ratio between the raising step and the simultaneous horizontal displacement step of the U-shaped form portions 2 corresponds to the slope of the oblique surfaces 101 of the concrete unit 1, and may be set or varied by modification of the transmission ratio in the mechanical part of the displacing mechanisms 8, specifically by the incorporation of screw spindles 9 and spindle nuts 10 of different pitch.

The raisable steel shattering illustrated in FIGS. 6 to 10 is for the simultaneous production of two upwardly converging piers 21, each of which has a rectangular constant cross section. The shattering consists of two separate steel forms 22 which are annularly closed, each for forming one of the piers 21, and possessing a corresponding cross section. These separate forms 22 which lean towards each other with the angle of convergence of the piers 21 have a relatively small height compared to the overall height of the piers 21 and are simultaneously raised successively by means of a shared hydraulic raising system. This consists of known hydraulically operated climbing hoists 17 which are fastened to the tops of both separate forms 22 and climb upwardly on vertical steel rods 18 set into the concrete piers 21 and projecting from the same. All the climbing hoists 17 are connected to the same hydraulic system 19 and are simultaneously connected through a shared control device 20 to the pressurized fluid infeed 120.

The two separate forms 22 are arranged displaceably on horizontal connecting bearings 23 situated at either side of the piers 21 and raisable together with the separate forms 22. In the embodiment illustrated, each separate form 22 is connected at either side with a carriage 24, which runs in the longitudinal direction on the corresponding horizontal bearer 23 and is guided on the same. The two carriages 24 are fastened to the coordinated separate forms 22 by means of vertical iron sections 25 and angled coupling brackets on either side. Each carriage 24 consists of two head portions 124 spaced apart from each other, which enflank the corresponding horizontal coupling bearer 23 and bear on the upper side as well as on the underside of the bearer by means of rollers 27. The two head portions 124 of each carriage 24 are interconnected at both sides of the corresponding horizontal bearer 23 by means of longitudinally directed sideways 224 constructed in lattice-like manner.

Each carriage 24 is connected to the corresponding bearer 23 by means of a displacing device indicated generally at 28 for the longitudinal displacement of the carriage on the bearer. This displacing device 28 consists of two screw spindles 29 which extend in the longitudinal direction of the horizontal bearer 23 and are situated above and below the bearer. One end of each screw spindle 29 is rotatably without displacement in axial direction in a pivot bearing 129 which is connected to the one end part 124 of the carriage 24 so as to swivel about a horizontal transverse axis. The other freestanding end of the screw spindle 29 is threaded through an associated spindle nut 30 which is swivelably arranged about a horizontal transverse axis on the corresponding bearer 23 by means of a bearing block 130. The two screw spindles 29 are positively coupled to each other by means of a chain drive 31, 32, so that they turn in the same direction. The drive to the screw spindles 29 is through a stepping mechanism 33 known per se, which is coupled to the chain drive 31, 32, or to the Threading 29, and is actuated by means of a rocking lever 34. The rocking lever 34 is actuated by a hydraulic operating cylinder 35 arranged on the carriage 24, in combination with a retraction spring which is not illustrated.

The two displacing mechanisms 28 cooperating with one of the separate forms 22 and situated at either side of the same are operated in opposed manner to the two displacing
mechanisms 28 cooperating with the other separate form 22 and also situated at either side of the latter. That is the displacing mechanisms 28 of the two separate forms are so constructed and arranged that under simultaneous actuation, they displace the coordinated pair of carriages 24-24, and consequentially the two separate forms 22, synchronously towards each other on the horizontal connecting bearers 23.

All the displacing mechanisms 28 for the horizontal displacement of the two separate forms 22 are actuated at the same time as the climbing hoists 17 for the raising of the framework. To this end, the actuating cylinders 35 of the displacing mechanisms are connected to the same hydraulic system 19 of the climbing hoists 17 and are connected at the same time as these to the pressurized fluid inlet 10 by means of the same control device 20, and are therefore acted upon by the pressurized fluid. During each actuation of the control device 20, and at the same time as the climbing hoists 17, the hydraulic cylinders 35 of the displacing mechanisms 28 thus receive a driving thrust and operate the coordinated screw spindles 29 through the switching or stepping devices 33. Consequently, the two separate forms 22 are successively displaced horizontally towards each other during each raising step, by one step on the connecting bearers 23. The ratio between the raising step and the reciprocal horizontal displacement step of the two separate forms 22 corresponds to the angle of convergence of the two concrete piers 21, so that the two piers can be built up at the same time. In this case too, the angle of inclination of the two convergent concrete piers 21 may be set and varied by modification of the transmission ratio in the mechanical part of the displacing mechanisms 28, specifically by exchange of the screw spindles 29 and of the corresponding spindle nuts 30.

To avoid the application of excessively long screw spindles 29 and the consequent inaccuracies resulting from bending and twisting of the spindles, the length of the screw spindles 29 corresponds to a fraction of the total distance of horizontal displacement which has to be covered by each raisable separate form 22 along the total height of the concrete pier 21 to be produced. Consequently, if at a definite intermediate height of the convergent concrete piers 21, the screw spindles 29 have been screwed almost completely through their associated spindle nuts 30, the nuts are freed from the connecting bearers 23 and repositioned on the bearers 23 in the horizontal position displaced further inwardly i.e. towards the vertical median symmetry plane of the pair of piers 21. To this end, each connecting bearer 23 is provided with several groups of holes 36 spaced apart from each other in the longitudinal direction, in which the bearing block 130 of each spindle nut 30 may be fastened by means of screws or bolts or preferably at different distances from the median vertical symmetry plane of the pair of piers 21 on the connecting bearer 23, and may thus be advanced progressively towards the said symmetry plane.

The invention is not limited to the examples illustrated, and several solutions differing in the structural sense in particular, are possible within the scope of the general principle of the invention. In particular, the displacing mechanisms 8 and 28 may be so constructed that, i.e. by reversing the pitch of the screw spindles 9 and 29, that they cause a simultaneous outwardly directed horizontal displacement of the form portions 21 and 22 during each raising step of the formwork. This arrangement allows the construction of concrete units 1 having upwardly diverging oblique surfaces 101, or the construction of piers 21 which diverge upwards. The displacing mechanisms 8, 28 themselves may be of different structure from that of the screw spindle embodiment, especially in their mechanical part.

1. Successively raisable shuttering for use in the casting of a tapering concrete structure, comprising two mutually opposed form portions horizontally displaceable relative to each other, at least one displacing mechanism interconnecting the form portions, a raising system to which the displacing mechanism is coupled, said displacing mechanism being arranged for simultaneous operation with the raising system to displace both form portions inwardly or outwardly by a predetermined amount during each raising step of said raising system, an interposed raisable connecting part on which said two form portions are displaceably guided, synchronously driven displacing mechanisms connecting said form portions to said connecting part and operable in opposite directions for reciprocal horizontal displacement of said form portions, fluid means for operating said raising mechanism and said displacing mechanism, a pressurized fluid supply, a control device interconnecting said fluid operating means to said pressurized fluid supply for simultaneous operation of said raising mechanism and said displacing mechanism, said displacing mechanism comprising a mechanical feed mechanism connected to said fluid operating means and including several parallel screw spindles positively coupled to each other, a fluid-operated cylinder to which said screw spindles are coupled for movement in the same sense, spindle nuts on said screw spindles, and a stepping gear connecting said cylinder to said spindle nuts.

2. Shuttering according to claim 1, characterized in that a chain drive couples said screw spindles to each other.

3. Shuttering according to claim 1, characterized in that the length of each of said screw spindles is a fraction only of the total horizontal displacement of the associated form portion considered over the entire height of said concrete structure, and each displacing mechanism includes means for stepped displacement of the point of connection of said spindle nuts on said connecting part.

4. Shuttering according to claim 1, characterized in that the length of said screw spindles of each displacing mechanism is a fraction only of the total horizontal displacement of the associated form portion considered over the entire height of said concrete structure, and each displacing mechanism includes means for stepped displacement of the point of connection of said spindle nuts on said connecting part.

5. Successively raisable shuttering for use in the casting of a tapering concrete structure, comprising two mutually opposed form portions horizontally displaceable relative to each other, at least one displacing mechanism interconnecting the form portions, a raising system to which the displacing mechanism is coupled, said displacing mechanism being arranged for simultaneous operation with the raising system to displace both form portions inwardly or outwardly by a predetermined amount during each raising step of said raising system, an interposed raisable connecting part on which said two form portions are displaceably guided, synchronously driven displacing mechanisms connecting said form portions to said connecting part and operable in opposite directions for reciprocal horizontal displacement of said form portions, fluid means for operating said raising mechanism and said displacing mechanism, a pressurized fluid supply, a control device interconnecting said fluid operating means to said pressurized fluid supply for simultaneous operation of said raising mechanism and said displacing mechanism, said displacing mechanism comprising a mechanical feed mechanism connected to said fluid operating means and including several parallel screw spindles positively coupled to each other, a fluid-operated cylinder to which said screw spindles are coupled for movement in the same sense, spindle nuts on said screw spindles, and a stepping gear connecting said cylinder to said spindle nuts.

6. Shuttering according to claim 5, characterized in that said connecting part between said form portions comprises auxiliary shattering plates at each side of the concrete unit in the area of the vertical lateral surfaces of the unit, said plates overlapping the later branches of the displaceable U-shaped form portions.

7. Shuttering according to claim 1, in which said concrete structure consists of two separate upwardly converging or diverging piers of constant cross section, wherein the two horizontally displaceable form portions each have separate units each annularly closed, and each encircling one of the piers and being appropriately inclined to match the inclination of that pier.

8. Shuttering according to claim 7, wherein the connecting part interposed between the two separate displaceable form portions consists of at least one horizontal bearer situated at one side of the piers, and carriages connected to the form portions and running on the bearer to effect longitudinal displacement of the form portions.