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**CONCRETE BUILDING FRAME CONSTRUCTION APPARATUS****DISCLOSURE****Background of the Invention**

The present invention relates to the construction of multi-level concrete building structures and, more particularly, to apparatus for such construction in which a deck support formwork assembly for a structural concrete slab is lowered into position and supported from the level above for the making of the next lower structural concrete slab.

10 The vertical frame elements of concrete building structures generally are made up of columns (which may be concrete, structural steel, or a composite of both concrete and steel) connected together via slabs of reinforced concrete. These slabs are the principle horizontal frame members for the
15 building. It is common to incorporate rebar and/or post tensioned beams in such structural concrete slabs. These slabs act not only as integral parts of building frames of multi-level concrete buildings, but also to define floors/ceiling soffits.

20 The most common way of constructing level dividing slabs in concrete multi-story buildings, is to construct formwork at a desired elevation for the level, install rebar and/or post tensioning tendons, and then fill the formwork with concrete which is allowed to cure. It is typical to build the slabs
25 sequentially in a "bottom-up" approach (one above the other).

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The support preferably is from the structural slab which defines the higher level. Attachment nuts are provided in the first structural slab to transmit loads to such upper slab.

5 A major advantage of the "top-down" approach to the construction of a concrete building is the speed and simplicity of the actual construction. Upper floors, once the structural slabs for the same have been made, can be finished (partitions, windows/curtain walls can be installed,
10 etc.) while the construction of lower slabs is taking place. And, indeed, it is not necessary for the concrete frame construction workmen to have access to such upper floors after the forms are lowered. Other advantages are that buildings can be built to zero lot line without having to fly forms over
15 adjacent buildings. The system is extremely cost efficient because it requires so few workers and because of the speed of erection. Full 8'0" floor-to-ceiling heights can be achieved with 8'6" (or less) floor-to-floor heights.

It should be noted that the broad concept of constructing
20 horizontal slabs in a "top-down" manner has been used in the past in other types of construction which cannot be used in constructing buildings of significant height. Reference is made, for example, to U.S. Patent Nos. 3,194,532; 3,275,719; and 4,029,286. In such arrangements the slab is not a ductile
25 diaphragm. The criteria for these other types of construction are completely different, and it is not obvious how those top down approaches will work in an arrangement in which the slab is a structural ductile diaphragm part of the frame in addition to dividing levels. Moreover, the apparatus is
30 different and is incapable of use for top-down concrete building construction.

The invention also includes a wheel for rotating the roll threaded rod. Such wheel has a center portion which is adapted to engage the roll threaded rod in a generally non-
35 rotating manner, which center portion is circumscribed by a

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FIG. 4 is an enlarged and partly exploded sectional view, generally showing the area encircled by the line 4-4 in FIG. 1A;

FIGS. 5A and 5B are enlarged plan and end sectional views, respectively, of a washer especially designed for the invention;

FIG. 6 is an enlarged sectional view generally showing the area encircled by the line 6-6 in FIG. 1B, after concrete is poured and set;

10 FIG. 7A is a plan view of a preferred embodiment of a wheel of the invention used to turn a rod to be described and lower the form assembly;

FIG. 7B is a sectional view of the wheel of FIG. 7A showing the same in engagement with a rod;

15 FIG. 8 is an enlarged sectional view of a coupler for a pair of axially aligned rods;

FIG. 9 is a nut pulling apparatus of the invention;

FIG. 10A is an elevation view of an alternate hanger arrangement;

20 FIG. 10B is a plan view of the alternate hanger arrangement of FIG. 10A;

FIG. 11 is an elevation view illustrating a preferred embodiment of the invention in which slabs are made above grade level for a multi-level concrete building structure;
25 and

FIG. 12 is an enlarged sectional view similar to that of FIG. 5, showing an alternate arrangement for supporting a threaded rod.

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site, a water barrier wall 21 is formed surrounding the site at which such slabs are to be made. Such barrier wall 21 is simply a slurry wall, and in an implementation of the invention for the construction of a multi-level underground
5 garage, the wall 21 was a 3-foot thick slurry wall that was 100-feet deep. As illustrated in FIGS. 1 and 2, the decks are dowelled and poured into the slurry wall via a keyway 22.

A generally vertical structural frame network of columns for interaction with the structural slabs is provided. Such
10 network includes a plurality of generally vertical columns 23 which extend upward from a stable base. In one realization of the invention, the steel columns were secured to bedrock by the formation of a grid of 5 to 8 foot diameter concrete caissons which served as foundations for the columns. Cages
15 of reinforcing steel were provided in the holes augured for the columns 23. Then tremied concrete was inserted in the holes to displace a polymer driller's mud that had been used within the holes to prevent the sides of the same from caving in. Enough concrete was poured in the holes to cover the
20 steel columns from bedrock to the elevation of the bottom slabs to be formed.

As mentioned earlier, the invention particularly relates to concrete construction in which the slabs act not only to define the floors/ceiling soffits of the various levels, but
25 also act as primary horizontal structural diaphragms. A significant aspect of the invention is its use in the making of such horizontal structural slabs in a top-down arrangement with the repetitive use of the same deck formwork assembly. This is unusual in that the building will not have a permanent
30 structural frame at the location at which slabs are made (or at any level below the same). It only does so after a slab is poured and cured at such location. In the traditional "bottom-up" approach this is no problem since the structural frame of a building is completed all the way from the
35 foundation to the top as the slabs are made. In contrast, when the horizontal structural slabs are made in a top-down

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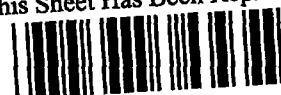
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Each of the threaded rods 26 terminates and is threadably connected to the deck formwork assembly in an associated pocket 19. FIG. 4 is an enlarged sectional view which illustrates the same in more detail. That is, each threaded rod extends through a flange 29 at the bottom of the pocket and then terminates in an anchor or end nut 31. Such nut is made non-rotatable with respect to the threaded rod end via, for example, the use of locking bolts 32. Thrust straps 34 also can be provided to transmit the thrust applied to the rod 26 to the flange 29 and, hence, to the main end beam 18 of the form assembly. A washer 35 is provided which is heavily greased to permit rotation of the roll threaded rod 26 and, hence, nut 32, with respect to flange 29. A plurality of shoulder nuts 28 to be embedded in the concrete slabs defining other levels are also provided on the rod as illustrated.

It will be recognized that there often is a significant load on the threaded rods, and in many situations it is desirable to facilitate the turning of the same. Washer 35 is especially designed to cooperate with grease to permit such rotation. FIGS. 5A and 5B are enlarged views of such washer, showing that it has radial grooves 36 on opposite sides of a center plate 37. Each groove on one side defines a channel for the distribution of grease from the rod to the side of the washer associated with such groove. As illustrated, the grooves 36 on one side have a circumferential component in one direction, whereas the grooves on the opposite side of the plate have a circumferential component in the opposite direction. Because of these opposite circumferential directional components, grease will be distributed in both directions of rotation of the threaded rod.

In the below-grade arrangement being described, before the deck formwork assemblies for a slab are lowered, the volume of material (earth) for the next lower level is excavated. The excavation is to the level, for example, indicated at 33 for bays 27 and 39. The volume excavated includes the

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repeated for each slab. This repetition is represented by bays 54 and 56.

The invention is also applicable to the use of a concrete vibrating screed. As is illustrated in bay 56, a screed rail 5 57 can be provided connecting two adjacent threaded rods 26 as illustrated. It will be appreciated, although not shown, that a similar screed rail connects the other two threaded rods of each form assembly. A carrier 58 for a vibrating screed 59 can travel along the length of the rails to position 10 the screed at an appropriate location and elevation therefor.

The shoulder nut attachment/threaded rod arrangement is used in the preferred arrangement being described, not only to lower and support the deck formwork assembly itself, but also to provide the support necessary to transmit the load of the 15 poured and curing concrete slab to the concrete slab above the same. That is, as is best illustrated by the bay 38, the threaded rods 26 extend upward to the concrete slab represented at 44 and support not only the formwork assembly 12, but the poured concrete for the next lower slab.

20 In some instances it is desirable to transmit the loads encountered by a deck formwork assembly and the concrete supported by the same, to more than one higher completed slab. FIG. 8 illustrates a coupler 61 joining axially aligned threaded rods 26 for this purpose. It will be noted from 25 FIG. 1 that the upper threaded rod is connected to the shoulder nut 28 at the upper structural slab, whereas the lower threaded rod is suitably received within the shoulder nut in the lower slab. With this arrangement, the loads on each deck formwork assembly will be transmitted to the two 30 adjacent upper slabs as long as the threaded connections all are tight.

After the shoulder nuts in a completed slab are no longer being used, they can be pulled from the slab. FIG. 9 illustrates a nut pulling arrangement. Such arrangement

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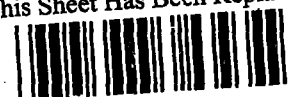


positioning of the cup 68. To this end, it includes a pair of hinged joints 69 and 71 which facilitate positioning adjustment. The freedom provided by the adjustment ability of the cup portion enables use of the arms at many locations
5 where other attachment apparatus might be difficult to use.

It is desirable that the articulating support arms be at a level just above the location desired for the new structural slab. Holes at the four corners of the finished slab allow the threaded rods to pass therethrough. It will be
10 appreciated that the lowering of the form, etc. is essentially the same as that described when the nut 28 is embedded within, or placed on top of, the upper structural slab itself.

As mentioned previously, the apparatus of the invention is particularly applicable to the formation of above-grade levels
15 for concrete multi-story buildings. FIG. 11 is a plan view schematically illustrating such an arrangement, generally referred to by the reference numeral 76. The specific design has twenty above-grade levels (19 floor/soffit slabs and one roof slab). The construction includes bays, two of which are
20 shown at 77 and 78 surrounding a core bay 79. The core bay is designed for stairwells, elevators, etc. and includes lightweight bracing represented at 81 to support those core elements which are installed before the structural slabs are formed with the invention. The building structural frame
25 includes a plurality of vertical columns 82 akin to the columns 23 of the below grade construction described previously. Each of the columns 82 is made up of column sections 83 which are joined as illustrated at 84 in the field in accordance with conventional techniques. Each of such
30 columns can be concrete, structural steel, or a composite of both, for example, concrete encased in a metal tubular shell. Such columns are supported via footings 86 or the like in accordance with conventional techniques depending upon local conditions. Temporary bracing represented by lines 87 is also
35 provided to aid in supporting the columns 82 until the horizontal structural frame slabs are formed in accordance

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the removal of such sleeve. It will be seen that the load carried by the threaded rod is transferred through the upside down nut and bearing plate 97 to the structural slab.

5 The "top-down" construction of the floor/ceiling structural slabs of the building frame provided by the invention greatly simplifies the construction procedure. It also enables the concrete structure to be completed in a much shorter time. It will be seen that after the next lower slab is made, it is not necessary for the workmen involved in the frame/slab
10 construction to have access to the other, higher levels. Thus, the invention makes it appropriate for a contractor constructing such a building to provide complete access for sub-contractors to each of the floors following, in essence, the construction of the structural slab. That is, as soon
15 as a slab is completed the interior walls, curtain walls, the interior finishing, etc. can be completed. Thus, when the instant invention is utilized, a building can be completely finished in little more time than is required to construct the frame for the same. Even making the frame is simplified
20 in view of the ability to support the horizontal slabs for one level from the next higher level.

As mentioned at the beginning of the detailed description, Applicant is not limited to the specific embodiments described above. Various changes and modifications can be made. As
25 mentioned previously, the specific embodiments are exemplary, rather than exhaustive. The claims, their equivalents and their equivalent language define the scope of protection.

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rod length change, and a washer is disposed between said engagement surface and said deck formwork assembly, which washer has a generally flat disk which engages said surface during said relative rotation, and channels are provided
5 extending radially of said disk face for distributing lubricant along said face during such relative rotation.

7. The apparatus of claim 5 further including a plurality of places along the length of said roll threaded rod adapted for selectively engaging such rod to provide said rotation.

10 8. The apparatus of claim 1 wherein said support is a slab form support arm attached at said level immediately above said level to be defined, to a generally vertical column of a support network for said slabs so as to impart load from said deck formwork assembly to said column.

15 9. The apparatus of claim 8 wherein the length of roll threaded rod extending between said deck formwork assembly and said support at said level immediately above the slab to be formed is selectively changeable.

10. The apparatus of claim 9 wherein said slab form support
20 arm includes a securance portion for rigidly securing the arm to said column, an elongated upper arm rod extending from said securance portion with an end thereof pivotally secured to said securance portion, a forearm rod pivotally secured to and cantilevered from an opposite end of said upper arm
25 portion, and a hand portion extending from said forearm rod adapted to hold an attachment which interacts with said roll threaded rod to provide said support.

11. The apparatus of claim 1 wherein said support is threaded
30 interiorly thereof and said roll threaded rod is provided with threads which mate with and engage the interior threads of said attachment whereby rotation of said roll threaded rod relative to said attachment results in changing the length

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the construction of such building to provide support through a roll threaded rod for a formwork assembly for another slab of such structure, comprising:

(a) a rod for engaging said attachment in a non-slip manner;

5 and

(b) a bearing plate which is engageable both with said slab and said attachment, the length of said rod extending between said bearing plate and said attachment being reducible whereby a pulling force is applied to said attachment when an effort
10 is made to reduce said length while said bearing plate is engaged with said slab.

18. The apparatus of claim 17 wherein said attachment is threaded interiorly thereof and said rod is provided with threads which mate with and engage the interior threads of
15 said attachment whereby rotation of said roll threaded rod relative to said attachment results in said length reduction.

19. In an arrangement for forming generally horizontally suspended slabs for a multi-level building structure, apparatus for attaching a roll threaded rod at one level for
20 a formwork assembly for a slab to be formed, comprising:

(a) means for securing the same to said roll threaded rod;
and

(b) means for supporting said apparatus at said one level.

20. The apparatus of claim 19 wherein said means for securing
25 said apparatus to said roll threaded rod includes a plurality of threads within the interior of said apparatus matingly engageable with associated threads on the exterior of said roll threaded rod.

21. The apparatus of claim 19 wherein said means for
30 supporting said apparatus includes a shoulder which is adapted to engage a collar at said level.

22. In an arrangement for forming generally horizontally suspended slabs for a multi-level building structure, a washer

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- (b) a support for said deck formwork assembly, positioned at the level of said building structure immediately above the slab to be formed with said deck formwork assembly;
- (c) a roll threaded rod extending between said deck formwork assembly and said support at said level immediately above said slab;
- (d) said support being an attachment for said roll threaded rod embedded in the concrete of the slab defining the floor at said level immediately above the slab to be formed; and
- 10 (e) said attachment being threaded interiorly thereof and said roll threaded rod being provided with threads on the exterior thereof which mate with and engage the interior threads of said attachment whereby rotation of said roll threaded rod relative to said attachment results in a change
- 15 of the length of roll threaded rod extending between said deck formwork assembly and said attachment.

28. The apparatus of claim 27 further including a plurality of places along the length of said roll threaded rod for engaging the same to provide said rotation, and a wheel which

20 engages said roll threaded rod at said places for said rotation.

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