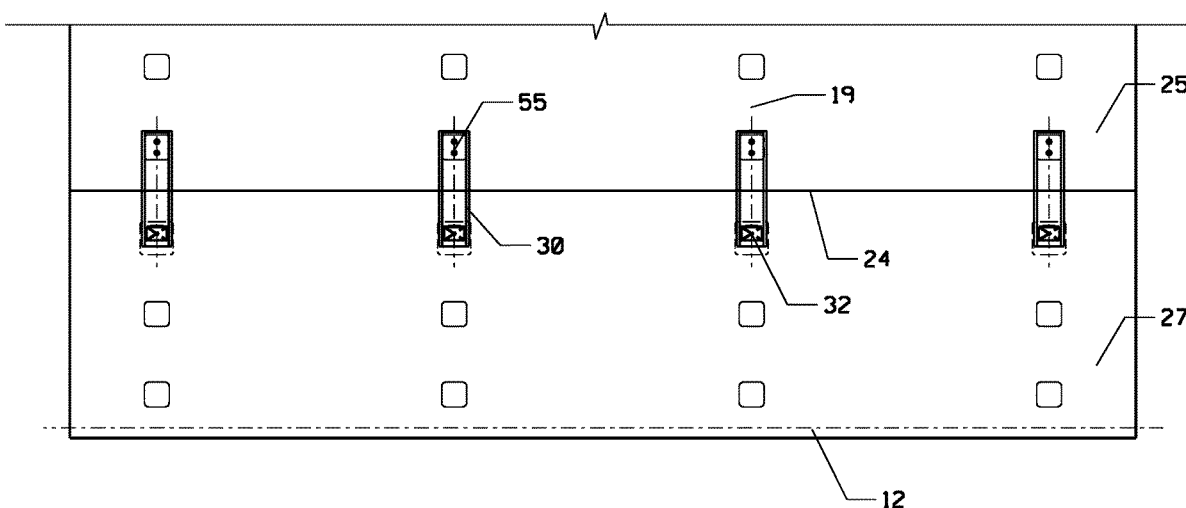




US 20210363711A1

(19) **United States**(12) **Patent Application Publication**
He(10) **Pub. No.: US 2021/0363711 A1**(43) **Pub. Date: Nov. 25, 2021**(54) **JACKING FORCE TRANSFER SYSTEM FOR
BRIDGES WITH PREFABRICATED DECK
UNITS**(52) **U.S. Cl.**CPC *E01D 21/00* (2013.01); *E01D 2/02*
(2013.01); *E01D 19/125* (2013.01)(71) Applicant: **Yidong He**, Bolingbrook, IL (US)(72) Inventor: **Yidong He**, Bolingbrook, IL (US)(21) Appl. No.: **17/325,224**(22) Filed: **May 20, 2021****Related U.S. Application Data**(60) Provisional application No. 62/704,703, filed on May
22, 2020.**Publication Classification**(51) **Int. Cl.***E01D 21/00* (2006.01)*E01D 19/12* (2006.01)(57) **ABSTRACT**

A jacking force transfer method to compress prefabricated deck units and to tension bridge girders. Prefabricated deck units are placed on top of bridge girders. Relative motion between girders and deck units is permitted along the direction of bridge girders while deck units are first installed. Subsequently, an end deck unit is made composite with the girders while jacking brackets are installed on top of the deck unit on the other end of the bridge. Hydraulic jacks react with jacking brackets to introduce a longitudinal compression in prefabricated deck units and, at the same time, a tension in the girders.



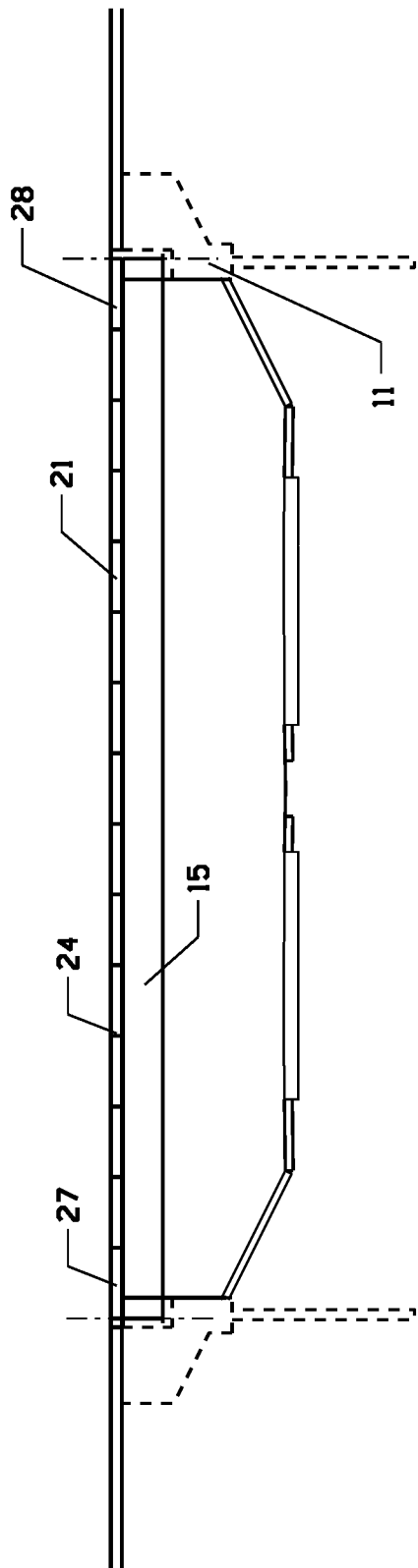


FIG. 1

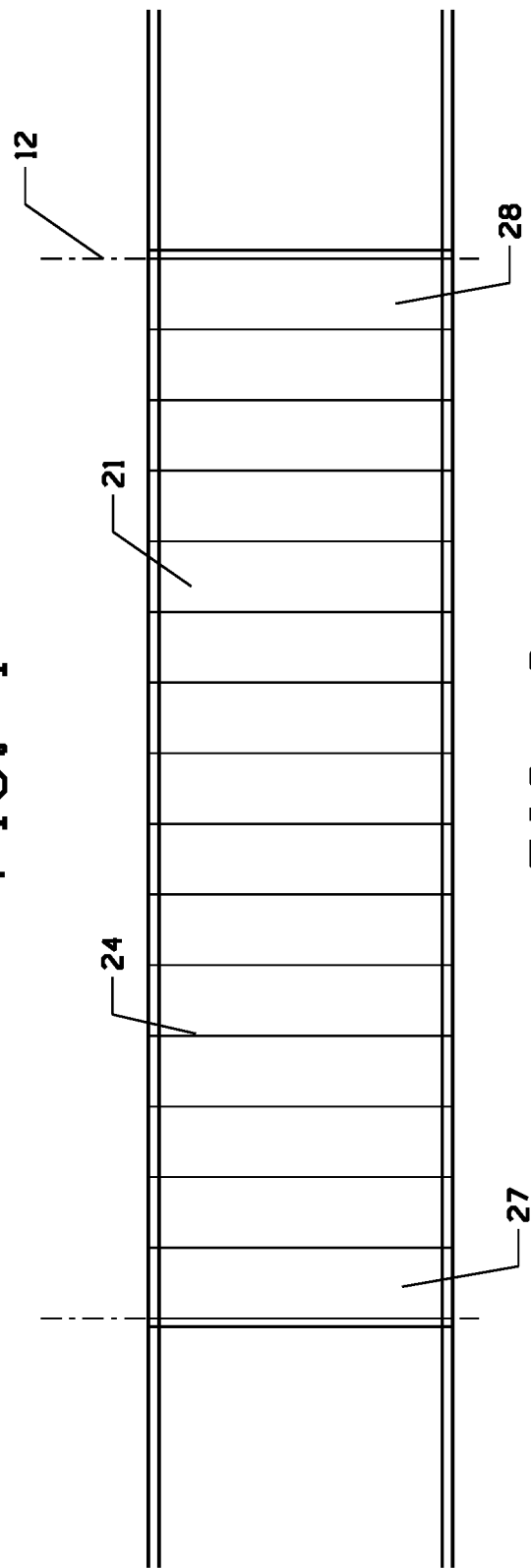


FIG. 2

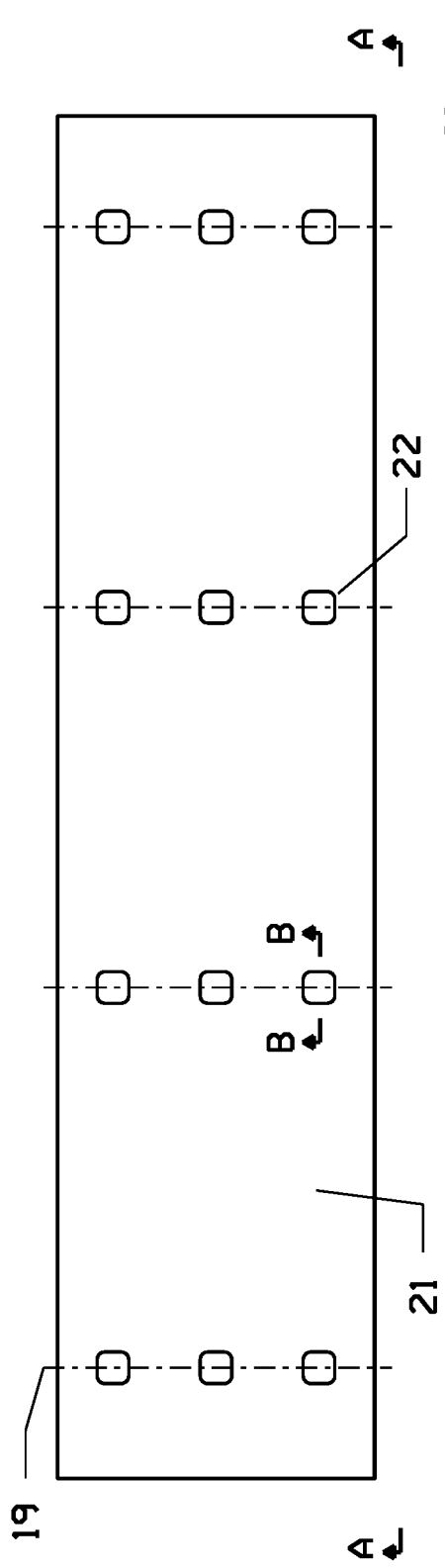


FIG. 3

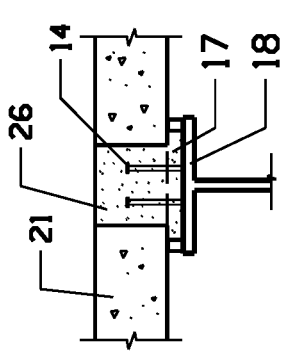


FIG. 3B



FIG. 3A

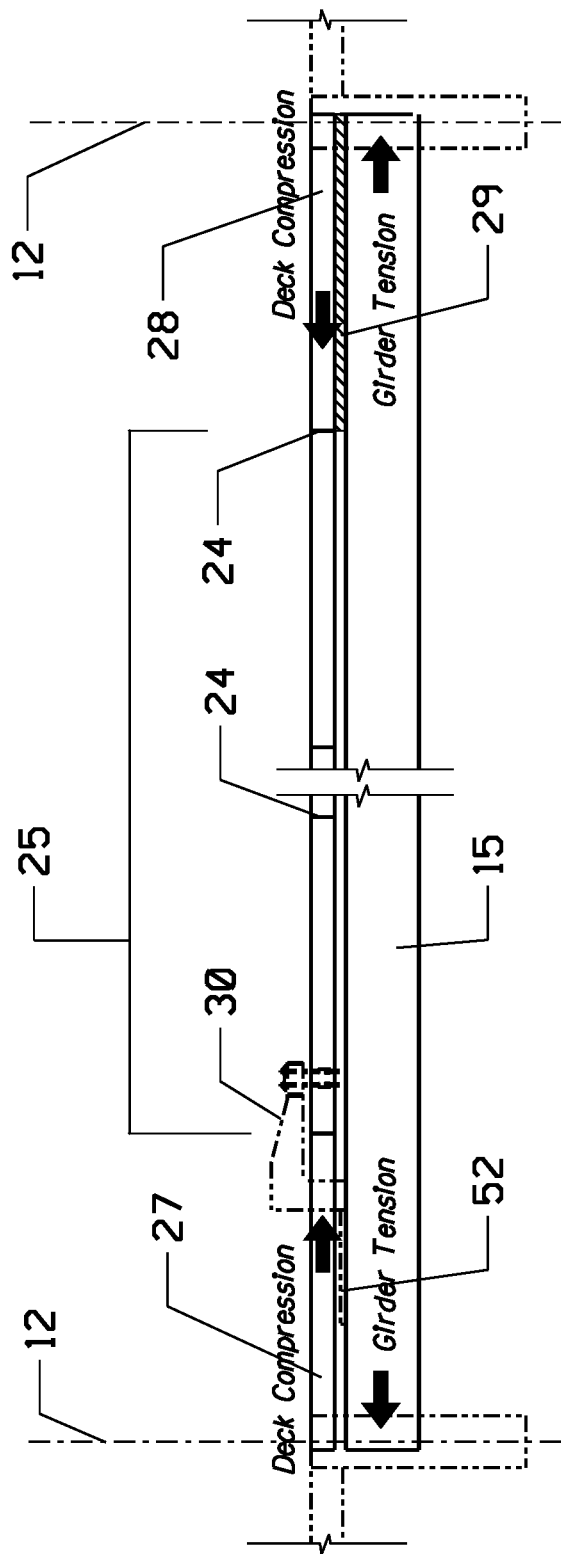


FIG. 4

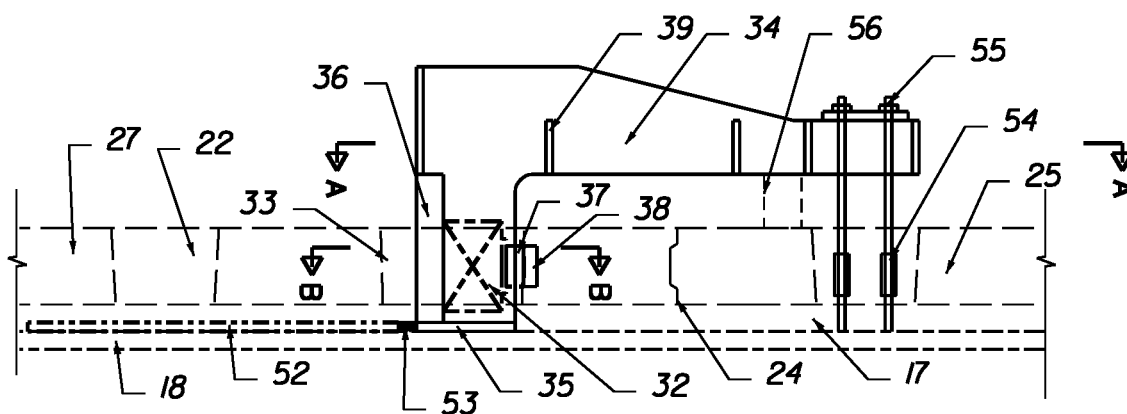


FIG. 6

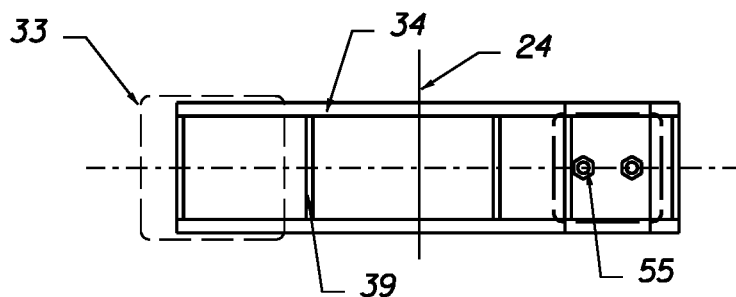


FIG. 6A SECTION A-A

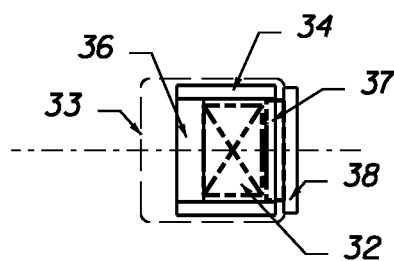


FIG.6B SECTION B-B

JACKING FORCE TRANSFER SYSTEM FOR BRIDGES WITH PREFABRICATED DECK UNITS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/704,703, filed May 22, 2020 by the present inventor.

FEDERALLY SPONSORED RESEARCH

[0002] Not Applicable

SEQUENCE LISTING OR PROGRAM

[0003] Not Applicable

BACKGROUND OF THE INVENTION

Field of Invention

[0004] This invention relates to the construction of bridges with prefabricated deck units.

Prior Art

[0005] For bridges with prefabricated full-depth concrete deck units, it is important to have a pre-compression force in the deck to ensure joint integrity in the service condition. The inventor has proposed several construction methods to apply compression force in prefabricated decks. U.S. Pat. Nos. 8,316,495 B2 and 7,475,446 B1 utilized post-tensioning to apply the needed deck pre-compression force. U.S. Pat. No. 8,266,751B2 proposed three methods to compress deck units with jacks. However, jacking methods presented in U.S. Pat. No. 8,266,751B2 carry some shortcomings, such as the need for extensive modifications to the supporting girder to accommodate the jacking frame attachment; the jacking frame extending outside the bridge deck limits (which can be impossible due to geometric limitations); the need for a large dimension setback of the bridge deck with time consuming cast-in-place deck closure after the jacking operation; or the need for a significant amount of work to remove the jacking frames.

[0006] The current invention provides a jacking force transfer system to further improve bridge construction with prefabricated deck units by minimizing the modification to the supporting girders. This allows all equipment and operations to come within the bridge deck limit; and requires no cast-in-place deck closure after the jacking operation.

Objects and Advantages

[0007] The present invention provides a jacking force transfer method for bridges constructed with prefabricate deck units that:

- Provides pre-compression across joints between deck units by reacting the deck with supporting bridge girders via the proposed jacking bracket;
- Conducts deck stressing on top of installed deck units to improve work safety;
- Operates entirely within the limit of bridge deck;
- Requires minimum modifications to the bridge supporting girder and deck units; and
- Requires no cast-in-place deck closure.

[0008] Further objects and advantages will become apparent from considering the ensuing description and drawings.

SUMMARY

[0009] The present invention proposes practical methods to transfer jacking force to prefabricated bridge deck units using a novel bracket assembly, which simplifies field operation, improves safety and reduces construction schedule.

DRAWINGS

Figures

[0010] FIG. 1 shows the elevation view of an example bridge used to describe the present invention

[0011] FIG. 2 shows the plan view of the example bridge

[0012] FIG. 3 shows the plan view of a typical prefabricated deck unit

[0013] FIG. 3A shows the section view of a deck unit

[0014] FIG. 3B shows the shear connector pocket and haunch detail

[0015] FIG. 4 shows the mechanism to apply deck compression force

[0016] FIG. 5 shows the layout plan of the jacking panel and jacking brackets

[0017] FIG. 6 shows the center section view of the jacking bracket

[0018] FIG. 6A shows top view of the jacking bracket

[0019] FIG. 6B shows section of the jacking bracket at deck level

REFERENCE NUMERALS

- | | | |
|--------|----|---|
| [0020] | 11 | abutment |
| [0021] | 12 | centerline of abutment |
| [0022] | 14 | shear connector |
| [0023] | 15 | girder |
| [0024] | 17 | haunch |
| [0025] | 18 | girder top flange |
| [0026] | 19 | center line of girder |
| [0027] | 21 | prefabricated deck unit |
| [0028] | 22 | pocket for shear connectors |
| [0029] | 23 | shear keys at match cast face |
| [0030] | 24 | joint between deck units |
| [0031] | 25 | typical deck unit |
| [0032] | 27 | deck jacking unit |
| [0033] | 28 | deck end anchor unit |
| [0034] | 29 | advanced grouting of haunch and shear connectors for the deck end anchor unit |
| [0035] | 30 | jacking bracket |
| [0036] | 32 | jack |
| [0037] | 33 | pocket for jacking bracket |
| [0038] | 34 | jacking bracket side plate |
| [0039] | 35 | jacking bracket bottom plate |
| [0040] | 36 | jacking bracket end bearing plate |
| [0041] | 37 | shims for jack |
| [0042] | 38 | bearing plate for deck jacking unit |
| [0043] | 39 | diaphragm for jacking bracket |
| [0044] | 52 | girder reaction plate |
| [0045] | 53 | filler plate for reaction plate |
| [0046] | 54 | hold-down rod coupler |
| [0047] | 55 | hold-down rod and nuts |
| [0048] | 56 | leveling block |

DETAILED DESCRIPTION

FIGS. 1 Through 6—Preferred Embodiment

[0049] A preferred embodiment of the bridge with prefabricated deck units using the present invention of the jacking force transfer system is illustrated in FIGS. 1 through 6 in the context of a single span bridge, hereinafter referred to as an “example bridge”. The example bridge has two abutments 11. The preferred embodiment of the bridge is comprised of steel girders 15 acting as main longitudinal structural members, and prefabricated concrete deck units 21 acting as the bridge deck. A deck unit 21 typically connects to adjacent deck units by match cast epoxy joints 24.

[0050] Girders 15 are placed on and supported by abutments 11. Prefabricated deck units are placed on top of girders 15, seating on a plurality of leveling devices that sets deck units 21 at the desired elevation and also allows for relative longitudinal motion between girders 15 and the prefabricated deck units 21.

[0051] Each prefabricated deck unit 21 consists of a plurality of pockets 22, similar to those used in conventional prefabricated deck placement, as shown in FIG. 3. Pockets 22 are provided to allow for mechanical connection of deck units 21 to girders 15 by means of shear connectors. Haunches 17 will also be grouted at the same time as the shear connector pockets 22. In the preferred embodiment, shear connectors 14 are shear studs welded to the girders 15. **[0052]** FIG. 3B shows the typical connection detail between deck unit and steel girders. The shear connector 14 is located within the pocket opening 22. The haunch height can be adjusted to meet the profile of the bridge. In the completed structure, grout is filled into the haunch 17 and pockets for shear connectors 22 to make deck units 21 composite with the girder 15.

[0053] FIG. 4 shows the overall mechanism of compressing prefabricated deck units in the preferred embodiment. The jacking mechanism consists of the following elements: 1) a jacking bracket 30 placed on the left end of the deck jacking unit 27, 2) a girder reaction plate 52 which is connected to the supporting girder 15 near the left end of the girder, 3) the right end deck unit 28 which is made composite to the supporting girder 15 by grouting the haunch and pockets for shear connectors 22, 4) typical prefabricated deck units 25 between both end units which are supported by girders 15 in the vertical direction and are unrestrained along the girder longitudinal direction, and 5) a jack 32 placed inside the jacking bracket 30.

[0054] Before deck jacking is applied; the right end deck unit 28 must be made composite to the supporting girder 15. At jacking time, the jack 32 is inflated and the jacking action causes compression in the deck and tension in the girder 15.

[0055] FIG. 5 shows the plan view of the deck jacking unit 27 and how the jacking brackets 30 are placed. One jacking bracket 30 and one jack 32 are required for one girder line.

[0056] FIGS. 6-6B show the details of the proposed jacking force transfer method on the jacking end. Girder reaction plate 52, which takes the jacking force from the jacking bracket 30 to the girder 15, shall be installed in advance in the fabrication shop or on-site before deck units are placed. The jacking reaction plate 52 can be attached to the girder with different methods. Typically, it is welded or bolted to the top flange of the steel girder 18. If concrete girders are used for the bridge, girder reaction plates 52 with shear studs can be cast with the girders 15.

[0057] The jacking bracket 30 is the key component of the proposed jacking force transfer method. The jacking bracket 30 performs the following functions: 1) housing the jack 32, 2) transferring the force from the jack 32 to the girder reaction plate 52, and 3) resisting the overturning moment caused by jacking force. The jacking bracket 30 consists of: 1) the jacking bracket end bearing plate 36, which interacts with the jack 32 directly, 2) a pair of jacking bracket side plates 34, which forms the frame to resist the overturning moment, 3) the jacking 180 bracket bottom plate 35, which reinforces the jacking bracket side plates 34 and jacking bracket end bearing plate 36 as they react with the girder reaction plate 52, 4) hold down rods 55 at the end of the jacking bracket side plate 34, which connect to the girder during jacking operation, 5) diaphragms for jacking bracket 39, which connect both jacking bracket side plates 34.

[0058] The jacking bracket 30 is installed inside a deck opening in the deck jacking unit 27. The jacking bracket bottom plate 35 sets on the girder top flange 18. The jacking bracket end bearing plate 36 shall be aligned with the girder reaction plate 52 in both vertical and transverse directions. In order to transfer the jacking force to the girder, the lower end of the jacking bracket end bearing plate 36 shall engage the girder reaction plate 52 tightly along the longitudinal direction of the bridge. Filler plates for the reaction plate 53 may be used to fill the gap between the jacking bracket end bearing plate 36 and the girder reaction plate 52. Dimensions in gaps can vary due to construction tolerance, such as variation in girder position, variation in girder reaction plate placement and variation in deck unit placement. Therefore, filler plates 53 with various lengths, typically in 1/4" increment, are prepared for each project. After the deck jacking unit 27 is installed, the distance between the pocket for jacking brackets 33 and girder reaction plates 52 is measured and a filler plate 53 with appropriate length is installed. The jacking bracket 30 is then placed with the jacking bracket bottom plate 35 tightly against the filler plate 53.

[0059] The front end of the jacking bracket (point toward the middle of the bridge span) seats on the leveling block 56 with appropriate height so that the bottom of the jacking bracket side plate 34 is parallel to the deck. Afterward, hold-down rods and nuts 55 are installed to connect the jacking bracket front end to the girder. Hold-down rods shall be securely connected to the girder and are capable to take tension in vertical direction. Hold-down nuts shall be snugly tightened only so that the jacking bracket 30 can have slight movement relative to the deck jacking unit 27 during jacking. Hold-down rods 55 are used to balance the overturning moment caused by jacking.

[0060] At the jacking time, a jack 32 is placed inside the jacking bracket 30 where the center of the jack 32 aligns with center of the deck unit 27 in the vertical direction. When the jack 32 is inflated, it pushes the jacking bracket end bearing plate 36 on the back end and the bearing plate embedded in the deck jacking unit 38 on the front end. The jacking force acting on the back end is transferred into girder tension via the girder reaction plate 52. The jacking force acting on the deck jacking unit 27 becomes compression across all joints 24 between prefabricated deck units and is balanced by the girder restraint force from deck end anchor unit 28 at the right end of the bridge. The offset between deck compression (at deck center) and girder reaction (at girder reaction plate 52) results in an overturning moment acting on the jacking bracket. Such overturning moment

causes tension in hold-down rods **55** and compression between the jacking bracket **30** and the girder top flange **18**.

[0061] Alternate embodiments for the present invention are described hereinafter:

The bridge layout can be a single span or multiple spans;

The girder **15** can be comprised of any other material or cross-section suitable to support the loads applied to these members such as steel I-girders, precast prestressed concrete beams, composite material I-girders, single or multiple box girders of steel or concrete, trusses, wood beams, etc.:

Though the preferred embodiment of the present invention is presented in the context of bridges, it is not limited to bridge applications. Any structural application requiring decking support by longitudinal structure members can utilize the present invention in alternate embodiments such as building floor systems and building roof systems;

Joints **24** between adjacent prefabricated concrete deck units can be of the match-cast type, with or without epoxy, or cast-in-place using concrete, grout or other suitable jointing materials. In the preferred embodiment, match-cast epoxy joints are used;

The preferred embodiment utilizes grouted haunch **17** and shear connector pockets **22** to restrain relative movement between the deck end anchor unit **28** and the girder **15** before jacking. Such restraint can be provided by other means such as installing steel restraining angles or providing another set of jacking brackets **30** on for deck end anchor units **28**;

The preferred embodiment utilizes grout to make deck units composite with supporting girders **15**. Any other materials such as UHPC or other means such as bolting or welding to prevent the deck unit from moving relatively to the girder can be utilized to form such composite action;

The preferred embodiment places the deck jacking unit **27** on the left end of the bridge and the deck end anchor unit **28** on the right end of the bridge. The reversed arrangement of the deck jacking unit **27** is also valid; and

The preferred embodiment utilizes one jacking bracket **30** per girder line **19**. The deck compression can be applied without having jacking brackets **30** on each girder line **19**.

Operation

[0062] The construction of the preferred embodiment in the context of the example bridge is illustrated hereinafter.

[0063] Abutments **11** are constructed. Girders **15** are erected. Prefabricated deck units **21** are erected, placing one unit adjacent to the previously erected one and applying epoxy to the adjacent faces of the two deck units. Means will be employed to provide a certain amount of compression over the epoxy joint to ensure the joint is properly set. This process is repeated until all deck units **21** are installed.

[0064] The deck end anchor unit **28** is made composite to the supporting girder **15** by grouting the shear connector pocket **22** and haunch **17**. Such composite action is preferably made early since the deck jacking can't be applied before the grout reaches the required strength. After all deck units are erected, jacking brackets **30** are installed. Jacking operations consist of the following steps:

Install a jack **32** inside each jacking bracket **30**;

Shim all jacks **32** tightly against the jacking bracket end bearing plate **36** and bearing plate for the deck jacking unit **38**;

Gradually increase the jacking load to the design value; and
Lock all jacks **32** to maintain the jacking force.

[0065] After the jacking operation, shear connector pockets and haunches are grouted, except those occupied by jacking brackets **30**. After the grout for shear connector and haunch reaches the specified strength, jacks **32** and jacking brackets **30** are released and removed. A secondary grouting will then be conducted to fill in the remaining opening left by the jacking brackets **30**.

[0066] The operational description above is particular to the preferred embodiment of the present invention in the context of a single span bridge heretofore defined. Alternate materials, member shapes, number of spans, means of jacking, means **290** of making composite action between deck and girder, etc. can be used in employing the structural construction system of the present invention.

Advantages

[0067] The present invention provides a practical method to transfer jacking forces to longitudinal compression in the prefabricated deck units when jacking the deck against the supporting girder. This significantly reduces the cost and time of construction required.

CONCLUSION, RAMIFICATIONS, AND SCOPE

[0068] In conclusion, the present invention provides a jacking force transfer method used in combination with prefabricated bridge deck units that is simple to implement. The present invention can accommodate a variety of structural configurations and can be rapidly deployed.

[0069] Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the preferred embodiments of this invention at present. For example, as illustrated and described herein, the present invention can be employed a variety of bridge span layouts, a variety of girder types, and via a variety of means to make composite action between deck and girders.

[0070] Thus, the scope of the invention should be determined by the appended claims and their legal equivalents, rather than by the examples given.

I claim:

1. A jacking force transfer system, whereby a jacking force or forces originating from a jack or jacks may be transferred to compress prefabricated units with support means disposed on an element or elements oriented primarily in the direction of said jacking force or forces, comprising:

- a. a load-carrying member or members,
 - i. wherein said load-carrying member or members are subjected to the jacking force or forces originating from a jack or jacks,
 - ii. wherein said load-carrying member or members have relative movement means disposed with the prefabricated units,
 - iii. wherein said load-carrying member or members are substantively oriented in the direction of the jacking force or forces, whereby said load-carrying member or members are subjected to axial and shear forces and bending moments,
 - iv. wherein said load-carrying member or members have affixment means disposed to the element or elements in a direction oriented primarily perpendicular to the direction of said jacking force or forces,

- v. wherein said load-carrying member or members have contact means disposed to the element or elements in a direction oriented primarily perpendicular to the direction of said jacking force or forces, and
- vi. where said affixment means and said contact means are substantively offset from one another in a direction oriented primarily parallel to the direction of said jacking force or forces, whereby two reactions result that act to stabilize said load-carrying members and act to resist overturning moments resulting from said jacking force or forces, and
- b. a load-carrying member or members,
 - i. wherein said load-carrying member or members have affixment means disposed to the element or elements,
 - ii. wherein said load-carrying member or members have contact means disposed with the load-carrying member or members of claim 1a, and
 - iii. wherein said load-carrying member or members are offset in a direction oriented primarily perpendicular to the direction of said jacking force, whereby said load-carrying member or members are subjected to substantively shear or compression forces.
- 2. The jacking force transfer system claim 1, wherein a unity or a plurality of the prefabricated units are composite with a unity or a plurality of the element or elements, whereby said unity or plurality of the prefabricated units are subjected to the jacking force or forces.
- 3. The jacking force transfer system of claim 1, wherein the element or elements are comprised of any one member or any combination of members selected from the group consisting of steel, concrete, wood, and composite materials.
- 4. The jacking force transfer system of claim 1, wherein the element or elements of claim 1 are comprised of any one member or any combination of members selected from the group consisting of I-girders, I-beams, box-girders, and box-beams.
- 5. The jacking force transfer system of claim 1, wherein the element or elements of claim 1 are comprised of any one member or any combination of members selected from the group consisting of bridge beams, bridge girders, and bridge slabs.
- 6. The jacking force transfer system of claim 1, wherein the element or elements of claim 1 are comprised of any one member or any combination of members selected from the group consisting of the same element or elements, contiguous elements, connected elements, and separate elements.
- 7. The jacking force transfer system of claim 1, wherein the prefabricated units are comprised of any one member or any combination of members selected from the group consisting of steel, concrete, wood, and composite materials.
- 8. The jacking force transfer system of claim 1, wherein the prefabricated units are comprised of any one member or

any combination of members selected from the group consisting of bridge deck panels, budding floor panels, and building roof panels.

9. The jacking force transfer system of claim 1, wherein the support means of claim 1 are comprised of any one member or any combination of members selected from the group consisting of shims, rollers, sliders, spacers, pre-formed filler, blocks, bearing pads, forms, grit, grease, lubricant, direct contact, grout, concrete, and channels.

10. The jacking force transfer system of claim 1, wherein the relative movement means of claim 1a are comprised of any one of any one member or any combination of members selected from the group consisting of physical gap, block-outs, and pre-formed flexible filler.

11. The jacking force transfer system load-carrying member or members of claim 1, wherein the affixment means of claim 1a are comprised of any one member or any combination of members selected from the group consisting of post-tensioning rods, tie rods, pipes, tubes, plates, cables, tendons, chains, nuts, welds, threads, fasteners, hooks, clevis, pins, and couplers.

12. The jacking force transfer system load-carrying member or members of claim 1, wherein the contact means of claim 1a are comprised of any one member or any combination of members selected from the group consisting of shims, plates, blocks, spacers, bearing pads, and direct contact.

13. The jacking force transfer system load-carrying member or members of claim 1, wherein the load-carrying member or members of claim 1a are located substantively to one end of the element or elements.

14. The jacking force transfer system load-carrying member or members of claim 1, wherein the load-carrying member or members of claim 1b are comprised of any one member or any combination of members selected from the group consisting of steel, concrete, wood, and composite materials.

15. The jacking force transfer system load-carrying member or members of claim 1, wherein the load-carrying member or members of claim 1b are comprised of any one member or any combination of members selected from the group consisting of plates, blocks, and channels.

16. The jacking force transfer system of claim 1, wherein the affixment means of claim 1b are comprised of any one of any one member or any combination of members selected from the group consisting of nuts, welds, threads, and fasteners.

17. The jacking force transfer system of claim 1, wherein the contact means of claim 1b are comprised of any one of any one member or any combination of members selected from the group consisting of shims, plates, blocks, spacers, and bearing pads.

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