Original Research Article

Research on Manufacturing and Construction Technology of 50m Steel Box Girder

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Abstract: In the construction of 50m steel box girder of Chengdu Tianfu Airport Expressway, in order to overcome the difficulty of making long steel box girder, China Tieshan Bridge first manufactured the plate unit in the Chengdu base factory, and then assembled the beam section, and transported the large piece for 28km. The steel beam in this project is an I-shaped structure, and each beam section is composed of a bottom plate, a web plate, a top plate, a horizontal connection and a cantilever arm. In the manufacture of beam sections, the actual assembly of each bridge steel plate girder is that each section is pre-assembled on the same tire mold frame, and the assembly iscarried out in sequence from the middle to the two sides, and the size error is controlled by the form of temporary matching between the blocks. And the overall linearity, to ensure the quality.

Keywords: Plate unit manufacturing; Penetration weld; Pre-assembled tire formwork; Beam section assembly.

1. Introduction

Tianfu International Airport is located in the east of Chengdu Longquan Mountain, Jianyang Lujia town, Tianfu Airport Expressway TJ10 profile, the starting point is located in Tianfu New District Xinglong Town Zebra village, the end is located in Baisha town Meijia village, the starting distance: AK2+500, the end distance: AK6+100. The main line length is 3.6km, the width of the roadbed is 34.5m, and the design speed is 120km/h, and the technical standard of two-way six-lane expressway is adopted. The bidding section includes A Branch Line No. 1 Super Bridge, A Branch Line No. 2 bridge, Shuangjian Interchange and interconnecting greening.

In this bid section, there are 4 50m steel box beams crossing Luxi River and Shuangjian Express Road respectively. How to ensure safe and smooth implementation of box girder manufacturing, transportation and lifting is a major difficulty in construction. This paper describes the processing, manufacturing and construction technology of 50m steel box beams.

2. Steel plate beam processing and manufacturing program and process flow

2.1 Typical structural composition of steel beams is shown in Table 1

The steel girder of this project is an I-beam structure, and each girder section consists of bottom plate, web, top plate, cross link and picket arm. The schematic diagram of the steel girder girder section is shown in Figure1.

Table 1 Main structural form of steel girder for each link.

Number	Joint number	Span	Cross section standard structural form	Engineering quantity(t)	Girder depth (mm)	Overcrossing existing structures
1	Left side of A branch line No.1 super large bridge	50m	I-beam	382	2540	Overcrossing the Luxi River
2	Right side of A branch line No.1 super large bridge	50m	I-beam	382	2540	Overcrossing the Luxi River
3	Left side of Bridge No. 2 on Branch A	50m	I-beam	382	2540	Overcrossing Shuangjian roads
4	Right side of Bridge No. 2 on Branch A	50m	I-beam	382	2540	Overcrossing Shuangjian roads

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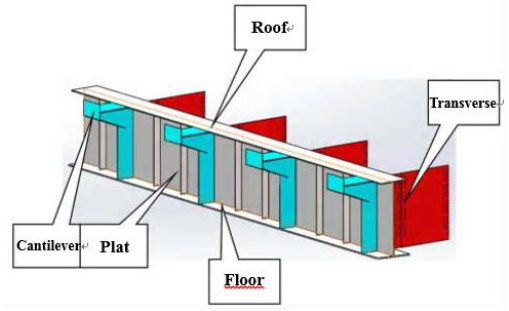

Figure 1 Schematic diagram of steel girder section.

2.2 Steel plate girder plate unit manufacturing program

The butt fusion weld of the top/bottom/web plate of the steel girder of this project is the key force-transferring weld, and its weld construction process needs to be controlled in strict accordance with the standard; the welding quality of the plate unit directly affects the dimensional accuracy of the girder section members and the product qualification.

2.2.1 Board Unit Classification

Considering the structural characteristics of steel plate beam, feeding, transportation, tooling design and mass production and other factors, we try our best to unify the size of plate elements, in order to reduce its types and splicing workload. According to the design drawings, the production workshop has preliminarily divided the plate units for each joint steel plate beam. The main plate units and the forms of the units are shown in Figure 2 to Figure 6.

The process control is standardized, and all the plate units are manufactured in the assembly line according to the type of workshop special mold frame, and the product quality is reliable.

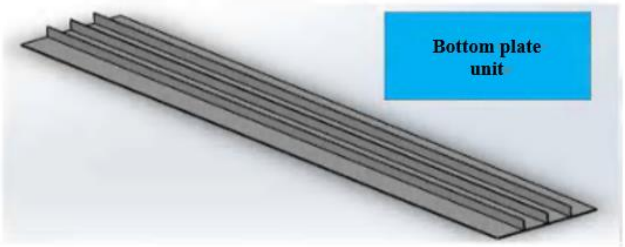

Figure 2 Base Plate Unit Diagram.

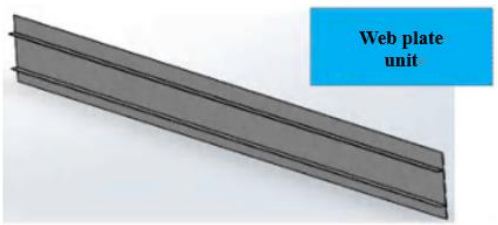

Figure 3 Web Unit.

Figure 4 Cross-partition unit diagram.

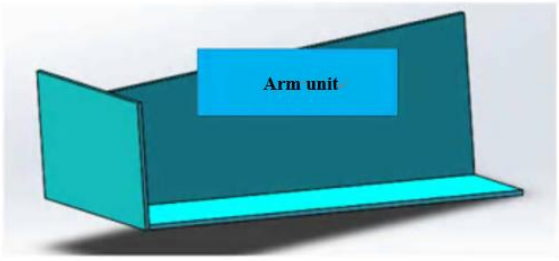

Figure 5 Armature.

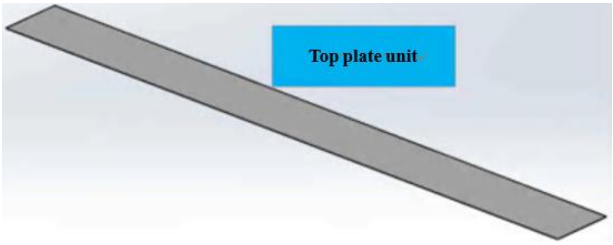

Figure 6 Topside Unit.

2.2.2 Key processes

Control points of board unit manufacturing:

(1) Steel plate leveling and pretreatment;

(2) CNC fine-cutting and undercutting;

(3) Assembling top, bottom and web units by utilizing plate rib unit assembly and positioning frames;

(4) Welding of top, bottom and web units with anti-deformation welding frames for plate ribs;

(5) Adopt anti-deformation welding measures for plate units with longitudinal ribs on one side;

(6) Prioritize automatic and semi-automatic CO_2 welding methods.

2.2.3 Typical board unit manufacturing process

(1) Roof unit, see process Figure 7 to Figure 8.

- Manufacturing process.
- Manufacturing process flow.

(2) Bottom plate, web unit.

- Manufacturing process, see Figure 9.
- Unit manufacturing process flow, see Figure 10.

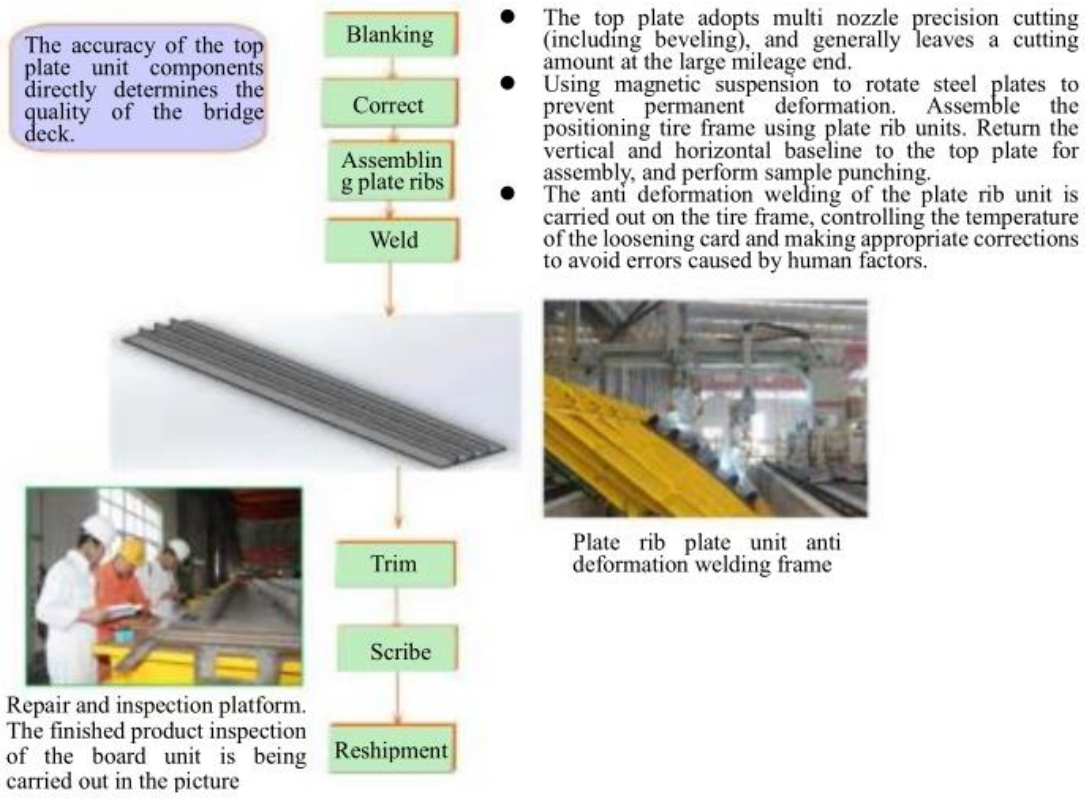

Figure 7 Top plate manufacturing process.

(3) Beam unit, see Figure 11 to Figure 13.

- Manufacturing process.

The beam is an I-shaped section, the upper side is welded with the roof unit, because its two sides are connected to the web, the upper connector plate, and the middle is connected by bolts, so how to ensure its geometric size, the accuracy of the bolt hole spacing, and ensure that the welding deformation is reduced in the section manufacturing is the key to the beam manufacturing. We will draw on the previous manufacturing experience of similar components to optimize the process flow and eliminate the impact of welding and finishing.

- Process flow.

3. Fabrication of plate girder sections

After the plate unit is made, the total assembly of the beam section is carried out in the workshop. According to the structural characteristics of the steel plate girder of the bridge, the construction method of multi-section continuous matching assembly, welding and preassembly is used. There are 24 beam sections in this bidding section. In order to meet the requirements of the construction period, the general assembly line of the beam section is pre-assembled at the same time. This bidding section is divided into 2 batches of processing and manufacturing. After the overall pre-assembly of each bridge is qualified, the beam section number is marked and the painting process is entered. In the manufacture of beam section, the welding of beam section is assembled and welded step by step according to the sequence of bottom plate→web plate→middle top plate→side top plate. The linear shape of the bridge and the allowable size error of steel plate beam members are controlled during assembly.

3.1 Plate two patchwork welding

Before assembling the beam section, two or three small pieces of the top (bottom) plate unit should be welded into one lifting member on a dedicated mold holder. The standard parts with preset welding shrinkage are used to control the distance between the two sides of the weld and the stiffener, and the reverse deformation is preset, so that the size and flatness of the welded plate can meet the design requirements. Due to the above scheme, the number of welds that need to be joined on the total assembly mold frame can be reduced by 50%. In this way, not only can shorten the manufacturing time, but also easy to control the external size of the steel plate beam.

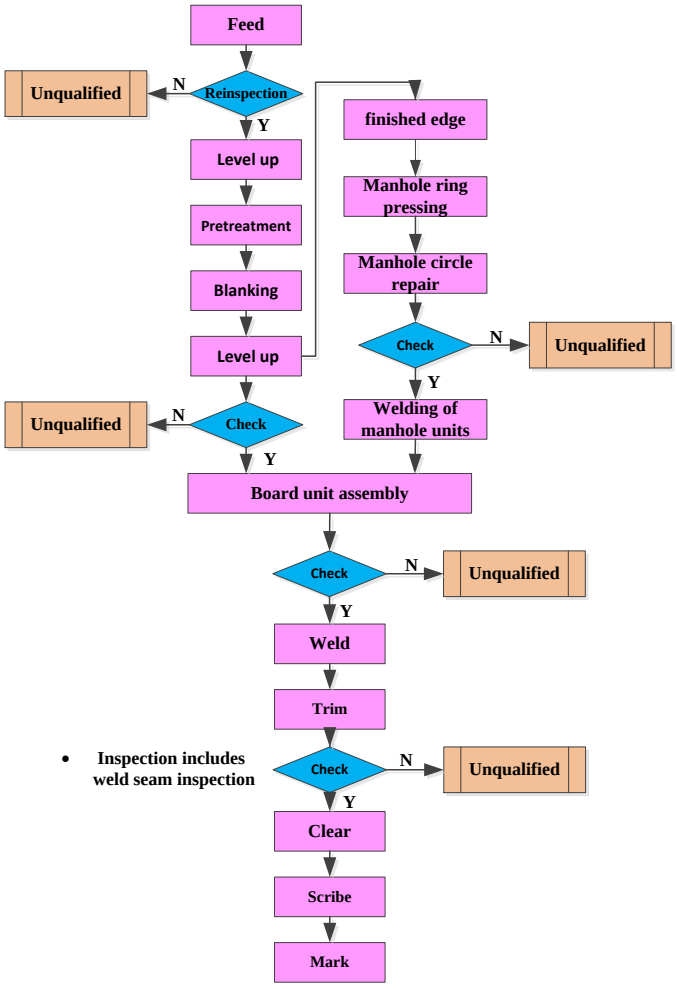

Figure 8 Flowchart of the process of making the top plate.

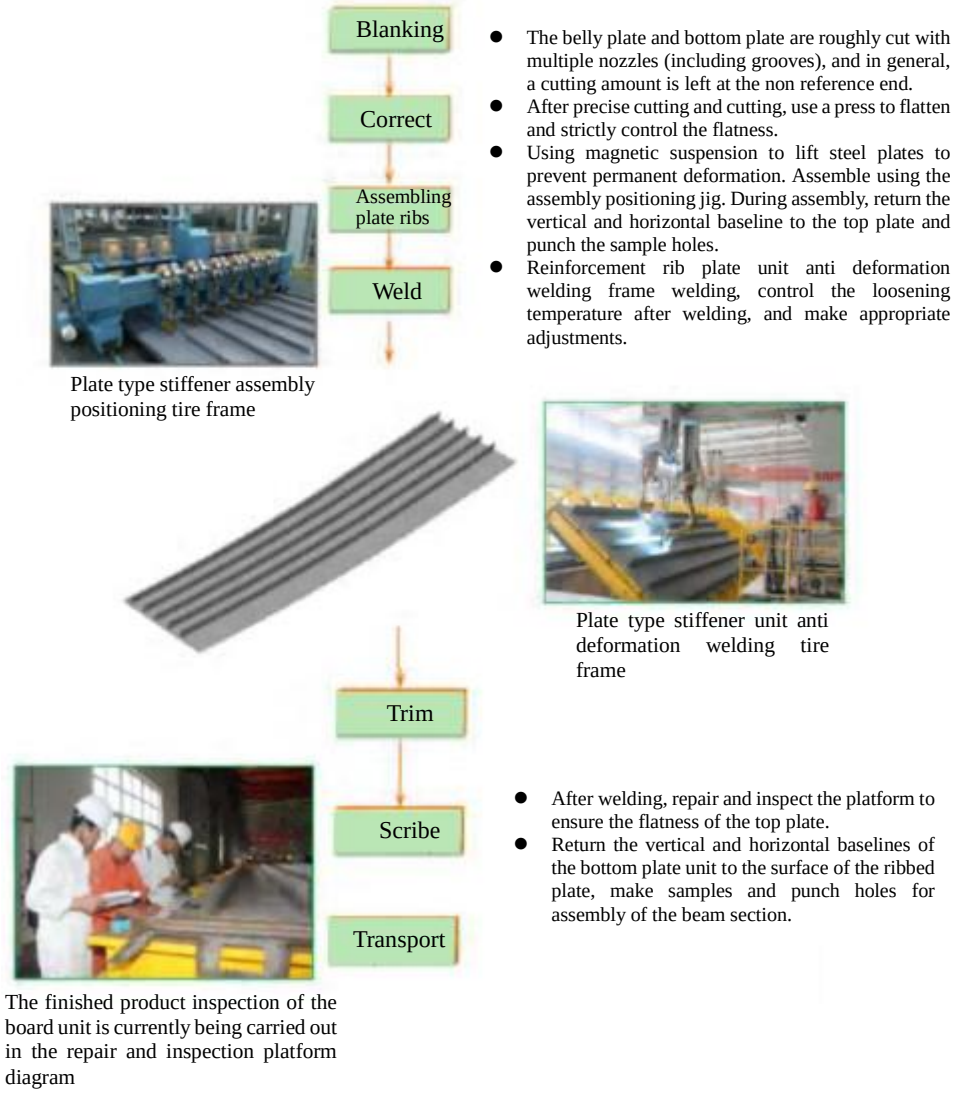

Figure 9 Manufacturing process.

3.2 Key technical measures

(1) The total assembly of the mold frame should meet the requirements of the Technical Specification. The mold frame should have the longitudinal and transverse reference lines, reference points and bridge center lines for locating the bottom plate unit, and special reference lines and reference points are set outside the mold frame to facilitate the retest and correction of the mold frame.

(2) The measurement work of the first plate unit on the tire of each beam segment and manufacturing should avoid the influence of temperature.

(3) Promote the use of ceramic liner single-side welding process.

(4) The selection of reasonable welding steps and anti-deformation, constraints and other technical measures to control welding deformation.

The plate unit is used as the part in the assembly base to implement the continuous adaptive assembly welding and preassembly of multiple beam segments, that is, the welding and preassembly of beam segments are completed once in the mold frame. The assembly adopts the “normal assembly method”, with the tire frame as the outer mold frame and the web as the inner mold frame. Each plate unit is positioned according to the vertical and horizontal baseline, and the reinforcement facilities are used to ensure that the component size meets the requirements. In order to make the butt welds of the beam section staggered, the end welds of the web and

longitudinal ribs are reserved for 200~300mm and are not welded until they are installed on the bridge and welded together with the ring joints. According to the general steps of bottom plate → web plate → top plate, the beam section is assembled and welded step by step.

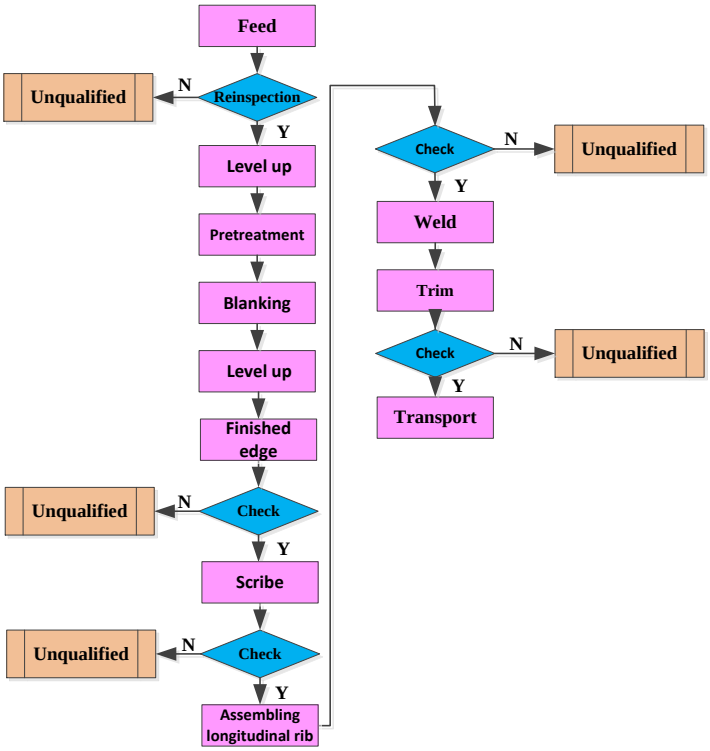

Figure 10 Unit Manufacturing Process.

3.3 Total assembly tire mold frame

The total assembled mold frame shall meet the following requirements:

(1) The elevation of each point of the linear shape on the longitudinal section of the mold frame is set according to the longitudinal slope and pre-arch degree given by the design; The cross section considers the welding deformation and the action of gravity, and sets the appropriate camber.

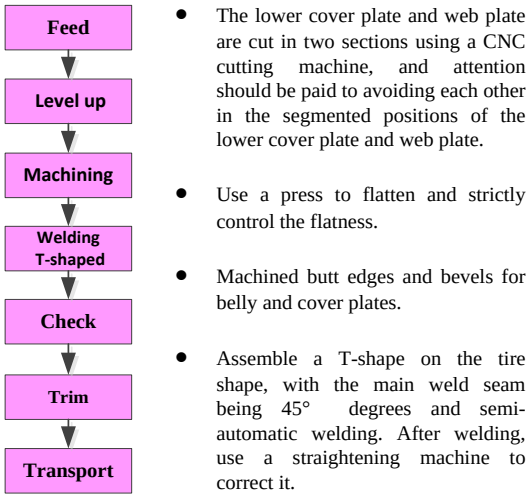

Figure 11 Manufacturing process for crossbeam units.

(2) The bearing capacity of the mold base must meet the requirements to ensure that no settlement occurs during the manufacturing process. The mold frame should have sufficient stiffness, and should not be deformed due to the increase of load during the assembly of the steel plate beam segment, resulting in the deformation of

the steel plate beam segment or the large installation stress of the steel plate beam segment.

(3) In the splicing assembly construction, the position and elevation errors of all installed components should be controlled by the reference points on the mold frame, so that the dimensional accuracy of the steel plate beam segment meets the design requirements.

(4) After each batch of secondary beam section is completed and removed, re-check and test the mold frame, truthfully record the test results, and confirm that the next batch of assembly can be carried out.

The workshop makes the total assembly mold frame, see Figure 14.

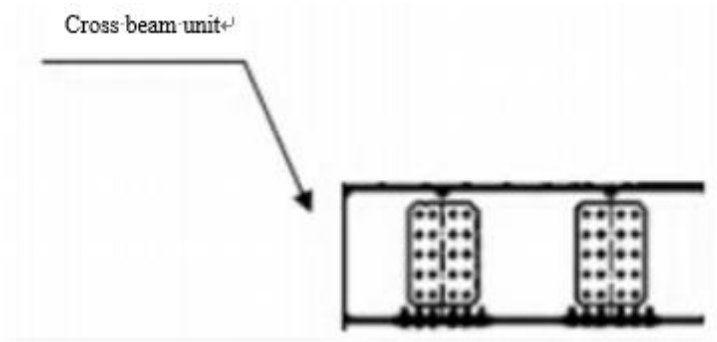

Figure 12 Structural diagram of crossbeam unit.

Figure 14 Assembling the tire mold frame diagram.

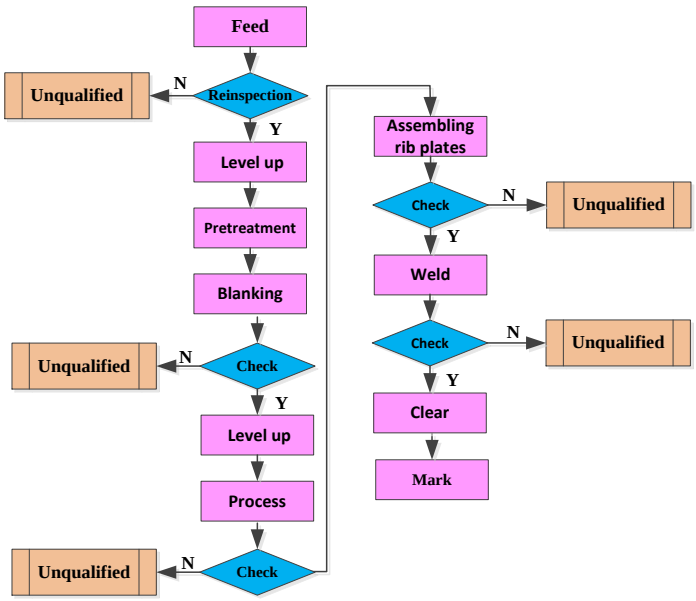

Figure 13 Crossbeam unit manufacturing process.

3.4 Manufacture of beam segments

The actual assembly of each bridge steel plate beam is preassembled on the same frame for all segments, in accordance with the sequence of gradual assembly from the middle to the two sides, and the dimensional accuracy and overall linear shape are controlled by temporary matching between the blocks.

(1) The block line shape is the control point of the whole segment foundation and the theoretical control line of the whole bridge line shape, so the bottom plate is first positioned by welding according to the horizontal and vertical bases. See Figure 15.

(2) Assemble welding web unit.

When the web is assembled and positioned, the position of the web is determined by the reference line of the bottom plate, and the linear alignment of each side web is checked by the total station. See Figure 16 for welding after all assembly.

(3) Assemble welding beam and arm unit. See Figure 17.

When the beam is assembled, pay attention to retest the spacing between the web plates of the two adjacent boxes to ensure the overall size of the beam block after the beam is assembled. When assembling the lifting arm unit, it should be ensured that the longitudinal bridge spacing and end elevation meet the requirements.

(4) Assemble welding roof unit.

In order to shorten the total assembly time and speed up the construction progress, two roof components are piece-welded into one lifting member on the molding frame before the roof components are used to assemble the beam segment.

(5) Assemble welded lifting lugs.

According to the horizontal and vertical baseline, the lifting lug plate assembly line is drawn in three dimensions, and the lifting lug plate unit is assembled and welded.

(6) The length is cut twice, and the welding site temporary matching parts are assembled.

After the beam assembly welding is completed, according to the manufacturing length of the beam section, the top, bottom plate and web non-reference end bevelings are cut. Temporary matching parts on welding site: the matching parts are pre-assembled positioning components between beam segments in the assembly site, which are related to the hoisting positioning accuracy on the bridge on the construction site, and the installation errors of the matching parts need to be controlled. Then disassemble and disassemble the mold frame, painting, shipping site.

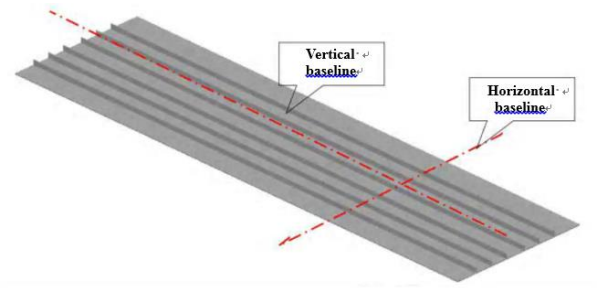

Figure 15 Blockwise Linearity.

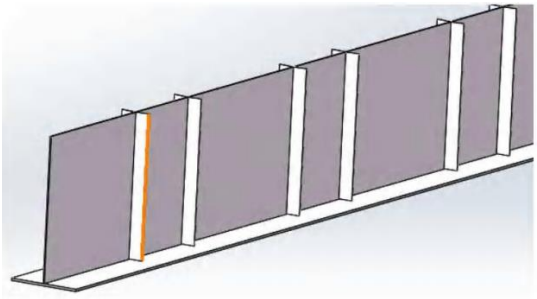

Figure 16 Welded web units.

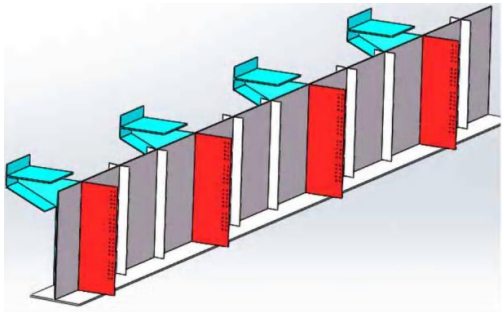

Figure 17 Assembly welding of crossbeam and pick arm units.

4. Conclusion

Assembly and welding should pay attention to the beam section welding, the automatic or semi-automatic CO_2 welding process is preferred, and when welding the top plate, the shrinkage of the transverse joint above and below the web must be precisely reserved, and the height of the steel box girder must be controlled.

Through the above technical measures and process control, the weld quality of the butt penetration weld of the top/bottom/web unit of the steel beam is strictly controlled, and the beam segment manufacturing and assembly of the beam segment are carried out in the sequence of gradual assembly from the middle to both sides. The dimensional error and overall alignment are controlled by temporary matching between the components and blocks, and all pass the test. Effectively ensure the quality of manufacturing and installation of 50m steel box

girder.

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