Discussion on fabrication of Deep Water Gravity Jacket

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Abstract. Deep water gravity jacket is a type of offshore steel structure developed in 1970s. Design depth of the type jacket is in 200m and 100~150m water depth is better. Now some foreign countries have the fabrication experience of the type jacket, however there is none fabrication experience in China. This paper describes how to fabricate deep water gravity jacket especially check of bearing capacity of foundation, panels fabrication of jacket, Buoyancy tanks and Gravity box, dimension control, machine and facility and etc., which fills in gaps of fabrication of deep water gravity jacket.

Introduction

Jacket as a offshore platform for offshore oil and gas exploration generally will be pile foundation type. The type of jacket will be fixed by pile which be penetration to sea bed [1] . The big difference between pile foundation and deep water gravity jacket is that gravity box is designed as gravity jacket foundation and buoyancy tanks is designed on top of jacket to provide buoyancy force. When installation offshore, buoyancy tanks will adjust position of jacket in the sea until putting jacket to the designated location, then fill iron sand into gravity box to fixed jacket. The deep water gravity jacket in this paper is 8 legs jacket. The detail information of jacket shows in the Table 1. And figure 1 shows the 3D model.

Table 1 Detail information of Jacket

Name	Legs	Top dimension(m)	Bottom dimension(m)	Height(m)	Water deep(m)	No. riser	No. Caisson	No. J-tube	Weight (t)
Jacket	8	40×75	66×66.5	114.3	100	10	1	1	27500

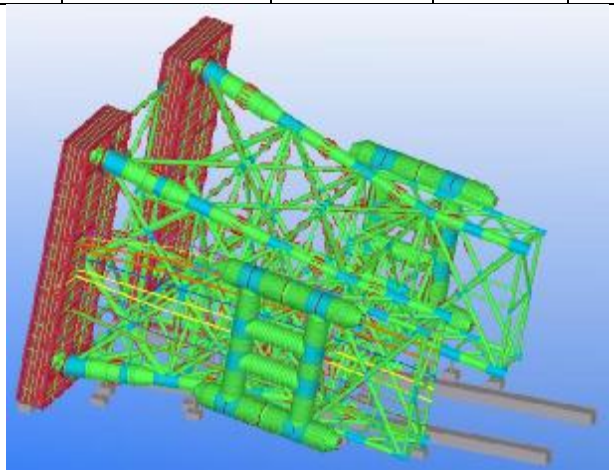

Fig.1 3D model of Deep water gravity jacket

Fabrication yard requirements

The special structure of gravity jacket causes the design weight of jacket is big, so the fabrication yard requirements are very high. According to the load-out and offshore installation information the jacket will be horizontal built. Figure 2 shows layout of jacket on the fabrication yard.

layout of launch cradle

Layout of launch cradle and steel plate for skid way shall meet the requirement of design of launch and skid way. Figure 3 shows the layout of launch cradle. The detail layout requirement as following:

- Ø Layout of steel plate for skid way and connection steel plate and slide block. Welding limited angle steel L100*100*10 inside and outside of skid way.
- Ø Installation of Teflon plate and smear lubricating oil.
- Ø Limited angle steel shall be welding inside and outside of skid way, and the gap between angle steel and timber is 50mm.

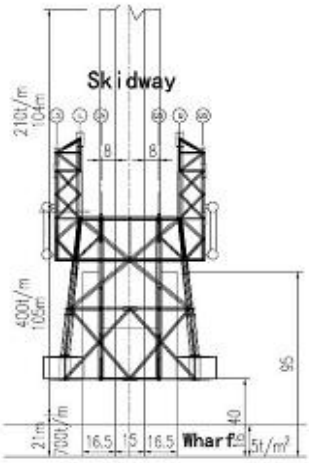

Fig.2 Layout of the Fabrication yard

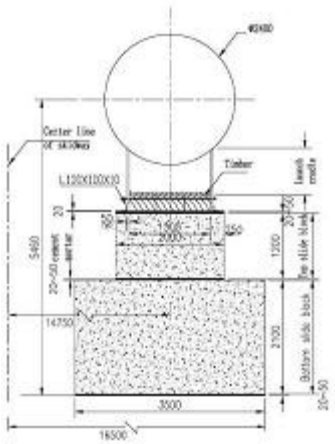

Fig.3 Profile of silde block

Requirements for yard foundation bearing capacity

According to Loadout Structural Analysis Report [2], the joints in Figure 4 are collected as bearing capacity analysis points. And Figure 5 shows effective length for bearing capacity analysis.

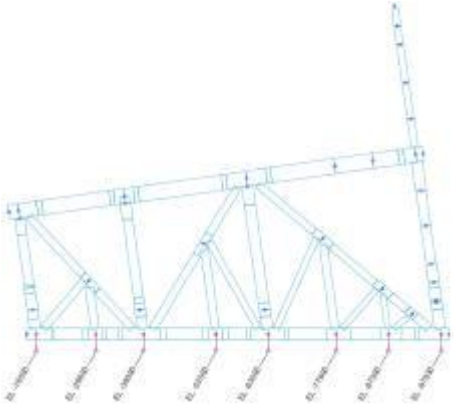

Fig.4 Bearing capacity analysis points

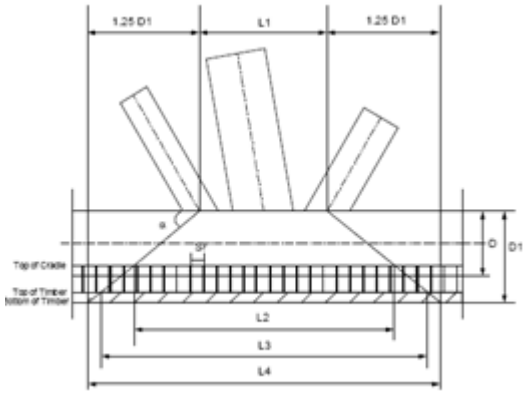

Fig.5 Effective length for bearing capacity analysis

According to support reaction of launch cradle @ Row LN and Row QS in condition of fabrication completion and loadout and the effective length for each joints, this paper use rigid connection analysis method[3] to check bearing capacity. The conclusion as following:

- Ø In condition of fabrication completion, the max. load @ Row LN is 288.34T/m which is at EL(-)16.5m. While the max. load @ Row QS is 334.78T/m which is at EL(-)16.5m. Considering the self-weight of slide block, the Max. load of Row LN and QS is 305.84T/m and 352.28T/m.
- Ø In condition of loadout, the max. load @ Row LN is 313.68T/m which is at EL(-)16.5m. While the max. load @ Row QS is 368.81T/m which is at EL(-)16.5m. Considering the self-weight of slide block, the Max. load of Row LN and QS is 331.18T/m and 386.31T/m.
- Ø The bearing capacity 400T/m of yard can meet the fabrication and loadout requirement.

Fabrication process

Fabrication process of gravity jacket can be separated the following parts:

1) Pre-fabrication of main structure and skid shoes;
2) Assembly on skid way;
3) Pre-fabrication and installation of appurtenance such as riser, J-tube and caisson;
4) Pre-fabrication and installation of buoyancy tanks;
5) Pre-fabrication and installation of gravity box;
6) Final painting and inspection;
7) Testing and commissioning.

Fabrication process

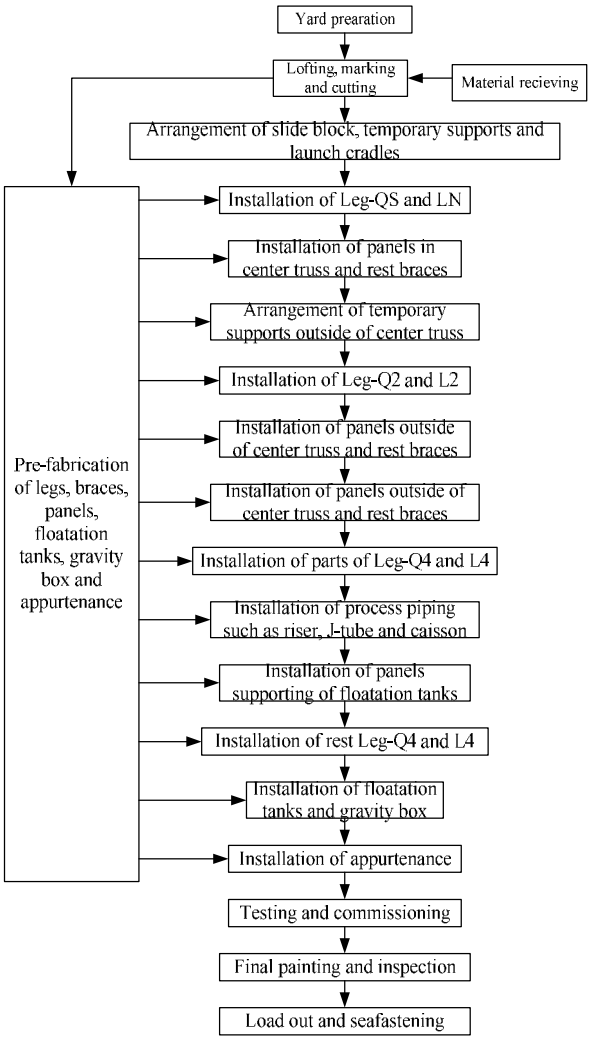

Fig.6 Fabrication process

Description of detail fabrication steps

Pre-fabrication of legs, vertical and horizontal panels

Ø Pre-fabrication of Legs (total 16 pieces)：

4 legs @ Row QS and LN will be separated to 2 pieces;

4 legs @ Row Q2, Q4, L2 and L4 will be separated to 2 pieces;

Ø Pre-fabrication of ring stiffener

Ø Pre-fabrication of vertical panels

2 vertical panels between EL(-)16500 and EL(-)38000 in the center truss;

4 vertical panels between EL(-)38000 and EL(-)63000 in the center truss;

2 vertical panels between EL(-)63000 and EL(-)97500 in the center truss;
2 vertical panels between EL(+)13500 and EL(-)16500 outside of the center truss;
2 vertical panels between EL(-)16500 and EL(-)38000 outside of the center truss;
6 vertical panels between EL(-)38000 and EL(-)63000 outside of the center truss;
4 vertical panels between EL(-)63000 and EL(-)97500 outside of the center truss;
2 vertical panels @ Row QN and LS outside of center truss.

Ø Pre-fabrication of horizontal panels

4 horizontal panels @ EL(-)16500、EL(-)38000、EL(-)63000、EL(-)97500 in the center truss;

4 horizontal panels @ EL(-)16500、EL(-)38000、EL(-)63000、EL(-)97500 outside of the center truss.

Ø Pre-fabrication of temporary structure such as temporary supports and lifting supporting

Pre-fabrication of floatation tanks and gravity box

Ø Pre-fabrication of floatation tanks

Floatation tanks will be separated to 2 parts refer to figure 7.

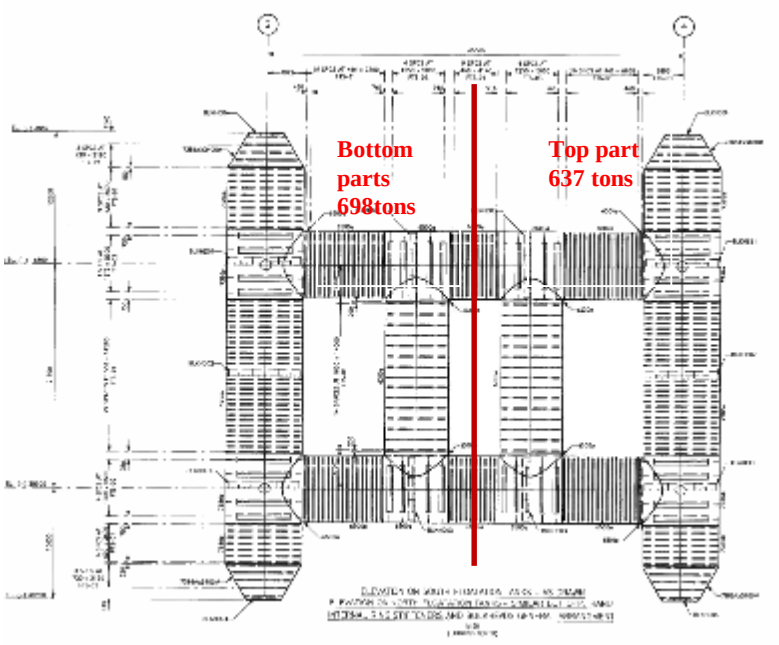

Fig.7 Floatation tank separation

Ø Pre-fabrication of gravity box

Gravity box will be separated to 4 parts refer to figure 8.

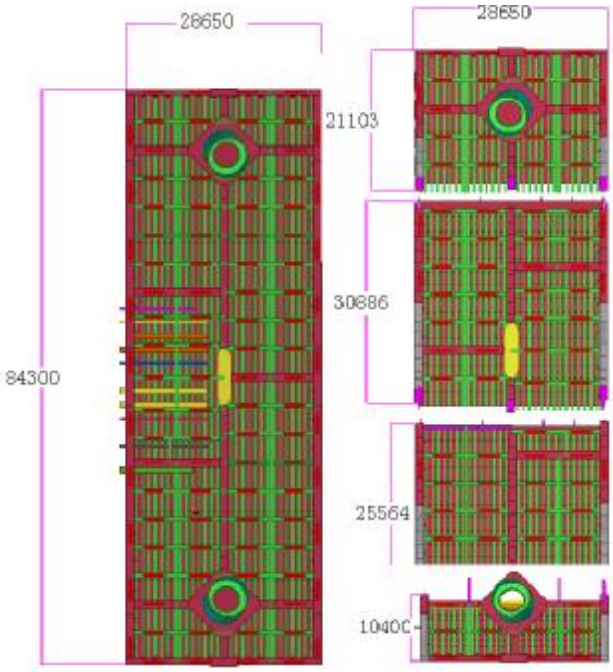

Fig.8 Gravity box separation

Arrangement of temporary supports

Temporary supports will be separated to 3 types which are supports for legs, gravity box and braces. Supports for floatation tanks are the same as supports for legs. Temporary supports will be welded by filled welding and welding foot is 0.7t (t is the thickness of stiffer plate or check plate). Figure 10~12 show the detail design.

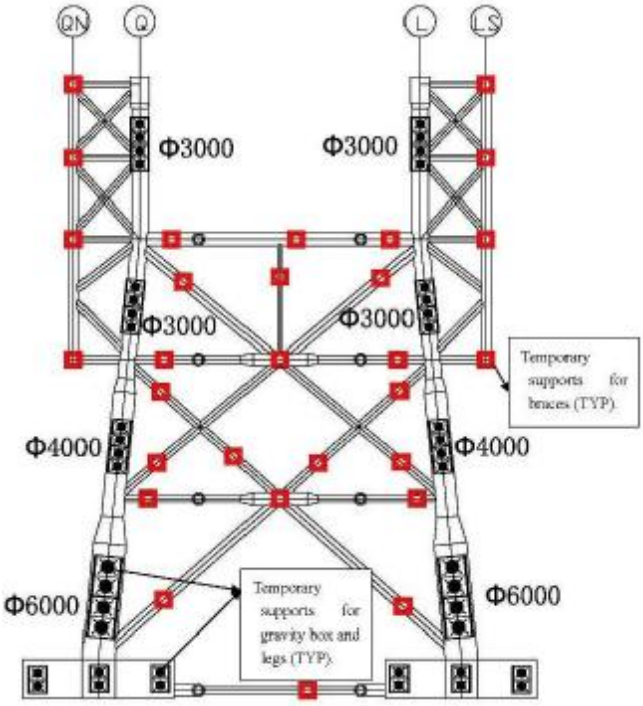

Fig.9 Arrangement for temporary supports

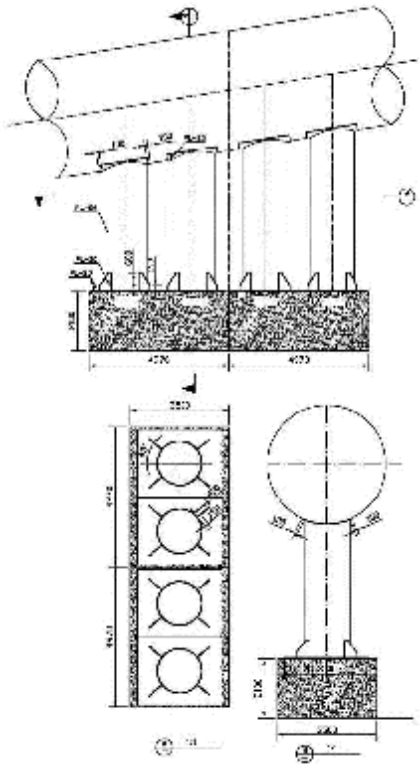

Fig.10 Temporary supports for legs

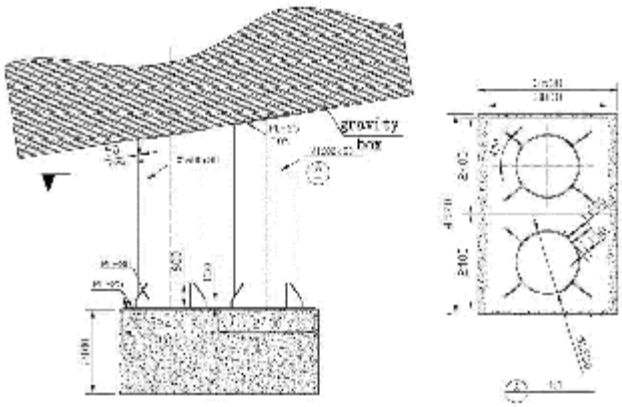

Fig.11 Temporary supports for gravity box

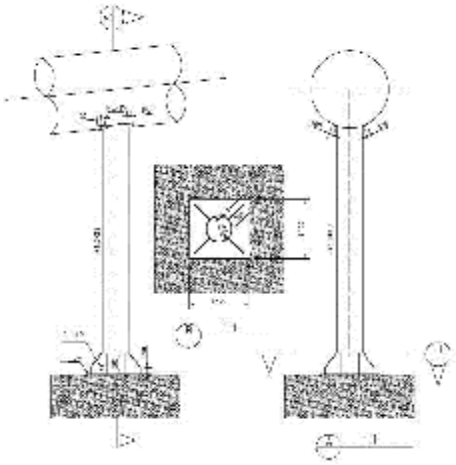

Fig.12 Temporary supports for braces

Assembly on skid way

The assembly sequence of jacket is from top to bottom. Figure 13~ 18 show the sketch of more important steps of jacket assembly.

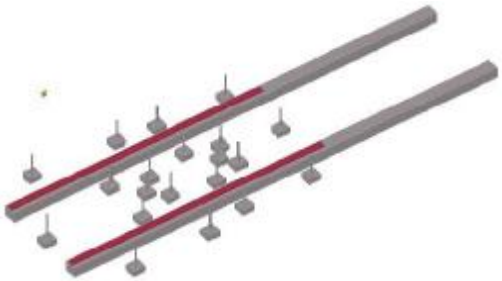

Fig.13 Arrangement of launch cradle and supports

Fig.14 Installation of structure in center truss

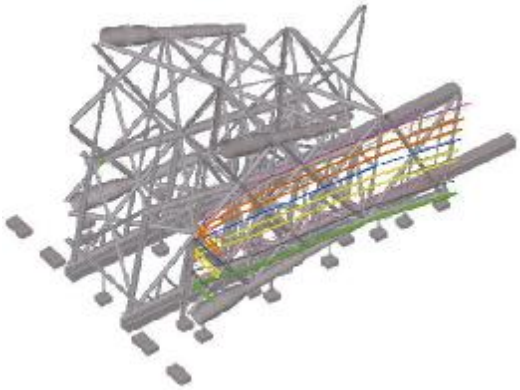

Fig.15 Installation of process piping

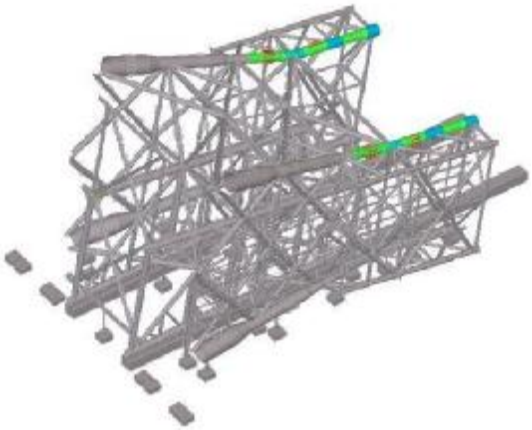

Fig.16 Installation of structure outside of center truss

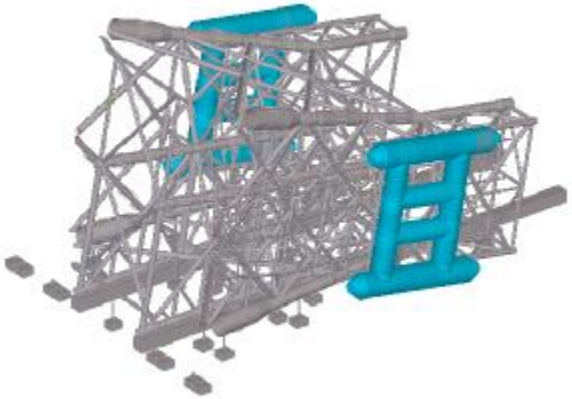

Fig.17 Installation of floatation tanks

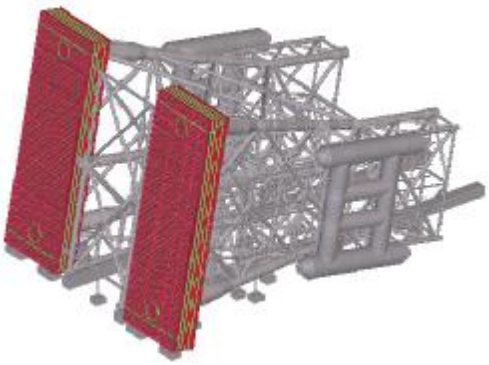

Fig.18 Installation of gravity box

Typical lifting

During assembly lifting and installation is very important especially gravity box. Figure 19 shows the lifting and installation of gravity box. This method can control the structural distortion and use the crane resource sufficiently.

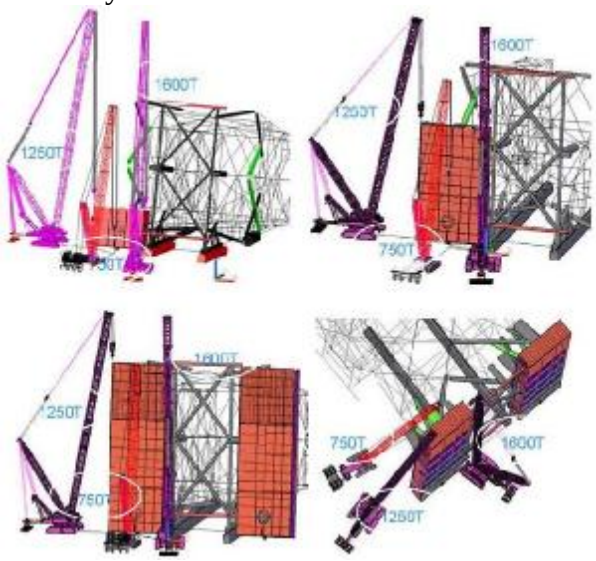

Fig.19 Lifting and installation of gravity box

Dimension control

For meeting the requirement of technical specification, fabrication of jacket will be performed the following technical requirements[4].

Lofting requirement

Table 2 Major lofting requirement

Type	Item	Standard range (mm)	Limited range (mm)	Marking
Cutting line and fit up line	Shape and dimension	±1.0	±2.0	White, clear and legibility
	Straightness	±1.0	±1.5	
	Location dimension	±2.0	±1.0	
Remark: Diagonal tolerance of each plate shall not over 2.0mm.				

Cutting requirement

Table 3 Major cutting requirement

	Item			Standard range (mm)	Limited range (mm)
Cutting accuracy requirement	Cutting by semiautomatic flame cutting machine	Rolling direction		±1.5	±2.5
		Longitudinal		±2	±3
		Diagonal		±2	±3
		Straightness	L≤4m	≤1.0	≤1.2
			4m＜ L≤8m	≤1.2	≤1.5
			L＞8M	≤2.0	≤2.5
	Cutting face	Roughness		0.1	0.2
		Straightness		≤1.5	≤2.5

	Bevel	Groove depth	±1.5	±2.0
		Bevel angle	±2°	±4°

Rolling and splice requirement for tubular

Table 4 Major rolling and splice requirement for tubular

Item		Requirement
Straightness	Any 3000mm	3mm
	Any 12000mm	10mm
	Lengths exceeding 12000mm	12mm
Radial direction deviation	Longitudinal seams	3.2mm
	Circumferential welds	Lessor of 0.2t or 6mm
outside circumferences deviation	Outside diameter≤605mm	±10mm
	Outside diameter＞605mm	±12.7mm
Roundness	The difference between the major and minor inside diameter	6mm

Requirement of assembly

Launch rail

The dimensional tolerance of launch rail centre lines shall be within ± 20 mm (3/4 in) of the theoretical position
and shall also be within ± 6 mm (1/4 in) of its reference elevation. The variation in elevation between any two
points on a launch rail shall not exceed 3 mm (1/8 in) within any 3 m (10 ft).

Global horizontal tolerances

The global tolerances for leg spacing at plan bracing levels are detailed below:
a) The horizontal centre to centre distance between adjacent legs at the top of a structure where a deck or other structure is to be placed (stab-in nodes) shall be within 10 mm (3/8 in) of the design values;
b) The horizontal centre-to-centre distance between legs at other locations shall be within 20 mm (3/4 in) of the design values;
c) The horizontal centre-to-centre diagonal distances between legs at the top of a structure where a deck or other structure is to be placed (stab-in nodes) shall be within 10 mm (3/8 in) of the design values;
d) The horizontal centre-to-centre diagonal distance between legs at other locations shall be within 20 mm (3/4 in) of the design values.

Global vertical tolerances

The global tolerances for vertical levels of plan bracing are as detailed as follows:
a) The elevation of plan bracing levels shall be within 13 mm (1/2 in) of the design values;
b) The vertical level of braces within a horizontal plane shall be within 13 mm (1/2 in) of the design values;
c) The vertical distance between plan bracing elevations shall be within 13 mm (1/2 in) of the design values.

Other requirements

Any other requirements herein not description shall refer to ISO 19902 2007.

Major equipment and facility and auxiliary materials

Major equipment and facility: crawler crane, winch, trailer, jack, wirerope and etc.

Major crane as following：

Table 5 Major cranes

Item	Name	Capacity	Quantity	Remark
1	Manitowoc 16000	400T	2	
2	Liebherr 1400	400T	2	With counterweight
3	Manitowoc 18000	750T	2	With counterweight
4	DEMAG CC8800	1250T	1	With counterweight

Auxiliary materials

Auxiliary materials for temporary support

Table 6 Auxiliary materials for temporary support

Item	Name	Specification(mm)	Material	Quantity	Gross Wegiht(t)	Remark
1	Plate	PL 50 X 3000 X 11000	GB 712-2000 D36	28	362.670	
2	Plate	PL 32 X 3000 X 12000	GB 712-2000 D36	8	72.346	
3	Plate	PL 25 X 3000 X 12000	GB 712-2000 D36	110	777.150	
4	Plate	PL 28 X 2500 X 12000	GB 712-2000 D36	12	79.128	
5	Plate	PL 20 X 3000 X 12000	GB 712-2000 D36	25	141.300	
			sum	183	1432.594	

Auxiliary materials for scaffolding

Table 7 Auxiliary materials for scaffolding

Item	Name	Specification(mm)	Material	Quantity	Gross Weight(t)	Remark
1	Plate	PL 25 X 3000 X X 9000	GB712-2000 D36	8	42.390	
3	H-steel	H 200 X 200 X 8 X 12 X 12000	GB/T 700-1988 Q235B	300	175.428	
5	Rod	Φ 25 X X X 12000	HRB400	8	0.370	
			sum	316	218.188	

Auxiliary materials for lifing

Table 8 Auxiliary materials for lifting

Item	Name	Specification(mm)	Material	Quantity	Gross Weight(	Remark
1	Plate	PL 25 X 2500 X 9000	GB712-2000 D36	180	794.813	Check plate and Rolled plate
2	Plate	PL 32 X 2500 X 9000	GB/T 700-1988 Q235B	20	113.040	Check plate and Rolled plate
3	Tubular	Φ 325 X 16 X 11000	GB/T 8162-1999 20#	120	159.720	Supports for brace
4	Tubular	Φ 273 X 25 X 12000	GB/T 8162-1999 20#	25	46.500	Supports for brace
5	Tubular	Φ 356 X 20 X 12000	GB/T 8162-1999 20#	100	198.000	Supports for brace
			sum	445	1312.073	

Gauging for Risers

Table 9 Gauging for Risers

Item	Name	Specification	Quantity
1	buckle detector	QQP-8"	1
2	buckle detector	QQP-10"	2
3	buckle detector	QQP-14"	1
4	buckle detector	QQP-20"	1
5	buckle detector	QQP-28"	4
6	buckle detector	QQP-42"	1
7	gauging plate	8"	2
8	gauging plate	10"	4
9	gauging plate	14"	2
10	gauging plate	20"	2
11	gauging plate	28"	8
12	gauging plate	42"	2

Conclusions

This paper describes fabrication process of deep water gravity jacket, checking bearing capacity of foundation, arrangement of temporary supports, dimension control, fabrication of floatation tanks and gravity box and equipment, facility and auxiliary materials involved in the construction which can provide good fabrication experience and reference of this type or similar jacket.

References

[1] Zhang Wanpeng: Installation and attention Problems of Petrol Pipe-Platform on the Sea.China Offshore Platform Vol.23 No.4 Aug, 2008

[2] Jacket loadout structural analysis report JC6640RS10001008 Rev.0 Dec. 2011.

[3] Code for design of building foundation GB 50007-2001.

[4] Petroleum and natural gas industries-Fixed steel offshore structures ISO19902 2007