



 <p>The investment and business development arm of National Oil and Gas Authority (NOGA)</p>	 <p>One of the world's largest independent owners and operators of LNG carriers</p>	 <p>Samsung C&amp;T Corporation is the parent company of Samsung Group</p>	 <p>GCC equally owned by the six member states of the Gulf Cooperation Council</p>
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# Bahrain LNG Import Terminal

By: Julien Aknin

Date: 23<sup>rd</sup> Sept 2020

Taken, January 2018



- Jetty Construction
  - i) Substructure
  - ii) Topsides
  
- Regas Jacket
  - i) Fabrication
  - ii) Installation

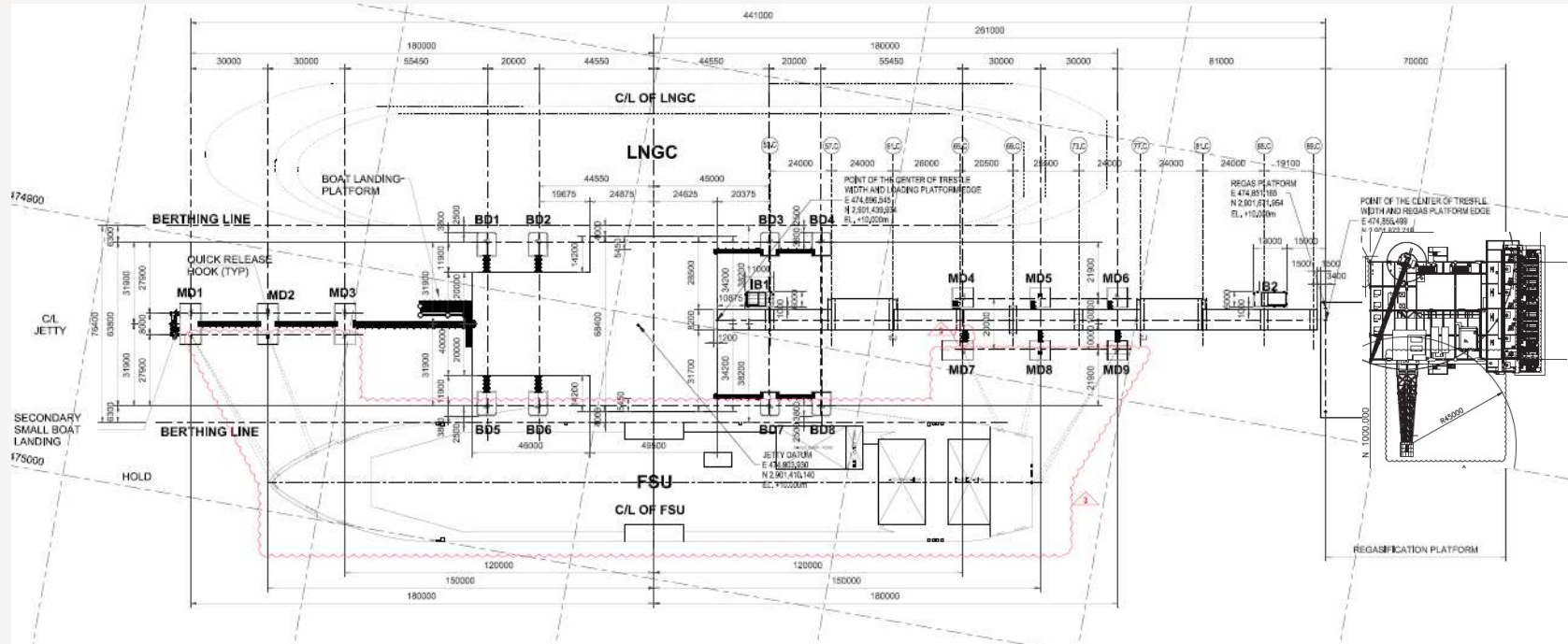


## OFFSHORE JETTY



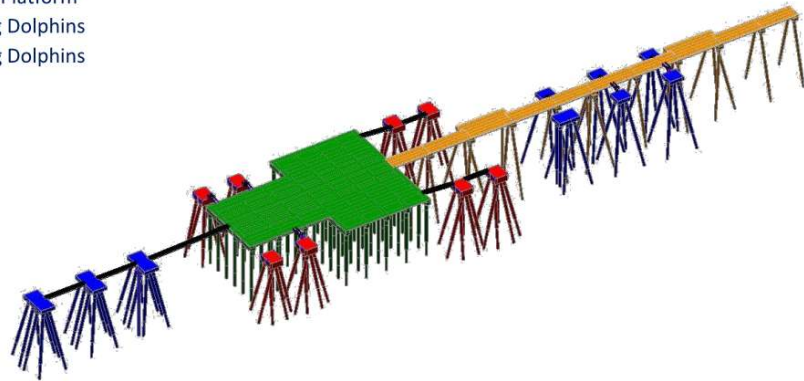
- Step 1 – LNGC delivers LNG to Bahrain.
- Step 2 – LNG is stored in a Floating Storage Unit (FSU).
- Step 3 – LNG is turned back into Natural Gas in a Regasification Module.
- Natural Gas is sent by buried undersea pipeline to shore.
- Natural Gas transferred via a buried onshore pipeline to the tie-in point with BAPCO grid at HMS.

# Jetty Overall Plot Plan



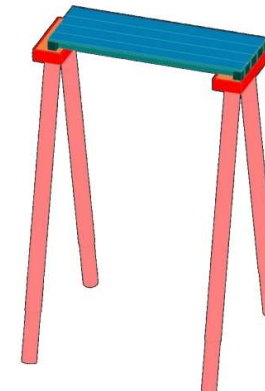
- Piling (215 piles) – LP, AT, 9MD, 8BD, SBL, SSBL, IB.
- CH, PT & RC beams installation.
- In-situ concreting.
- Topsides installation on AT & LP (PRM, stick-built).
- 5 | • Jacket & RGP Topsides.

- Access Trestle
- Loading Platform
- Berthing Dolphins
- Mooring Dolphins



### Typical Vertical Sequence

#### Access trestle

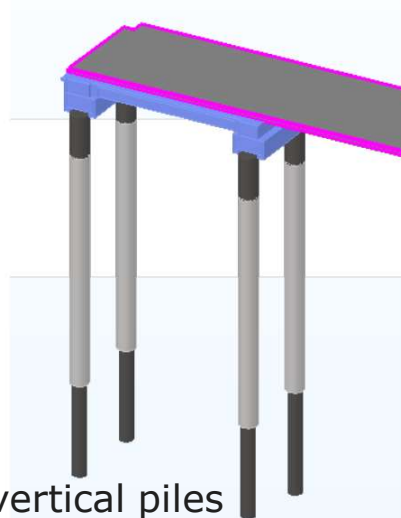


1. Pile Driving
2. Pile Drilling
3. Socket
4. Crosshead
5. In-situ Concrete
6. Installation bearings
7. Installation PT-Beams
8. Top slab

### Typical Vertical Sequence

#### Loading Platform

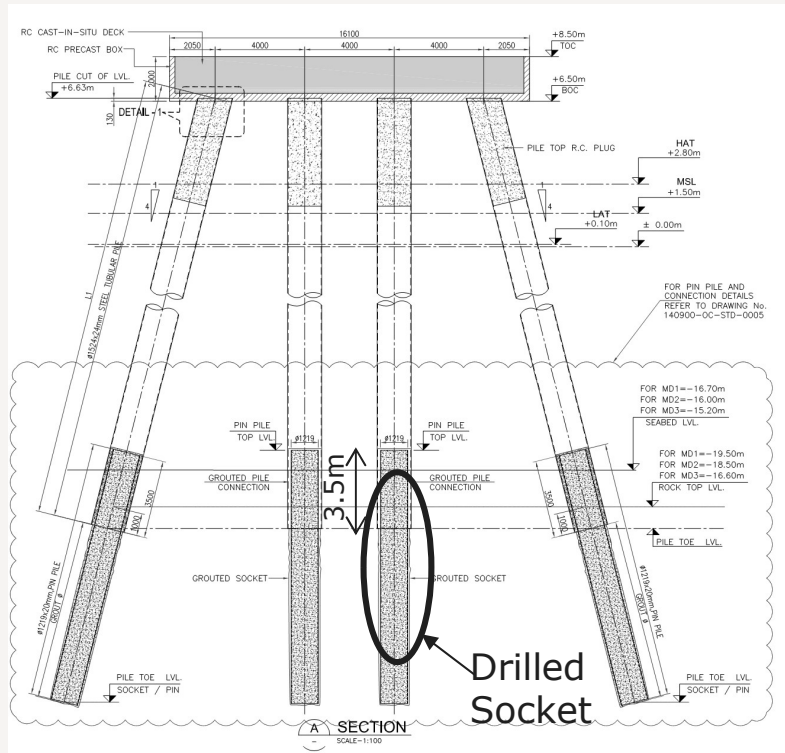
1. Pile A-5
2. Pile B-5
3. Pile B-6
4. Pile A-6
5. Crossheads
6. In-Situ Concrete Pile Plugs & Crossheads
7. T-Beams
8. Diaphragm Concrete
9. Top Slab



- Loading Platform: 68 vertical piles

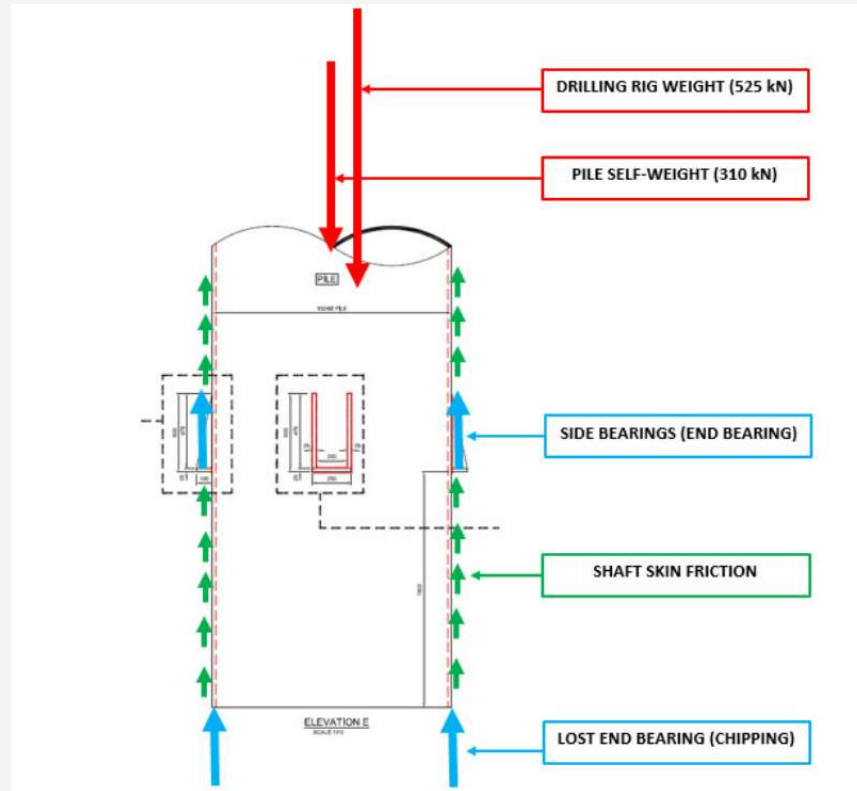
- AT: 28 piles (majority raked piles).

# PILING (outer & pin pile)

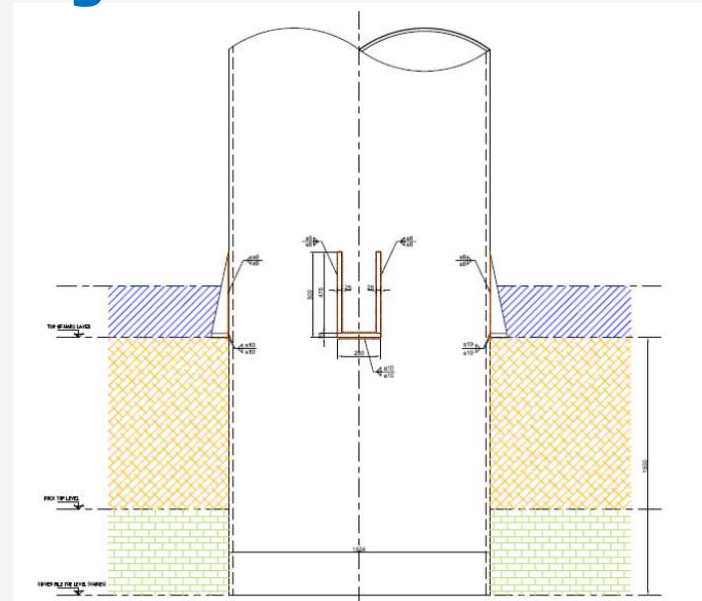


- Piles consist of a driven steel pipe  $\text{Ø}1524\text{mm}$  (24mm) and  $\text{Ø}1219\text{mm}$  (22mm) pin pile inserted in drilled socket,  $\text{Ø}1400\text{mm}$  and  $\text{Ø}1100\text{mm}$ .
- Load is taken by the shaft resistance (skin friction) in the drilled socket alone. End bearing is disregarded.
- Pile Installation sequence:  
Drive outer pipe → Drill the socket → Insert the inner pile → Grout the pile → Pile cut-off.
- Pile test campaign: driven piles may not provide adequate axial resistance to carry temporary loads (i.e. pile self weight & drilling equipment).
- Sinking of driven piles (low side friction and loss of end bearing).

# Side Bearings



Side bearings sit on relatively hard soil /rock and resist vertical movement of pile induced by weight of RCD rig and pile itself.



Type 1 : rest on top of calcarenite. SB @1.5m above pile tip.

- Use side bearings to create additional resistance & prevent uncontrolled sinking of driven piles during drilling of pile socket (3 types).
- Type 1: 4 side bearings designed to rest on top of unit 4c (calcarenite strong layer) but not encountered everywhere at site.
- Type 2: 8 side bearings designed to rest on top of weathered bedrock weaker than calcarenite and so more numerous. Larger side bearings.



Side bearings (outer pile)



Type 2

10:43 22/JUN/2017

Pile Drilling



## Piling



Hydro hammer Pile driving



RCD platform



- Piling guide positioning
- Upending of piles
- Positioning into the piling frame
- Pile driving with hydro hammer S120/S150
  - > driving to design toe level.
  - > driving to blow count.

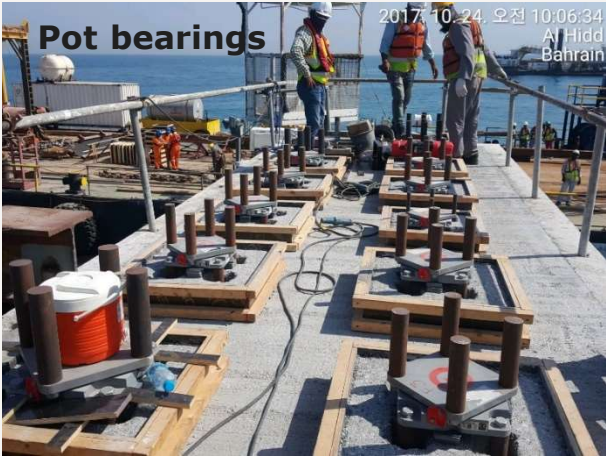
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# Jetty construction (AT)



**AT Cross heads**

**Stages 1 & 2 in-situ concreting**

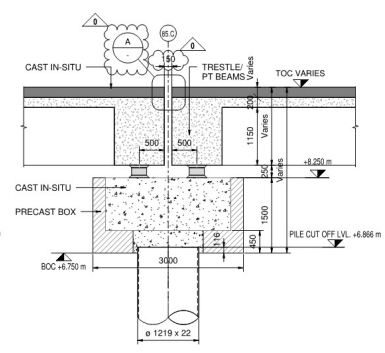


**Pot bearings**

**Stages 3 & 4 in-situ concreting**



**PT beams installation**



**Stages 5 & 6 in-situ concreting**

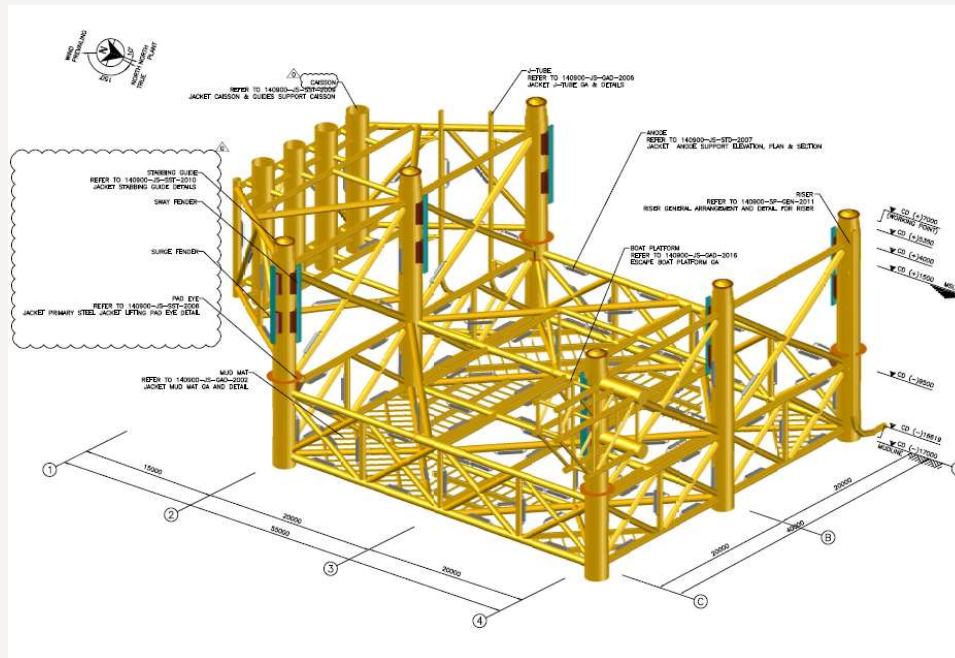


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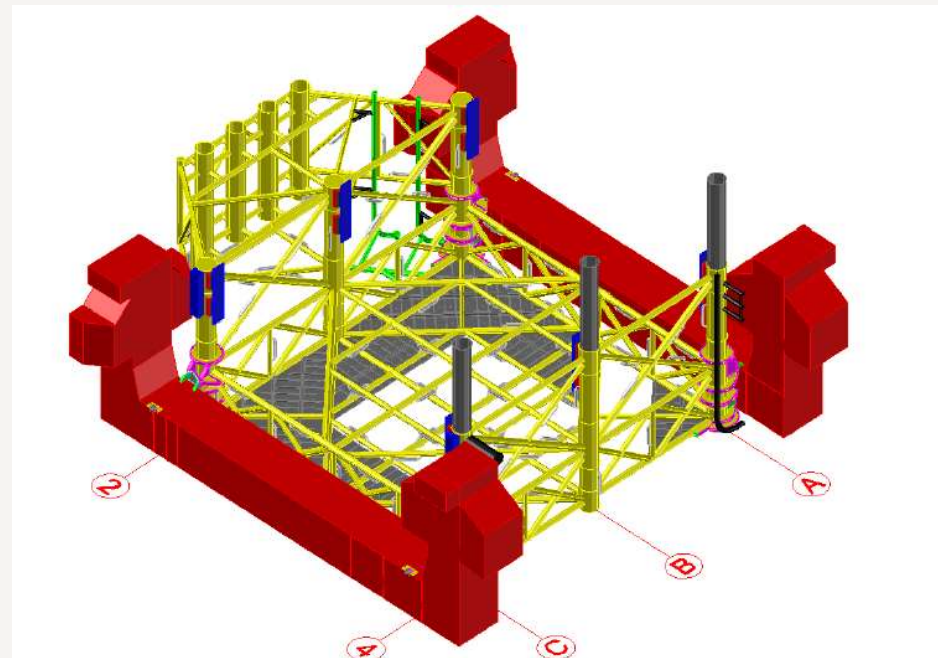
# Jetty construction (Topsides)



# Regas Jacket & Buoyancy Tanks



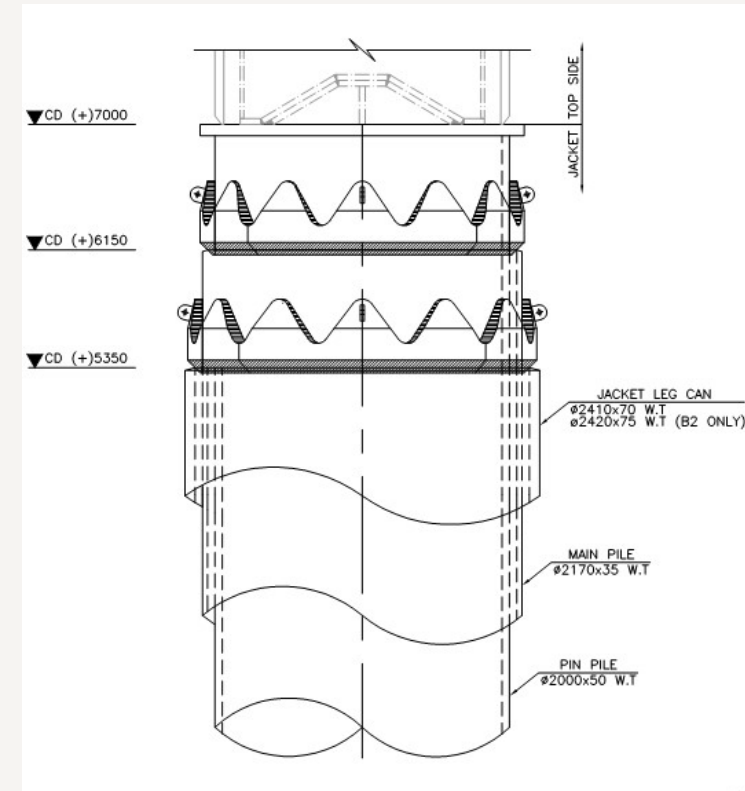
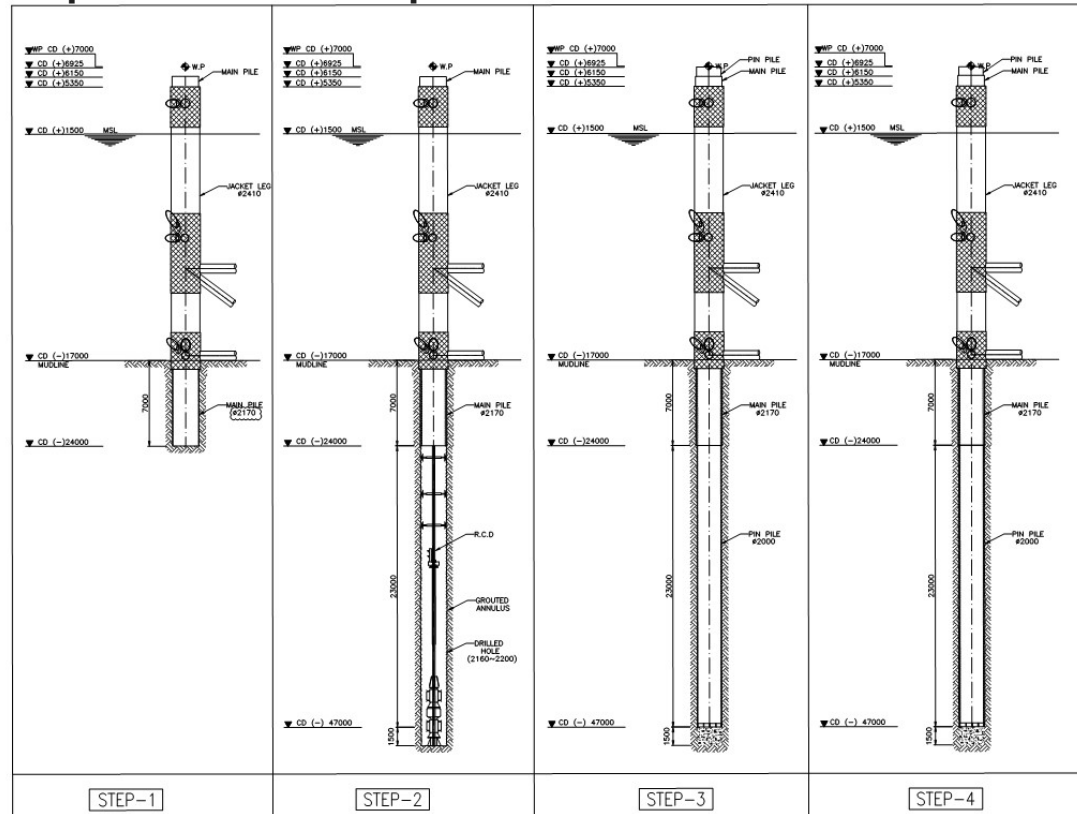
3D Regas Jacket view



Buoyancy tanks for JKT installation

# Regas Jacket piles & details

## JKT pile installation sequence



## Typical details: crown shims

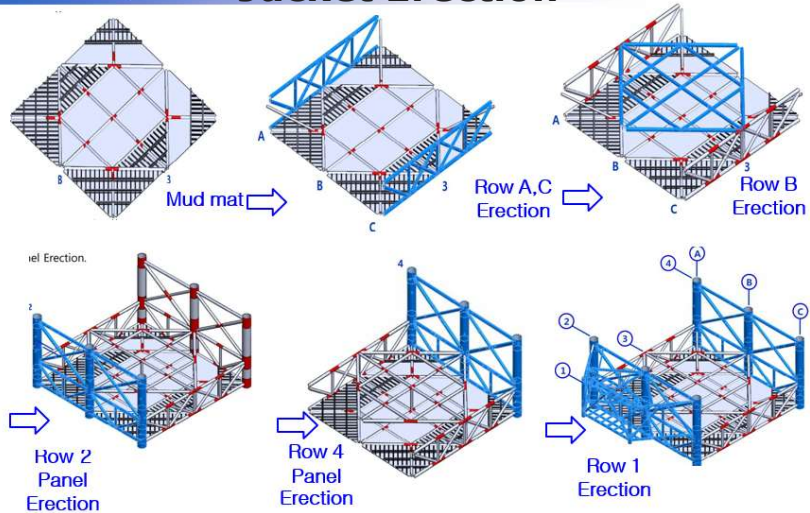
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- A Main Pile (casing) in JKT leg is driven using the hammer up to design depth from mudline (-17.0m CD).
- A R.C.D is used to excavate rock layers to required pin pile tip depth plus 1.5m.
- Pin pile to be stabbed and lowered into the excavated drilled hole through main pile.
- The annulus between the pin pile and drilled hole is filled with grout, supplied via a cementing string at the bottom of the hole.

# Jacket Fabrication (SKMT yard, Gosung, S.Korea)

Erection sequence

## Jacket Erection



## Jacket Pre-erection



## JKT & BT construction progress



## Pin piles witness PAUT for butt weld joint



## Background for float-off method

### 1. Topside Weight Increase

- Bidding Weight: 3,800MT.
- Latest NTE Weight: 7,200MT.

### 2. Jacket Weight Increase accordingly

- Bidding Weight: 726MT.
- Latest Weight: 1,838MT (Net) & 2,022MT (NTE).

### 3. Lack of Lifting Capacity of Proposed HLV

- Max. Capacity with Radius 43m: 1,600MT for Fix & 1,400MT for Revolving.

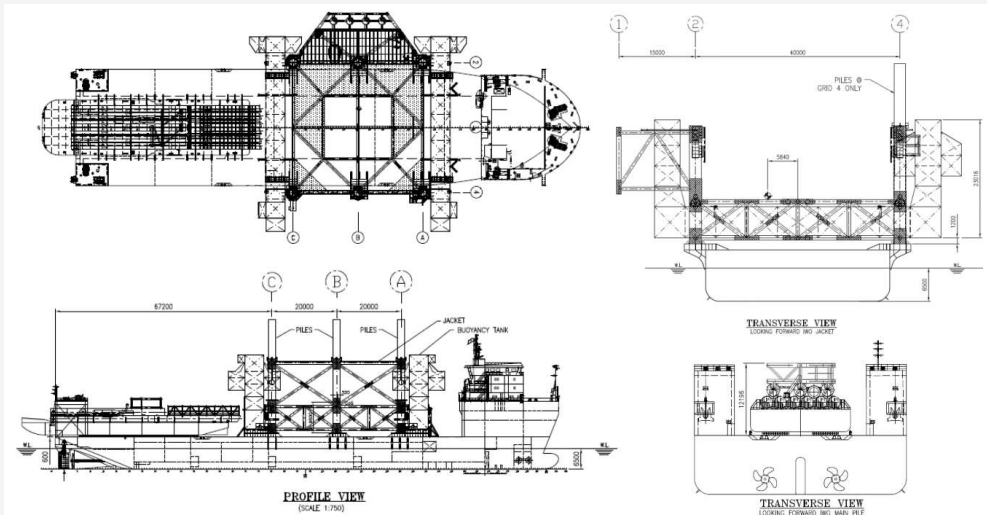
### 4. Large Capacity HLV to be Mobilized

- At least 4,000MT Capacity HLV considering Lifting Radius with NTE of Jacket.
- Possibility for mobilization to be checked.
- Difficulty for mooring in site with limited area with Breakwater.
- DP2 (Dynamic Positioning System 2) HLV to be mobilized.

### Conclusion

- Almost impossible to mobilize DP2 HLV at that moment.
- Alternatively, Float-off Method to be Unique Solution.
- Concerns for Engineering and Operation to be solved in due course.

# Jacket Stowage Plan & Transportation (Wishway SSHLV)

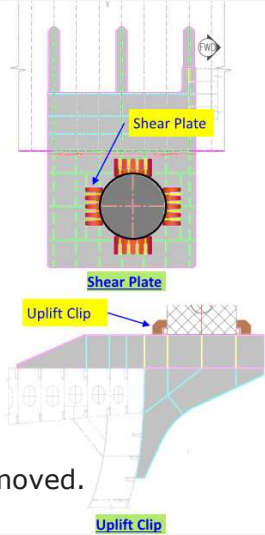
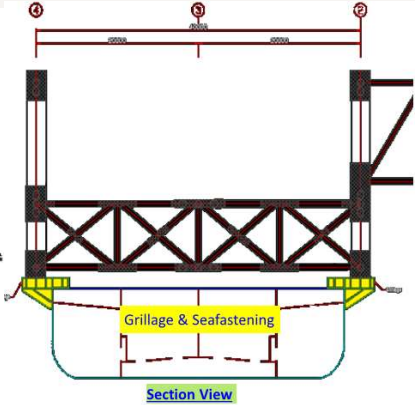
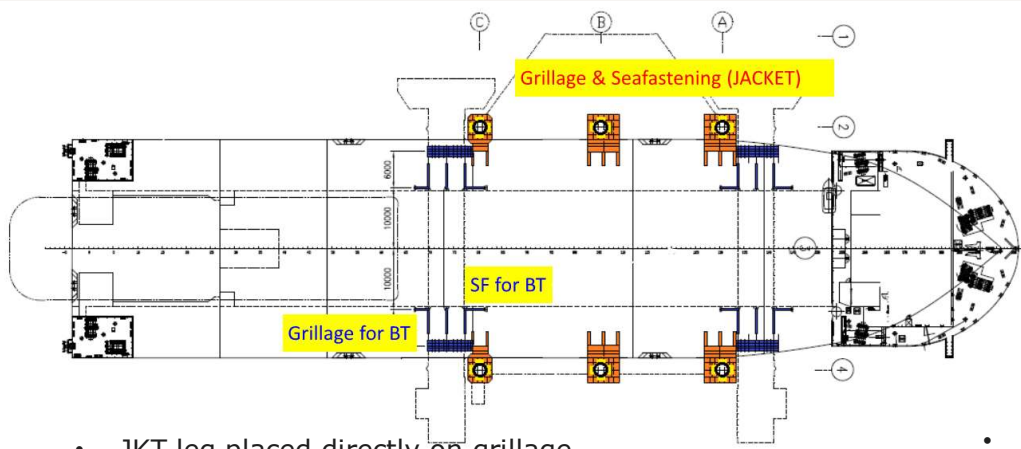


Weighing Result			Calculation		
NET	Gross (±2%)	COG	NET	Gross (±10%)	COG
<b>3,515Ton</b>	3,585 Ton 3,445 Ton	X: -2.09m Y: -0.10m	3,393Ton	<b>3,745Ton</b>	X: -1.97m Y:+0.13m Z:-8.16m

ITEM	DESCRIPTION	EXPECTED WEIGHT (MT)
1	REGAS JACKET	~ 2025
2	3 NOS. OF MAIN PILES ON JACKET	~ 218
3	2 NOS. OF BUOYANCY TANKS	~ 1502
4	MATERIAL BARGE WITH CARGO	~ 1895

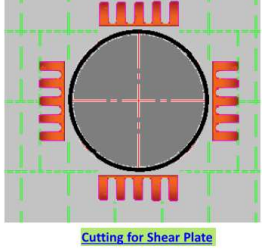
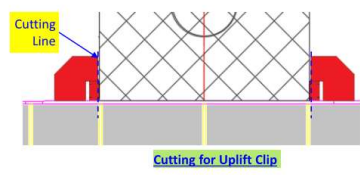
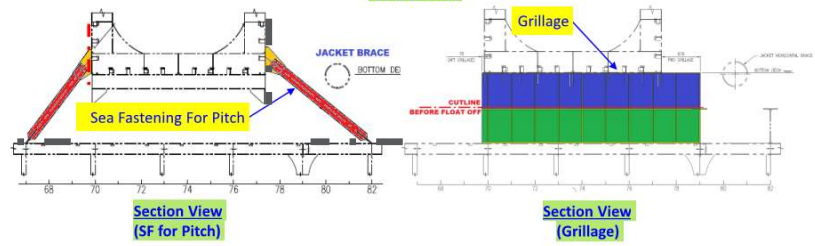
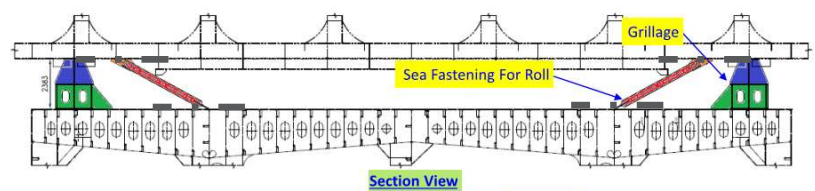


# Grillage & Seafastening G.A for JKT & BT



- JKT leg placed directly on grillage.
- Shear finger plate to restrain lateral force.
- Clip plate to restrain vertical uplift force.

- All uplift clips to be removed.
- Edge face of shear plate to be removed.

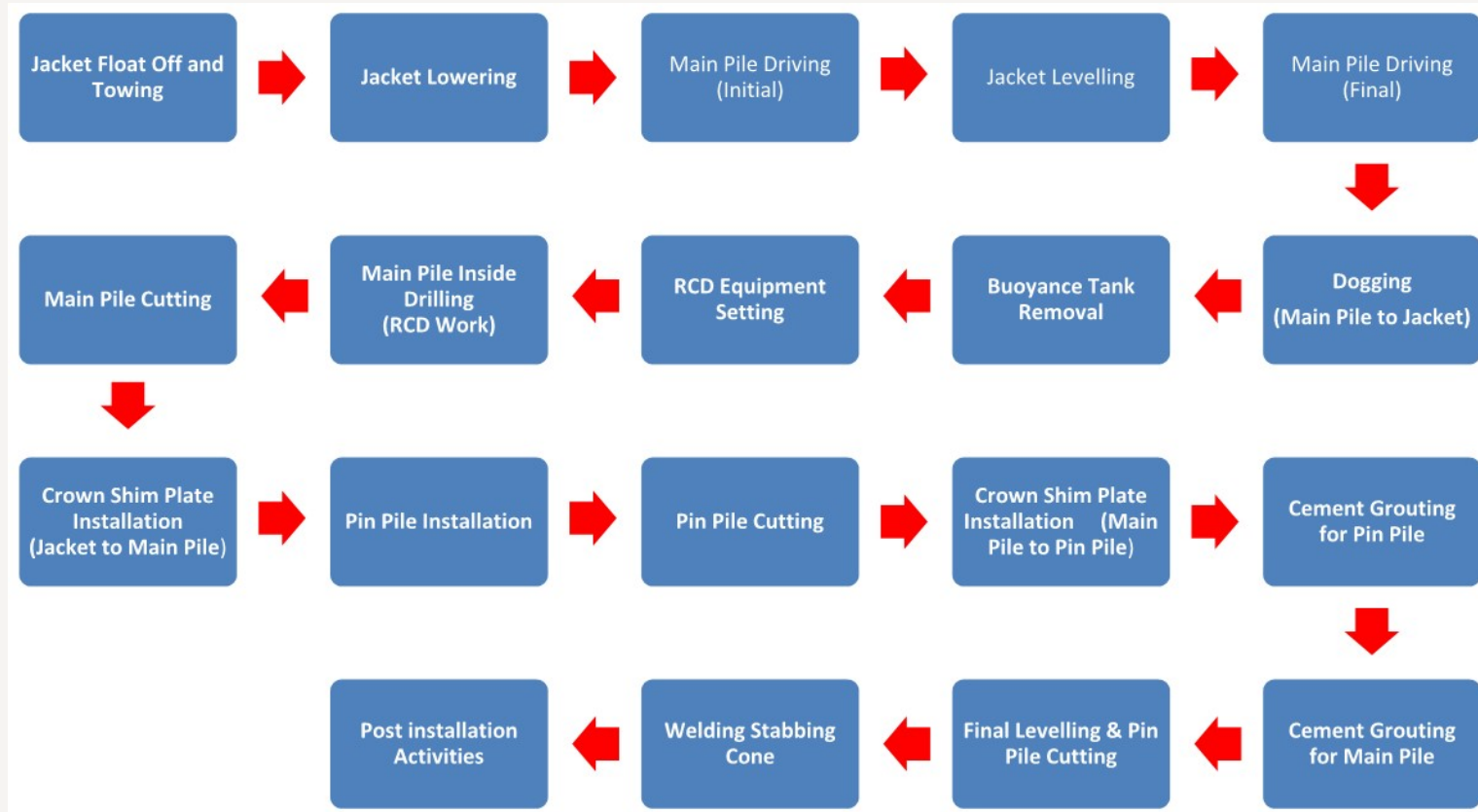


17

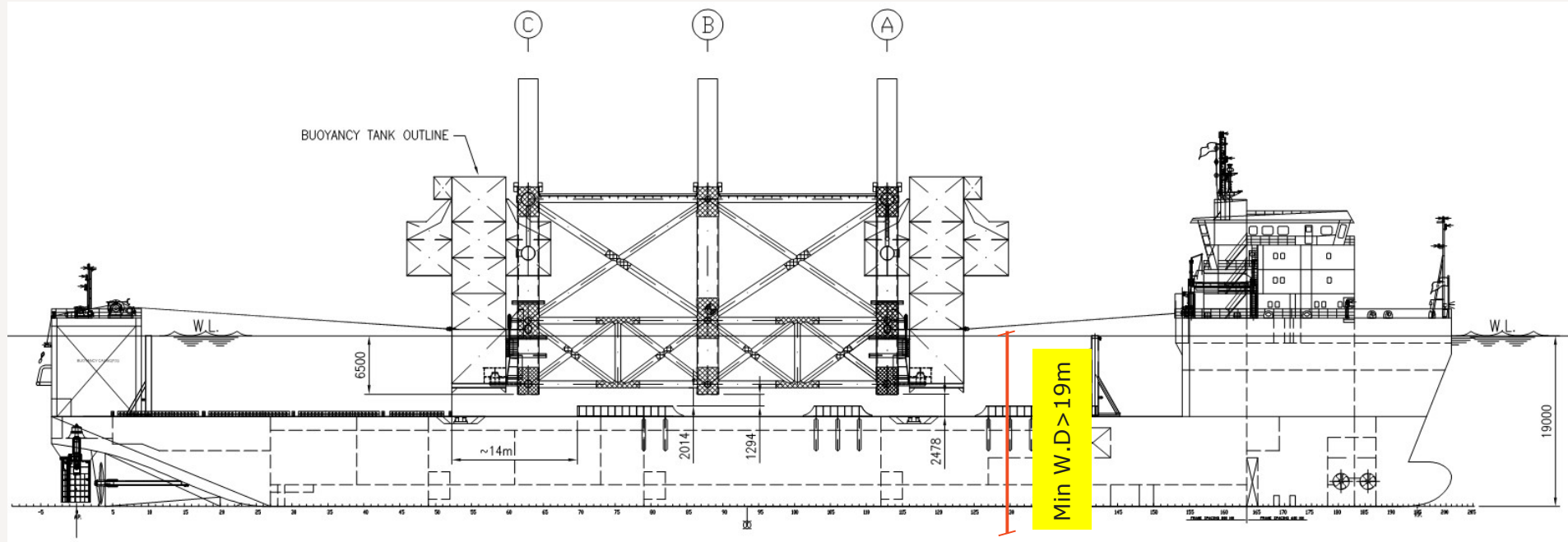
- SF: all tubular braces to be cut-off before float-off.
- Grillage: upper part to be cut before float-off.

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## Overall Jacket installation sequence

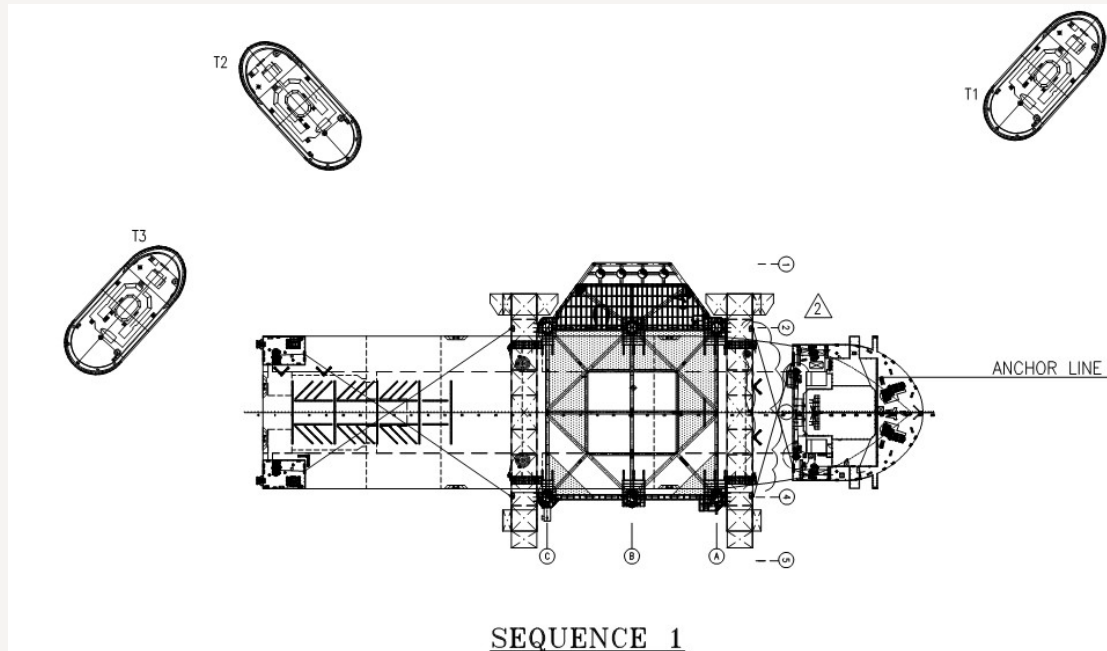


## Main parameter for float-off location



- Max submersible draft = 9m (1) ; Max draft submerged = 19m ; Depth moulded = 10m
- Target JKT draft for float-off = 6.5m (2)
- Max. grillage height = 1.2m (3)
- Min. UKC between JKT and vessel deck = 0.5m (4)
- Expect JKT vessel draft for float-off = (2)+(3)+(4)  $\approx$  8.2m < 9m less than submersed draft (1)
- Min. UKC between SSHLV and seabed = 0.8m -> Min W.D  $\geq$  19m

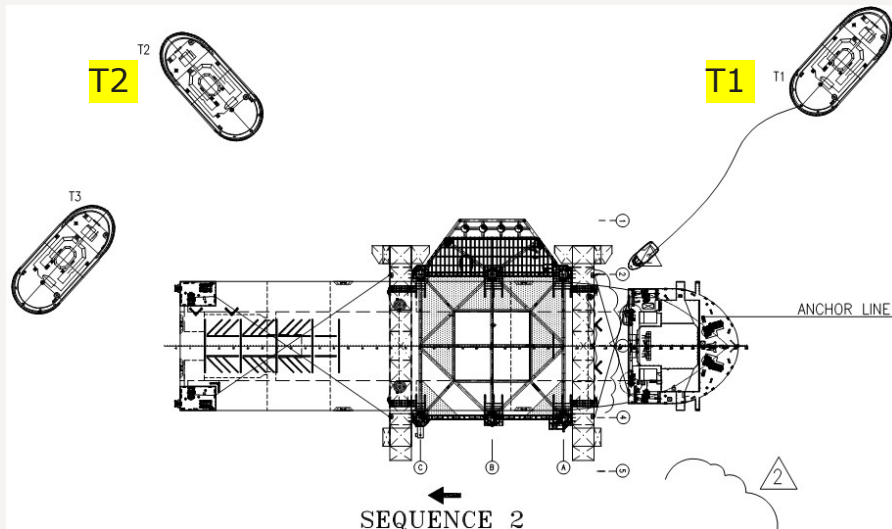
## JKT float-off sequence (1)



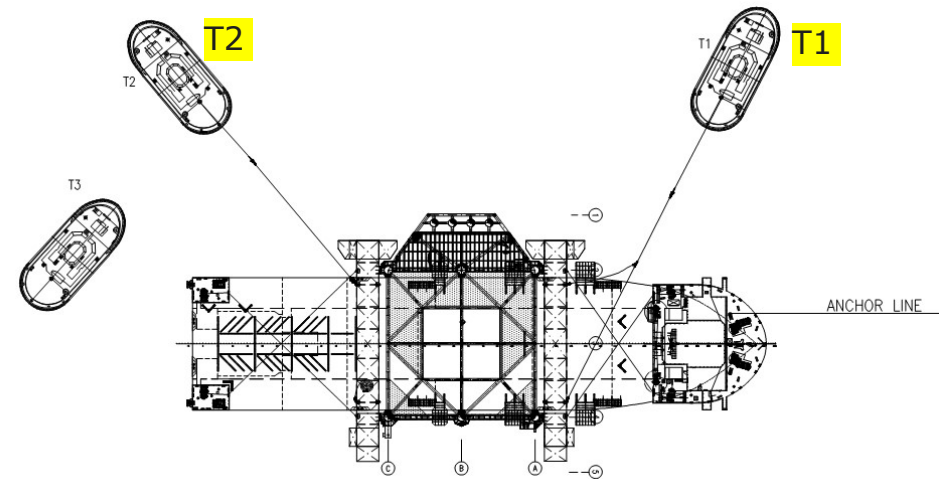
- Forward winches on 'D' deck to forward BT outboard padeyes already connected.

- After material barge offloading, line boat assists to connect both stern caissons mooring lines to pre-rigged 2m pennant wire attached to pad-eye on outboard side of BT.
- Continue to ballast up to load out draft.
- All tugs on standby.
- Check JKT floating levels are even keel.
- Commence to Float off operation once agreed by all parties.

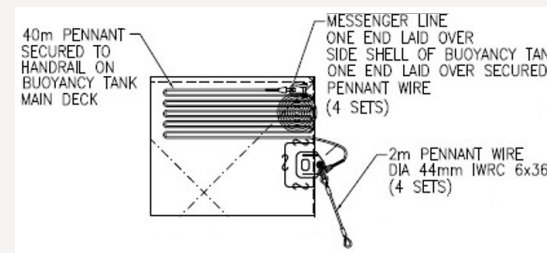
## JKT float-off sequence (2/3)



- Once Vessel reach submersible draft, line boat to run tow line from Tug T1 toward BT.
- Line boat picks up messenger line from BT and passes messenger line to stern of tug.
- Tug to connect messenger line to tugger winch.
- Tug heaves pennant to deck and secures in shark jaws and tow wire connected.
- Line boat repeats above steps to connect pennant wire and towline for T2.
- After T1 towlines connected, mooring lines on stern caissons start to shift JKT 14m toward the 'Wish Way' stern.
- JKT is moved slightly aft of 'Wish Way' midship.

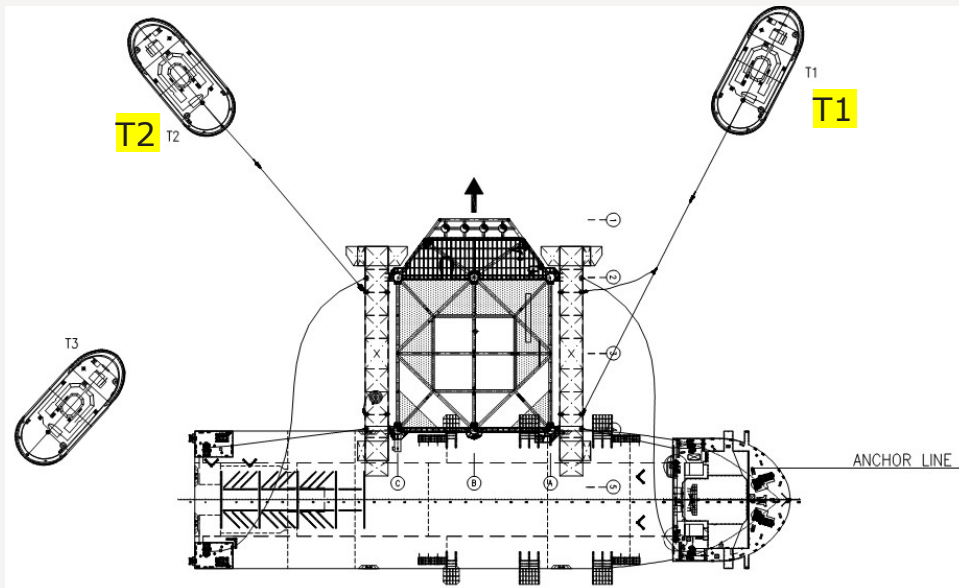


- T1 & T2 Tugs tension up towline.
- 'Wish Way' mooring lines maintain tensions to pull JKT to 'Wish Way' PS.



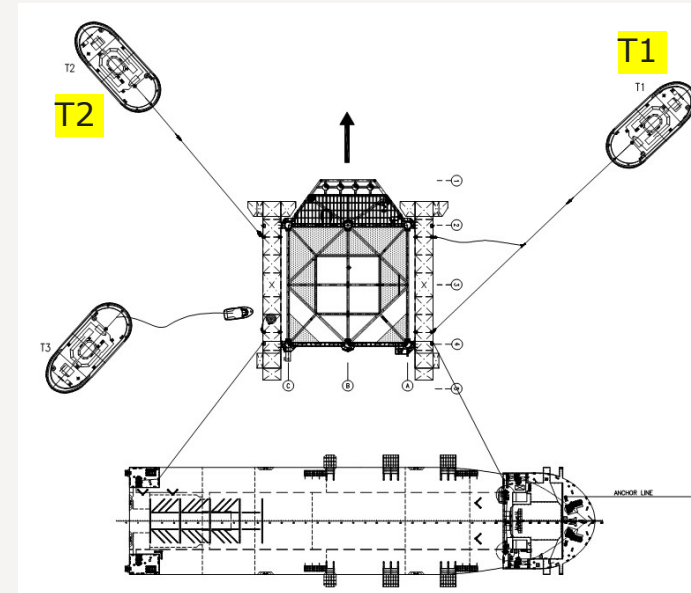
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## JKT float-off sequence (4/5)



- T1 & T2 Tugs tension up towline and continue to pull out JKT out of 'Wish Way'.
- PORT caisson mooring lines maintain tension to assist heading control.
- Once Row 3 pass to grillage, slack STBD forward Mooring line and stern caisson mooring line.

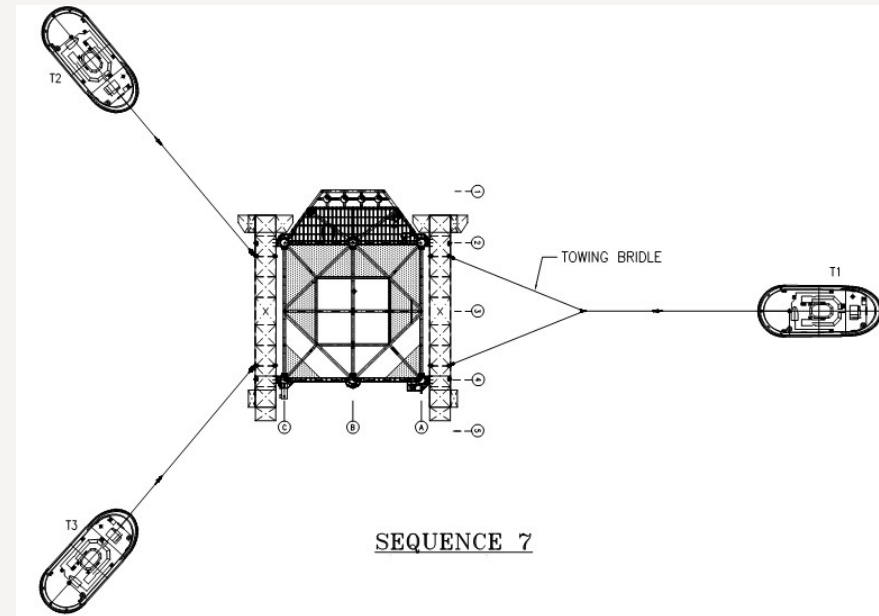
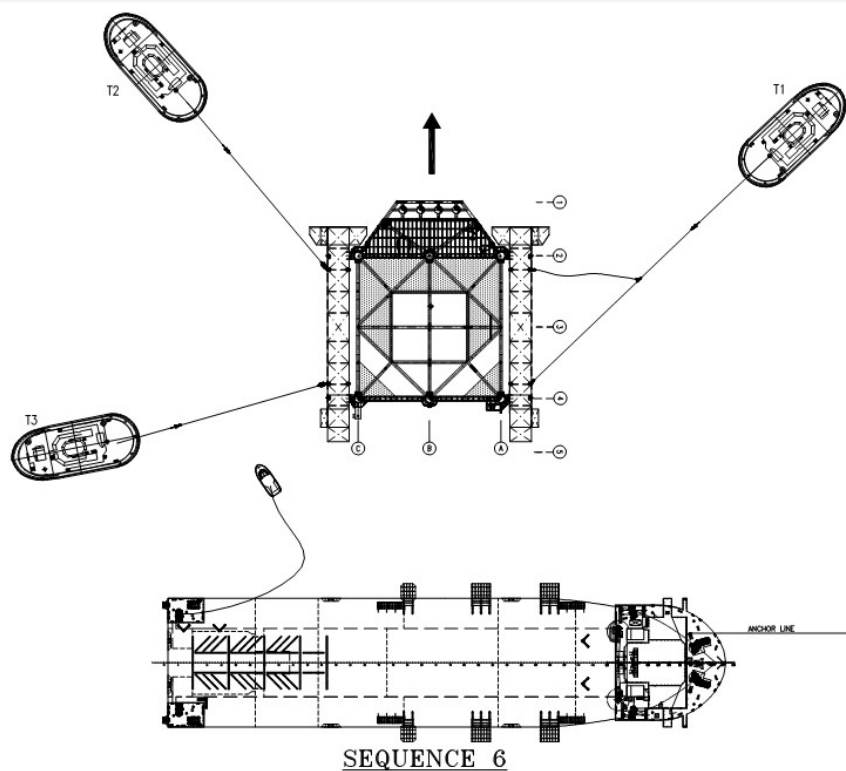
22 |



- T1 & T2 pull JKT & BT out of 'WishWay'.
- Disconnect STBD caisson mooring line from padeye.
- HOLD JKT & BT in position using lines from T1 & T2, Port winch and port caisson.
- Line boat run tow line from T3 toward BT.
- Line boat picks up messenger line from BT and passes messenger line to stern of T3.
- T3 to connect messenger line to tugger winch.
- T3 heaves pennant to deck and secures in shark jaws and tow wire connected.

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## JKT float-off sequence (6/7)



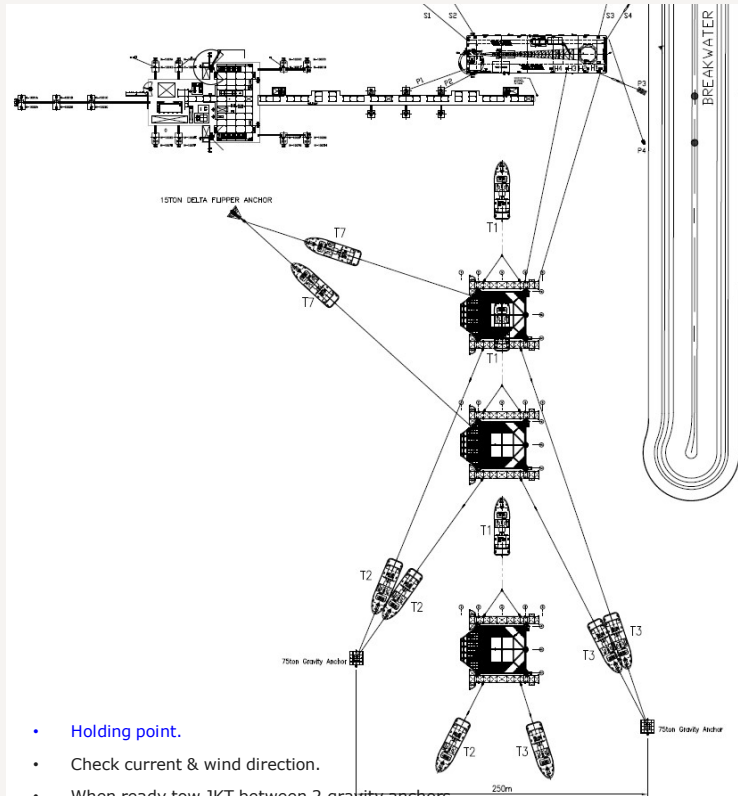
- 'WishWay' demobs.
- JKT & BT ready in wet tow configuration.

23

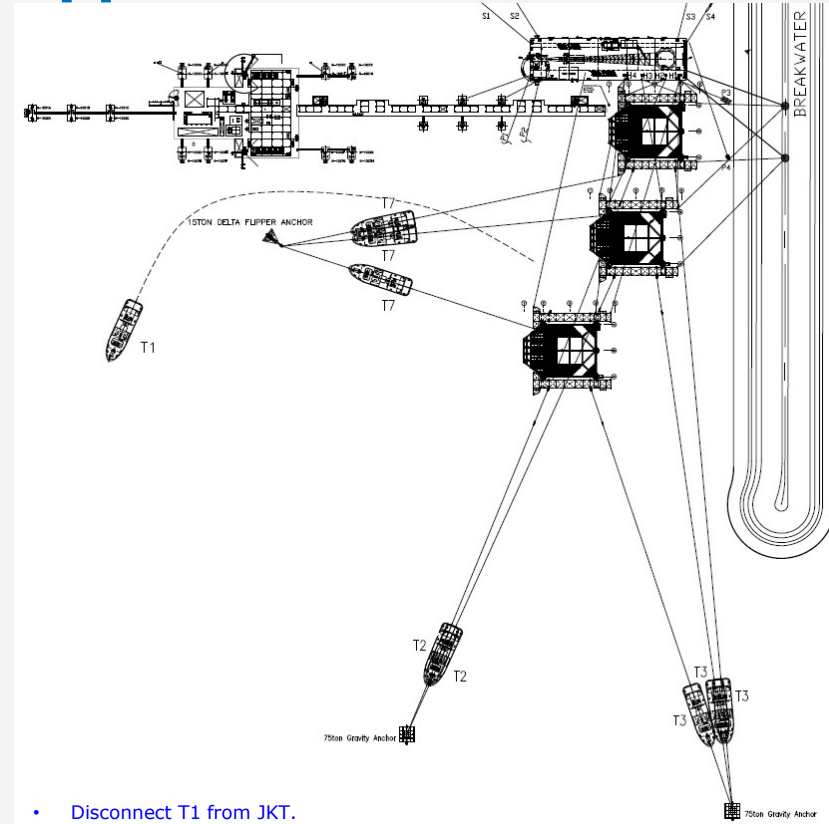
- All tugs connected to pennant wires.
- Disconnect port caisson mooring lines from padeye.
- All tugs tension up and tow JKT & BT away from 'WishWay'.

COWI

# Jacket Final approach



- Holding point.
- Check current & wind direction.
- When ready tow JKT between 2 gravity anchors.
- Connect to T3 and 75Ton GA by work boat.
- Connect to T2 and 75Ton GA by work boat.
- Connect to T7 and 15Ton delta flipper anchor.
- Connect HD-1000 30T winch lines H1 to BT A-4 guy line connection by work boat.
- Connect HD-1000 10T winch lines H3 to row A-4 padeye.

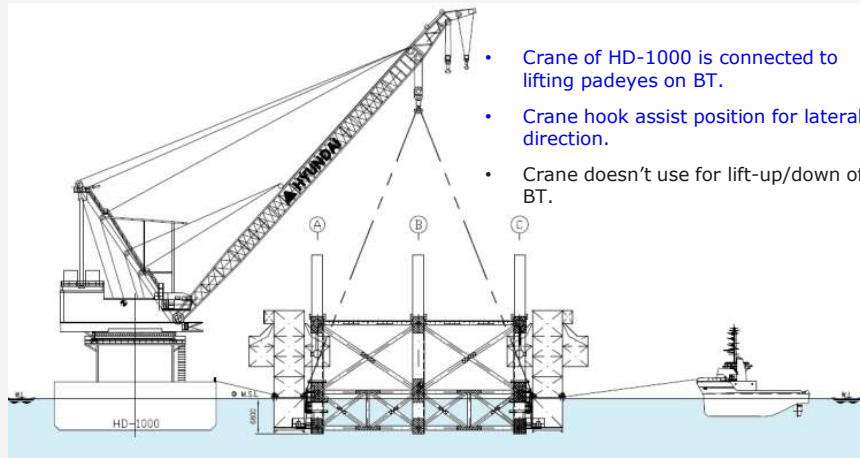


- Disconnect T1 from JKT.
- Connect to HD-1000 30T winch line H4 to BT A-2 guy line connection by work boat.
- Connect to HD-1000 10T winch line H2 to BT A-2 padeye.
- Connect to HD-1000 10T winch and row 4 secondary lines.
- Set-up final JKT position.

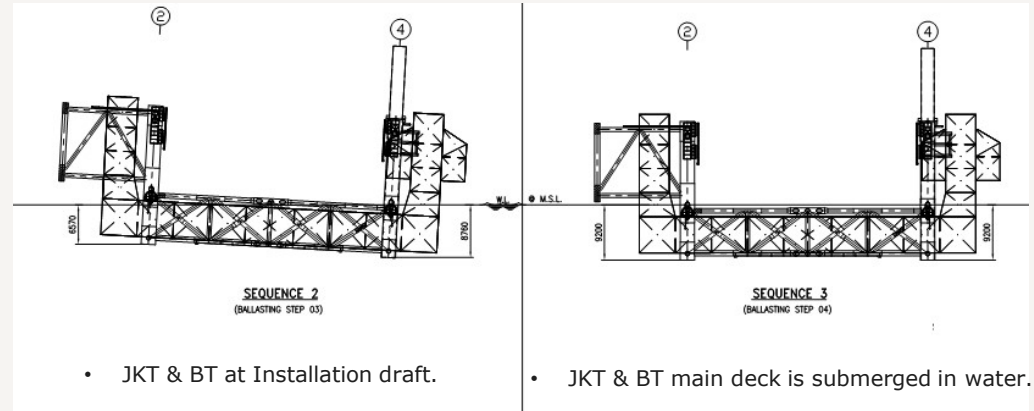
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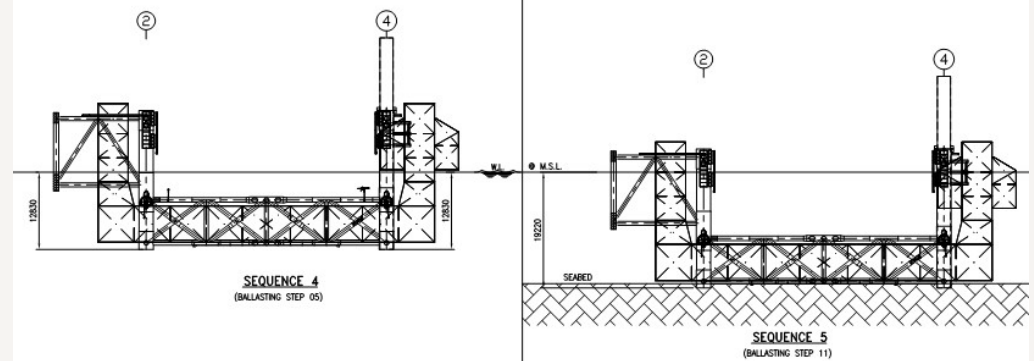
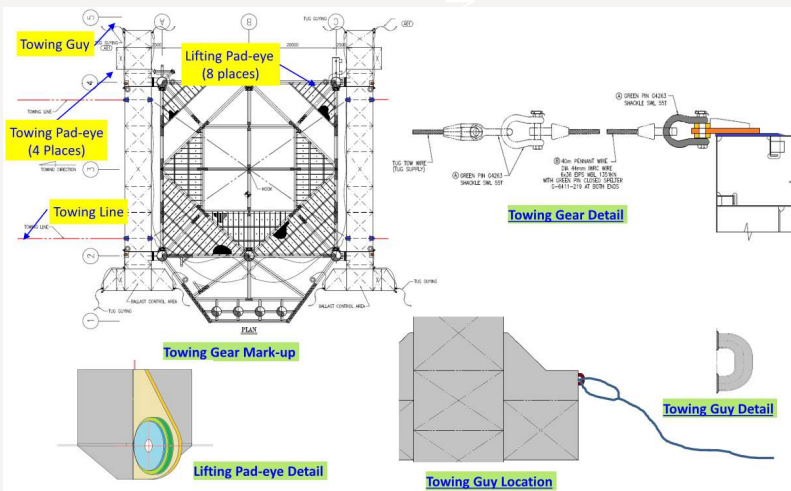
# Jacket Set-down



- Crane of HD-1000 is connected to lifting padeyes on BT.
- Crane hook assist position for lateral direction.
- Crane doesn't use for lift-up/down of BT.



- JKT & BT at Installation draft.
- JKT & BT main deck is submerged in water.



- JKT & BT stability tank is about to submerge in water.
- JKT & BT at Installation draft.



**Pile Material Barge on WishWay**



**Ballasting on WishWay**



**JKT towed to overnight position**



**JKT pulling from HD-1000 to its designated position**



**JKT before ballasting**



**JKT in final position (after ballasting)**

Thank you

