Structural concepts for minimum facility platforms for Marginal field development in western offshore, India

A collaborative project
By
IIT Madras and IEOT,ONGC

21 April 2007

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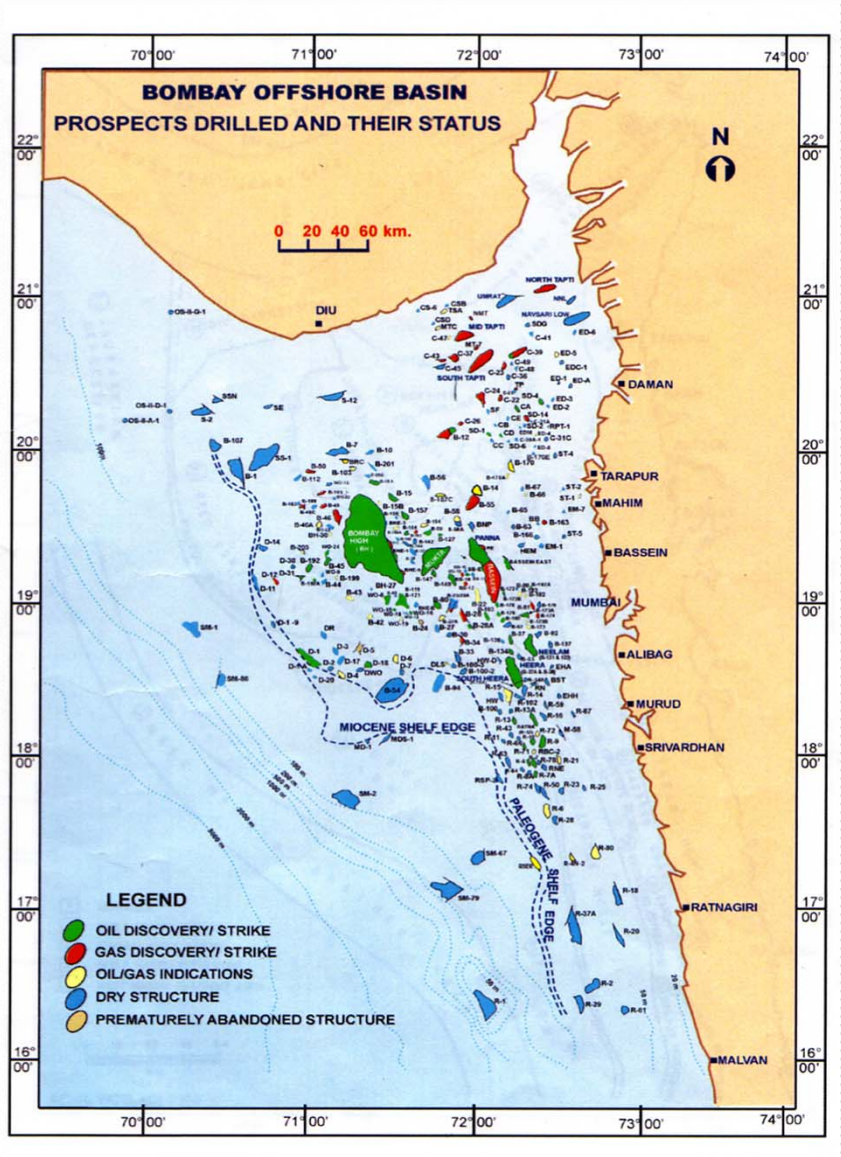
Outline

- Conventional Wellhead Platforms
- Existing Marginal platforms
- Minimum Facility Platforms
- Basic Requirements
- Environmental Conditions
- Installation by Jackups
- Concepts
- Technical Feasibility
- Cost Comparison
- Conclusions



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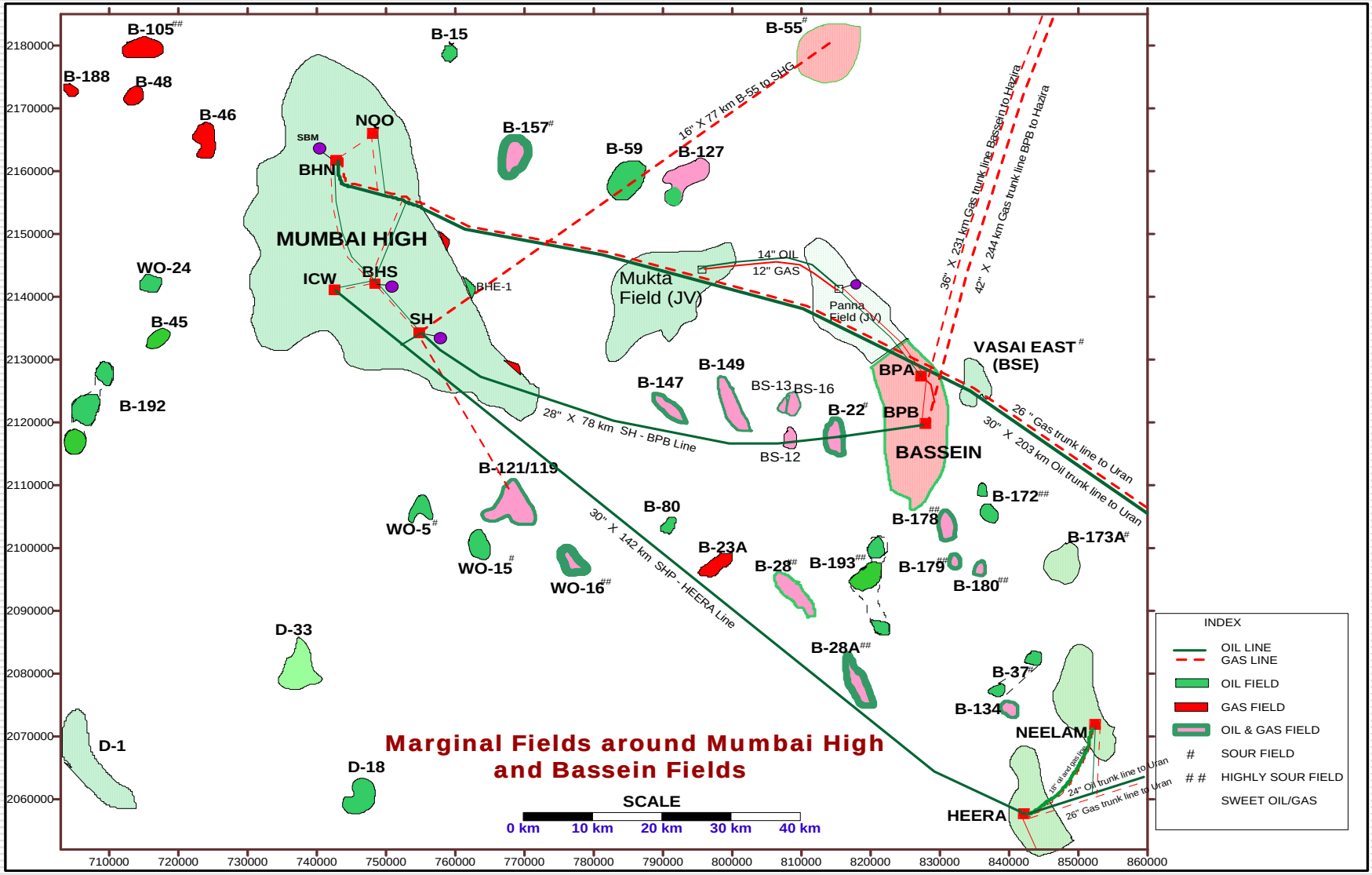
Field Map Western Offshore, India



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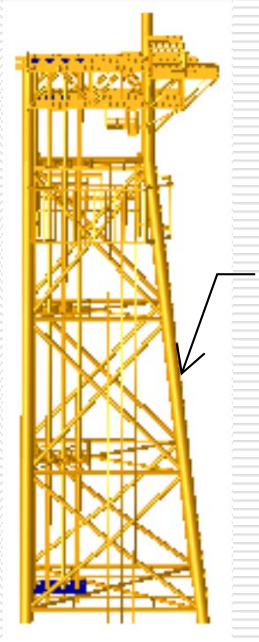
CONVENTIONAL WELL PLATFORM CONFIGURATIONS

SINGLE PILE CONFIGURATION



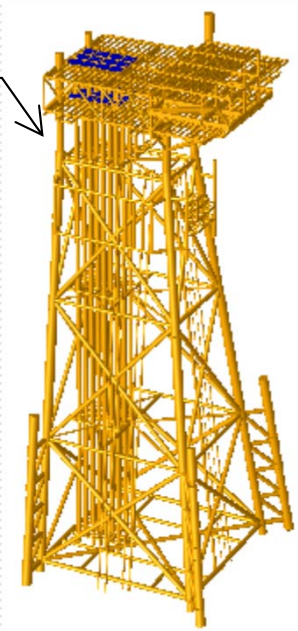
Main Pile of
- 60 INCH
- 68 INCH
- 72 INCH
- 84 INCH
- 90 INCH

SKIRT PILE (ONLY) CONFIGURATION

Skirt Piles of
- 84” SKIRT WITH 48” LEG
- 84” SKIRT WITH 60” LEG
- FULL BRACING 84” SKIRT WITH 60” LEG

SKIRT & MAIN PILE CONFIGURATION

Combinations of
- 54” SKIRT WITH 48” MAIN PILE
- 54” SKIRT WITH 54” MAIN PILE
- 60” SKIRT WITH 54” MAIN PILE



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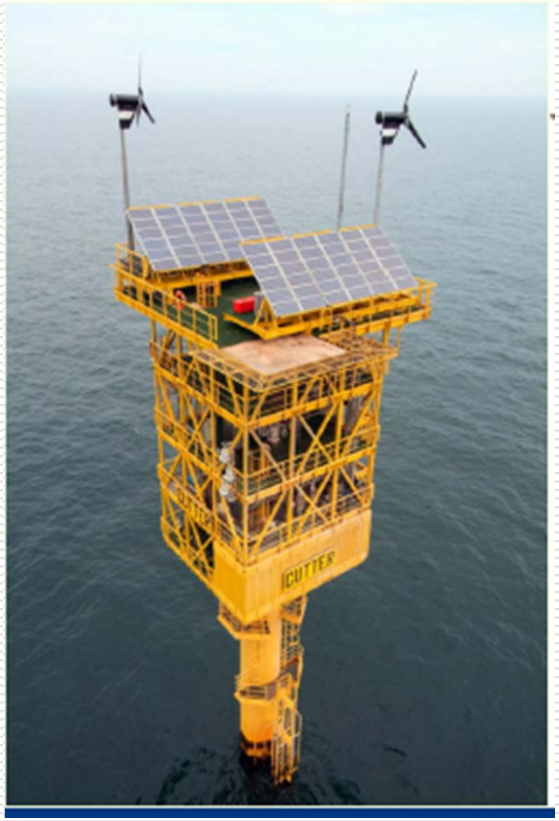
Concepts used in other regions in the industry

UK



Norway

Australia

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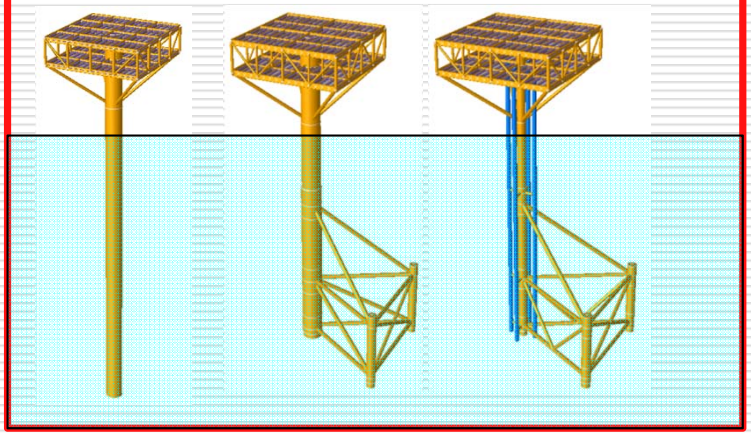
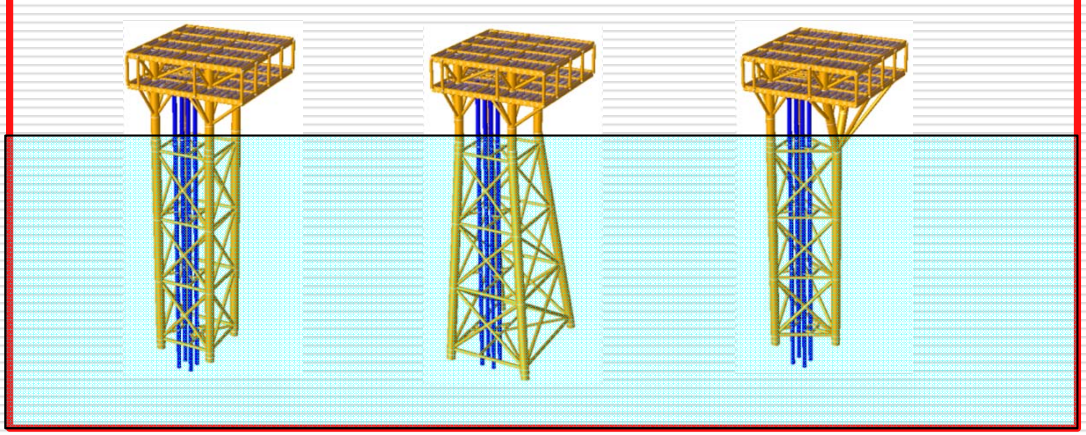
PROPOSED CONCEPTS FOR WESTERN OFFSHORE

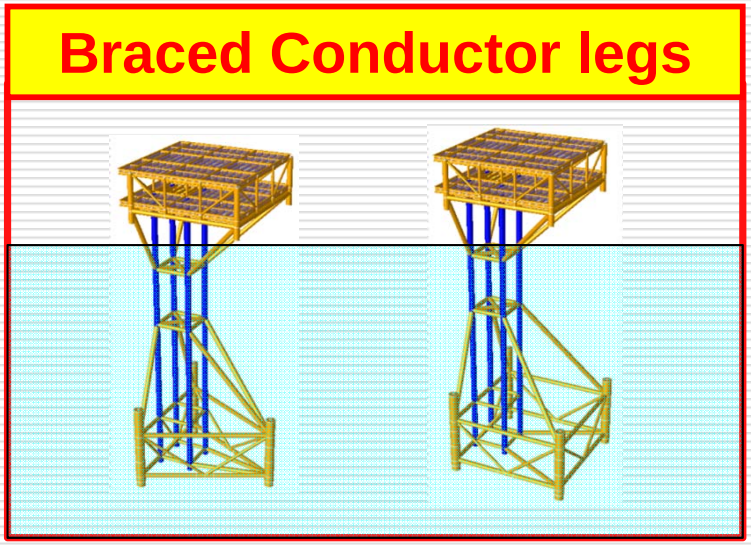
Mono Pile Concepts



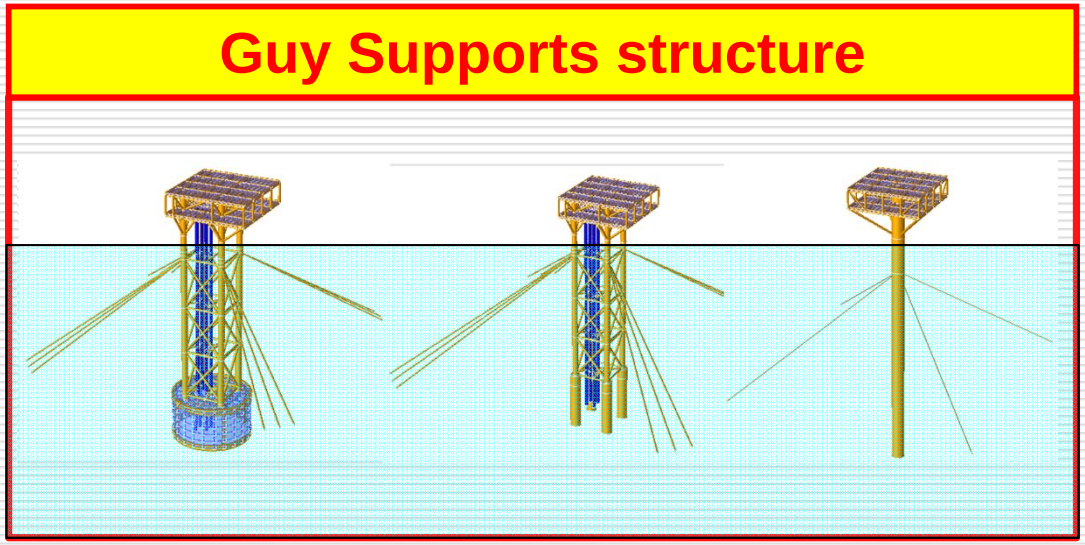
Jacket Type Concepts



Braced Conductor legs



Guy Supports structure



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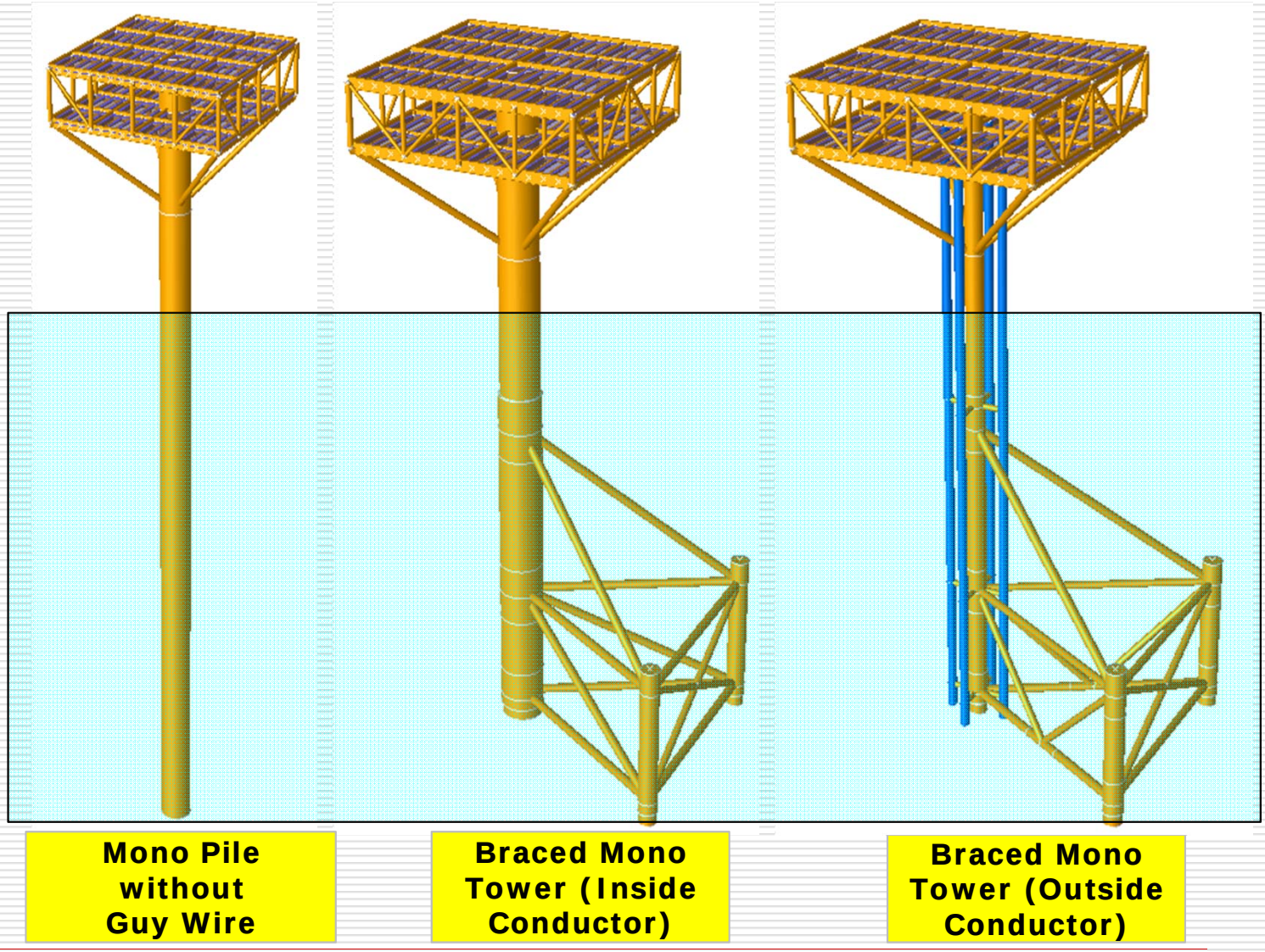
Mono Pile Concepts

Mono pile concepts involve driving of large diameter pile and supporting the deck from the single leg. This can be augmented by additional skirt piles in order to reduce large bending of mono piles. The mono pile houses 3 or 4 conductors inside thus reducing the wave loads.

Another alternative to this is to have conductors outside the mono pile.



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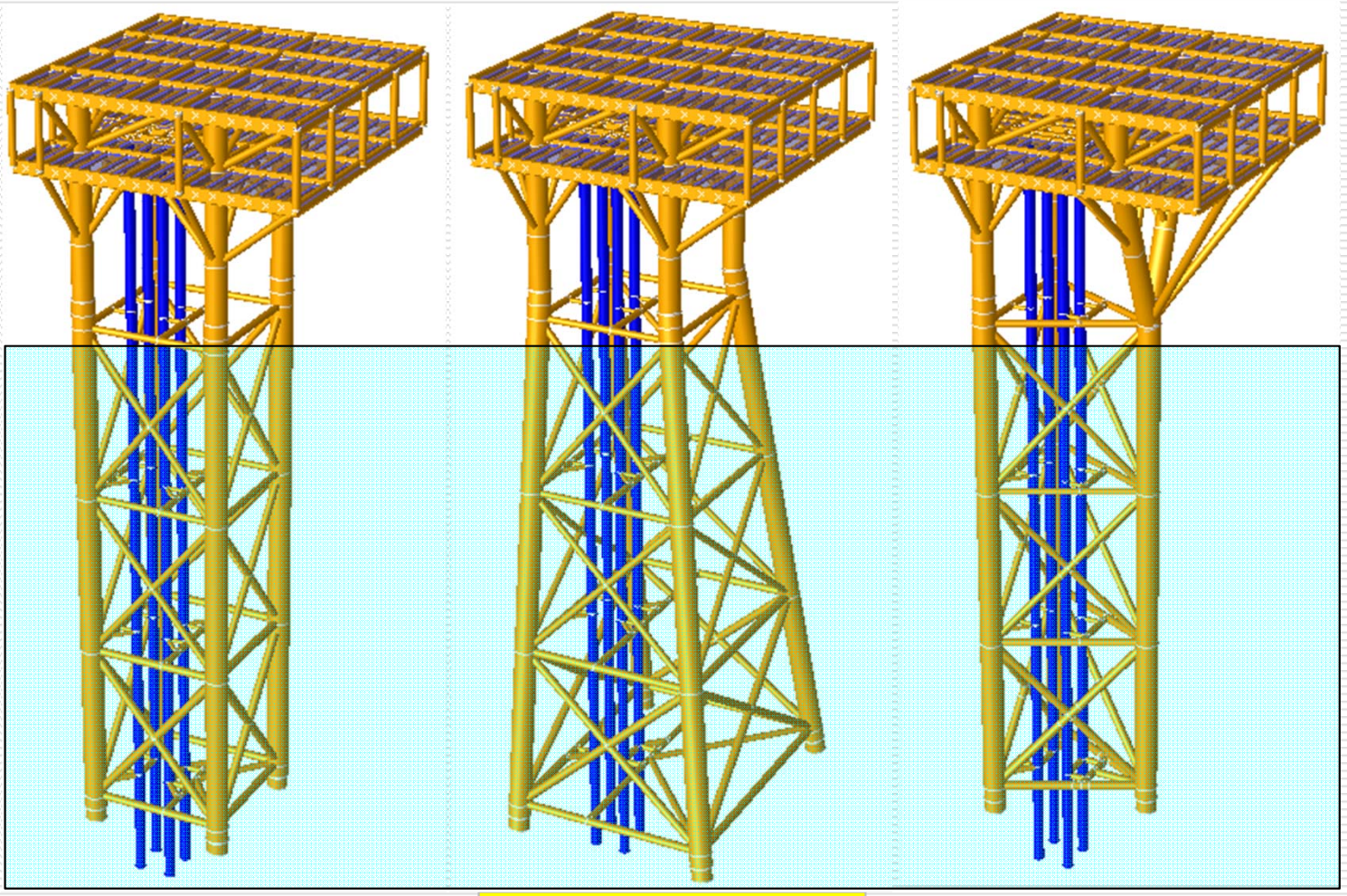
Jacket Type Concepts

Jacket type concepts involves 3 or 4 legs with conductors inside the jacket framing. The jacket legs are either battered or vertical. Three alternate scheme are proposed are shown in figure.

The above concepts can be extended to water depths exceeding 30m and has the flexibility of increase in number of wells or topside configurations.



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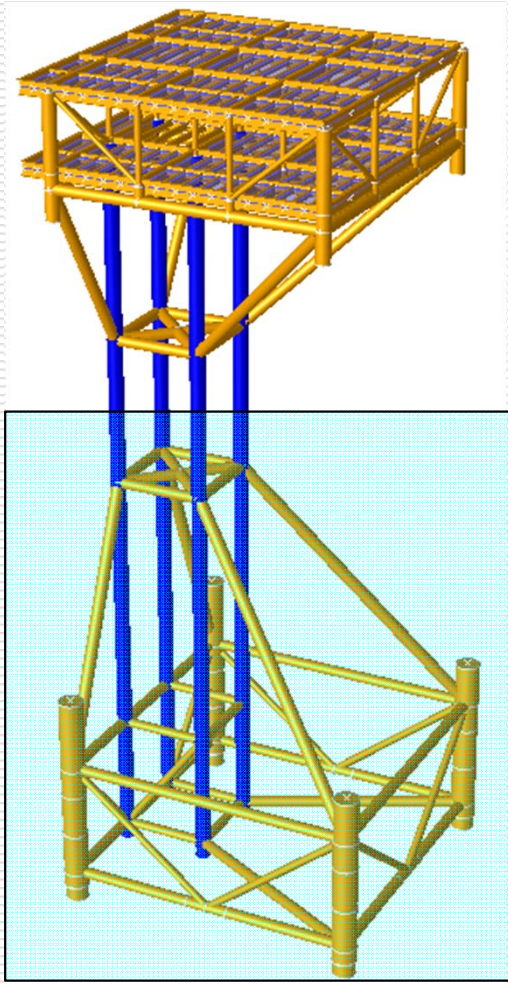
Braced Conductor Leg Concepts

In this concepts four conductor cum legs are braced to form frame which will be fixed to the seabed by skirt piles.

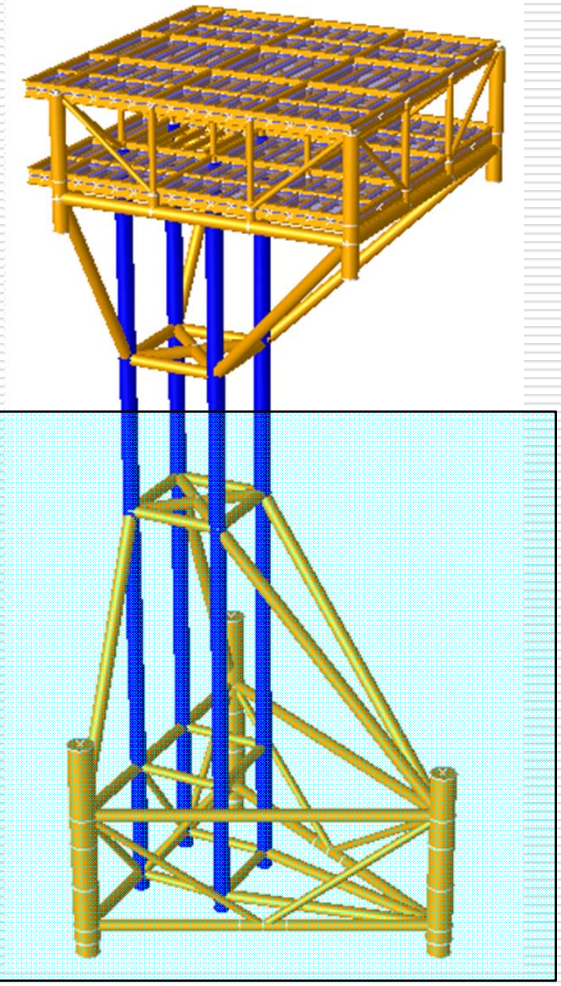
The advantage of these concepts is that the wave loads is reduced considerably since the jacket legs and framing near water level is reduced.

3 (a)



Braced Leg Jacket (4 Piles)

3 (b)



Braced Leg Jacket (3 Piles)

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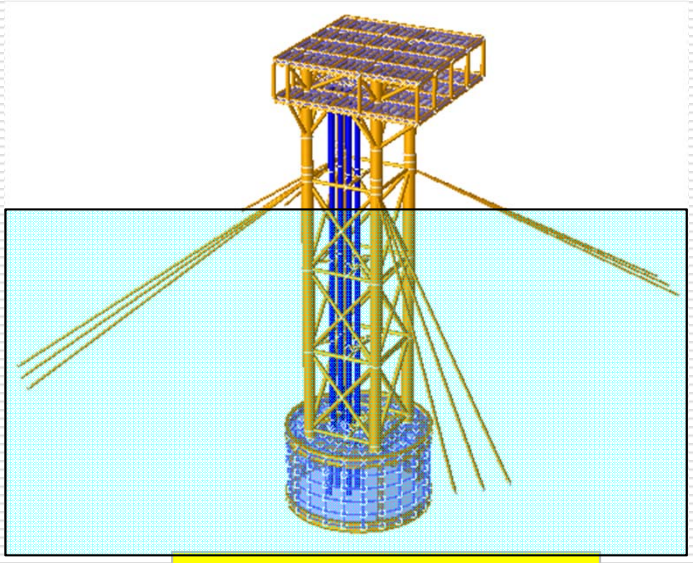
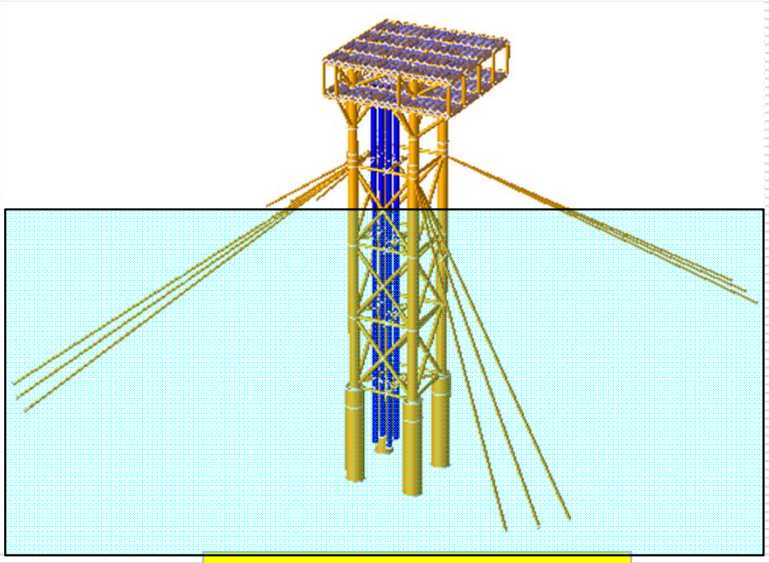
Guy support Structures

4(a)



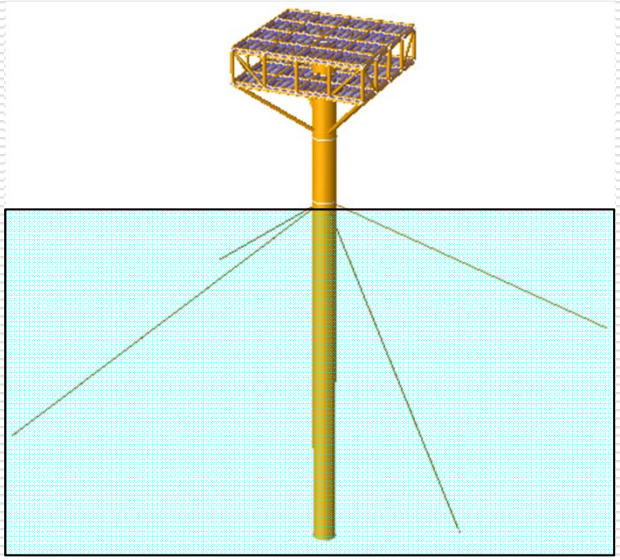
4 Legged Jacket with Hollow Base Steel Caisson

4(b)



4 Legged Jacket with Steel Caisson with Each Legs

4(c)



Mono Pile with Guy Wires

The slender structure as proposed earlier are transversely supported by guy wires to reduce lateral deflection and bending stresses. Further the support reaction in terms of pile loads will be reduced considerably.

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Focus of the development

- Understanding the requirements of marginal field.
- Developing new concepts to suit the west coast environmental parameters.
- Pile Loads and configurations will govern the economics of the concept.
- Pile Load distribution from past experience shows that
  - Dead Load : 25%
  - Facilities (Equipment) : 20%
  - Wave + current Load : **50%**
  - Wind Load : 5%
- Installation costs for offshore platforms play a major role and hence installation by means of unconventional methods may need to be reviewed.
  - Smaller Crane barges
  - Pipe lay Vessel with cranes
  - Jackups
  - Self installation methods

Item	Cost
Engineering	5%
Structure	25%
Equipment	25%
Installation	**50%**

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CONVENTIONAL WELLHEAD PLATFORMS

- Design life varies from 25 - 30 years.
- No. of wells varies from 4 – 16.
- Water depth ranges from 20m – 100m.
- Two level deck with the dimension of 20m x 40m.
- Large space (40’ x 20’) for CTU operation
- Separate Helideck is provided.
- Platform crane provided.
- Boat landing is provided.
- Total topside weight is in the order of 2000 – 2500 Tonnes
- Modular rig such as Sundowner VI or VII is allowed.
- Unmanned platform with temporary two or four man bunk house

MARGINAL FIELD WELLHEAD PLATFORMS

- Design life varies from 5 – 10 years.
- No. of wells varies from 2 - 4.
- Water depth ranges from 20m – 60m.
- Two level deck with the dimension of 20m x 20m.
- No separate Helideck is provided. Main deck can be used as helideck.
- **No Pedestal crane provided.**
- V notch ladder type Boat landing is provided.
- Total topside weight is less than 750 Tonnes
- No Modular rig is allowed.
- Unmanned platform.
- No temporary bunk house provided.

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Limiting Parameters

- Access to wells for drilling by jackup from north face, the skirt piles or projection of substructure on the north face to be avoided.
- The soil conditions and environmental parameters in shallow water is substantially different from conditions exist in many other parts of world
- Large deflection shall be avoided as the platform supports well heads.
- Dynamics of the slender platform shall be kept in mind to avoid resonant vibrations and subsequent fatigue related issues.
- Installation robustness to avoid delay in projects during execution

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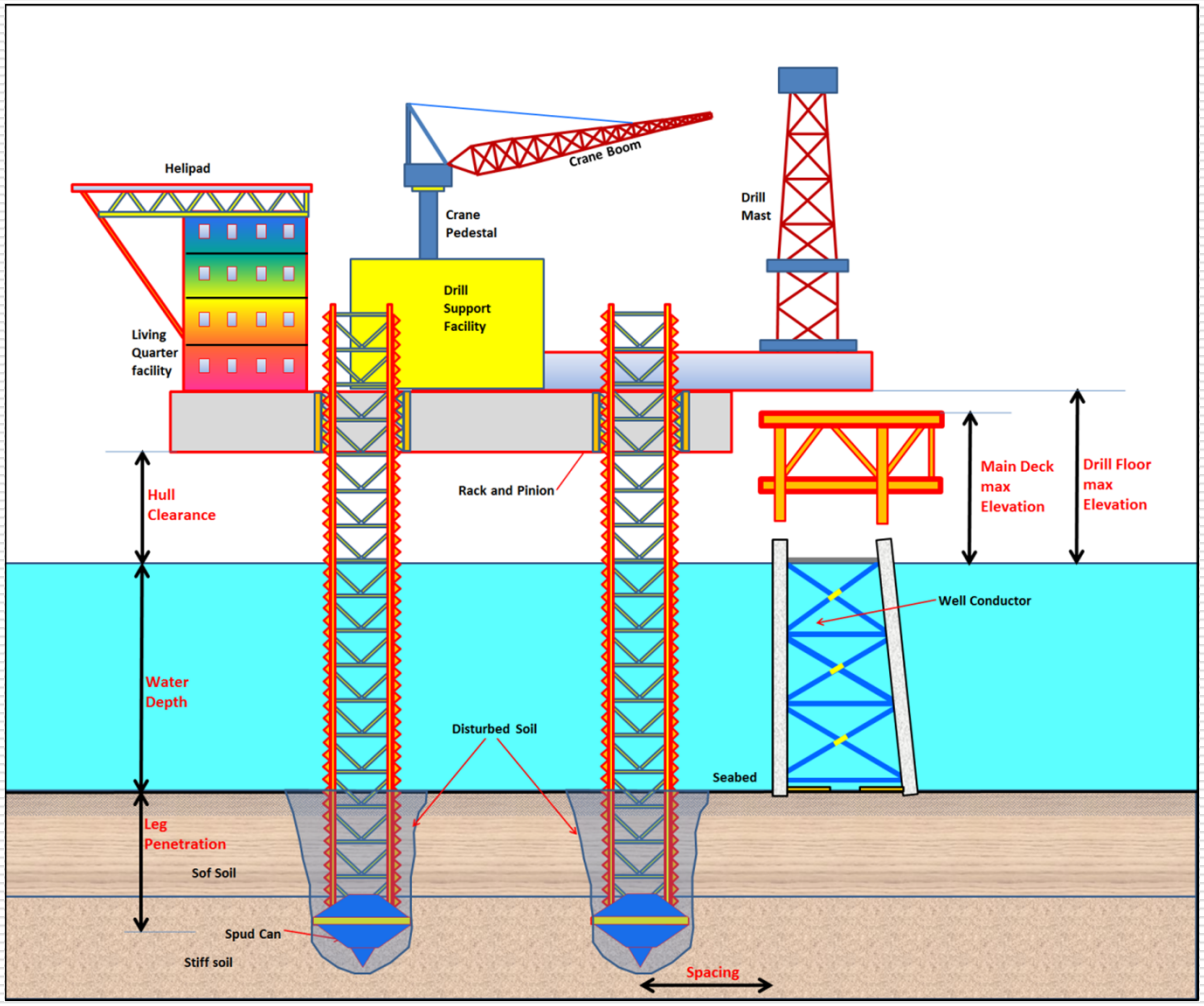
Installation by Jackup rigs

- The cost optimization by means of unconventional installation spread was considered to be an option such as use of Jackups.
- Due to limitations on size of jackets / deck modules, jackups are not suitable. Height limitation due to vertical movement of jackup legs will be a constraint.
- Jackup foot print during installation may hamper future drilling activities.
- Hence use of small derrick barge / pipe lay vessels with crane capacity of 1200 Tonnes is found to be suitable for this type of installation.



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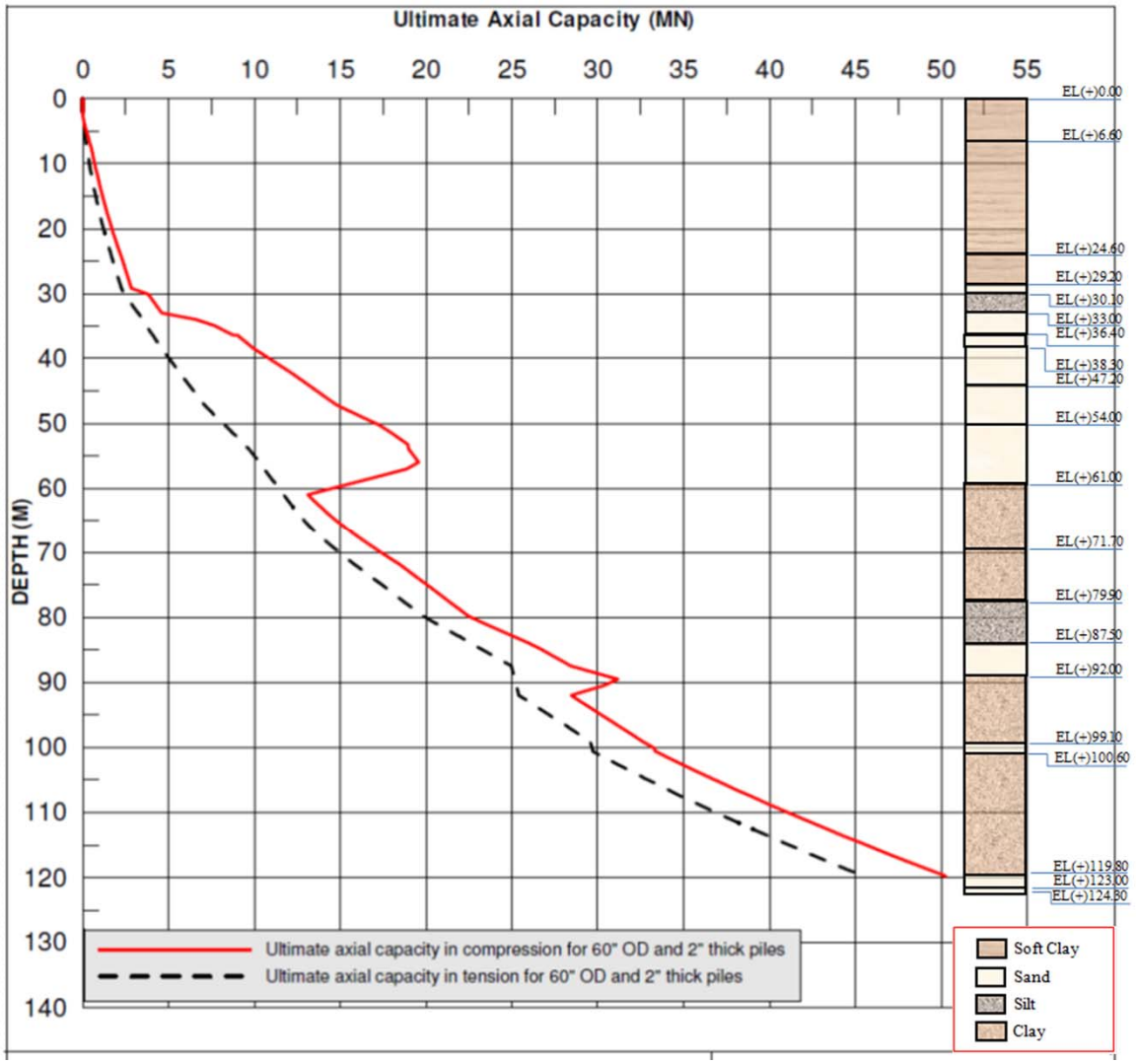
REPRESENTATIVE SITE

Environmental conditions at C-series location has been considered for this study. The location selected has some of the difficult parameters to be used in design such as wave, current and geotechnical conditions. Similar conditions are expected at other marginal field. It can be observed that the top 30m is a soft clay offering very les pile capacity.

Parameter	1 year return	100 year return
Wave height (m)	10.366	17.073
Wave period (sec)	10.4	13.90
Surface current(m/sec)	1.341	1.768
Water depth (m)	30	30
Wind speed (km/h) (1-hr.Avg)	77	138



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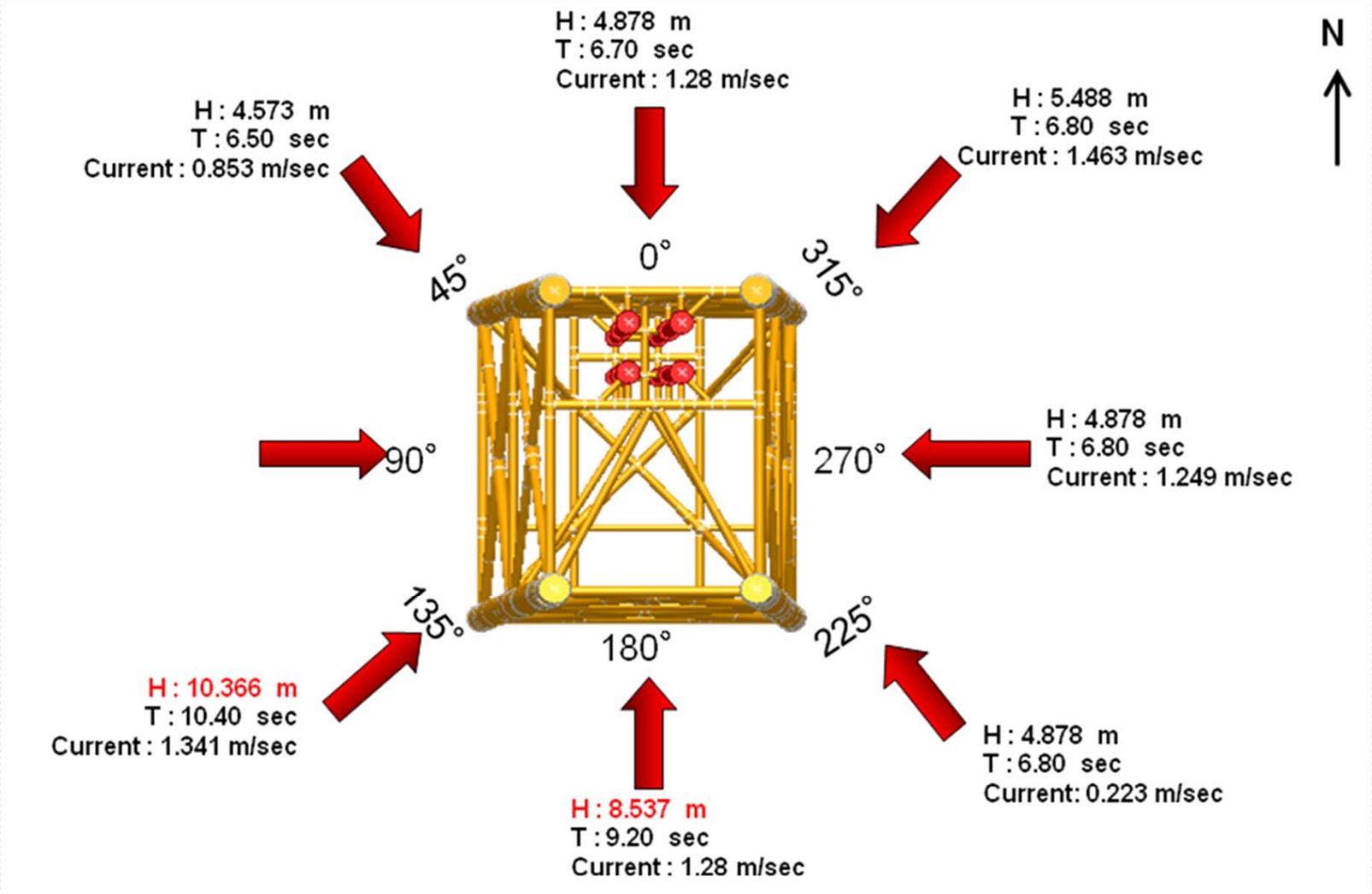
WAVE AND CURRENT 1 YEAR RETURN PERIOD (OPERATING)



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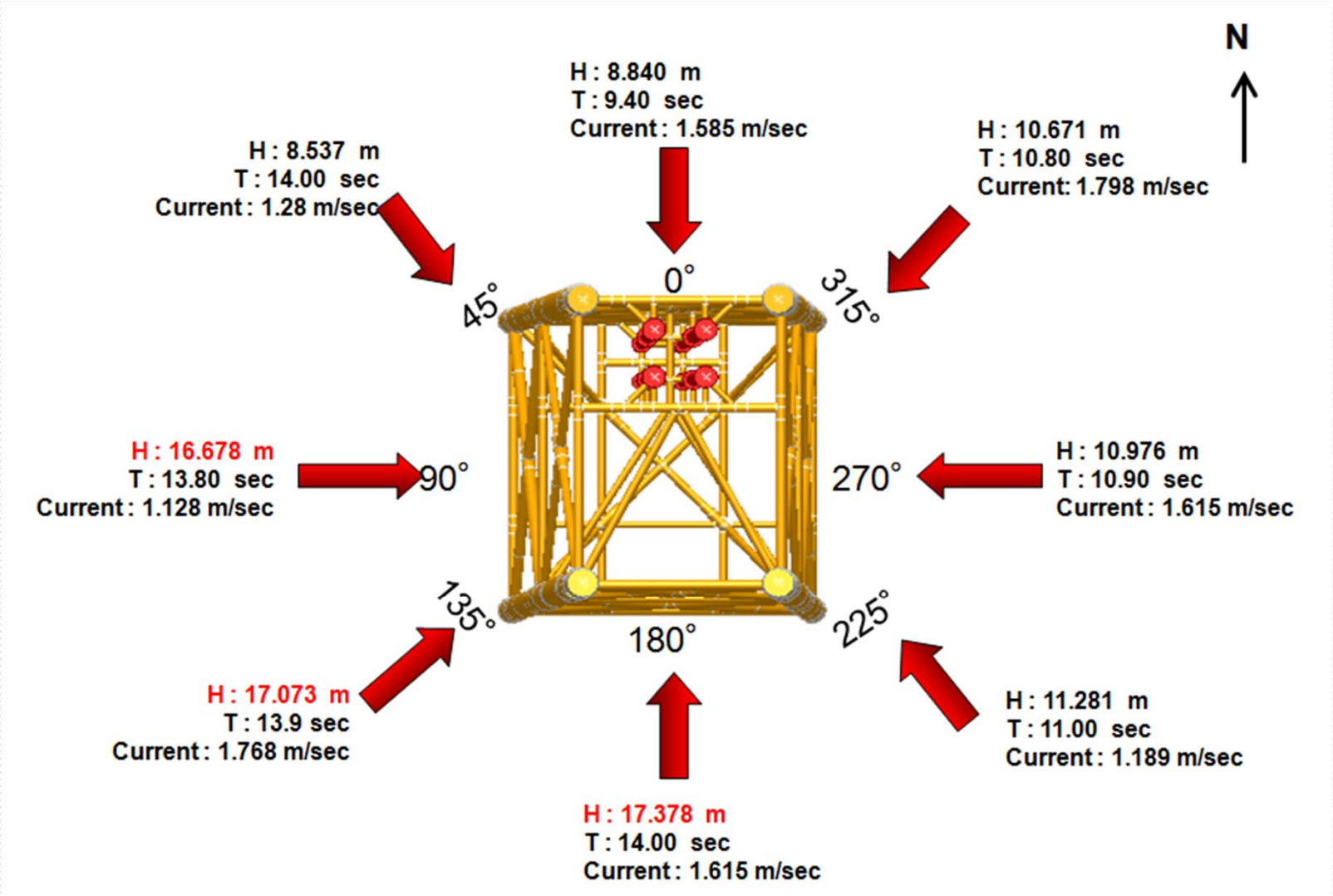
WAVE & CURRENT 100 YEAR RETURN PERIOD (EXTREME STORM)



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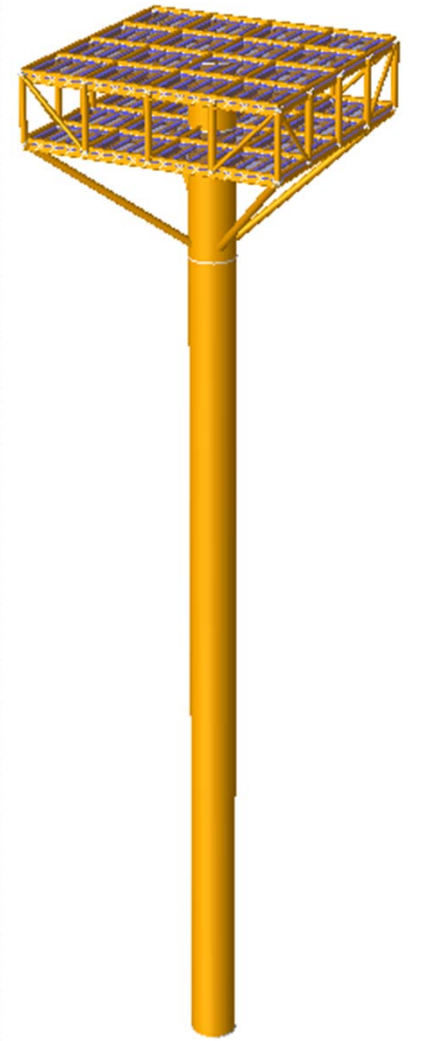
Topside Weight : 750 Tonnes
Jacket Weight : 330 Tonnes
Installation : Crane Vessel
Offshore Work : Crane Barge

Number of piles : 1 Main Pile
Pile Diameter : 142”
Penetration : 80m
Pile Weight : 350 Tonnes

Estimated Total Weight : 1430 Tonnes
Estimated Offshore Time : 6 Days
Estimated Cost : US$ 16M

Risk : Large deflection
Additional MSF required

Mono Pile without Guy Wire



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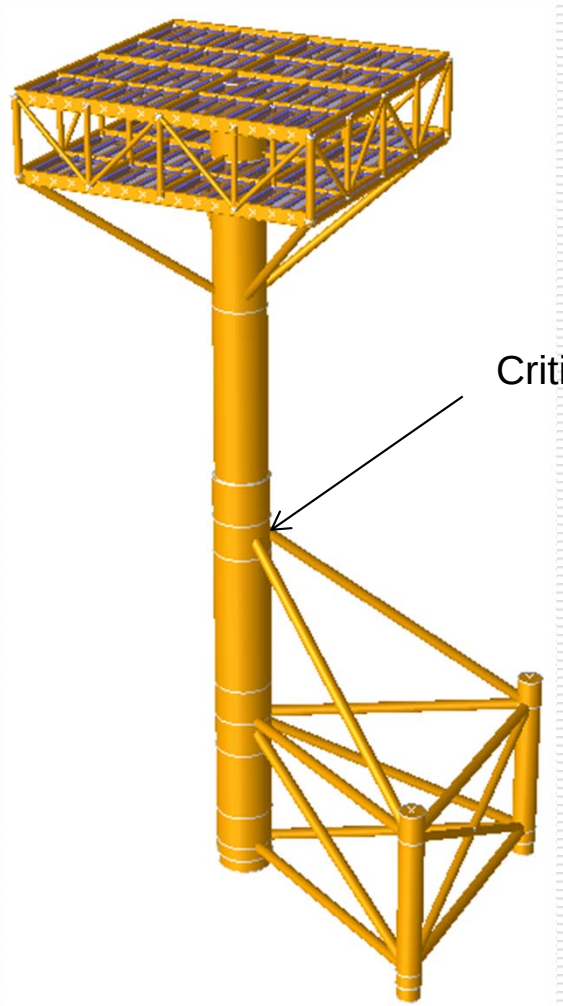
Topside Weight	: 750 Tonnes
Jacket Weight	: 370 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Number of piles	: 1 Main & 2 Skirt Piles
Pile Diameter	: 142” (Main)
	: 60” (Skirt)
Penetration	: 80m
Pile Weight	: 630 Tonnes
Estimated Total Weight	: 1750 Tonnes
Estimated Offshore Time	: 12 Days
Estimated Cost	: US$ 22M

Risk : Fatigue at brace junction
Additional MSF required

Braced Mono Tower (Inside Conductor)



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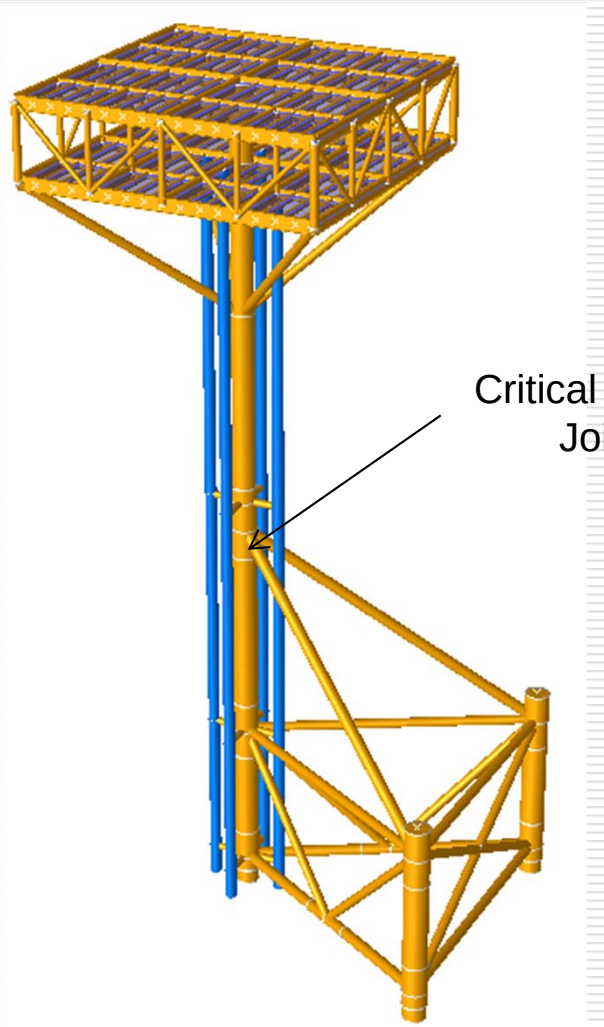
Topside Weight	: 750 Tonnes
Jacket Weight	: 300 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Number of piles	: 1 Main & 2 Skirt Piles
Pile Diameter	: 60”
Penetration	: 80m
Pile Weight	: 470 Tonnes
Estimated Total Weight	: 1520 Tonnes
Estimated Offshore Time	: 12 Days
Estimated Cost	: US$ 21M

Risk : Fatigue at brace junction
Additional MSF required
Conductors exposed to damage

Braced Mono Tower (Outside Conductor)



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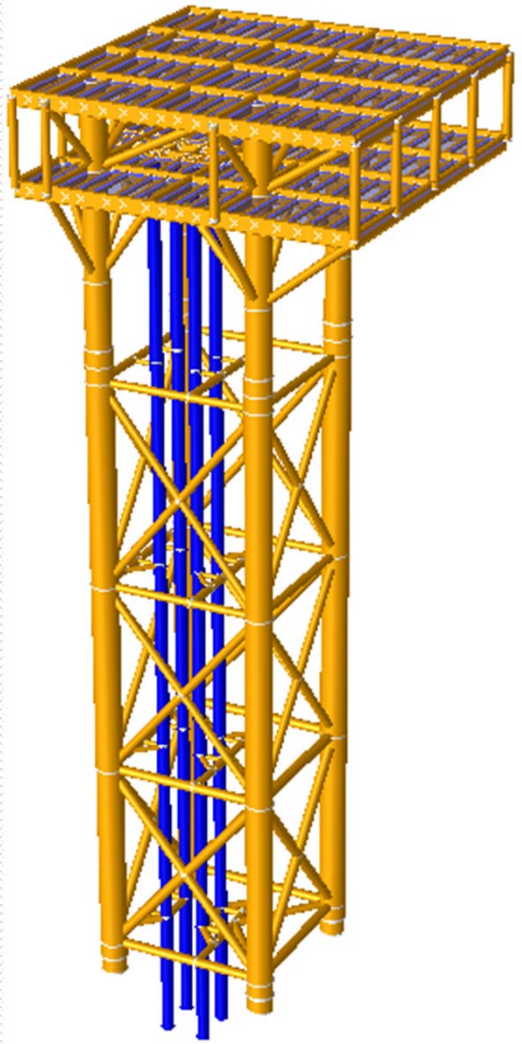
Topside Weight : 750 Tonnes
Jacket Weight : 460 Tonnes
Installation : Crane Vessel
Offshore Work : Crane Barge

Number of piles : 4 Main Piles
Pile Diameter : 60”
Penetration : 80m
Pile Weight : 640 Tonnes

Estimated Total Weight : 1850 Tonnes
Estimated Offshore Time : 15 Days
Estimated Cost : US$ 25M

Risk : Increased pile loads due to limited dimensions of jacket base

4 Legged Jacket Structure



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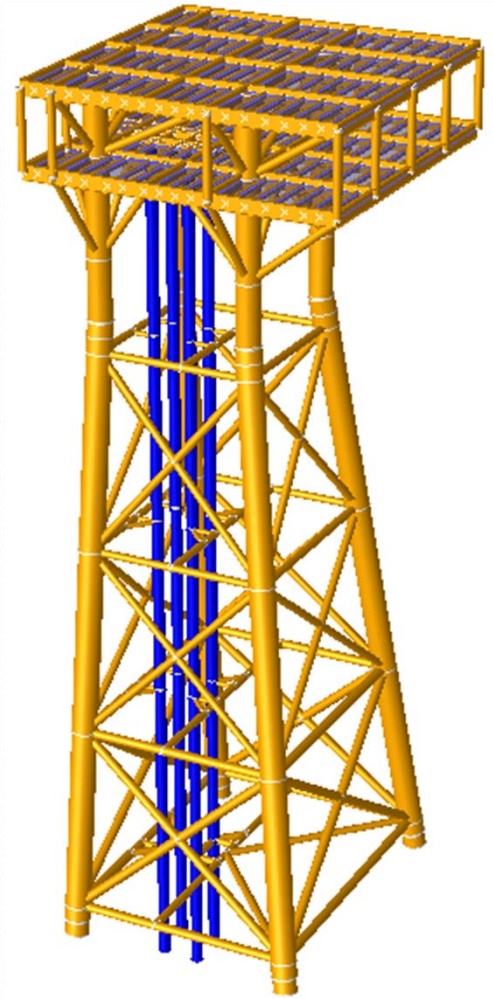
Topside Weight : 750 Tonnes
Jacket Weight : 490 Tonnes
Installation : Crane Vessel
Offshore Work : Crane Barge

Number of piles : 4 Main Piles
Pile Diameter : 60”
Penetration : 80m
Pile Weight : 640 Tonnes

Estimated Total Weight : 1880 Tonnes
Estimated Offshore Time : 15 Days
Estimated Cost : US$ 25M

Risk Level : No major issues

4 Legged Jacket Structure with Batter piles



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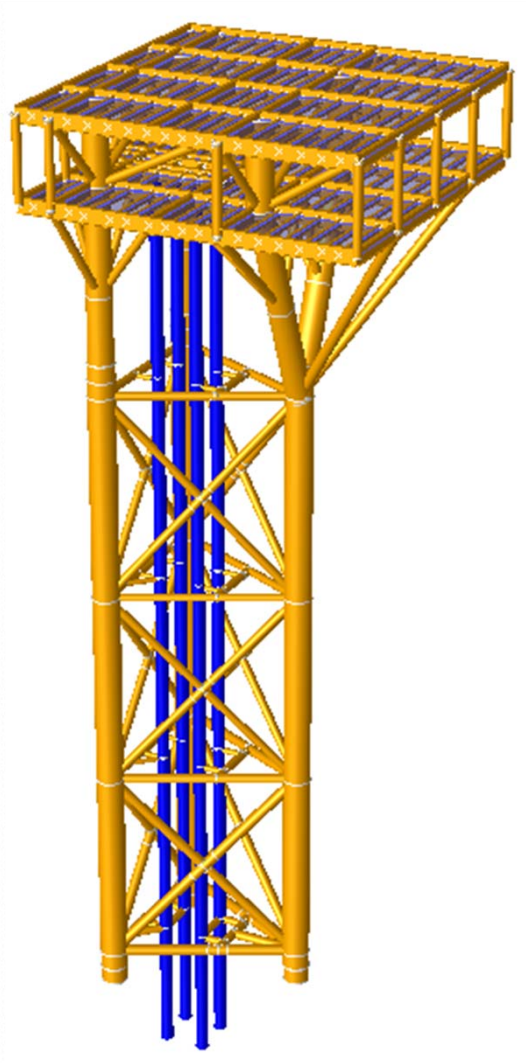
Topside Weight	: 750 Tonnes
Jacket Weight	: 350 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Number of piles	: 3 Main Piles
Pile Diameter	: 60”
Penetration	: 88m
Pile Weight	: 510 Tonnes
Estimated Total Weight	: 1610 Tonnes
Estimated Offshore Time	: 15 Days
Estimated Cost	: US$ 23M

Risk Level : Large Pile loads at south pile
Installation difficulty

3 Legged Jacket Structure



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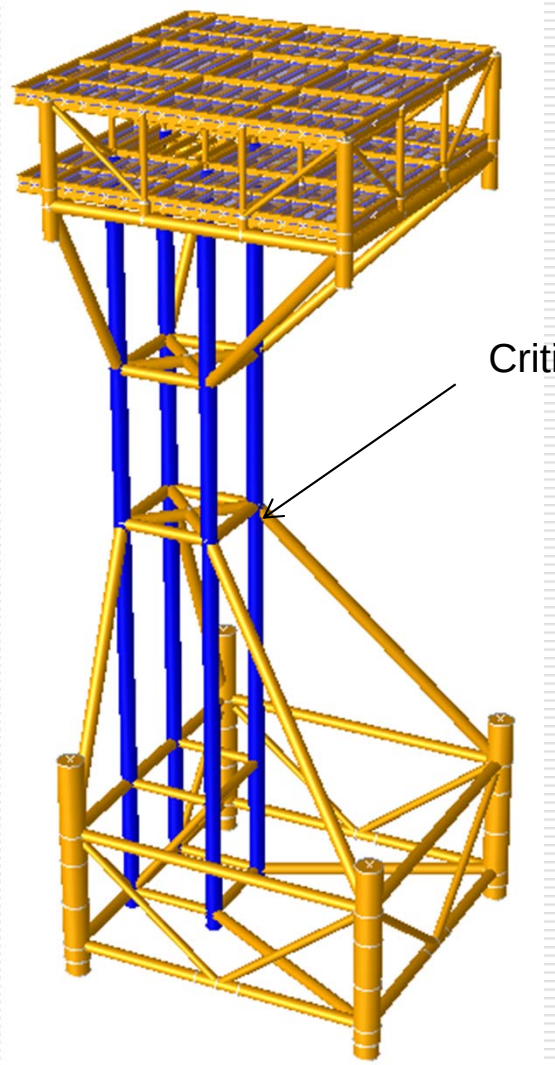
Topside Weight	: 750 Tonnes
Jacket Weight	: 500 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Number of piles	: 4 Skirt Piles
Pile Diameter	: 60”
Penetration	: 77m
Pile Weight	: 530 Tonnes
Estimated Total Weight	: 1780 Tonnes
Estimated Offshore Time	: 15 Days
Estimated Cost	: US$ 24M

Risk Level : Conductor legs exposed for damage
MSF is required
Fatigue at brace junction

Braced Leg Jacket (4 Piles)



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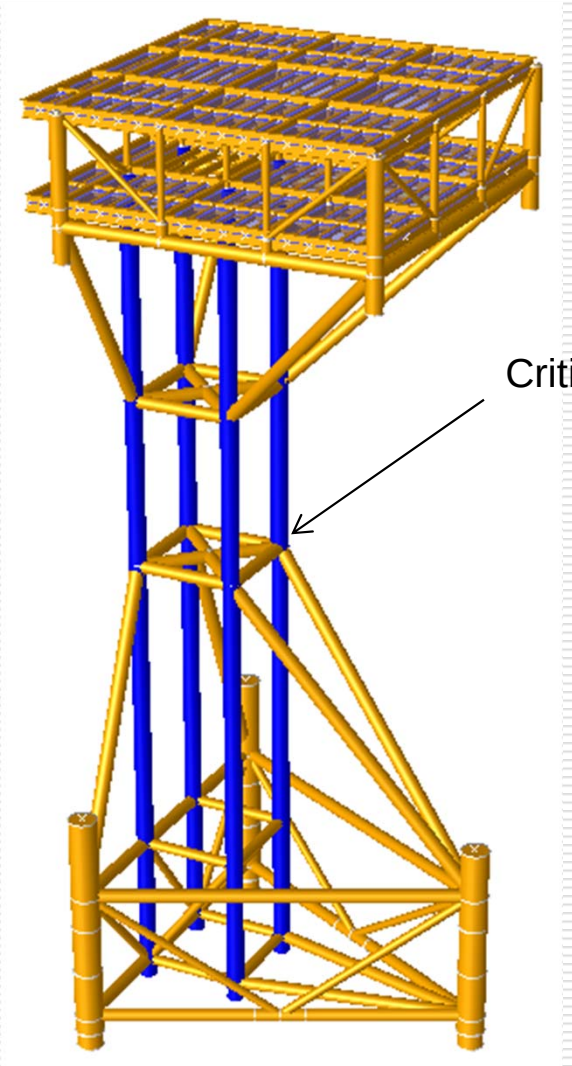
Topside Weight	: 750 Tonnes
Jacket Weight	: 450 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Number of piles	: 3 Skirt Piles
Pile Diameter	: 60”
Penetration	: 77m
Pile Weight	: 400 Tonnes
Estimated Total Weight	: 1600 Tonnes
Estimated Offshore Time	: 12 Days
Estimated Cost	: US$ 21M

Risk Level : Conductor legs exposed for damage
MSF is required
Fatigue at brace junction
Large pullout loads on south pile

Braced Leg Jacket (3 Piles)



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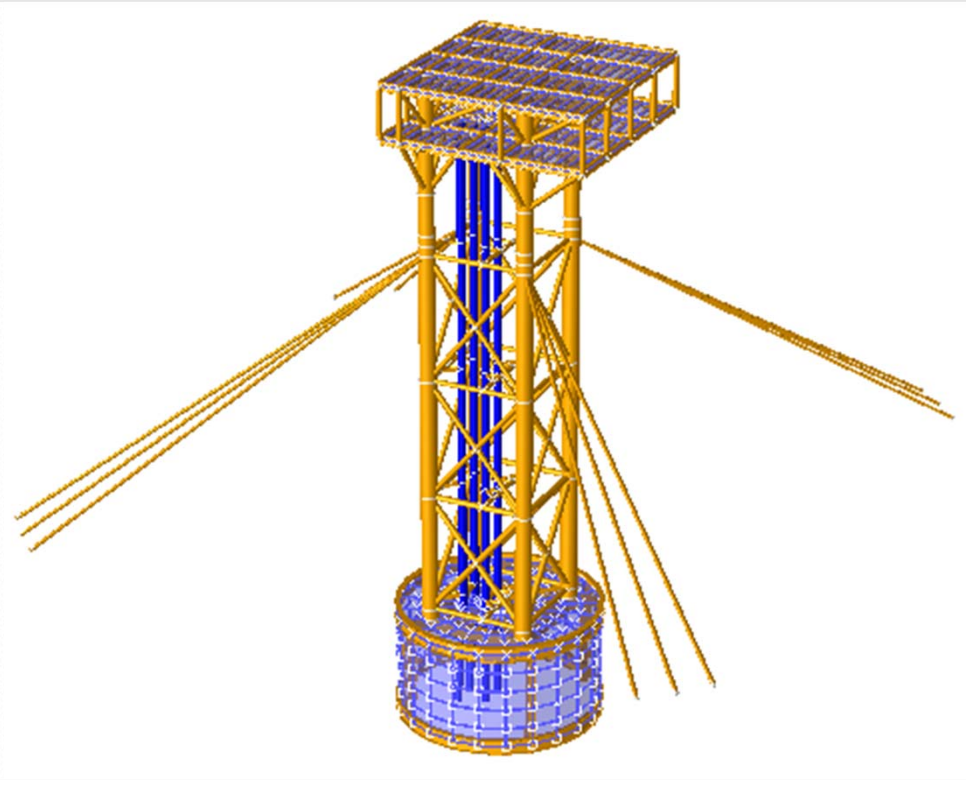
Topside Weight	: 750 Tonnes
Jacket Weight	: 440 Tonnes
Caisson Weight	: 400 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Estimated Total Weight	: 1590 Tonnes
Estimated Offshore Time	: 18 Days
Estimated Cost	: US$ 25M

Risks : Installation of guy systems
Installation of large caisson
Damage to guy wires
Approach by boat
Large anchor forces

4 Legged Jacket with Hollow Base Steel Caisson (with Guy Wire)



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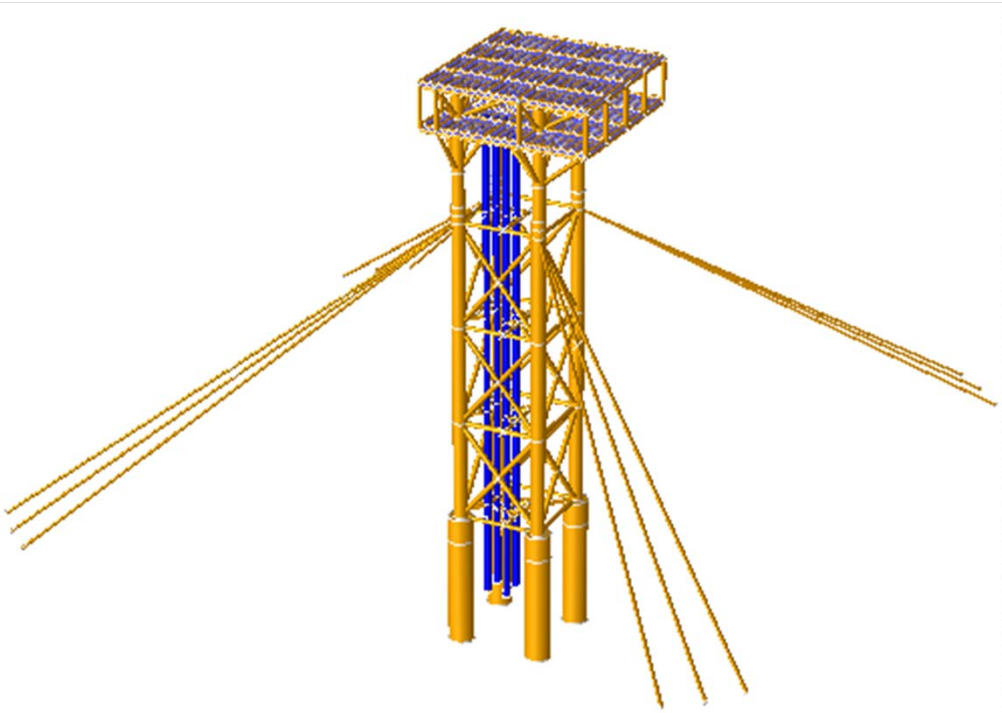
Topside Weight	: 750 Tonnes
Jacket Weight	: 480 Tonnes
Caisson Weight	: 250 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Estimated Total Weight	: 1480 Tonnes
Estimated Offshore Time	: 18 Days
Estimated Cost	: US$ 24M

Risks : Installation of guy systems
Damage to guy wires
Approach by boat
Large anchor forces

4 Legged Jacket with Steel Caisson with Each Legs (with Guy Wire)



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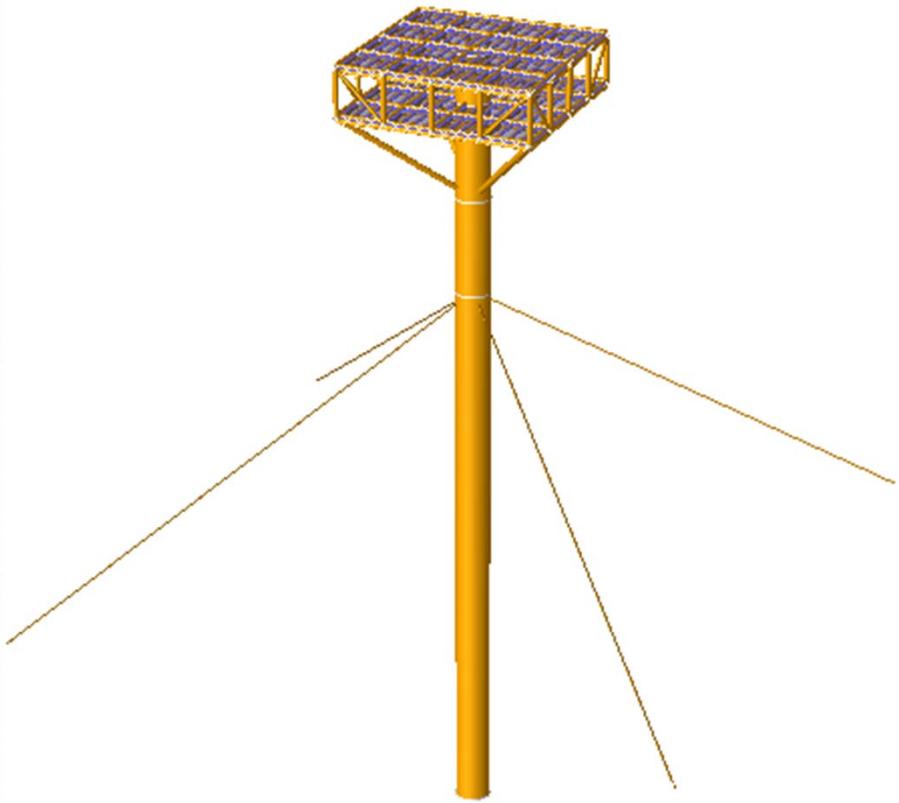
Topside Weight	: 750 Tonnes
Jacket Weight	: 330 Tonnes
Installation	: Crane Vessel
Offshore Work	: Crane Barge
Number of piles	: 1 Main Pile
Pile Diameter	: 142”
Penetration	: 80m
Pile Weight	: 350 Tonnes
Estimated Total Weight	: 1430 Tonnes
Estimated Offshore Time	: 15 Days
Estimated Cost	: US$ 22M

Risk : Installation of guy systems
Damage to guy wires
Approach by boat
Large anchor forces

Mono Pile with Guy Wire



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Weight Comparison

S. No	Description	Jacket (MT)	Pile (MT)	Total (MT)	Recommendation
1a	Mono pile	330	350	680	Feasible for 1-2 conductors
1b	Braced Mono tower (Inside Conductor)	370	630	1000	Recommended
1c	Braced Mono tower (Outside Conductor)	300	470	770	Recommended with large diameter mono pile
2a	4 Legged Jacket Structure	460	640	1100	Recommended
2b	4 Legged Jacket Structure with Batter Piles	490	640	1130	Recommended
2c	3 Legged Jacket Structure	350	510	860	Not Recommended
3a	Braced Legs (4 piles)	500	530	1030	Recommended
3b	Braced Legs (3 piles)	450	400	850	Not Recommended
4a	4 Legged Jacket with Hollow Base Steel Caisson (Guy Wire)	440	400	840	Not Recommended
4b	4 Legged Jacket with Steel Caisson with Each Legs (Guy wire)	480	250	730	Not Recommended
4c	Mono pile with Guywire	330	350	680	Not Recommended

Variation of weight among the concepts is limited to 10 to 20% except for mono pile

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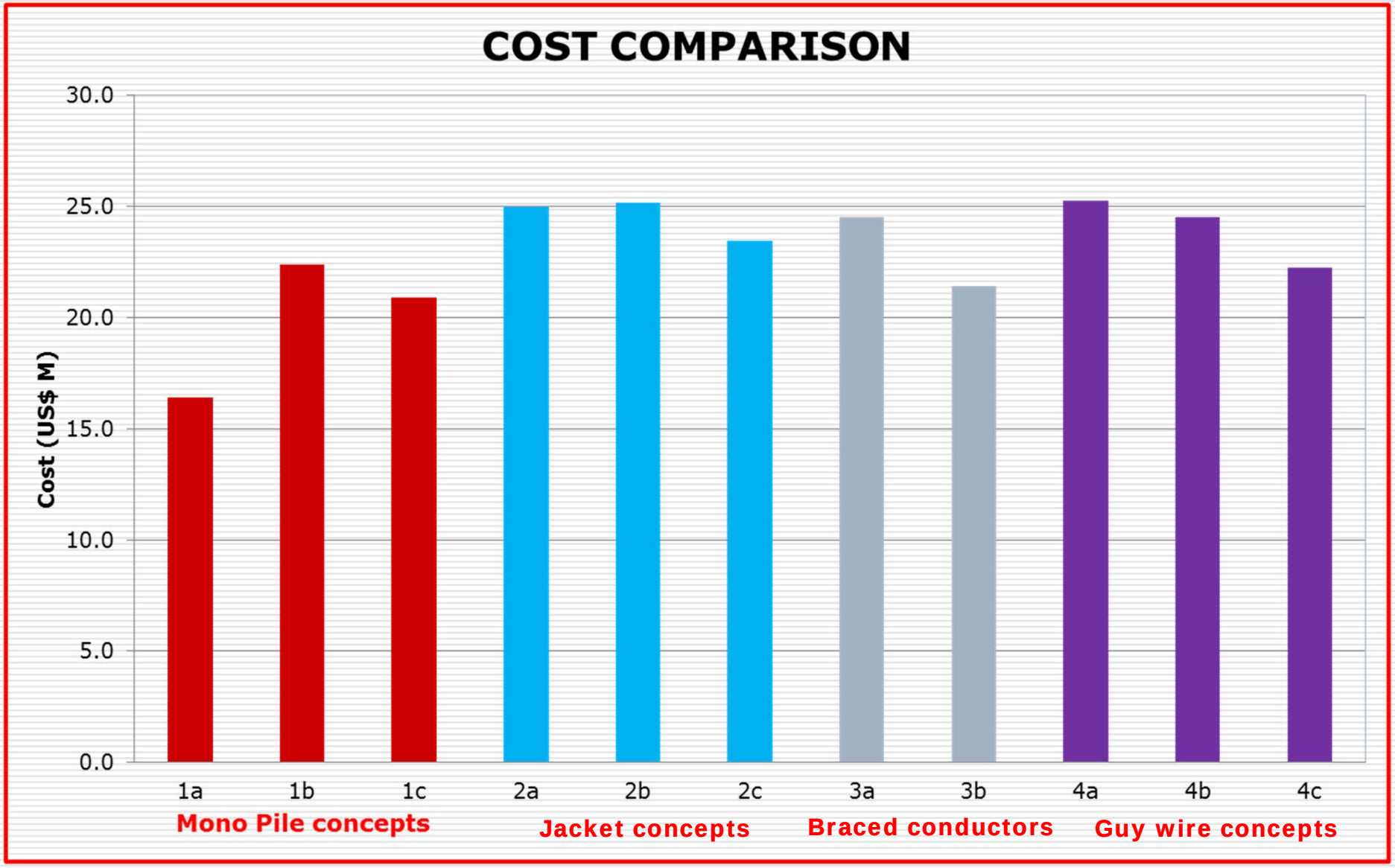

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Technical Feasibility

- Design of Mono pile and braced mono pile system has limitations on the deck foot print size. The concept can be adopted if the topside dimensions can be limited to less than 20m x 20m.

- Braced conductor leg concept can be implemented with sufficient conductor protection system which may alleviate the safety issue. The limitations on the deck foot print applies to this option also.

- Guy support structures require pile foundations for wire anchor system which will be costly. Further, guyed wire support systems not recommended based on installation and safety issues due to potential failure of guy wires.

- Hence an optimized conventional jacket will prove to be a potential candidate both in terms of safety and installation even though cost is slightly higher.

- Installation by jackup rigs shall be considered carefully only for water depths less than 30m.

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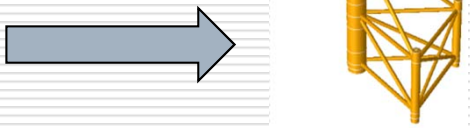
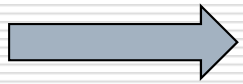
Conclusions

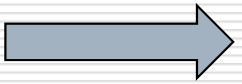
- Mono pile with braced skirt pile system offers economical solution and can be installed by small derrick or pipe lay barge as the weight of each component is less than 650 Tonnes. Hence this can be implemented in upcoming marginal fields with water depth not exceeding 50m.

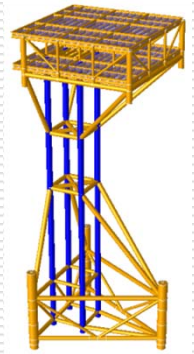


- For other marginal fields where water depth is greater than 50m, optimized jacket concepts are recommended.



- Braced conductor legs can be used with sufficient leg protection and fatigue design.





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Thank you

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Deflection for Various options					
Options	Option Description	X - deflection (mm)		Y - Deflection (mm)	
		Operating	Storm	Operating	Storm
1a	Monopile	282	1125	393	936
1b	Braced Mono tower (3 piles)_Inside Conductor	64	212	105	267
1c	Braced Mono tower (3 piles)_Outside Conductor	163	3783	207	647
2a	4 Legged Jacket Structure	85	486	149	426
2b	4 Legged Jacket Structure With Batter Piles	80	301	50	109
2c	3 Legged Jacket Structure	99	674	149	1190
3a	Braced Legs (4 piles)	160	363	120	372
3b	Braced Legs (3 piles)	175	476	149	622
4a	4 Legged Jacket with hollow base steel caisson	39	100	38	69
4b	4 Legged Jacket with steel caisson with each legs	14	42	17	30
4c	Monopile with Guywire	20	99	27	83

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