Fabrication, Launch and Towing of SPU

A development project of Subsea 7

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Introduction

Oil and gas reserves from the natural reservoirs under seabed are produced based on Exploration, Exploration drilling, Engineering and Production. Deepwater water explorations for the quest of hydrocarbon reserves resulted in the concept of subsea field development with wellhead and production equipment on the seabed. With improvement in technology, oil and gas industry is aiming for transforming the functions of processing the hydrocarbons to the seabed. Effective subsea field development solutions eliminates the need for traditional platforms having processing facilities at the topside. The trend towards a higher degree of standardization and continued improvement in the quality of products being offered led to the development of Submerged Production Unit (SPU). The motivation behind subsea processing is for handling and treatment of the produced fluids for mitigating flow assurance issues prior to reaching the platform in order to maximize the cost and mitigate the risks.

Main Objectives

1. The main objective for the master thesis is to optimize the fabrication plan by looking into the best way of assembly of all equipment, modules, structural section units etc. on the platform with an efficient method to connect the structural joints.
2. The logistics and production of GRP especially the different ways (split or tubular) the GRP structural units can be fabricated based on the facilities available, suppliers expertise, storage requirements, cost and time.
3. Review various production yards, select the best based on its facilities and resources in Norway to optimize the production plan.
4. Finally launching plan and towing analysis of the SPU using the software OrcaF lex with measured data from model test at Sintef Ocean.
5. With all the materials and equipment details known, estimate the lead time for each item and then for the entire production process.

Background

The SPU is made of steel bottom frame with pontoons, Glassfibre Reinforced Plastic (GRP) beams and pillars with subsea buoyancy materials, processing equipment and GRP covers. GRP forms the major part of the SPUs structural component. The process involves fabricating the buoyancy material and GRP and assembling them together. Fabrication facilities limitations, snag points, water depth, cost, equipment dimensions, subsea buoyancy material fabrication methods are some driving factors involved in modelling the SPU. Different launching methods of using Dry docks, Floating docks, Syncrolifts are considered in the thesis. Conventional way of lifting the equipment using cranes of construction vessels on site during deployment is avoided as the structure is heavy consisting of all equipment for processing. So, Constant Depth Tow Method is used to tow the structure to the field.

Evolution of SPU Model

Industrial visit to the GRP fabricators in Norway resulted in identifying the crux areas to be considered in the modelling of SPU. Vacuum Infusion process is used in the GRP manufacturing process. It is a technique that uses vacuum pressure to drive resin into a laminate. Shop dimensions, crane capacities, internal transport facilities and the logistics are noted for consideration in the design of SPU. The concept of splitting the GRP beam in to a base and a top and then laminating them with buoyancy modules inside turned out to be an economical and feasible way of fabrication as it results in reusing the moulds and lamination avoids the usage of Alloy 625 bolts.

With all the background information a model is developed in Autodesk Inventor. In order to avoid the complexity of connecting the longitudinal, vertical and transverse GRP beams from inside, a model with reduced crossection at the beam ends was developed initially to have joint connections outside. It seemed to have high stress concentrations at the reduced cross section, which could result in loss of strength and buoyancy. So a 3D joint is modelled providing the access for connecting the longitudinal, transverse, and vertical GRP beams together.

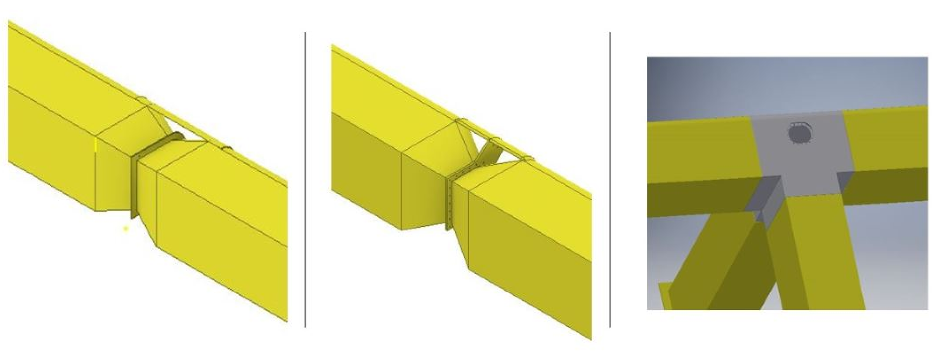

Figure 1: Evolution of SPU Model

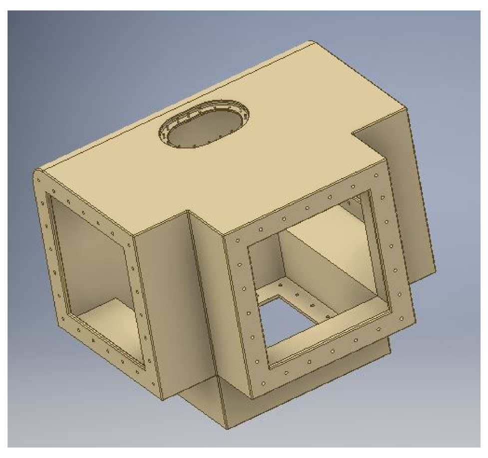

Figure 2: 3D Joint

Polyurethane foam, Co-Polymer foam, Syntactic foam are some of the subsea buoyancy materials considered for application. Pure syntactic foam has the density range from 380 to 650Kg/m^3 providing an operational capability upto full ocean depth.

Results

Pre fabricated GRP beams are used as moulds for fabricating the buoyancy modules made of syntactic foam(resins, macrospheres and microsphere mixture). 3D joints are used for connecting the longitudinal, transverse and vertical beams together.

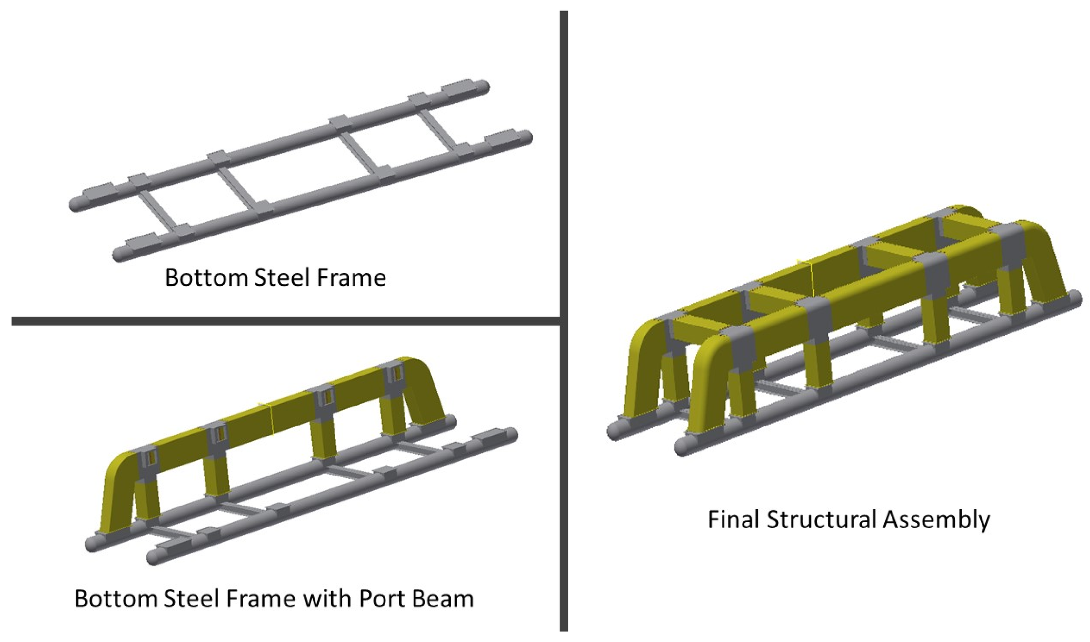

Figure 3: Assembly Plan

Analytical Hierarchy Process(AHP) is used to identify the best launching method. Syncrolift resulted in cost efficient and safe launching method for SPU.

Yard/Factors	Cost	Safety	Fabrication facilities	Commisioning facilities
Yard 1 (Dry Dock)	0.163	0.122	0.657	0.630
Yard 2 (Syncrolift)	0.540	0.558	0.196	0.218
Yard 3 (Covered Dry Dock)	0.297	0.320	0.147	0.151

Table 1: AHP Matrix for Yard Selection

Wave height of 7m, Wave period of 6 to 24s, Dean Stream regular waves, Wave direction 0, 45, 90, 135 and 180 degrees, Current in 90 degrees at 1m/s and Vessel speed of 4knots are the inputs for the analysis. Towing analysis resulted in finding the clump weights to be 50T forward and 30T aft. End force in Global-X direction is 422.121 KN. Effective tension maximum is 837.385 KN for a 7m and 20s wave in 180 degrees and current in 1m/s and 90 degrees. DNV-OS-H202 is used to calculate the tug efficiency factor, and the required BP is 30T.

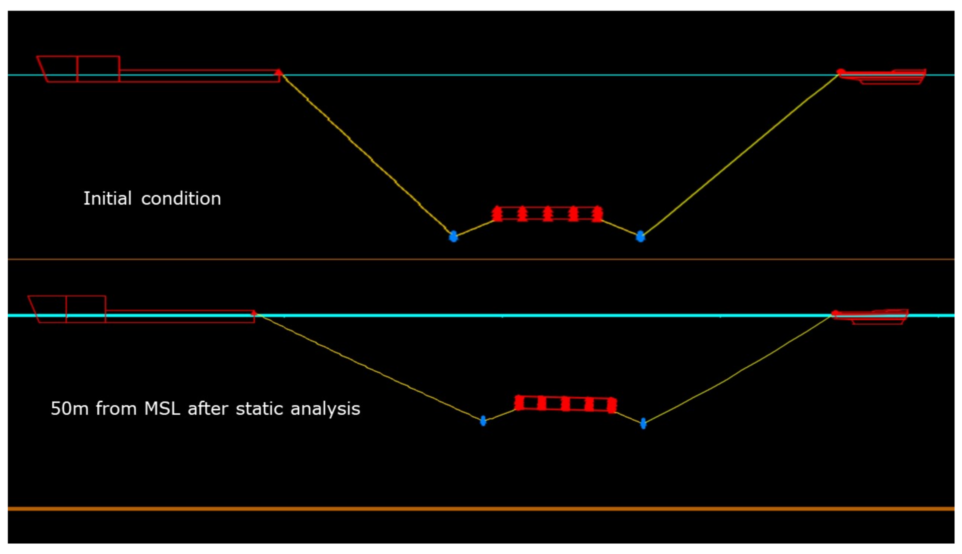

Figure 4: Towing Configurations

Forthcoming Work

Lead time analysis with more importance given to GRP beams fabrication, buoyancy material fabrication, main equipment and their assembly is the final work in progress for the thesis. Forces acting on the structure during towing, impact loading, stability check, bolt calculations and weather window are to considered in the forthcoming research.

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