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LOADOUT DEVELOPMENT BY F.E. ANALYSIS METHODOLOGY FOR SIMILAR 300K VLCC SIZE FSO

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ABSTRACT

End of July, 2002 Hyundai Heavy Industries Co. Ltd. Offshore Division is successfully completed Load-out & Float-off work of "AMENAM KPONO/FSO Project" similar to 300K VLCC size. The AMENAM FSO hull and topside module built at the HHI Offshore yard using "On-Ground Building Method" developed by HHI. Various methodologies/techniques like Flexi-built FPSO Hull, Topside module erection method, Load-out and Float-off methodology etc. are combined to develop a successful on-ground building method. In this paper, we described the "Hull Structural Strength Analysis Methodology" using 3-D Finite Element Analysis and results. This analysis is performed to verify the structural integrity of the AMENAM FSO hull during the main load-out on two semi-submersible barges combined together.

Keywords : Load-out, On-Ground building, Active shoe

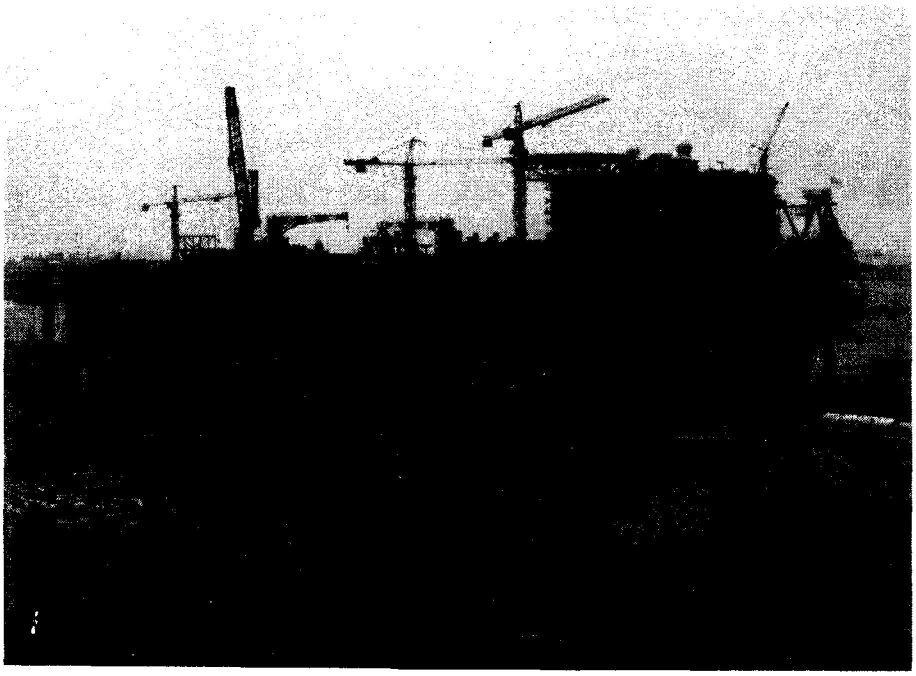

Figure 1. Overall view -Before the Load-out of AMENAM FSO/KPONO

1. Introduction

Overall length of AMENAM FSO is 298m and the estimated lightship weight is 48,000 Metric ton. HHI had selected 51,000 Metric ton for the design of load-out in order to have sufficient engineering margin. During the past 20-years, HHI had numerous experience of load-out operation including a 30,000 ton base load-out. But in those load-outs, load-out barge capacity was big compared with loaded out weight and load-out length was not exceeding 100 m. In AMENAM FSO load-out case, load-out length is about 140 m from the quay-side and total load-out barge capacity is 70,000 ton (2 x 35,000ton each).

AMENAM FSO has two inner skin bulkheads and side shell. These bulkheads supported by symmetrical 124 m active shoes during the normal load-out operation. From the simple beam analysis results, each longitudinal bulkhead and side-shell share 82% and 18% load respectively, under the active shoe up-lifting force. Even though after the connection of two barges, the Double Barge Unit's (DBU) tank capacities were only 65% and 35% near the longitudinal bulkhead and side-shell. So, to cover this insufficient tank capacity, HHI made a special loads sharing plan using in-house software program. After the special load sharing, each of longitudinal bulkheads and side-shells has taken the 16,575ton and 8925ton of uplifting force respectively, especially from 124m active shoes.

Following design criteria was selected during the load-out operation:

Table 1-1. Design criteria during the load-out

Design criteria				
Wind (knots)	Wave Hs(m)	Wave Tz(sec)	Current (knots)	Tide (cm)
40	0.5	3~6	0.6	60

Maximum tide deviation of 60cm is the average tidal variation prevailing at ULSAN Bay in end of July 2002 with maximum deviation rate of 10cm per hour. The TPC(Ton per centimeter) of the DBU is 110ton. For safe tidal compensation, HHI installed two nos. 500m^3/hour capacity potable pump even though main pumps capacities of 4x2000m^3/hour are adequate to cater for both load and tidal compensation. The active jacks stroke are 250mm. Since wind, wave and current forces are resisted by the other load-out equipments like mooring lines, fenders, link-beams & etc., environmental forces are not considered in strength analysis.

For the 3-D F. E. analysis, Hull structure has been modeled through DNV SESAM program. PLATE WORK module of DNV SESAM program has been utilized for the plate yield and buckling unity check. The model composed of 184,229 nodes and 319,578 plate & beam elements. The AMENAM FSO hull structure is modeled by means of three or four node shell and two node beam elements. Steel panels are modeled by plate & shell elements with appropriate thickness, while girders, webs and longitudinal stiffeners are modeled by T-beam with appropriate geometrical properties (flange and web thickness) and eccentricity. Plate element sizes in the model are as same as the longitudinal spacing of hull structure (800mm ~ 930mm).

2. Model geometry

The AMENAM FSO full ship 3-D F.E. model consists of eight (8) super elements and detailed block divisions as shown in the Fig.2-1 below.

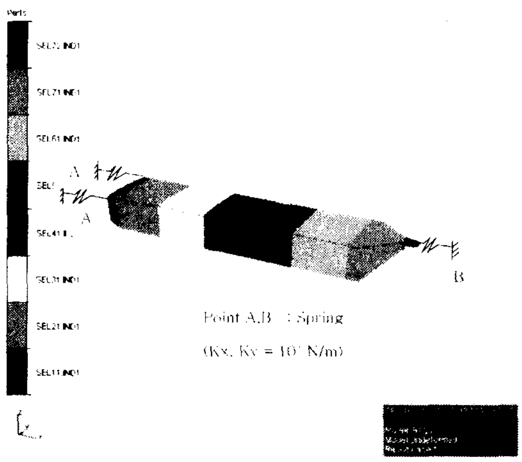

Fig. 2-1 The 3-D model and boundary condition of AMENAM FSO

2.1 Basic Model Load

From the past experience, (a) load-out weight, (b) yard settlement and (c) barge deflections due to still water bending moments are main loads arises during the load-out operation. From the preliminary F. E. analysis results it has been noted that maximum deflection of AMENAM FSO was about 100mm (Hogging mode) during active shoe supporting condition and As per "Foundation Analysis & Design Report" maximum yard settlement will not exceed 35mm during the load-out operation.

From these results it has been concluded that active jack stroke 250mm has sufficient margin during the hull deformation and yard settlement for normal operation. So, Yard settlement effects have not been considered as the load-out design load but for the temporary support design case yard settlement effects have been considered.

- Vertical gravity Loading

1) Hull structural dead loads (BLC 1)

The structural coded weight was generated automatically by SESAM program. Non-coded misc. items e.g. external turrets, living quarters, topsides modules, etc weights were calculated based on weight control reports and inputted as separate loads. Contingency of 10% was considered to account stiffeners, paint and welds.

2) Topsides module loads -Include equipments (BLC 2)

Topsides module loads were calculated from overall equipment layout drawing and weight control report. The loads were considered as uniformly distributed load on the deck.

3) Turret & suspended loads (BLC 3)

Turret and suspended loads were extracted from vendor design report.

4) Living quarters and helideck loads (BLC 4)

Living quarters and helideck loads were from weight control report and living quarters design report.

From the vertical gravity loading, SESAM program generates weight, C.O.G of loaded weight and natural deformation of AMANEM FSO in sagging mode under the simple support condition. HHI developed the active shoe system in order to eliminate the stress concentration that may arise due to hull deformation.

- Uplifting force from Active shoe

5) Active jack up-lifting force (BLC 5)

The active shoe system is able to distribute load effectively and evenly on the load-out beams. The active jack up-lifting forces and locations were calculated using HHI in-house calculation sheets. To make good stability during the load-out operation, different up-lifting forces are calculated at each active jack groups. Values are shown in Fig. 2-2. Total up-lifting force is same as vertical gravity load summary of load-out condition.

- Deformation for boundary displacements

6) Hull natural deformation (BLC 6)

For the structural integrity at jack-down condition, the boundary displacement was extracted from active jack-up condition and combined with barge deformation to cover the Stillwater bending moment effects. The detail information is shown in Fig.2-3.

7) Barge deformation at 10m, 60m and 100m progress during the main load-out (Include barge still water bending moment effect) - BLC 7 ~ 9

After the progressive on board the DBU conditions, the barge still water bending moment effect with or without ballasting or de-ballasting, AMENAM FSO natural hull deformations are related. Still water bending moment and displacements was extracted from the NAPA program results. For detail information, are refer to attached Fig.2.3.

2.2 Load Combinations and boundary conditions

During the main load-out, boundary conditions considered are as shown in Fig.2-1 and active jack was located on web frame No. 18 to 42 of each side shell and longitudinal bulkhead. Hydro jack location and up-lifting force are as shown in Fig. 2-2 and total weight was approximately 51,000 ton.

For the consideration of barge deformation during the main load-out, HHI considered combination of hull natural deformation (BLC6) & barge deformation (BLC7 ~ 9) applied at each load-out step. For detail, refer Fig. 2-3.

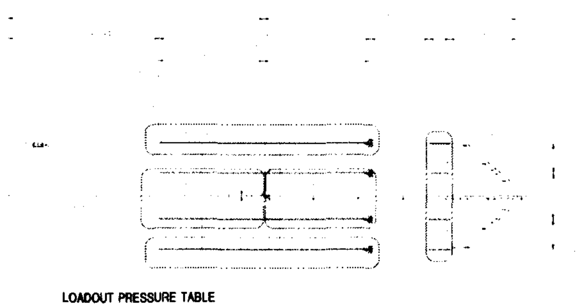

Fig. 2-2 Hydro jack up-lifting force location in load-out

1) Load combination 1 (LCB 1)

Combined vertical gravity loading and up-lifting force for jack active condition (Load-out initial condition)

LCB 1 = BLC1 + BLC2 + BLC3 + BLC4 + BLC5

2) Load combination 2 (LCB 2)

Combined jack active condition and barge hull deformation from still water bending moment after progressed 10m on board of the barge

LCB 2 = BLC1 + BLC2 + BLC3 + BLC4 + BLC6 + BLC7

3) Load combination 3 (LCB 3)

Combined jack active condition and barge hull deformation from still water bending moment after progressed 60m on board of the barge

LCB 3 = BLC1 + BLC2 + BLC3 + BLC4 + BLC6 + BLC8

4) Load combination 4 (LCB 4)

Combined jack active condition and barge hull deformation from still water bending moment after progressed 100m on board of the barge

LCB 4 = BLC1 + BLC2 + BLC3 + BLC4 + BLC6 + BLC9

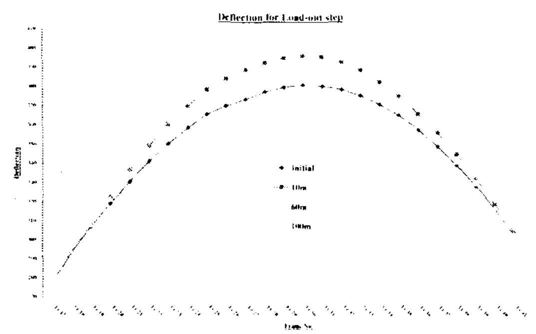

Fig. 2-3 Hull deformation during the Main load-out (Including barge deformation)

2.3 Results

During the load-out, the maximum deflection of AMENAM FSO was 340mm between A.P. to F.P. but within the active shoe support the deflection was less than 100mm.

The maximum Von-Mises stress in plate elements was 214 N/mm^2 at side shell of during 100m progressed on board condition. Stress contours near the longitudinal center of gravity location at initial condition are shown in Fig. 2-4 ~ 2.7. All plates were within the allowable stress limits during main load-out condition.

The yield and buckling checks have been carried out using PLATE WORK module of SESAM programs for plate elements and based on the criteria of DNV classification Notes No.30.1, respectively. The maximum value of buckling unity check is 0.88 at side shell plate after 100m progressed on board in barge condition. For all plates, stiffeners, girders buckling stress are within the allowable limits.

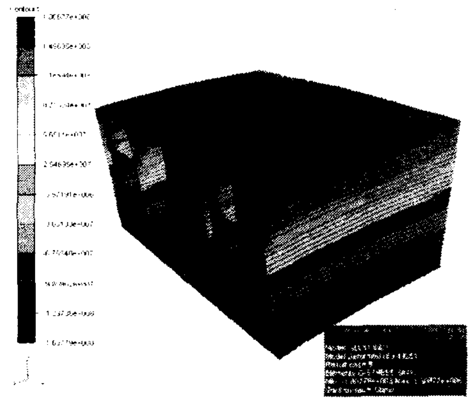

Fig. 2-4 Load-out Initial condition X-axis bending stress contour (Near the L.C.G Location: -161N/mm^2 ~ 180N/mm^2)

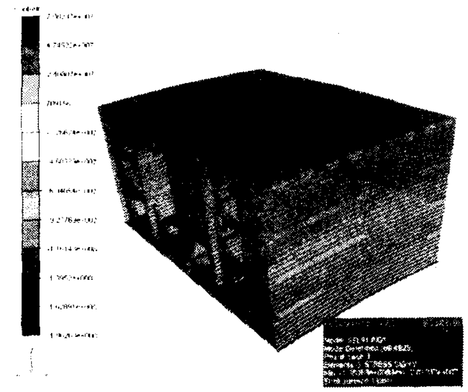

Fig. 2-5 Load-out Initial condition Y-axis bending stress contour (Near the L.C.G Location: -186N/mm^2 ~ 71N/mm^2)

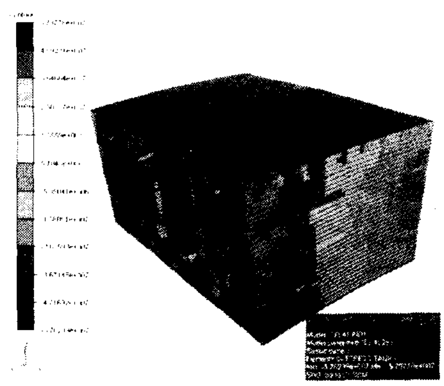

Fig. 2-6 Load-out Initial condition shear stress contour (Near the L.C.G Location: -58N/mm^2 ~ 57N/mm^2)

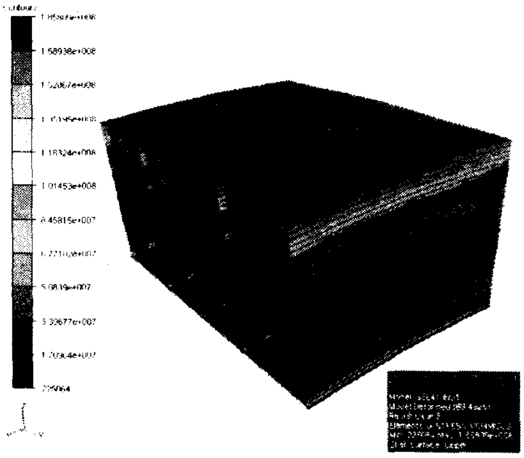

Fig. 2-7 Load-out Initial condition Von mises stress contour (Near the L.C.G Location: $-161N/mm^2 \sim 180N/mm^2$)

3. Conclusion

The AMENAM FSO has been verified by the 3-D F.E. analysis for the load-out condition using SESAM program. The design load conditions for the hull structure has considered very conservatively for this purpose.

During the active jack support condition, AMENAM FSO has a hogging mode and maximum deflection in longitudinal direction is about 300mm and in transverse direction is 34 mm at side shell. As per API-RP2A, all the structures are within the allowable limits of deflection (284840/360 = 791 mm for primary, 284840/180 = 1582 mm for secondary).

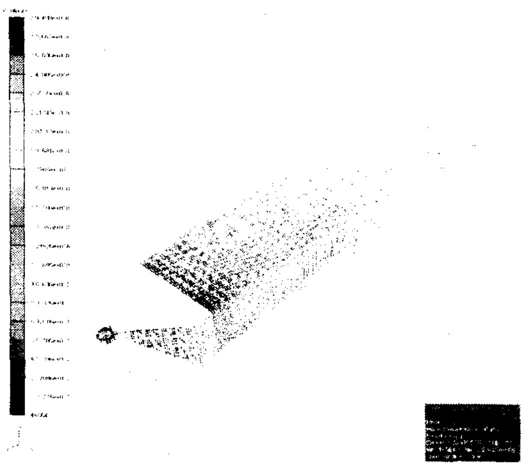

Fig. 3-1 Von-mises stress and Hull deformation during the load-out (Including barge deformation)

For the plate elements, the maximum Von-Mises stress is 214 N/mm^2 at the side shell during the progressed 100m in barge condition. Also there is no overstressed plate element noticed in all the strength analysis load cases.

Based on the analysis results, all structures found safe during the load-out condition.

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