TRANSPORTATION OF LIVING QUARTERS

BEHALF OF TOMBUA LANDANA PROJECT
ANGOLA, WEST AFRICA

By:

ANDREW HARYANTO	**1525985**
FENNY WIYONO	**1525983**

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Approval

FINAL THESIS ABOUT TRANSPORTATION OF LIVING QUARTERS

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Discipline	Name	Signature	Date
Tutor I	ir. Frans van Heerden		
Tutor II	ir. Rene Camerik		
Supervisor I	ing. Pieter van Greuningen		
Supervisor II	ing. Hans de Gruyter		

SUMMARY

The oil mining increased along with the higher demand of energy in the world. Fulfilling this requirement, Chevron Corporation and several other companies, intends to explore a new oil field by installing a new offshore oil platform in block 14, Angola, West Africa called as the Tombua Landana project.

The complete platform itself consists of several parts. One of them is the Living Quarters (LQ) which is built in Houston, USA. It is functioned as the accommodation for offshore workers during their working period over there. In this project Heerema Marine Contractors (HMC) as the Transportation and Installation Contractors is responsible to transport the LQ safely and on schedule.

For this project, the internship students were responsible to design the support structures which are called grillages and seafastenings to secure the LQ during the transportation. The students did the internship project as group so that the design can be optimized better than individually. During the internship, the students studied literatures such as the HMC's standard criteria, AISC code (American Institute Steel Construction), offshore manuals, and discussed the design with the internal experts. The students worked four days in the office and one day in the school per week for 5 months.

There are many aspects that must be considered for transporting LQ since the sea parameters influence to the transportation as static and dynamic loads. The main idea of the design is to transfer the loads from LQ through the support structure to the barge's strong points in a proper way. The transferred load must be less than the capacity of the barge otherwise the engineer must redesign the support structures. In the end, the support structure must be friendly fabricated and suitable for load-out phase, transportation phase, and installation phase.

By doing this internship, the students gained a lot of knowledge about offshore engineering, experiences as employees in the Dutch-International company, applied the theoretical lessons from school in a real project, and got familiar with the work atmosphere in the Netherlands where they can free to ask anything.

PREFACE

Thanks to Jesus Christ, for his grace and his faithfulness so this final thesis report can be accomplished in time. The report is used as one of the graduation requirements for Double Bachelor's Degree Program in Hogeschool Utrecht both with Gadjah Mada University and Petra Christian University. Therefore, the author would say thank to:

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2. ing. Hans de Gruyter as the supervisor 2 from Heerema Marine Contractors.
3. Ir. Frans van Heerden as the supervisor 1 from the Hogeschool Utrecht.
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9. Our family in Indonesia who support us faithfully.
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Finally, the authors realize that this final thesis is still not perfect yet. Therefore, the authors expect some recommendation from the readers to make it better.

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Andrew Haryanto (hi_i_m_andrew@yahoo.com)
Fenny Wiyono (sephine_fenc@yahoo.com)

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LIST OF ABBREVIATIONS

AISC	American Institute of Steel Construction
AWS	American Welding Society
BP	Bollard Pull
C.o.G.	Centre of Gravity
DEC	Delta Engineering Cooperation
DSME	Daewoo Shipbuilding and Marine Engineering
EPCI	Engineering, Procurement, Construction, and Installation
ft.	foot
HMC	Heerema Marine Contractors
H_{sig}	Significant wave height
kN	Kilonewton
LOA	Length Over All
LWL	Length on water line.
m	meter
mm	millimeter
m/s	meter per second
MBL	Minimum Breaking Load
mT	metric ton
N/A	Not Applicable
PG	Plate Girder
T_e	Tug Efficiency
TPR	Towline Pull Required
ULC	Ultimate Load Capacity
WF	Wide Flange

LIST OF DEFINITIONS

Ballast	A heavy substance such as water, sand or iron placed in special compartments of a vessel or structure to influence its weight or stability.
Barge	A flat-bottomed boat, to serve special purpose such as transporting platform modules.
Bollard	To fix a mooring rope of a vessel
Bollard Pull	The pulling force of a tug boat
Bow	The forward part of the hull of a ship or boat, the point that is most forward when the vessel is underway
Brace	A diagonal connection (a beam or pipe) to give a construction more stability or to restrain a structure from sideways motion
Breaking load	Certified minimum breaking load of wire rope, chain or shackles.
Bridle	A span of chain, wire, or rope that can be secured at both ends to an object and slung from its center point.
Bulkhead	A watertight division-construction to create different compartments in a barge or structure so that it will be ballasted accurately
Cargo	The item to be transported by a barge.
C.o.G.	(Centre of Gravity) the theoretical point in the cross-section of a body in which the resultant of the gravity forces is acting
Deck	The general term for a working area on an offshore platform or of a barge
Draft	The vertical distance from the waterline to the bottom of the hull.
Dry Weight	The weight of the object without allowances for inaccuracies, contingencies, and rigging

Girder	A large support beam used in construction, normally of iron or steel.
Grillage	Steel construction that is functioned to secure the cargo to the barge deck, improve the distribution of the weight of the cargo into the supporting underground (land or barge)
Heave	Linear vertical (up/down) motion
Hull	The body of a ship or boat
Lift weight	The design weight which is included the allowance for dynamic amplification (shock load)
Load-out	To put large cargo from construction-site (quay) onto vessels or barges, by use of skid beams or trailers (or lifting)
Pitch	The rotation of the barge about the transverse (side-to-side) axis
Portside (PS)	Looking towards the bow end of the ship it is the left site
Quay	A solid embankment or structure parallel to a waterway used for loading and unloading ships.
Rigging	All lifting equipment which consists of grommets, slings, shackles, and spreaderbars.
Roll	The rotation of the barge about the longitudinal (front/back) axis
Scow	Any of various flat-bottomed boats with sloping ends
Seafastening	Steel structures to provide and secure the shipload
Shackle	An open or closed link of various shapes with extended legs; each leg has a transverse hole to accommodate a pin and to fix a sling to a padeye.
Skid	A metal runner for transporting load over the structural element below.
Sling	A length of cable laid steel wire with eyes on both ends used to make the connection between the lift points on the structure to be lifted and the crane hook

Starboard (SB)	When looking towards the bow end of the ship: the right side
Stern	End of the ship in which direction it is usually not sailing (normally the propellers are fitted to this end)
Surge	Linear longitudinal (front/back) motion
Sway	Linear lateral (side to side) motion
Towing equipment	All towing equipment on the towing boat and the towed object used to effect the towage.
Towline pull required	(TPR) The towline pull computed to hold the tow or a cargo by a towage or a voyage.
Trim	The longitudinal out-of-level situation of a vessel or barge
Tugboat (tug)	A boat used to maneuver, primarily by towing or pushing other vessels in harbors, over the open sea or through rivers and canals.
Tugger line	Steering line
Yaw	The rotation of the barge about the vertical (up-down) axis

CHAPTER 1

INTRODUCTION

1.1. Project Description

The development of oil and gas offshore mining has been increased along with the development of industries in the world. One of the countries that had been developed rapidly for its oil and gas mining is Angola, West Africa. Angola is the second of the largest oil producing countries in Africa, after Nigeria. Situated in the lower Congo Basin, offshore Angola, there is block 14 where nine major oil offshore fields were discovered since 1997: Kuito (1997), Benguela (1998), Belize (1998), Landana (1998), Lobito (2000), Tomboco (2000), Tombua (2001), Gabela (2002), Negage (2002).

Those nine major oil offshore fields were discovered by Chevron Texaco which is one of the largest energy companies in the world and its partners (Sonangol P&P, TotalFinaElf, AGIP, and Petrogal). One of those fields which was explored is Tombua and Landana field and the project was named Tombua Landana. This project will be Chevron Texaco's third deepwater offshore project in West Africa. For executing the Tombua Landana project, Chevron Texaco has awarded Daewoo Shipbuilding and Marine Engineering (DSME) an EPCI (Engineering, Procurement, Construction, and Installation) contract for the platform including the pipelines. In this project, DSME has asked Heerema Marine Contractors (HMC) as the subcontractor for the transportation and installation of the platforms while Noble Denton was chosen as a warranty surveyor.

The oil platform is needed for oil and gas mining. It is a large structure which is functioned as the house of workers and machinery to drill and then produce oil and natural gas in the ocean. Different oil platform are illustrated in Figure 1.1. The oil platform for Tombua Landana project is compliant piled tower platform which is built on steel jackets anchored directly onto the seabed. This kind of platforms is economically feasible for installation in water depths up to about 3000 feet (910m).

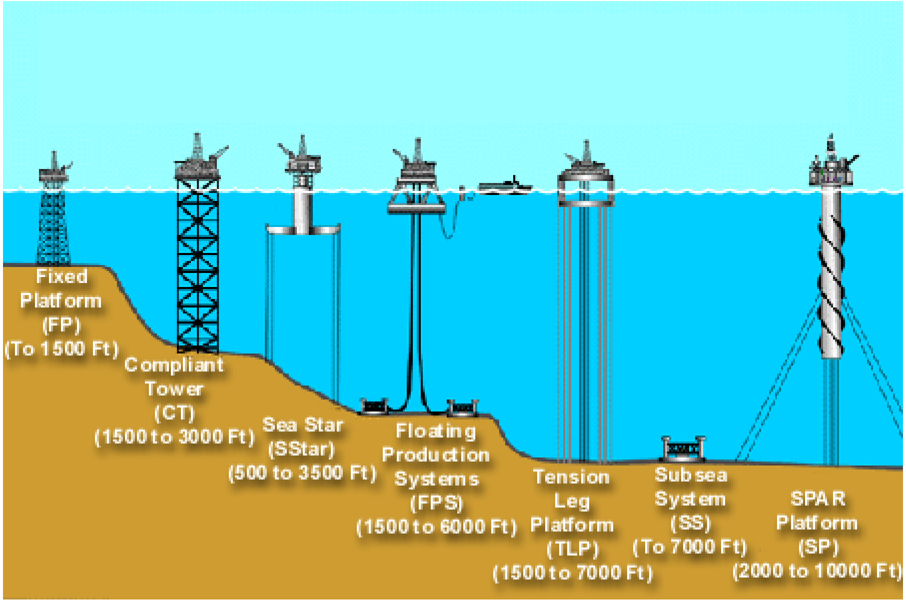


Figure 1.1. Type of Offshore Oil Platforms

In the oil offshore mining platform itself, of course, an accommodation is needed for the workers to live in. Its specific name is Living Quarters (LQ) which is built by Delta Engineering Corporation (DEC) in Delta yard, Houston, USA. To transport it to the offshore site a barge is needed. During the transport, the LQ will have to be supported and restraint against movement. The structures, those are required for this purpose, called “grillage” and “seafastening” (Figure 1.2.).

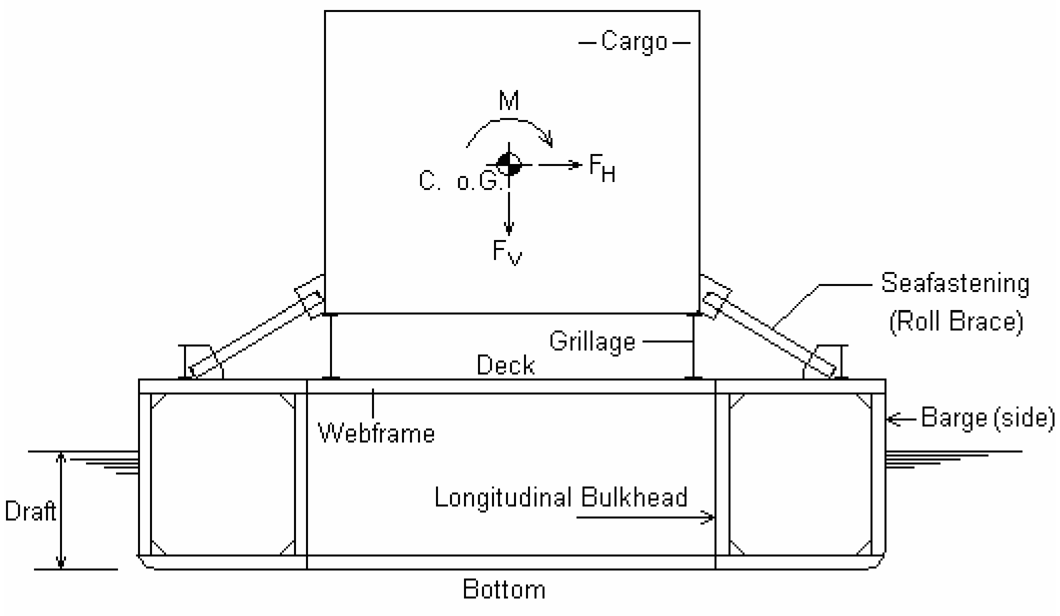


Figure 1.2. Typical Transport Layout

This internship project is focused on the transportation of LQ from Houston, USA to Angola, West Africa (Figure 1.2.), including the design of grillage and seafastening. The transportation is a part of the whole phases and relates to another phase. In this internship project, installation and load-out must be considered as well.

1.2. Objectives

The objective of this project is to transport LQ from Houston, USA to Angola, West Africa safely, on schedule, and friendly fabricated. Fulfilling these requirements, the steel structures are needed to keep the cargo (Living Quarters) in its fixed position during the transportation within consideration to the sea parameters during the departure window.

1.3. Boundary Conditions

Since there are plenty of factors involved during the transportation of the cargo, the boundary conditions must be measured before doing the next steps. The boundary conditions for this internship project are mentioned below:

1. The transportation forces are determined according to Noble Denton criteria or are supplied by specialist marine engineers.
2. The applicable codes and standards according to American Standard for Steel Construction (AISC).
3. The calculation method, based on Heerema Standard Criteria.
4. The cargo specifications are determined by the client (DSME).
5. The trailers arrangements are determined by Mammoet and Delta Engineering Corporation (DEC). Heerema Marine Contractors (HMC) has a review function.

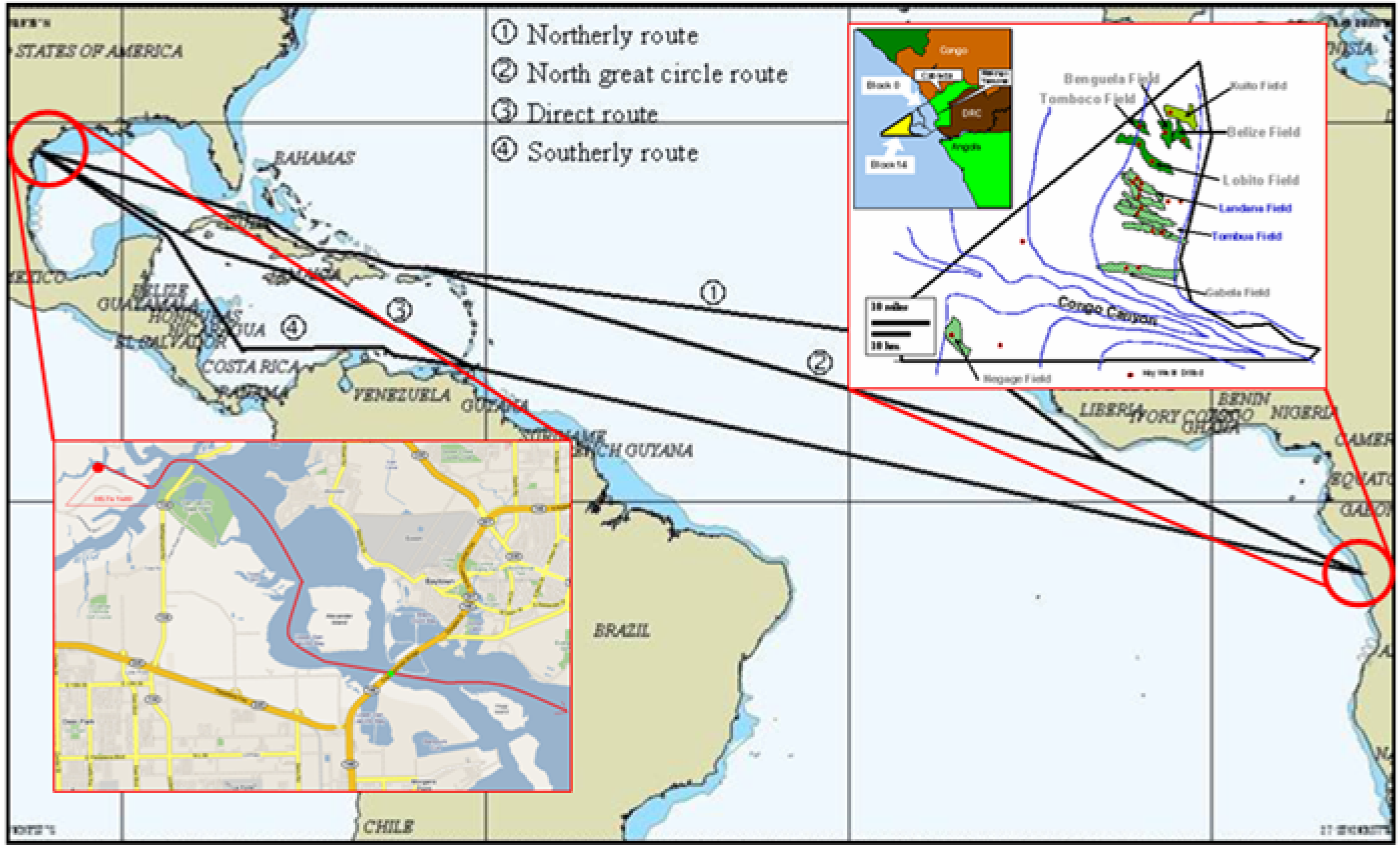


Figure 1.3. Transportation Routes and Place's Inset

1.4. Benefit of the Internship Project

- For students

  This project can give a new experience where students can apply their knowledge that they already got during their study. Students can learn how to apply the American standard in a real project and get familiar with the real work atmosphere in Netherlands, by cooperation with internal experts in their fields.

- For company

  The final thesis report can be used as a reference for the project.

- For academic purpose

  This report can be used as basic knowledge for other research, related with offshore platforms transportation projects.

CHAPTER 2

Living Quarters and Barge

2.1. Living Quarters

The cargo which is transported in this project is called Living Quarters (LQ) (Figure 2.1). LQ is the accommodation for the workers during their work on an offshore platform. It is designed and built by Delta Engineering Corporation (DEC) in Delta Engineering yard, Houston, USA. There is a certain reason why the LQ is built in Houston instead of Angola. Insufficient equipment and expertise in Angola caused the LQ is constructed in Houston and furthermore the oil company (Chevron Texaco) has cooperated with the fabricator (DEC) because of their specialization for constructing LQ.

Figure 2.1. Living Quarters

LQ is a relatively small part compared to the main platform but it plays an important role. It will be placed all together with the other constructions to form a complete oil drilling platform (Figure 2.2.). The installation of LQ will be done by Thialf, Heerema’s crane vessel (Figure 2.3.). In this internship project, the general part of the installation phase will be discussed.

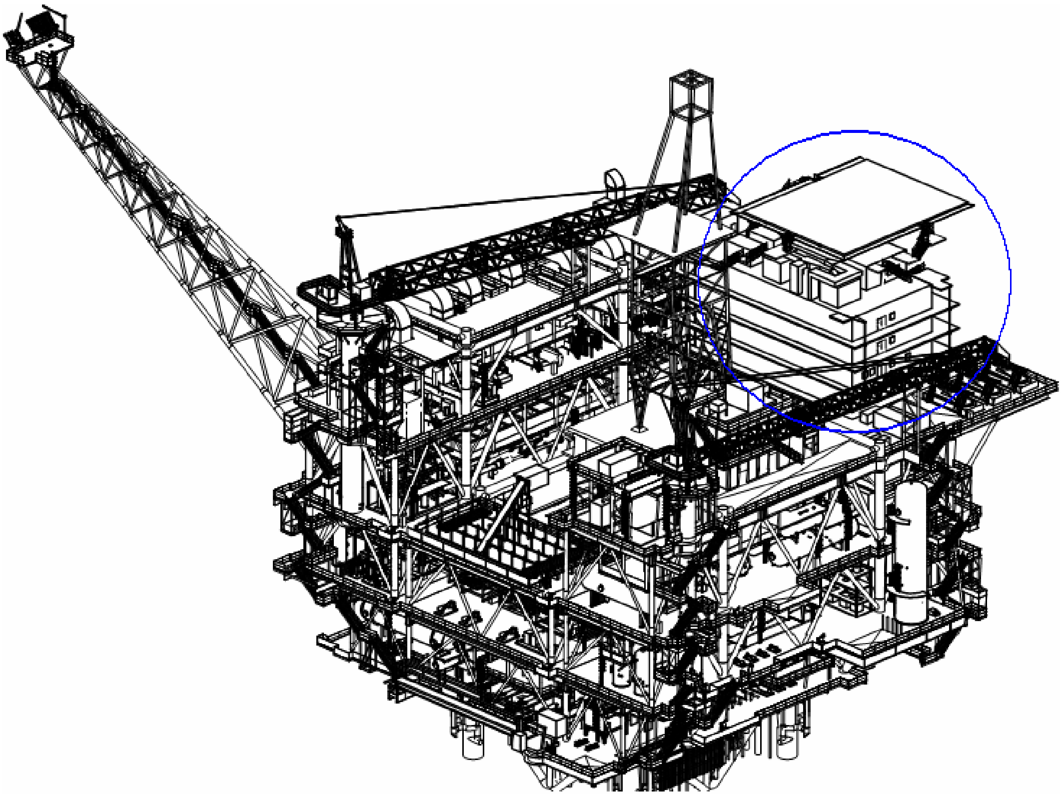


Figure 2.2. Living Quarters on the Main Platform

Figure 2.3. Thialf

2.1.1. Living Quarters Specifications

LQ is a steelwork construction building which has four stories (Figure 2.4.). It is made from high grade steel, Fe510. It can accommodate 120 beds.

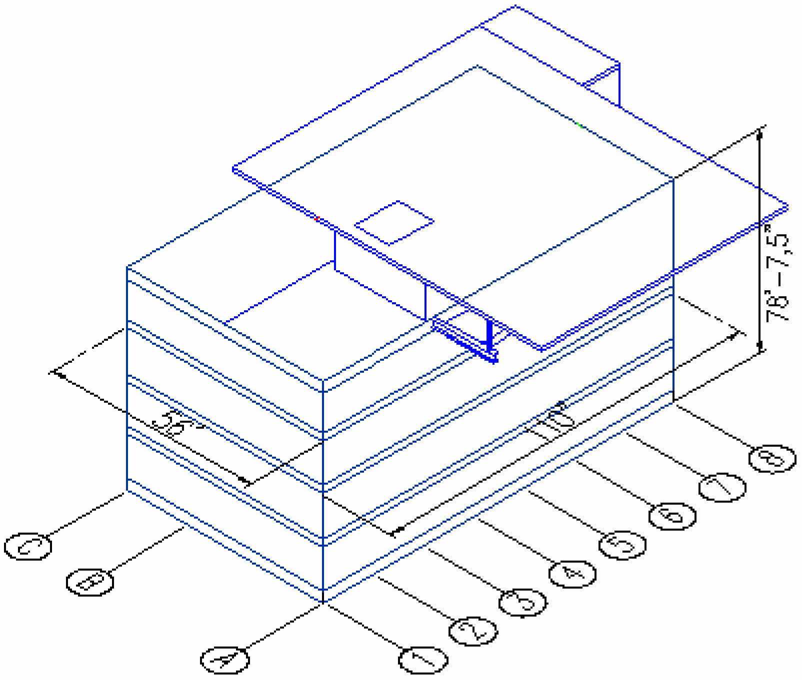


Figure 2.4. Living Quarters and Its Dimensions

There are twelve strong points in the LQ that function to transmit its weight to the structural elements below (strong points of the barge). These strong points are located in the row A and row C. Each row has six strong points that can be seen in Figure 2.5. These strong points will also be used for considering grillage and seafastening design.

2.2. Barge

The cargo transportation needs a ship called barge to across through the sea. A barge is a flat bottomed ship, used for transportation of heavy goods. Most of them are not self propelled and need to be pulled by tug boats. The barge, used for this project, is Crowley-411 (Figure 2.6.). Both the barge and the tug boat are provided by Crowley Maritime Corporation.

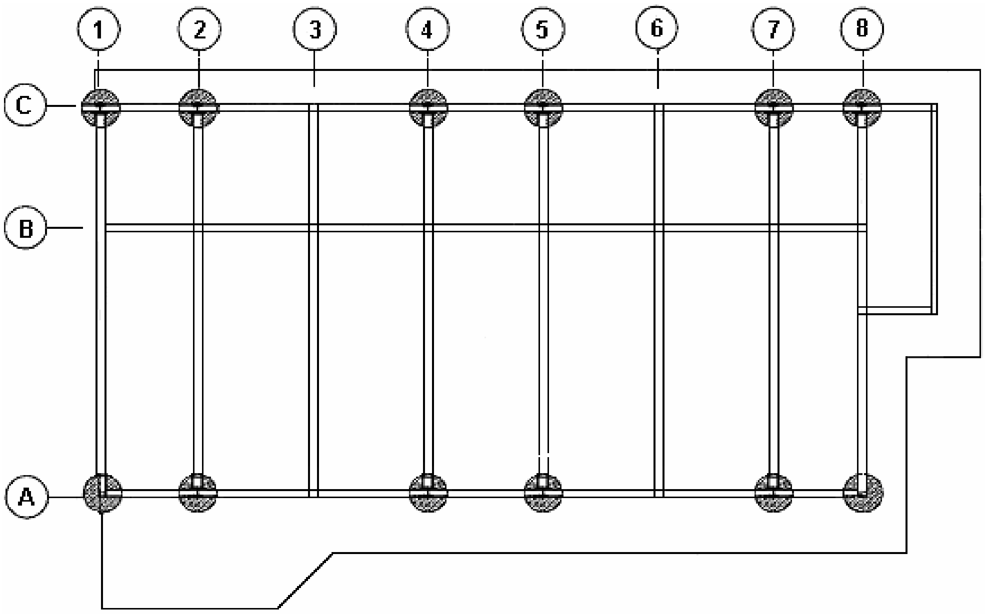


Figure 2.5. Strong Points of Living Quarters

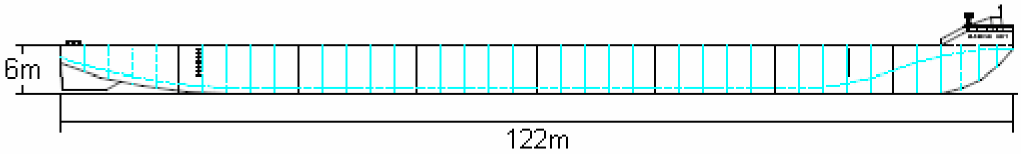


Figure 2.6. Crowley-411

2.2.1. Crowley-411 Specifications

There are many parts of the barge with different names as shown in Figure 2.7. The front side of the barge is called bow while the end of the barge is called stern. The right side of the barge is called starboard while the left side of the barge is called portside. The barge has three longitudinal bulkheads, seven transverse bulkheads and two side shells. Between two transverse bulkheads there are four transverse webframes which have 10ft (3.048m) spacing. The barge specifications are described below:

Length	: 400 ft	(121.92m)
Width	: 99.5 ft	(30.328m)

Height : 20 ft (6.096m)
Frame spacing : 10 ft (3.048m)
Longitudinal Bulkhead spacing : 29.25 ft (8.915)
Transverse Bulkhead spacing : 50 ft (15.24m)

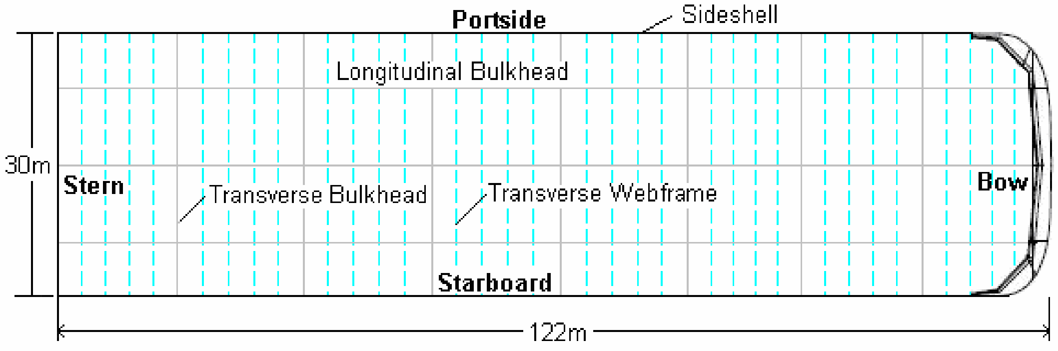


Figure 2.7. General Plan of Crowley-411

There are points which are called bulkhead columns in the barge. They are located at the intersections between longitudinal bulkheads or side shells and transverse bulkheads or transverse web frames. These points are considered as the strong points of the barge. Each of them is able to hold a load up to 2857 kN, depending on its position and construction details. The detailed capacity can be shown in sheet 5.7, Appendix A

2.2.2. Ballast Tanks

There are two kinds of ballast tanks, side ballast tanks and centre ballast tanks. For Crowley-411, there are four side ballast tanks and eight center ballast tanks. The configuration of the ballast tanks has influences to the load-out, transportation, and installation phase. For this project, the installation phase is used as a consideration for the grillage and seafastening design.

There are three conditions of filling the ballast tanks, full tanks (95-100% filled), slack tanks (5-95% filled), and empty tanks (1-5% filled). The condition of each tank depends on the requirements. For this project the condition for tank 2 and tank 7 are full tanks while the others are empty. One advantage of full tank condition compared to slack tank is that the ballast water does not give dynamic forces to the barge which is caused by motion during transportation. On the portside it will be filled 100% while on the starboard it will be filled 95% (Figure 2.8.). It is done because the LQ centre of gravity (C.o.G.) is more to the starboard, so that is needed to fill the tanks on the portside with more water to keep the stability of the barge.

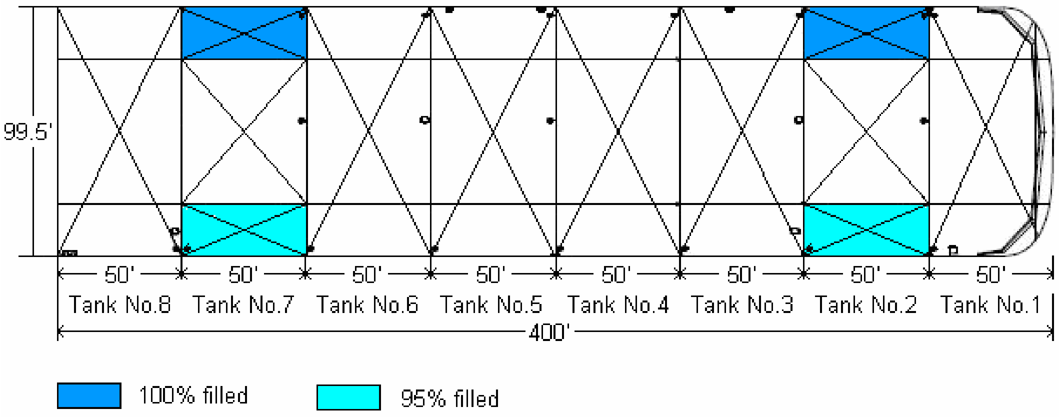


Figure 2.8. Ballast Tanks Configuration of Crowley-411

Each ballast tank has a certain capacity (tones) as shown in the Table 2.1.:

Table 2.1. Ballast Tank Capacity

Tank no.	Capacity (mT)
1	1925
2P	583
2S	583
2C	1825
3	2725
4	2724
5	2725
6	2725
7P	586
7S	586
7C	1811
8	1917

P = Portside S = Starboard C = Centre

2.3. Living Quarters Position on the Barge

There are many aspects, which must be considered for locating the LQ on the barge. The strong points of the cargo, the weight of the cargo and its C.o.G., the strong points of the barge, and the configuration of ballast tanks must be taken into account before determining its location on the barge. Furthermore the LQ C.o.G. will be used for the transportation analysis.

To optimize the distribution load, the strong points of the LQ will be located on the barge as symmetrically as possible (for portside-starboard direction). The loads will be distributed from the strong points of the LQ to the maximum strong points of the barge (bulkhead columns). The transferred load must be less than the bulkhead columns capacity. Beside that the LQ's C.o.G. should be located as near as possible to the barge's C.o.G. in order to minimize the use of ballast. The other consideration is the unavailability of pumps in the barge. Once the ballast tanks are filled with water, their condition can not be changed anymore during sailing across the sea. So, the ballast tanks condition must be valid not only for the transportation phase but also for the installation phase. The overview of the general installation phases is described more detailed in Chapter 4.

In this project, the ballast arrangement is done by the marine engineer based on the LQ layout on the barge which is located 200ft from the bow (Figure 2.9.). This layout is not the final layout since there are still any possibilities to change it from the client (Daewoo Shipbuilding and Marine Engineering / DSME) and the Mammoet as the company who provides the trailers. Nevertheless, until now the shown layout is still valid. The final layout of LQ (sheet 4.6, Appendix A) on the barge will be done by Heerema Marine Contractors (HMC), approved by DEC.

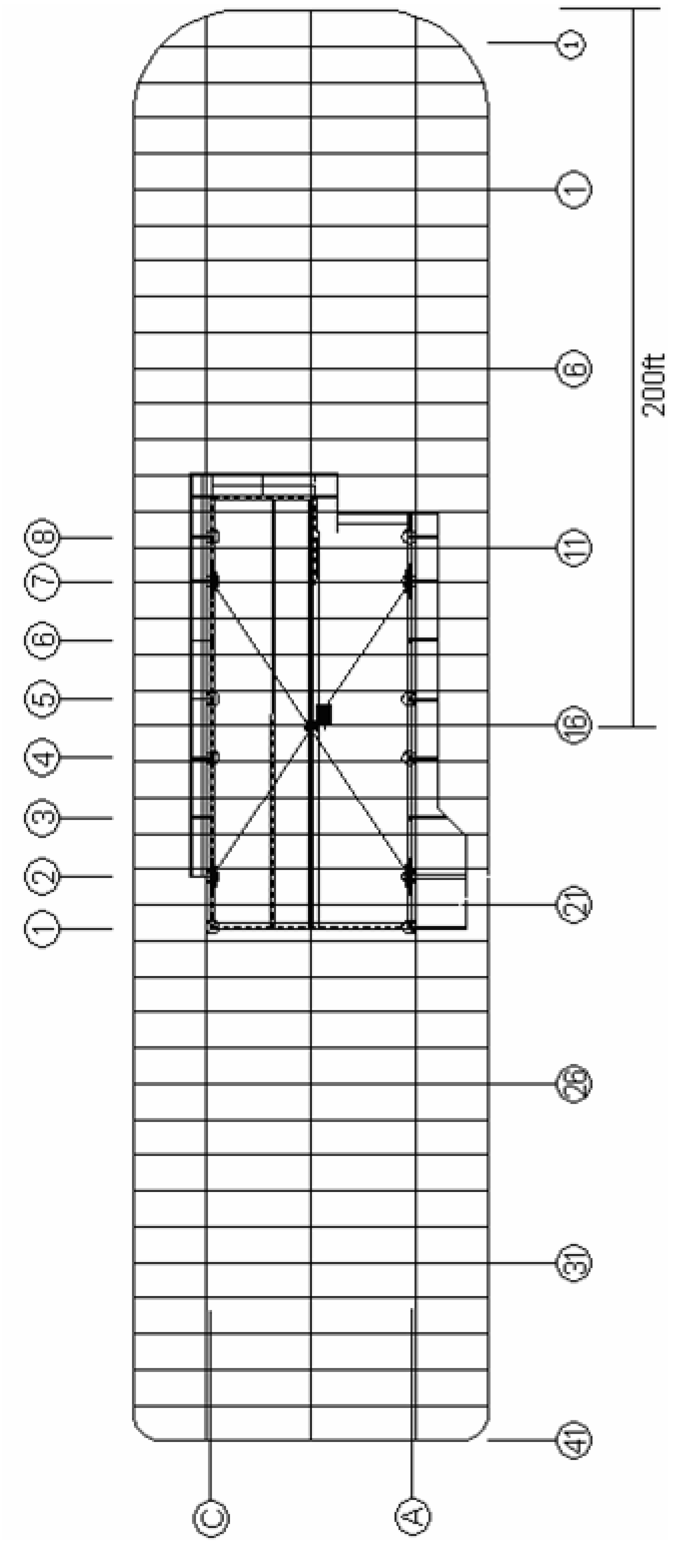


Figure 2.9. Living Quarters on the Crowley-411 Layout

CHAPTER 3

Transportation Aspects

3.1. Transportation Descriptions

The party who is responsible for the transportation of the living quarters (LQ) is Heerema Marine Contractors (HMC). This company is responsible from post load-out until the installation of the LQ. Although HMC is only responsible for the transportation and installation, HMC takes part in all the phases (during LQ construction). HMC still makes contact with DEC (Delta Engineering Corporation) during LQ construction. It is done in order to ensure that the LQ design is suitable with the grillage and seafastening design.

In order to maintain the transportation schedule flexible, large departure window of LQ has been considered. It allows the barge to depart anytime between August 30th, 2008 and October 10th, 2009. There are four routes (Figure 3.1.) that can be used for LQ transportation:

1. Via Northerly Route
2. Via North of Cuba and Atlantic great circle (North Great Circle)
3. Via Direct route
4. Via Southerly route

Person who has the right to decide about the transportation route is the captain of the tug boat. He is the one who knows a lot about the sea conditions and moreover he has a lot of experiences.

Figure 3.1. Transportation Routes

3.2. Transportation Forces

Transportation forces are generated when the cargo is transported offshore on the barge. They consist of static and dynamic forces and also the accelerations that depend on the weight, geometry, support conditions of the cargo, and the environmental conditions that are encountered during transportation. The types of motions that can happen to a barge are shown in Figure 3.2.

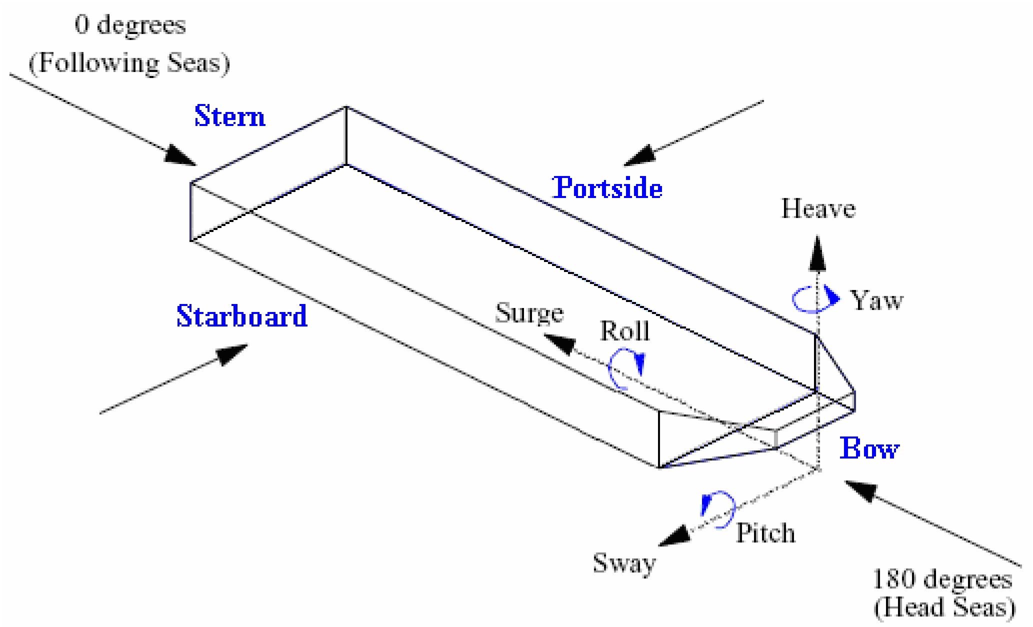


Figure 3.2. Barge Motion

There are two types of motion on the barge, translation and rotation. Translation itself consists of heave, surge, and sway. Among them, heave is the most critical. The vertical force of heave motion together with the moment caused by roll motion is used for calculating dynamic load. This dynamic load influences the load on each LQ strong points. The second motion is rotation which consists of roll, pitch, and yaw. Among them, roll is the most critical motion while yaw is the less one. Generally the horizontal force of roll motion is bigger than the horizontal force of pitch motion. The horizontal force of roll motion is used for calculating transverse seafastenings (roll braces) while the horizontal force of pitch motion is used for calculating longitudinal seafastenings (pitch stoppers).

In order to minimize the risks and secure the transportation from the fabrication yard to the offshore site, it is important to plan the transportation carefully. All possibilities that may be happened during the transportation must be taken into consideration. It is done to avoid the undesirable incidents. Since transportation forces are generated by the motion of the barge, the environmental conditions such as winds, waves, and currents must be taken into account. These criteria are according to Noble Denton for large barges in the open sea (Table 3.1.).

Table 3.1. Noble Denton Motion Criteria

	Single amplitude (10 second full cycle period)		
Type	Roll	Pitch	Heave
Small barges	25°	15°	5 m
Large barges	20°	12.5°	5 m
Small vessels	30°	15°	5 m

Note: Small barge: L<76m or B<23m

Large barge: L≥76m LOA and B≥23m

Small vessel: L<76m or B<23m

Ref. Noble Denton Criteria

3.3. Sea Parameters

The transportation of heavy cargo from fabrication yard to offshore site is a risky operation. The sea parameters influence the stability of the barge, the design of grillage and seafastening, and the cargo itself. Therefore they must be taken into account in order to get a sufficient safe operation. The data required for transportation analysis is known as Metocean (Meteorological and Oceanographic) data which is prepared by Noble Denton as a warranty surveyor. The most important parts are the wind and the wave current along the transportation route.

However, at certain locations, it is needed to consider the extreme condition that can happen at a certain period. Since the departure from Houston, close to the Gulf of Mexico, the extreme conditions that may happen are such as, tropical cyclones and winter storms. Therefore the transportation schedule must aware these conditions as well. For design purposes, the extreme conditions are predicted within 100 years of return periods.

Heerema also considers about sea condition while deciding to use a barge instead of a vessel. In this case, the sea condition is relatively more stable and more predictable than Indian Ocean. Surely that the distance between Houston and Angola is not as far as from South Korea to Angola, so it is more efficient for using the barge and tug combination than using a vessel. Moreover the depth of the quay in Delta yard is only 5m. That depth is not sufficient for the vessel to enter the quay.

CHAPTER 4

Grillage and Seafastening Design

4.1. Grillage

Grillage is a common type of structures in offshore engineering which is designed to withstand all vertical forces either from the static loads or dynamic loads. The design is generally directed to simplicity the fabrication process, rather than necessarily minimizing the weight. Moreover, all grillage design shall allow for the incorporation of shim plates to ensure the levelness of the supports to account local deviations and the shape of the barge.

4.1.2. Grillage Concept Design

Grillage is made from high grade steel Fe 510, which has 345N/mm^2 of yield stress. It consists of five plate girders, two beams of PG 380 x 1524 x 38 x 28.58 and three beams of PG 190 x 1524 x 38 x 25.4 which is known as a parallel beam (Figure 4.1.). This concept of parallel beam connection is to support one beam directly on the top flange of the other in order to get a better load distribution in relation to the structural capacity of the barge. To attach one beam to another welding are used. For this project, there are six grillage beams that are typical.

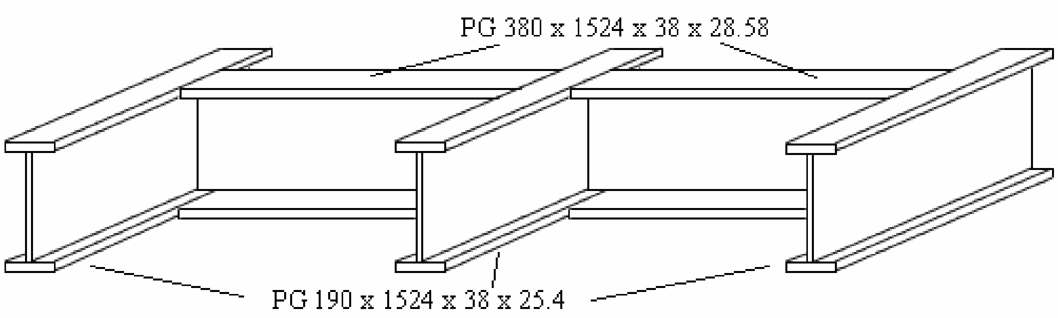


Figure 4.1. Grillage Beam

There are several steps to design the grillage, as follows:

First, find the general information about the living quarters (LQ). It is included the LQ center of gravity (C.o.G.) position (sheet 5.1, Appendix A), the LQ strong points position, and also the LQ weight. These data are provided by Delta Engineering Corporation (DEC) as the fabricator and consultant for Tombua Landana LQ. There are two kinds of LQ weights, dry weight and lift weight which is included 5% of contingency. The load design is according to dry weight since grillage is only used during the transportation,

Second, determine the location of the shim plates (Figure 4.2.) Shim plates are plates with certain thickness and certain quality of steel. They are used as a transfer point between LQ and the grillage. The main aim of shim plates attachment is for transferring static and dynamic loads to the grillage. The LQ drawings are necessary for finding the best possible shim plate location. It is proposed to locate the shim plate exactly below the strong points of the LQ to prevent eccentricity between the centre of a column and the shim plate itself. It means that there is no shear force, deflection, and moment through the LQ beam.

Figure 4.2. Shim Plate

Third, calculate the load distribution from the LQ to its strong point. It is determined by DEC as the consultant and contractor of LQ. DEC sent the detail forces of static load of LQ which can be used as the load distribution reference, either for static load distribution or dynamic load distribution. According to this reference, HMC (Heerema Marine Contractors) can design the grillage with the actual load distribution. Figure 4.3. shows the percentage load of each strong point.

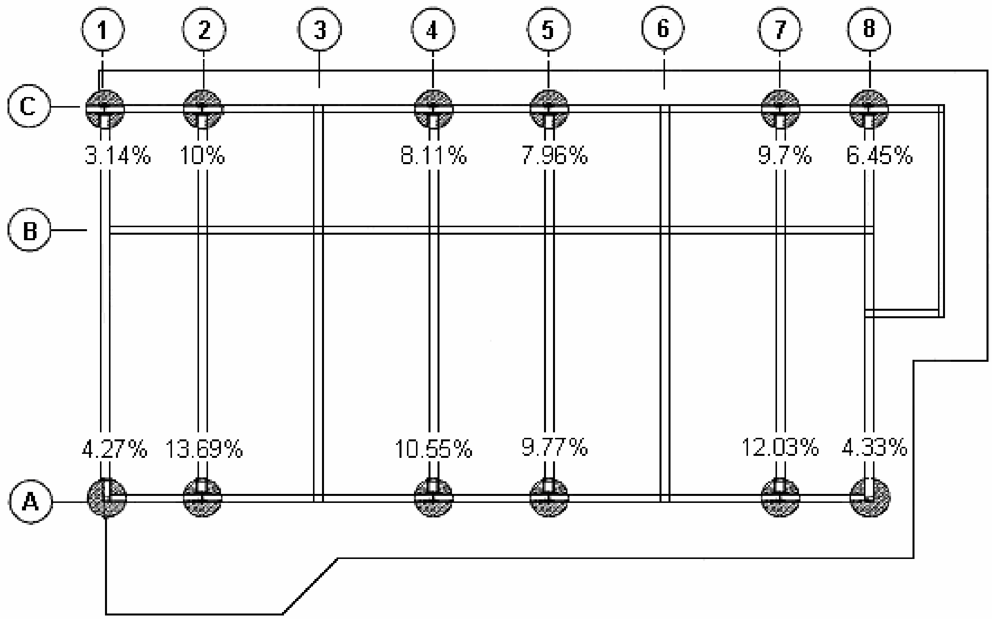


Figure 4.3. Load Distribution of Living Quarters

Fourth, determine the position of LQ relatives to the barge. This step is not a simple thing to do since the designer must realize about several aspects as mentioned below:

a. The LQ layout affects the ballast arrangements in order to maintain the stability of the barge.
b. The LQ layout affects the design of grillage beam. The grillage beam must be able to transfer the load from LQ to the barge frames, so the LQ position on the barge must consider about the barge's strong points including the plate capacity as well. Otherwise the barge will collapse because of overloading from LQ. Sheet 4.7, Appendix A shows the layout of grillage beam for this project.

c. Related to point "b", the grillage beam also influences the load-out process. Especially when the load-out process uses the trailer to transport the LQ onto the barge. The grillage beam configuration must give sufficient free space between grillage and the trailer wheels. The minimum required free space is 1ft (3.048m). The grillage layout is shown in Figure 4.4. and for more information about relation between LQ grillage beam layout and the trailer is shown in Figure 5.6. and appendix B.

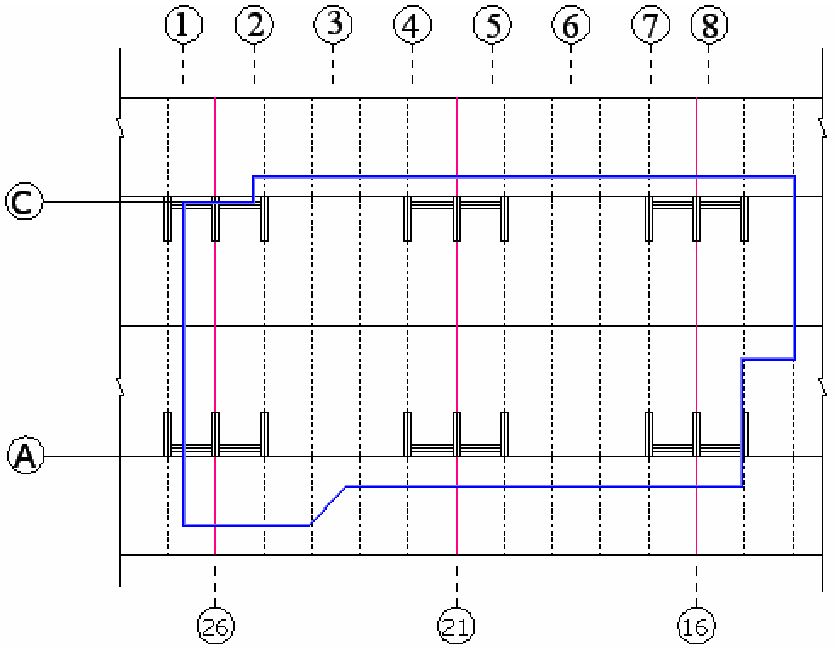


Figure 4.4. Grillage Beam Layout

Fifth, calculate the actual forces. There are two kinds of loads, static and dynamic load. Static loads state for the dead load while LQ is loaded onto the barge. Dynamic loads occur when the loaded barge is sailing. The dynamic load is influenced by barge motions, such as heave, roll, and pitch. Actually, dynamic loads are complicated loads, since the position of LQ relatives to the barge has affects as well. See Figure 4.5. for roll to starboard forces and Figure 4.6. for pitch to bow forces. The complete calculation is shown in Appendix B.

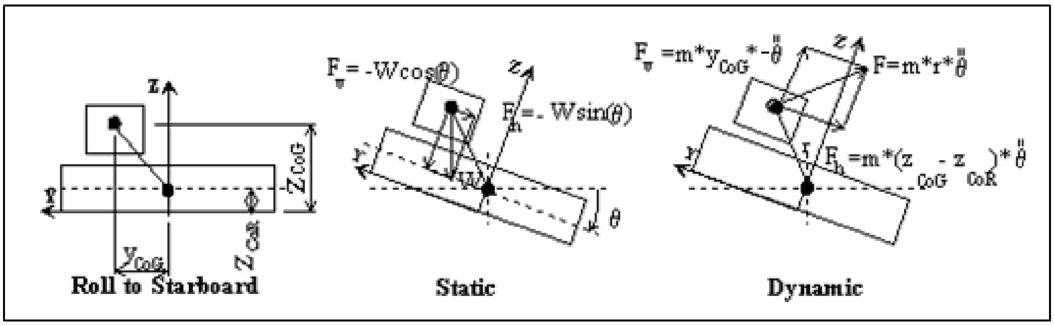


Figure 4.5. Roll to Starboard Forces

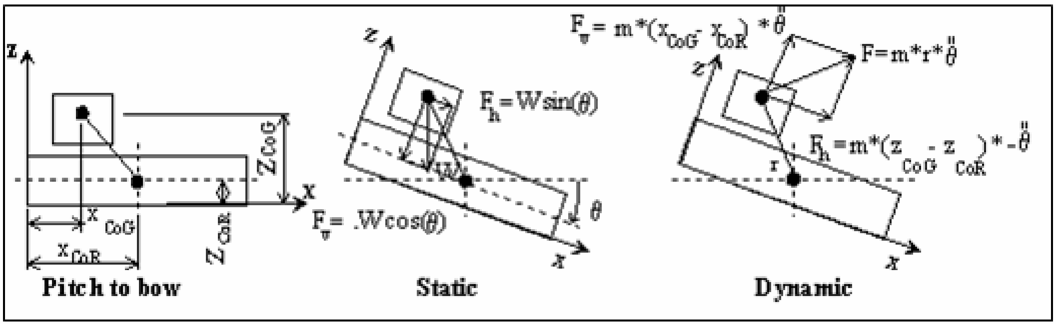


Figure 4.6. Pitch to Bow Forces

Sixth, design the grillage beam. As mentioned before, the grillage beam must transfer the LQ load to the strong points of barge. There are some strong points of the barge; they are:

a. intersection between longitudinal bulkhead and transverse bulkhead
b. intersection between rail girder and transverse bulkhead
c. intersection between longitudinal bulkhead and transverse web frame
d. intersection between rail girder and transverse web frame
e. Side shell

Every strong point has its own capacity and has to govern the transferred load from grillage support. When the barge capacity is not strong enough, the designer has to redesign the grillage beam. It can change of the grillage beam location or the configuration of the grillage beam itself.

Seventh, check the grillage beam capacity. Checking is always needed to be done in order to ensure that the construction is strong enough. This kind of checking is about strength checking of the grillage beam profile that is compared to the allowable stress. The ratio between occurred stress and allowable stress according to AISC (American Institute of Steel Construction) is called Unity Check (U.C.). The U.C. must be less than 1. The formula as follows:

$$U.C. = \frac{\text{occured stress}}{\text{allowable stress}} \leq 1.0$$

The occurred stress is: $\sigma_c = \sqrt{\tau_\perp{}^2 + \tau_{//}{}^2}$

The allowable stresses according to AISC code are:

a. Axial compression : 0.60 Fy (N/mm^2)
b. Axial tension : 0.60 Fy (N/mm^2)
c. Shear : 0.40 Fy (N/mm^2)
d. Bending : 0.66 Fy (N/mm^2)
e. Combined : 0.66 Fy (N/mm^2)

Eighth, design the wing plate, end stiffener, and welding details for the grillage beam.

4.1.1.1. Wing Plate

The grillage beams end on the rail girders and the longitudinal bulkheads. There are two possibilities of the end of the grillage beam, whether it will use wing plate or end stiffener. Before deciding to use wing plate or end stiffener, the capacity of the longitudinal bulkhead and rail girder must be compare to the reaction force of the grillage beam first. If the capacity less than the vertical reaction, wing plate must be attached in the end of the grillage beam. In the other words if the capacity more than the vertical reaction, it is only need end stiffener.

The wing plate (Figure 4.7.) is attached on the bulkhead or web frame. The main purpose of the wing plate is for spreading the vertical reaction of a grillage beam to the bulkhead plate or web frame and giving the resistance through the uplift dynamic force. Since the wing plate stands on the plate, the designer has to consider the frame profile underneath the wing plate and its weld size. Designing wing plate which stands on massive plate such as longitudinal bulkhead is different when it stands on the rail girder beams, though they have to hold the same vertical reaction.

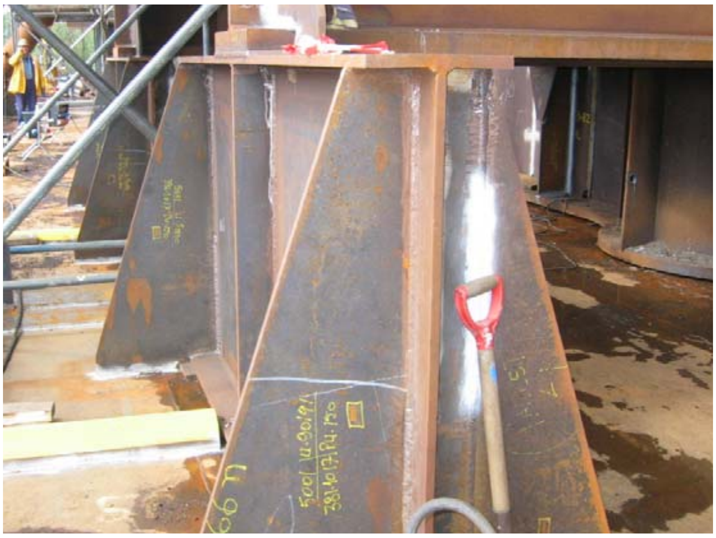


Figure 4.7. Wing Plate

There are several factors that must be taken into account while calculating the wing plate, such as:

a. Dimensions of the shim plate. The wider it is the effective area of the wing plate becomes less.
b. The throat size of the weld, both weld to web and weld to barge deck.
c. Grillage beam profile since the wing plate is attached from the deck till the top flange of grillage beam. In the other hand, the width of wing plate is influenced by shim plate width and the vertical reaction.
d. Plate buckling. The buckling capacity check must be done by engineer to make sure that wing plate will not collapse due to buckling forces through the plate thickness.

For more detailed calculation and the cross section of the wing plate, see sheet 4.29-43, Appendix A. The design of the wing plate is not based only on the reaction force but also on the uplift dynamic force. The weld resistance underneath the deck has to be checked against the uplift dynamic force (sheet 4.44-45, Appendix A). The purpose of this checking is to ensure that the welding underneath the deck is strong enough. In some cases, while the uplift force is occurred in the end stiffener, the welding underneath the deck cannot hold it. It means in that place, the wing plate must be attached to against the uplift force so the grillage beam still stands with a proper connection to the deck.

Wing plate can be attached in two ways, depends on how much free space between wing plate and trailer wheels is available. First, when the sufficient free space is available, the wing plate can be attached before load-out. It means that the wing plate attachment is done during grillage preparation. Second when the required minimum free space is unavailable, the wing plate will be attached after load-out. It means, during load-out, the grillage beam only has end stiffener to spread the vertical static load. More information about the end stiffener is explained in the next paragraph.

For this project, wing plate will be attached in the end of grillage beam on the longitudinal bulkhead because its capacity is less than the vertical reaction of the grillage beam. Wing plate will be attached in the end of grillage beams except for detail A and E (sheet 4.29 and 4.42, Appendix A).

4.1.1.2. End stiffeners

It has already stated before that if the capacity of the longitudinal bulkhead or rail girder more than the vertical reaction, only end stiffener is needed (Figure 4.8.). For this project, end stiffeners will be attached in the end of the grillage beam for detail A and E (sheet 4.29 and 4.42, Appendix A). Its vertical reaction is less than the capacity of the longitudinal bulkhead and the rail girder.

Figure 4.8. End Stiffener

Not likely wing plate that functions to spread the vertical reaction, end stiffener functions to prevent web buckling, maintain the shape of the beam and its rigidity. That is why it is still needed to attached end stiffener although the unity check is less than 1.

4.1.1.3. Welds

Welding is one of the most common methods that are used for joining two steel sections. In this project, the welding procedure including the allowable stresses is based on American Welding Society (AWS) structural welding code. There are many types of welds, such as groove welds, fillet welds, plug welds, etc. It will use fillet weld as shown in Figure 4.9. There are many types of welds, such as groove welds, fillet welds, plug welds, etc. In this case, fillet welds will be used. When calculating the strength of fillet welds, the throat size should be used since it is a critical part of the welds. The welds will also be treated as if it is a perfect triangle.

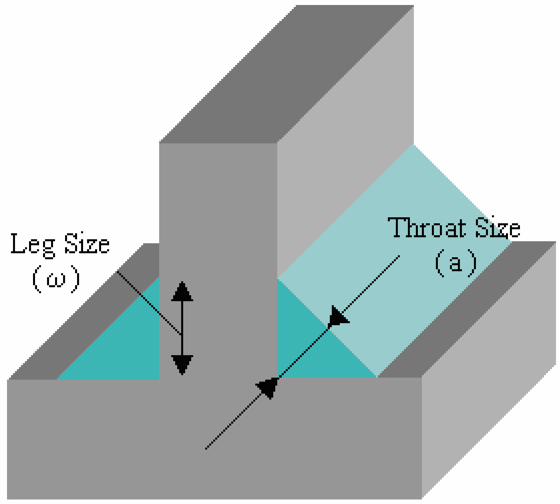


Figure 4.9. Fillet Weld

There is the minimum value for weld which depends on the thicker plate to be joined (Table 4.1.) and the maximum value depends on the thinner plate to be joined. These values are based on AWS.

Table 4.1. Fillet Weld Minimum Size (AWS)

Thickness of thicker plate to be joined	Minimum leg size of fillet weld*
thru $^{1}/_{2}$ in	$^{3}/_{16}$ in
over $^{1}/_{2}$ in thru $^{3}/_{4}$ in	$^{1}/_{4}$ in
over $^{3}/_{4}$ in thru $1^{1}/_{2}$ in	$^{5}/_{16}$ in
over $1^{1}/_{2}$ in thru $2^{1}/_{4}$ in	$^{3}/_{8}$ in
over $2^{1}/_{4}$ in thru 6 in	$^{1}/_{2}$ in
over 6 in	$^{5}/_{8}$ in

* Do not need exceed the thickness of the thinner plate

There are many different parts that need to be joined by welding as mentioned below:

1. Welds between the flange and the web of grillage beam
2. Welds between two grillage beams
3. Welds between stiffeners and the web of grillage beam
4. Welds between wing plate and the web of grillage beam

5. Welds between wing plate and the deck of the barge
6. Welds between seafastening and the plate which is attached to the LQ beam
7. Welds between seafastening and the plate which is attached to the seafastening beam

Grillage beam is a plate girder so it is needed to join the flange and the web. The length of this weld is continuous along the beam. The connection between two grillage beams is welded on both sides of the web. In this case, the top flanges of these two beams are level. It make the welds can be designed as simple as possible. Because of the throat size needed for all welds under the minimum value, all the throat size of the welds can be made the same. Moreover, it can make the execution easier. The throat size is 13.5mm which is based on the minimum value while the leg size is 19.05mm. The detail calculation can be seen in sheet 4.28, Appendix A.

Ninth, check the barge capacity. There are couples of checks for barge capacity, depend on where the grillage beam ends. First, check the capacity of the bulkhead columns. The reactions of the grillage beam must be less than the capacity of the bulkhead columns. Second, check the capacity of the plates below the grillage beam whether they are strong enough to hold all the reaction forces from the grillage beams or not. If the grillage beam ends at rail girder, the capacity of the rail girder itself must be checked.

4.1.2. Grillage Calculations

See sheet 4.1-4.76, Appendix A.

4.2. Seafastening

Seafastening is defined as steelwork installed after load-out to restrain the cargo for horizontal roll and pitch forces. It is a temporary structure which made from tubular steel tube (Fe 510, Fy = 345N/mm^2). It will be removed after arrived at installation site so it is designed for ease of fitting and removal.

4.2.1 Seafastening Concept Design

Seafastening should be located under the LQ strong columns in order to get optimum load distribution. Moreover, it can prevent the LQ beam from deflection. The seafastening layout is shown in Figure 4.10 and sheet 4.11, Appendix A. The length depends on the web frame spacing. The minimum angle of the seafastening is 20°. If the angle is less than 20°, the construction process will more difficult. The welder needs a certain sufficient space for doing welding and attaching to the roll brace.

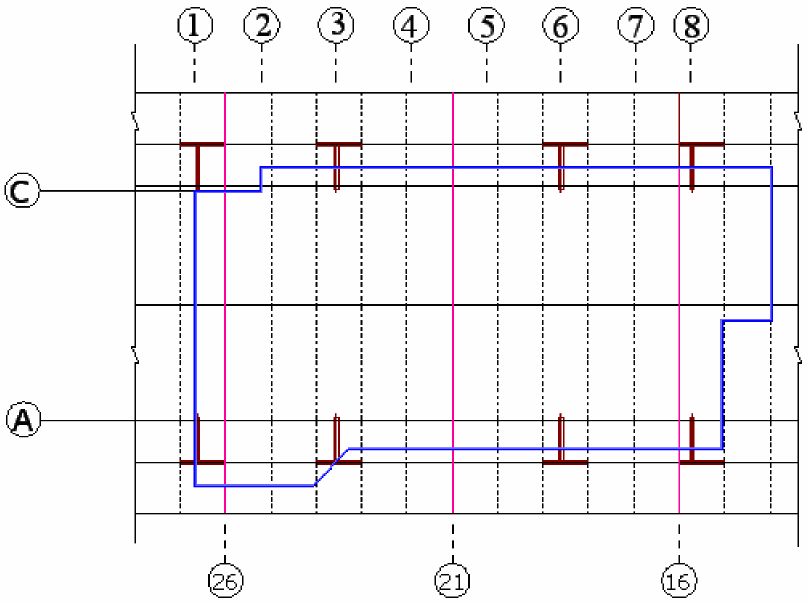


Figure 4.10. Seafastening Layout

There are two kinds of seafastening, transverse seafastening (roll brace) and longitudinal seafastening (pitch stopper) (Figure 4.11. and Figure 4.12.). Transverse seafastening will hold the horizontal force in starboard-portside direction which is caused by pitch motion while longitudinal seafastening will hold the horizontal force in bow-stern direction which is caused by roll motion. Transverse seafastening uses 10.75in of tubular steel pipe while the longitudinal seafastening uses 12in of tubular steel pipe.

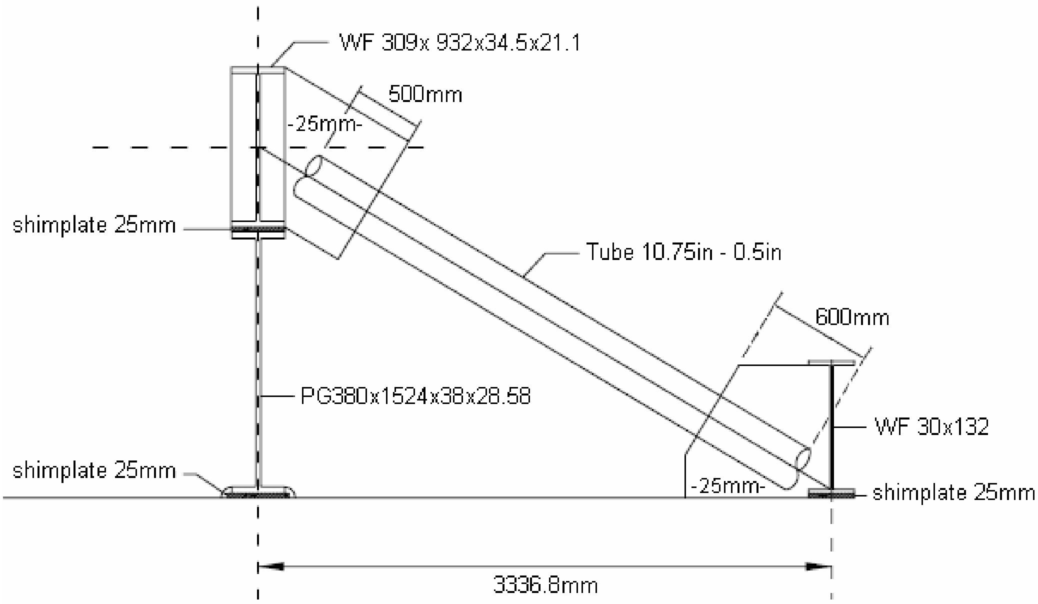


Figure 4.11. Roll Brace

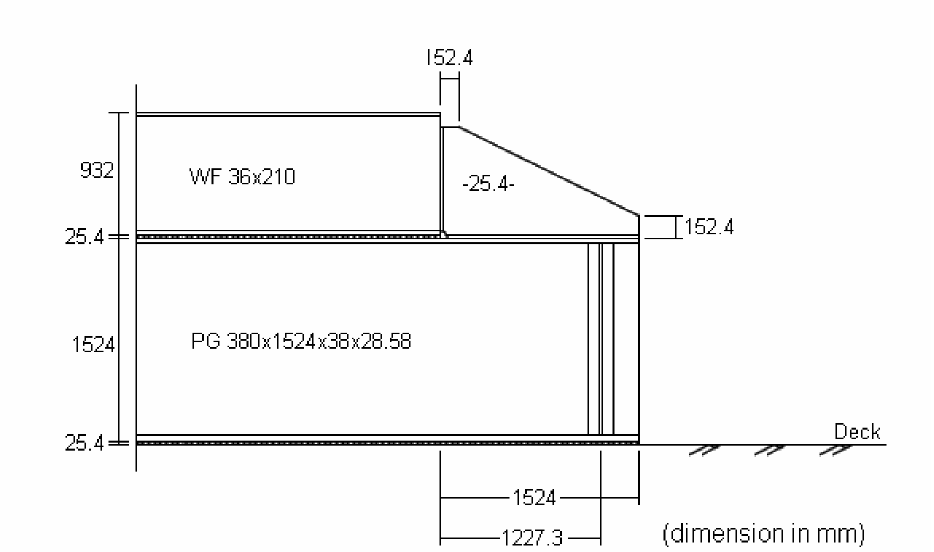


Figure 4.12. Pitch Stopper

The concept design of seafastening is almost the same with the grillage concept design. The load from LQ will be transferred through the seafastening roll brace and then transferred to seafastening beam. Then the vertical load is transferred to the strong point of barge. The vertical reaction from seafastening beams must be less than the capacity of the local barge frame. If the capacity less than the vertical reaction, the seafastening can be extended until get better load distribution. The other way that can be done is to attach more seafastening which will increase the cost of course because it will cause more work for removal.

4.2.2. Seafastening Calculations

See sheet 4.77-4.95, Appendix A.

4.3. Barge Capacity Checks

The barge should have adequate size and strength to ensure that it can hold all reaction forces caused by static and dynamic loads. There are many kinds of barge capacity checks that should be done, such as local capacity check (bulkhead column capacity check), web frame capacity check (plating capacity check), and rail girder capacity check.

4.3.1. Local Capacity Check

Local capacity check is the checking in the bulkhead columns of the barge. The checking uses ‘Bulkhead Column Capacity‘ spreadsheet which determines the maximum allowable load on the bulkhead column. Parameters to be entered are barge specifications and frame properties. Then the result is compared to the vertical reaction caused by the vertical load. The reaction forces must be less than the bulkhead column capacities. If the vertical reaction is more than the bulkhead column capacity, the shim plate can be move a little bit in order to get better load distribution. The other way that can be done is by adding more LQ strong columns so the vertical reaction will be less.

Figure 4.13. shows the illustration of load distribution from strong points of LQ to the strong points of the barge (bulkhead columns). It can be seen that the ends of the grillage beam locate on different plates of the barge, on row 2 and row 3. The bulkhead column capacities in row 2 and row 3 are different. The capacity in row 2 is less than row 3 (sheet 5.7, Appendix A).

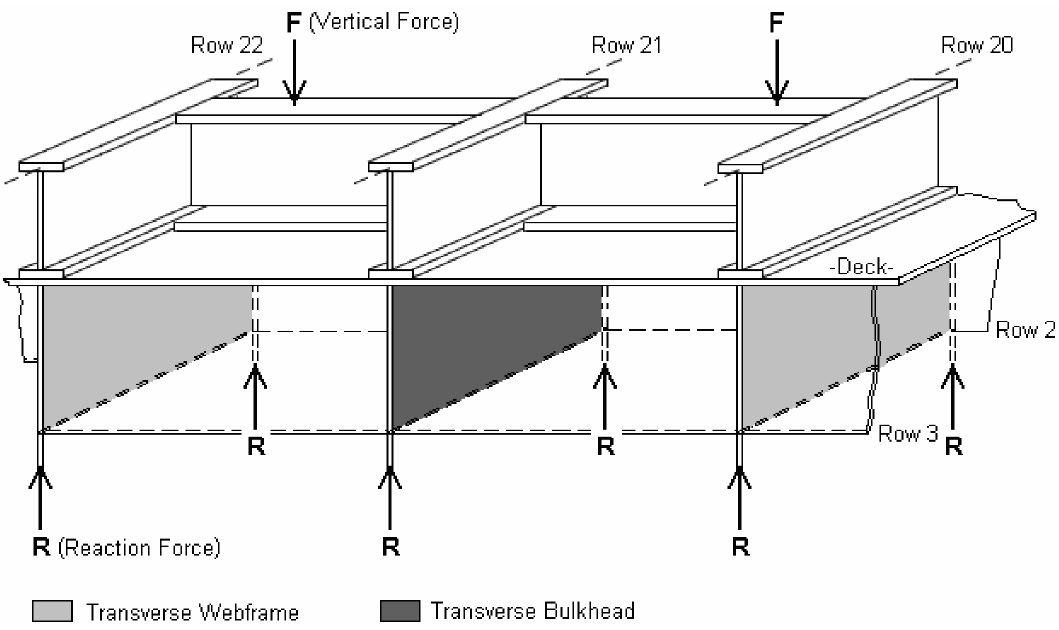


Figure 4.13. Concept of Load Distribution

4.3.2. Web Frame Capacity Check

Not only the bulkhead columns, but also web frame must be checked. It must be checked for its plating capacity which is got from the ‘Plating Capacity’ spreadsheet (sheet 4.100, Appendix A). It determines the maximum allowable load on plate under compression. Then the result is compared with the vertical reaction of the grillage beam. Parameters to be input are the plate’s support type and plate specifications.

4.3.3. Rail Girder Capacity Check

In spite of longitudinal bulkhead, the barge also has rail girder in the longitudinal direction. The barge is equipped with rail girder. which functions as a track for the crane. If the support of grillage beam is located on the rail girder, its capacity must be checked (sheet 4.42, Appendix A). It must be ensured that the rail girder will not collapse due to overloading of the vertical reaction from the grillage beam. The rail girder is a 24x12” profile which made by cutting the 36WF160 profile (Figure 4.14.).

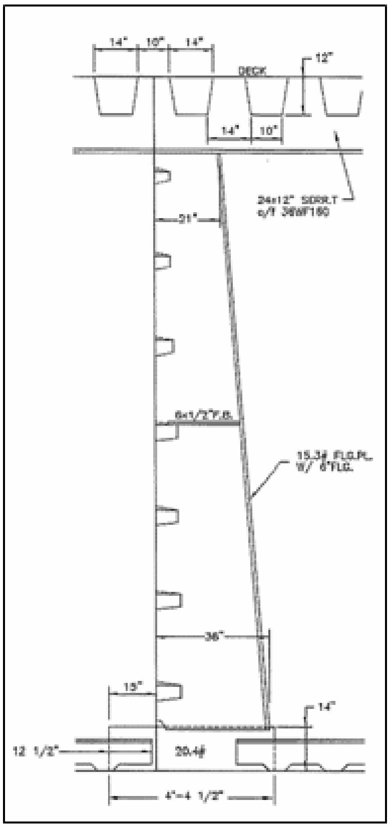


Figure 4.14. Typical Rail Girder

Since it is a honey-comb profile (Figure 4.15.), it has only 10in of effective width with 235 N/mm^2, so the rail girder capacity check will be done as below:

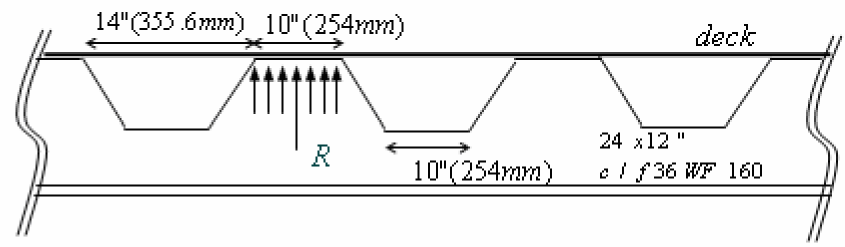


Figure 4.15. Rail Girder

$$F_{eff} = 254x0.6F_y x t_w$$

In which:

Fy = 235 N/mm^2

t_w = 16.5mm

$$F_{eff} = 254mmx0.6x235N / mm^2 x16.5mm$$
$$F_{eff} = 590931N$$
$$F_{eff} = 591kN$$

For grillage beam ends on rail girder, instead of longitudinal bulkhead, needs to compare the vertical reaction force and the rail girder capacity first. In case that the reaction force is more than rail girder capacity, it means that wing plate has to be designed to spread the force. If the rail girder capacity already governs the forces, it means that only end stiffener which is needed. For instance, compare between detail D and detail C (see sheet 4.38-4.43, Appendix A).

CHAPTER 5

Transportation and Installation Phase

5.1. Transportation Phase

Heerema Marine Contractors (HMC) is responsible for the transportation of living quarters (LQ) from hand-over until arriving at the installation site. The transportation phases are defined into three mains steps. They are load-out phase, sailing phase, and installation phase. Each phase has detailed compulsory activities. For that reason HMC needs to determine the necessary activities in each step.

5.1.1. Load-out

Load-out means transferring cargo onto barge for transporting it to its final location. The fabricator, Delta Engineering Corporation (DEC), is responsible for this phase. HMC only stands as the witness, to check and proof that everything is in good condition. There are two kinds of load-out:

- By skidding (Figure 5.1.)

  Push and pull strand jacks (skidding by pull-push method, using cable strand jacks to pull on to the transport barge).

Figure 5.1. Skid Beam

- Using trailers (Figure 5.2.)

  Use a mobile train of self-powered skid with continuous support of pneumatic tires, roll onto the barge.

Figure 5.2. Trailers Moving a Module

In fact, the load-out process is a complex process. Therefore, there are pre load-out activities which are done before the cargo was moved onto the barge. Here are some of the activities:

1. General check

   Covering the visually check of LQ and obtain the weight report.

2. Lift points check

   Doing the general review of the lift points completion according to as-built drawing and checking them which may damage slings.

3. Installation of main lift rigging

   The main purpose of this step is to ensure that slings can be connected to padeyes without any obstacles during the process. Several things that must be done are:

   a. check slings to avoid the damage,

   b. check slings identification marking with rigging drawings,

   c. check slings are laid down according to drawing,

   d. check sling tie-downs per lashing drawing,

e. check no obstructions in the vicinity of lift points,
f. check if shackle safety pins are installed,
g. check no sharp edges on structure which may damage the slings,
h. check if all protective wood is in place and secured.

4. Installation aids:
   a. lift points
   b. protection on roof of LQ
   c. safe access to lift points for sling removal
   d. lift off guides
   e. tugger line attachments
   f. safe access to working areas
   g. guides and bumper system

When a barge is loaded, it has an inclination between bow and stern. If this inclination is too big it can lead to a failure operation. Preventing the failure, the barge level must be kept the same as the dockside level, which means that ballasting or de-ballasting is required. Besides ballast preparation, grillage also has to be attached before load-out.

The LQ load-out of Tombua Landana project is done in Delta yard as shown below (Figure 5.3.):

Figure 5.3. Delta Yard

The available space in Delta yard is less than the required space of 400ft barge. The actual condition makes the stern load-out can not be done directly. Therefore LQ load-out will be done twice as described below:

1. Move the LQ from Delta yard to first barge which has 250ft long. It will be done in the stern to bow direction (Figure 5.4.).

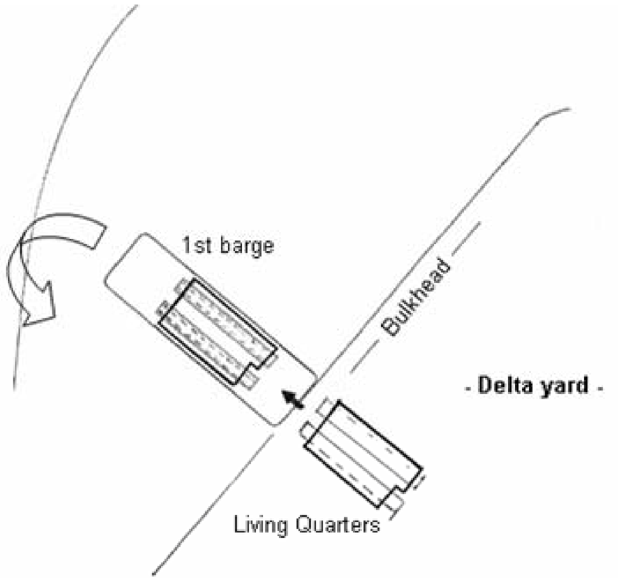


Figure 5.4. First Phase

2. Turn the first barge stern to Crowley barge stern and then move the LQ to Crowley barge. It is also done in stern to bow direction (Figure 5.5.).

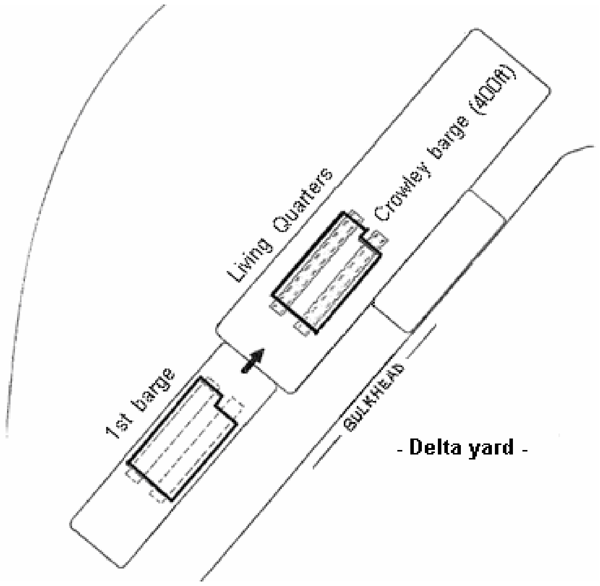


Figure 5.5. Second Phase

The complete phases which are proposed by Mammoet, as the supplier of the trailers can be seen in Appendix C.

Mammoet has a discussion with HMC during determining the most applicable position for LQ load-out. As written in chapter 4, there is a relation between grillages layout and the trailer's position. The cross section of grillages and trailer from HMC proposal is shown in Figure 5.6. When this report was written, HMC was still waiting for the confirmation from Mammoet due to the difference proposal of grillage-trailer layout between them.

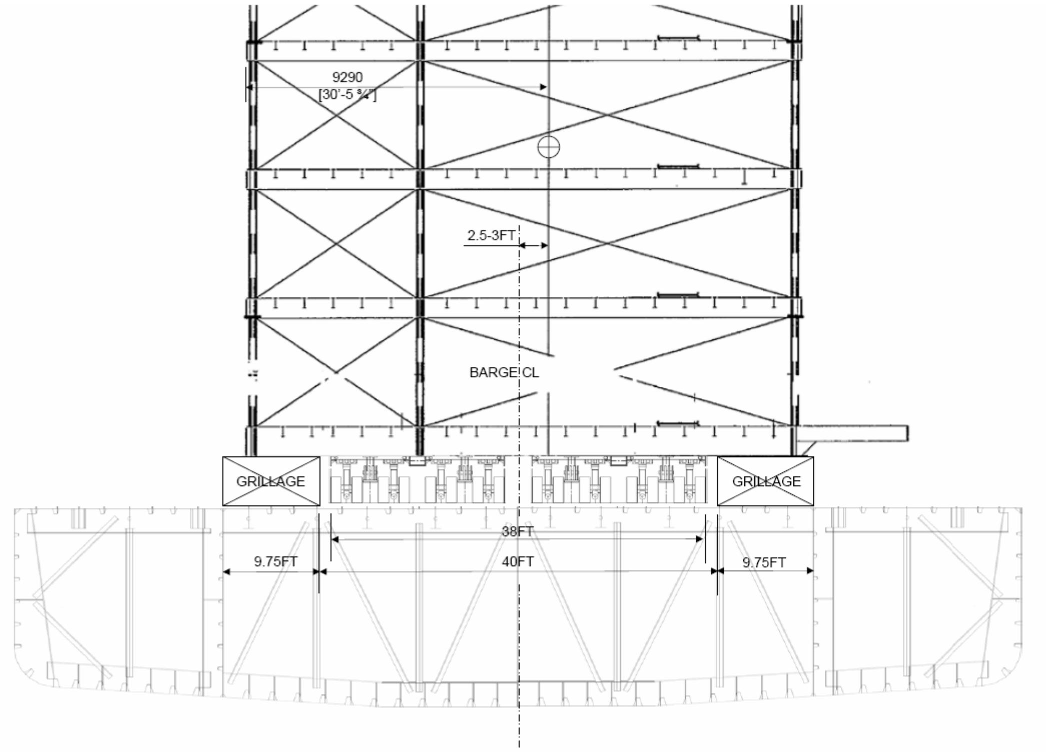


Figure 5.6. Cross Section of Grillages and Trailer (HMC's Proposal)

5.1.2. Sailing overseas

Since the transportation is performed through the sea, the sea parameters must be taken into account. They influence the stability of barge and the cargo during transportation. Maintaining barge and cargo stability needs several things to be prepared well before. For once it sails, nothing can be done anymore. This sub-chapter describes any factors which must be designed in order to keep everything in a safe condition.

5.1.2.1. Ballast Arrangement

The C.o.G. of the cargo is not always located at centre of gravity (C.o.G.) of the barge. When the cargo is located onto barge which has certain weight and centre of buoyancy, there will be an inclination between bow-stern (trim) and portside-starboard (list) which cause instability of the barge. Therefore ballast arrangement is needed to maintain this inclination small (slight trim). Figure 5.7. and Figure 5.8. show the trim and the list. The other purpose of ballast arrangement is to get certain value of draft. The required draft of Crowley-411 is 40% of the barge depth. One thing should be realized is that trim and list are different with pitch and roll. Pitch and roll are part of barge's motions due to sea parameters while trim and list are adjusted angle of barge due to ballast arrangement.

The ballast arrangement must give the optimal trim, list, and draft. It means that the barge needs to submerge into the water to maintain its stability. When the barge does not have sufficient draft, it tends to sway which will affect the stability of the barge. In the other hand, when the barge has more draft, it is more stable but the consequences are that the bollard pull will get more stress and bigger propulsion is needed.

It will be a difference case for list. It can be imagined when the barge has over list to starboard, for instance, both of the tug boat and the barge will tend to move to the starboard direction. It means that the captain has to maintain the direction line quite often otherwise the tug boat and the barge will run into circle direction.

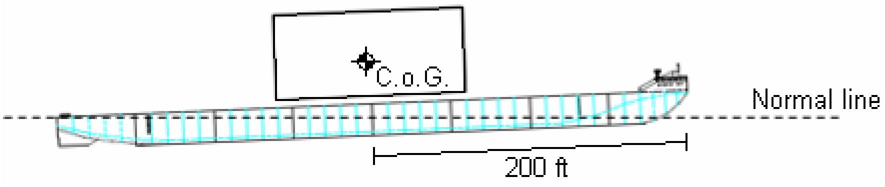


Figure 5.7. Trim Condition (Starboard View)

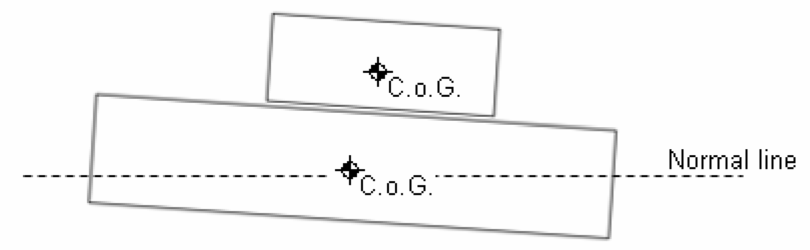


Figure 5.8. List Condition (Stern View)

5.1.2.2. Bollard Pull

It has been stated before that the barge is non-propelled so a tug boat is needed to pull it. The pulling force of a tug boat is called bollard pull. A sufficient bollard pull is required in order to overcome the sea conditions which give loads to the barge and the tug boat itself. Bollard pull of the towing barge should be sufficient enough to maintain zero speed against the wind velocity, current velocity, and other sea state parameters. The criteria, used to calculate bollard pull, is based on Noble Denton criteria which has 20m/s of wind velocity, 0.5 m/s of current velocity, and 5m of significant wave height (Ref. to Noble Denton Criteria).

There are tree kinds of environmental loads on the barge and its cargo which will be taken into account for calculating the bollard pull:

- Wind load

  Wind is an important environmental parameter that influences the design of the floating offshore structure. It acts on both the cargo and barge itself that will contribute as a load which depends on the size of the barge and cargo (Figure 5.9.). There are different shapes of cargo being transported by HMC such as solid box and open truss.

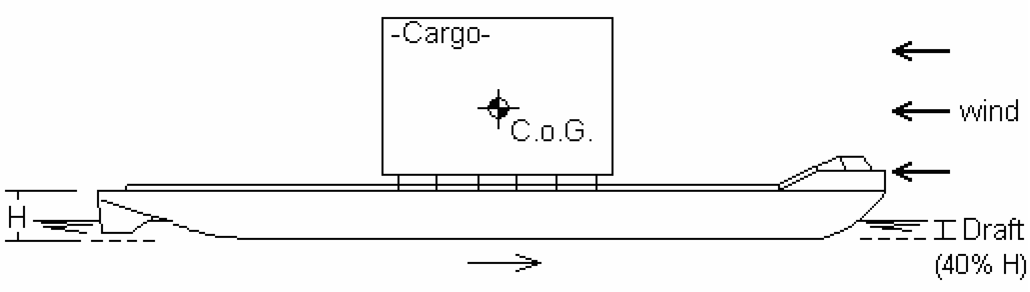


Figure 5.9. Wind Load

To calculate the wind force, the barge and the cargo must be taken into accounts which are considered as solid boxes. Their dimensions influence the shape coefficient. There are several things that must be known before determining shape coefficient (Figure 5.10.), such as:

- ratio between the greater dimension of the member and the lesser dimension of the member (l/w),
- ratio between the dimension of the member normal to the wind and the dimension of the member in the direction of the wind (b/d),
- ratio between the member height and the dimension of the member normal to the wind must be known first (h/b).

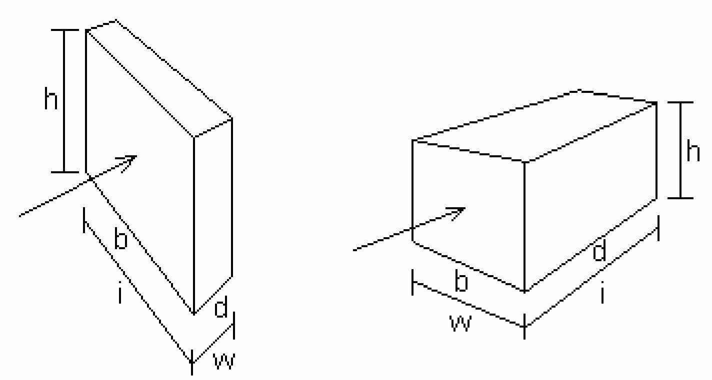


Figure 5.10. Wind Direction to the Cargo

- Hull resistance

The hull resistance of a ship is the resistance of a ship when it is sailing on the water. The hull resistance is a result of the friction of the water along the hull, the pressure distribution along the hull depending on its shape, and the waves that are generated by the ship. The friction will be higher along with the current velocity. In this project the current velocity is only 0.5m/s or 1.0m/s so the hull resistance is quite small and it has no significant influence to the required bollard pull. For Crowley-411 there is a scow at the end of the ship and the hull resistance is 0.2mT (sheet 4.110, Appendix A).

- Wave drift load

Since the transportation performs across the sea, the wave holds an important role. It contributes the largest load to the environment loads. That is why it is needed to calculate this load accurately. The small change in input will cause totally different result. The slope of the bow to the water surface is 48 degrees and from the calculation the wave resistance is 20.9mT (sheet 4.110, Appendix A).

By sum up the wind resistance, the hull resistance, and the wave resistance, the total towline pull required can be obtained. There is a tug efficiency since many aspects influenced it. This efficiency depends on the required bollard pull, the sea state parameters, and the towing speed (Table 5.1.), which is determined by using formula as below:

$$\boxed{\text{TPR} = \sum (\text{BP} \times T_e/100)}$$

Where: T_e = the tug efficiency (%)

(BP x Te/100) = the contribution to the towline pull requirement of each tug

Table 5.1. Tug Efficiency

Continuous Bollard Pull (BP), tonnes	**T_e (%)**		
	Calm	**H_{sig} = 2m**	**H_{sig} = 5m**
BP ≤ 30	80	50 + BP	BP
30 < BP < 90	80	80	30 + [0.75 x (BP - 30)]
BP ≥ 90	80	80	75

In this case, it requires 32.62mT of TPR to pull the barge. But since the tug efficiency is only 53.35%, the required bollard pull become 61.14mT (sheet 4.110, Appendix A).

5.1.2.3. Tug Boat

Tug boat is a boat, used to pull the non-propelled barge. The tug selection should fulfill the minimum bollard pull requirements. The tug boat that will be used is called “Invader” with a capacity of 150,000lbs (68mT) (Appendix D). It is provided by Crowley Maritime Corporation.

5.1.2.4. Towing Equipments

Since the barge is pulled by a tug boat, the tug boat must be facilitated with towing equipments. To arrange these equipments, the worst sea state characteristics of the route should be considered. In this project, the barge which has a wide bow is pulled from the forward end of the barge via suitable bridles. The components of these equipments are:

- Towline connections, including towline connection points, fairleads, bridle legs, and bridle apex (Figure 5.11.)
- Intermediate pennant
- Bridles recovery system
- Emergency towing gear (Figure 5.12.) and Appendix E

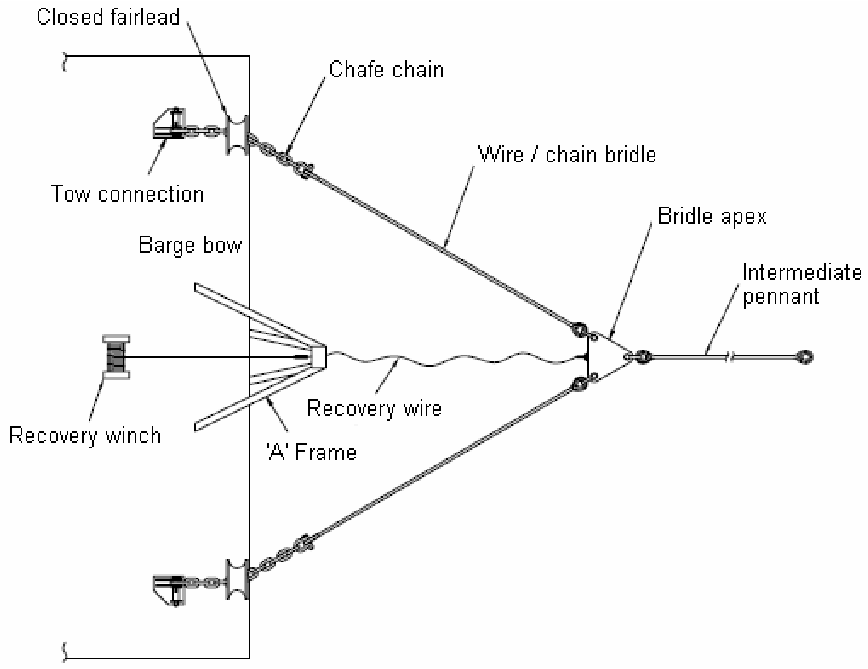


Figure 5.11. Main Tow Bridle with Recovery System

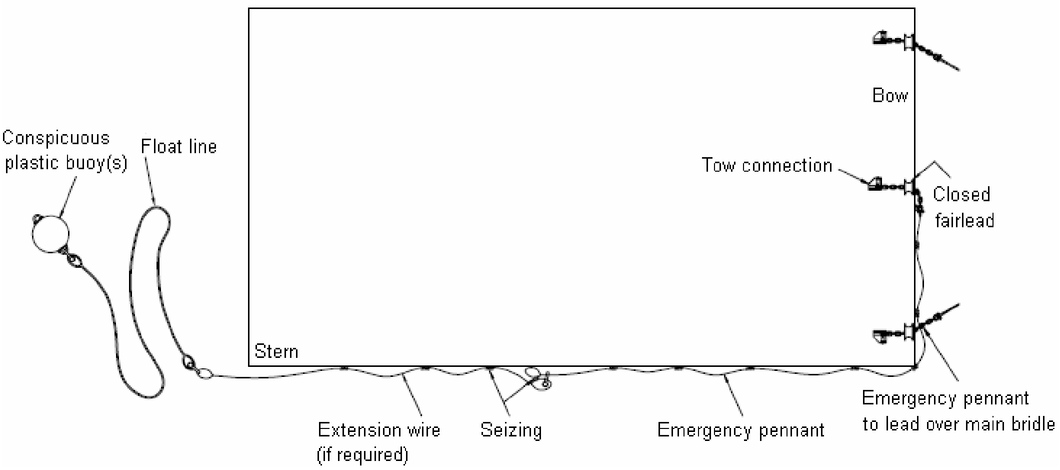


Figure 5.12. Emergency Towing Gear

The towing barge should be equipped with towing winch where its minimum breaking load (MBL) is based on the actual continuous static bollard pull (BP) as shown in Table 5.2.

Table 5.2. Towline Breaking Load (MBL)

Bollard Pull (BP)	Benign Areas	Other Areas
BP ≤ 40 tonnes	2 x BP	3 x BP
40 < BP ≤ 90 tonnes	2 x BP	(3.8 - BP/50) x BP
BP > 90 tonnes	2 x BP	2 x BP

Since the routes of LQ transportation have extremes (tropical cyclone in the Gulf of Mexico, Caribbean seas, West Indies and winter storms in the Gulf of Mexico), the towline breaking load is computed for other areas.

MBL = (3.8 – BP/50) x BP

= (3.8 – 68/50) x 68

= 165.92 mT

There is ultimate load that the bridle can hold:

ULC = 1.25 x MBL

= 1.25 x 165.92

= 207.4 mT

ULC = MBL + 40

= 165.92 + 40

= 205.92 mT

→ ULC = min (207.4 ; 205.92)

= 205.92 mT

There is a certain length of towline, used to pull the barge as shown in Figure 5.13.

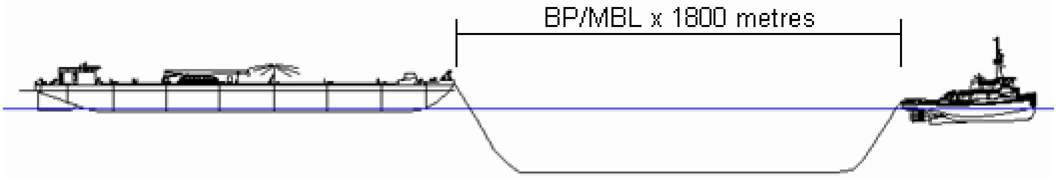


Figure 5.13. Barge and Its Tug Boat

$$\text{Towline length} > \frac{BP}{MBL} \text{ x 1800metres}$$

Where: BP = Bollard pull (mT)

MBL = Minimum Breaking Load (mT)

Towline length = BP/MBL x 1800 m
= 68/205.92 x 1800 m
= 594.41 m

In case of towline failure, an emergency towing gear should be provided to recover the bridle. This equipment is preferably located at the bow of the barge and should consist of a spare bridle or towing pennant, fitted with a floating rope and buoy, allowing it to be picked up without any difficulties. The other way to cope with towline failure is by providing at least one anchor. It is attached to a chain cable or wire, which is arranged for release manually.

5.2. Installation Phase

LQ installation (Figure 5.14.) is done in second phase of installation. The second phase is scheduled to be accomplished in the end of December 2008. The Thialf takes the installation for the Tombua Landana project. The installation use only single crane, for the one Thialf crane's capacity (7000mT) is already sufficient for the weight of LQ (1622mT). For the LQ installation, there are three main activities, they are pre-installation, installation and post installation. Since there are plenty of detailed steps, it is decided that only the main steps will be described in this final thesis report.

1. Pre-installation activities
    a. Pre-lift activities on Thialf
       Consist of preparation for fender, mooring and tugger lines.
    b. Pre-installation activities on top sides platform
    c. Pre-lift activities on Crowley 411
       Confirm if Crowley 411 is ready to commence installation operations and safe to enter
    d. Pre-lift activities on tugboats
    e. Pre-lift activities on LQ
       Need to check the condition in LQ to be sure that LQ is clear of any items that can obstruct installation.

2. Installation activities
    1. move the barge to its position according to the drawing installation
    2. check the environmental conditions, such as wind and waves
    3. check the rigging layout according to the drawing (sheet 1, Appendix F)
    4. cut LQ seafastenings
    5. attach tugger lines / steering lines
    6. lift-off LQ
    7. Install LQ
    8. Transfer personnel to the platform in order to monitor operations and for de-rigging.

3. Post-installation activities
    1. release shackles, remove slings and transfer to SSCV deck
    2. Helideck completion
    3. Removal of LQ rotation wire guides
    4. Remove padeyes
    5. Remove guides and bumpers
    6. Demobilize personnel back to the SSCV
    7. Move-out SSCV and sail to another project location.

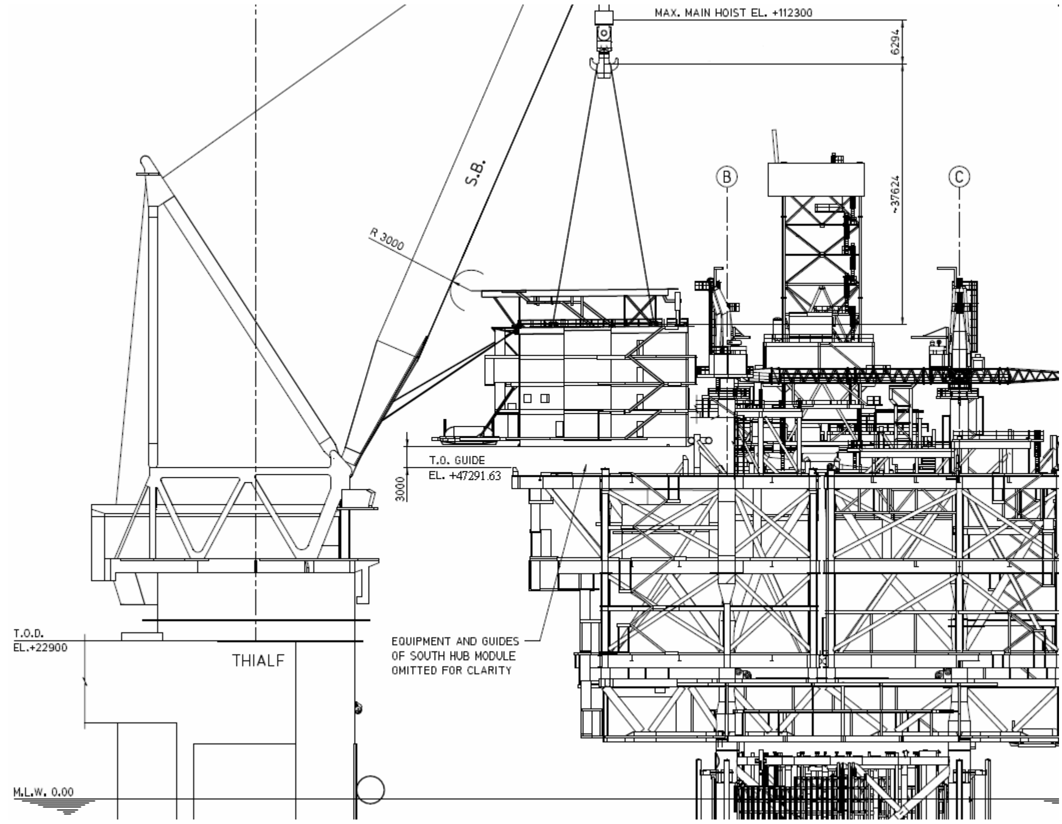


Figure 5.14. Living Quarters Installation

CHAPTER 6

Conclusions and Suggestions

6.1. Conclusions

Transportation of offshore oil platform is influenced by the sea parameters, such as wave, wind, and current in the sea. They have significant influences to the transportation of the platform. Therefore it is needed steel structures to secure the platform during the transportation. For this project, the platform which is transported is Living Quarters. To transport it, six grillages are needed, eight roll braces as transverse seafastenings, and two pitch stoppers as longitudinal seafastenings.

There are six grillage beams which function to withstand all the vertical force caused by static and dynamic loads. Each of the grillage beam has 20ft long. It is a parallel beam which consists of three PG 190x1524x38x25.4 and two PG 380x1524x38x28.58. The connection between each beam uses fillet weld with leg size of 19.05mm. The wing plates and the end stiffeners are attached in the end of the grillage beams in order to spread the load and to maintain the rigidity of the beam itself. To withstand all the horizontal forces caused by static and dynamic loads, seafastenings are needed. The roll braces are 10.75in diameter of tube steel and attached from Living Quarters beam to the barge deck. The pitch stoppers are plate with 1in. thick which is connected to Living Quarter's beam and grillage beam.

Since the barge is not self-propelled, it needs a tug boat to pull it by using 61.14mT of bollard pull. The tug boat which will use for this project is called "Invader" tug boat which is provided by Crowley as the provider of the barge as well.

6.2. Suggestions

1. The Moses analysis for knowing the dynamic forces during transportation must be done, instead of using Noble Denton criteria.
2. It is better to have a 3D model which contents cargo, grillage, seafastening, and barge in one model. Although it takes time to develop a 3D model, it gives more accurate results for the design.
3. Organizing some courses for the internship students will make the learning process goes faster.
4. Choosing the unit system, Imperial or Metric in the preliminary design will be better, especially when designing for the American client.

REFERENCES

Straathof, A. Offshore Technology: Introduction Courses for the T&I 'Junior' Engineer. Netherlands: Heerema Marine Contractors (HMC).

Blodgett, Omer W. (1966, June). Design of Welded Structures. Cleveland, Ohio: The James F. Lincoln Arc Welding Foundation.

Standard Symbols for Welding, Brazing, and Nondestructive Examination. Miami, Florida: American welding Society (AWS).

Table Profile. Netherlands: Heerema Marine Contractors (HMC).

Standard Criteria. Netherlands: Heerema Marine Contractors (HMC).

www.hmc-insite.com (HMC Intranet)

www.wikipedia.org

LIST OF FORMULAS

Source: HMC's IPEX Manual

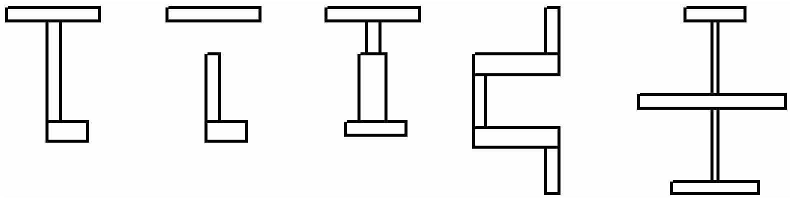
1. PLATE GIRDER PROPERTIES

The spreadsheet 'PLATE GIRDER PROPERTIES' calculates the section properties of plate girders built-up from a maximum of 15 sections. The calculated section properties are equivalent to the SACS nomenclature. Different units for input and output can be selected, allowing for automatic unit conversion.

Validity of the spreadsheet

The spreadsheet is only valid for open plate girders, with no more than one web in any horizontal cross-section. A web is defined as a part with a larger height (Z) than breadth (Y), a flange is defined as a part with a height equal or smaller than the breadth.

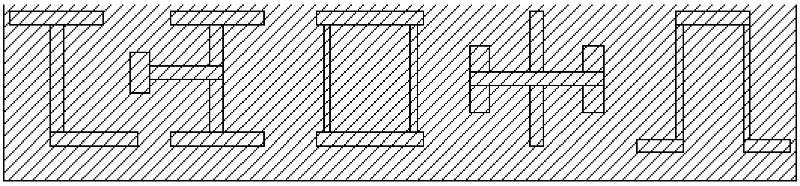
Sections that **can** be entered:



Please note that the spreadsheet has the following **imperfections**:

Flanges should not protrude beyond the widest flange.
The widest flange should not be given an offset e_y.
Plate sections should be stacked on top of each other.
The Az shear area is calculated using the mean web thickness at the intersection with the flanges.

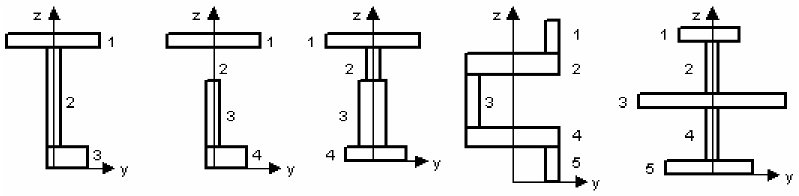
Sections that **CAN NOT** be entered:



Input: entering sections and co-ordinate system.

The origin of the co-ordinate system used by the spreadsheet is positioned at the bottom of the plate girder at the centre line of the widest flange. Sections (webs and flanges) of the plate girder should be entered from top to bottom. The spreadsheet will stack each successive section below its predecessor and shift the co-ordinate origin to the bottom of the last section, in the centre of the web or flange with the largest breadth. See figure below.

Sections with a C.o.G **not** on the Z-axis can be offset by entering the positive or negative distance, e_y, towards the Z-axis, i.e. the distance between the C.o.G's of the subject section and the widest one. **Therefore, the widest section should not be given an offset.**



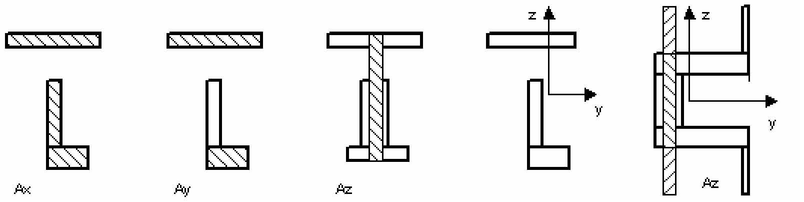
Unit conversion

Plate girder properties can be entered and calculated in several units; Millimetres, centimetres, meters and inches. The plate girder weight per length can be calculated in kN/m, kg/m, mT/m, lb/ft, lb/inch and lb/yard. When different input and output units are selected the spreadsheet will automatically make the proper conversion.

Selecting the units is done by clicking once on the appropriate button from one of the menus (**Input**, **Output** and **Weight)** situated on the right hand side of the spreadsheet.

Output and calculations

The output properties are with respect to Y-Z coordinates parallel to the input axes but with their origin at the plate girder C.o.G. (See figure below.) This co-ordinate system is identical to that of SACS-IV. Also the calculated properties are conform the SACS-IV nomenclature.



Dimensions

Maximum breadth of the plate girder, Y , equals the width of the widest section.
Plate girder total height, Z.
Plate girder unit weight is: ρ_{steel} * g * Ax , where ρ_{steel} = 7850 kg/m^3 and g = 9.81 m/s^2 or converted to the appropriate dimensions.

Areas

$$Ax = \sum (b*h)_{all}$$

$$Ay = \sum (b*h)_{flanges}$$

$$Az = t_{mean} * h_{tot} = t_{mean} * Z$$

Note that the spreadsheet uses the mean web thickness to calculate the shear area's:

$$t_{mean} = \frac{\sum (b*h)_{webs}}{\sum h_{webs}} . \text{ Hence: } Az \neq \sum (b*h)_{webs}$$

Distances to neutral axis

$$e_y = \frac{\sum (e_{y,input} * b * h)}{Ax} + Y/2$$, from left outer fibre.

$$Z - e_z = \frac{\sum (e'_z * b * h)}{Ax}$$, where e'_z is from the top outer fibre to the C.o.G of the subject section. Hence e_z is the distance between the plate girder C.o.G and bottom outer fibre.

Moments of inertia and torsional constant

$$I_y = \sum (e^2{}_{z,i} * b * h + \frac{b*h^3}{12})$$, where $e_{z,i}$ is the distance between the plate girder C.o.G and the C.o.G of the subject section ($e_{z,i}$ = (Z - e_z) - e'_z).

$$I_z = (\sum \left(e^2{}_{y,input} * b * h + \frac{h*b^3}{12} \right)) - \left(\frac{\sum e_{y,input} * b * h}{\sum b * h} \right)^2 * Ax$$, i.e. I_z equals the moment of inertia w.r.t. the Z-axis through the C.o.G of the widest section minus the product of the total area and the square of the distance between the input- and output- Z-axis

$$I_T = \frac{1}{3} * \sum l * t^3$$, where the thickness t is the smallest of either h or b.

The torsional constant (or torsional resistance) I_T does not include a correction factor acc. Föppl, ref. Technische Formelsammlung by K Gieck, Aufl. 27, Sect. P21.

Section modulii

$W_{y,bottom} = \frac{I_y}{e_z}$ and $W_{y,top} = \frac{I_y}{Z - e_z}$, $W_{y,min}$ is the smaller one of these two

$W_{z,left} = \frac{I_z}{e_y}$ and $W_{z,right} = \frac{I_z}{Y - e_y}$, $W_{z,min}$ is the smaller of these two. Therefore, due to the definition of Y, **the sections should not protrude beyond the widest one.**

$W_T = \frac{I_T}{t_{\max}}$, where $t_{\max}$ is the largest section thickness. (Not presented in output)

Radii of gyration

$$r_y = \sqrt{\frac{I_y}{Ax}} \text{ and } r_z = \sqrt{\frac{I_z}{Ax}}$$

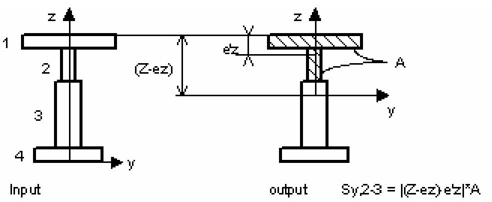
Statical moments

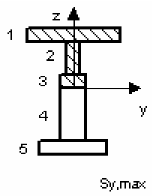
The statical moment can be used to determine the shear stress acting between two adjacent sections. It is calculated by multiplying the area under consideration and the distance between its C.o.G and the plate girder C.o.G:

$$S_y = \sum (b * h * \left| (Z - e_z) - \frac{\sum b * h * e'_z}{\sum b * h} \right|)$$

The shear stress at a section can be calculated using the equation $\tau = \frac{D * S_y}{b * I}$

Note that the statical moment, listed on the right hand side of a row in the input table, can be used to derive the shear stress between the section mentioned on that row and the secton just below.

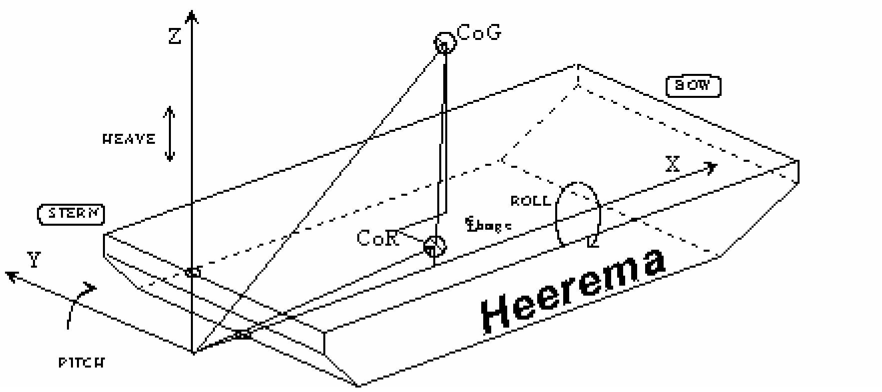




You can obtain the $S_{y,max}$ by dividing the section that contains the plate girder C.o.G into two sections, separated along the (output) Y-axis.

2. TRANSPORTATION FORCES

The spreadsheet 'TRANSPORTATION FORCES' calculates the static and dynamic transportation forces and accelerations. Parameters to be entered are transportation criteria, cargo specifications and barge or ship information. **Input and output of the spreadsheet are consistent with the Bartran axis system. Angles and moments, however, are according to the Right Hand Rule!**



Transportation criteria

Input:

The single amplitude angle for roll, θ_{roll} in degrees.

The full cycle period for roll, T_{roll} in seconds.

The single amplitude for pitch, θ_{pitch} in degrees.

The full cycle period for pitch, T_{pitch} in seconds.

The single amplitude for heave, A_{heave} in meters.

The full cycle period for heave, T_{heave} in meters.

The spreadsheet will automatically detect the Noble Denton criteria ('General guidelines for marine transportations' 0014/NDI/JR - dec. 1986, section 5.2.1) and will prompt so on the sheet.

Noble Denton Criteria are:

	Single amplitude (10 sec full cycle period)		
Type	Roll	Pitch	Heave
Small barges	25°	15°	5 m
Larger barges	20°	12.5°	5 m
Small vessels	30°	15°	5 m

Note that the 5 m heave at a 10 sec. cycle period accounts for a vertical accelerations of 0.2 g.

Cargo specifications

A suitable name for the cargo can be entered for reference purposes.

Input:

The weight of the cargo, W in kN.

The mass moment of inertia about the roll axis, M_oI_x in Tm^2.

The mass moment of inertia about the pitch axis, M_oI_y in Tm^2.

The x - co-ordinate of the cargo centre of gravity, x_{CoG} in m.

The y - co-ordinate of the cargo centre of gravity, y_{CoG} in m.

The z - co-ordinate of the cargo centre of gravity, z_{CoG} in m.

Barge / ship information

The name or description of the barge / ship can be entered for reference purposes.

Input:

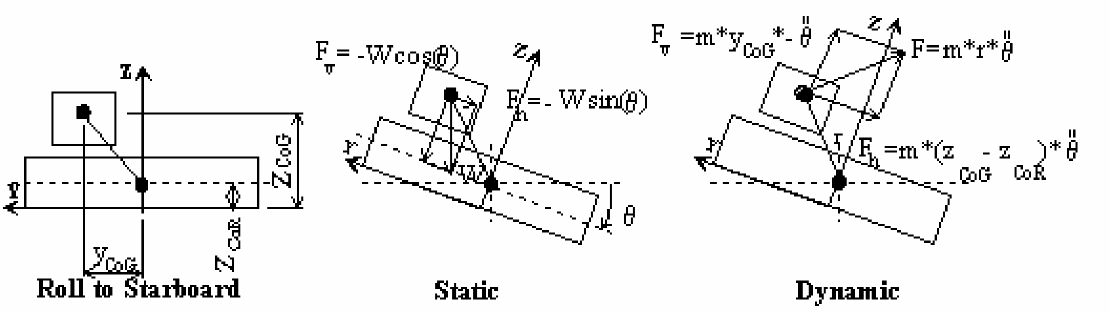
The x - co-ordinate of the centre of rotation, x_{CoR} in m. (Usually x_{CoR} is a few meter shorter than half the barge length)

The centre of rotation is on the waterlevel: z_{CoR} = meandraft in m.

Note that by default the centre of rotation in y - direction is at half breadth of the barge.

Transportation forces and accelerations

The calculated transportation forces and accelerations are a combination of dynamic forces and static forces on the centre of gravity of the cargo. The spreadsheet calculates the vertical force, the horizontal force, the moments and the heave in the centre of gravity of the cargo. These forces and moment are calculated for roll to starboard and portside, and pitch to stern and bow. **Note: the output forces are exerted by the module on the barge, their workpoint is the module C.o.G**. An example is given below for roll to starboard, roll to portside and pitch are calculated in a similar fashion. Shown is the stern of a barge with cargo:



Roll to Starboard **Static** **Dynamic**

Roll

Static forces:

$$F_{v,static} = -W * \cos(\theta_{roll}) \text{ kN}$$
$$F_{h,static} = -W * \sin(\theta_{roll}) \text{ kN}$$

Dynamic forces:

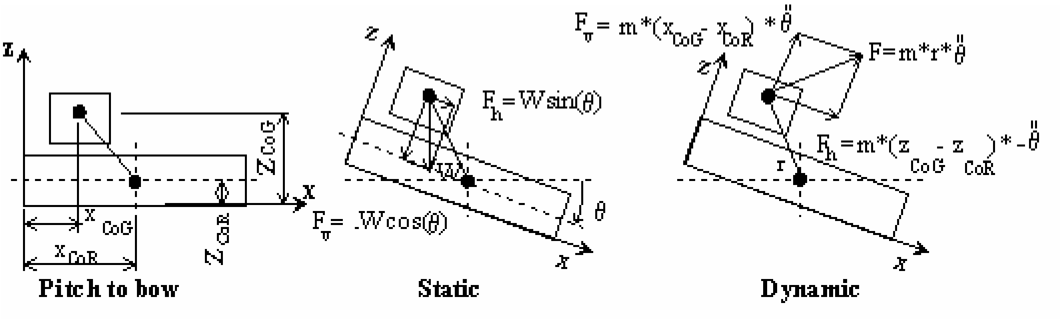
$$F_{v,dynamic} = \frac{W}{9.81} * y_{CoG} * \left(\theta_{roll} * \left(\frac{2\pi}{T_{roll}} \right)^2 \right) \text{ kN}$$
$$F_{h,dynamic} = \frac{W}{9.81} * (z_{CoG} - z_{CoR}) * \left(-\theta_{roll} * \left(\frac{2\pi}{T_{roll}} \right)^2 \right) \text{ kN}$$
$$M_{roll} = M_o I_x * \left(\theta_{roll} * \left(\frac{2\pi}{T_{roll}} \right)^2 \right) \text{ kNm}$$
$$H_{roll} = \frac{W}{9.81} * \left(A_{heave} * \left(\frac{2\pi}{T_{heave}} \right)^2 \right) \text{ kN}$$

Combined forces:

$$F_{v,SB} = F_{v,static} + F_{v,dynamic} \text{ kN}$$
$$F_{h,SB} = F_{h,static} + F_{h,dynamic} \text{ kN}$$

Pitch

Below the forces acting at a module, and exerted on the barge, are shown for pitch to bow:



Static forces:

$$F_{v,static} = -W * \cos(\theta_{pitch}) \text{ kN}$$
$$F_{h,static} = W * \sin(\theta_{pitch}) \text{ kN}$$

Dynamic forces:

$$F_{v,dynamic} = \frac{W}{9.81} * (x_{CoG} - x_{CoR}) * \left(-\theta_{pitch} * \left(\frac{2\pi}{T_{pitch}} \right)^2 \right) \text{ kN}$$

$$F_{h,dynamic} = \frac{W}{9.81} * (z_{CoG} - z_{CoR}) * \left(\theta_{pitch} * \left(\frac{2\pi}{T_{pitch}} \right)^2 \right) \text{ kN}$$

$$M_{pitch} = M_o I_y * \left(\theta_{pitch} * \left(\frac{2\pi}{T_{pitch}} \right)^2 \right) \text{ kNm}$$

$$H_{pitch} = \frac{W}{9.81} * \left(A_{heave} * \left(\frac{2\pi}{T_{heave}} \right)^2 \right) \text{ kN}$$

Combined forces:

$$F_{v,stern} = F_{v,static} + F_{v,dynamic} \text{ kN}$$

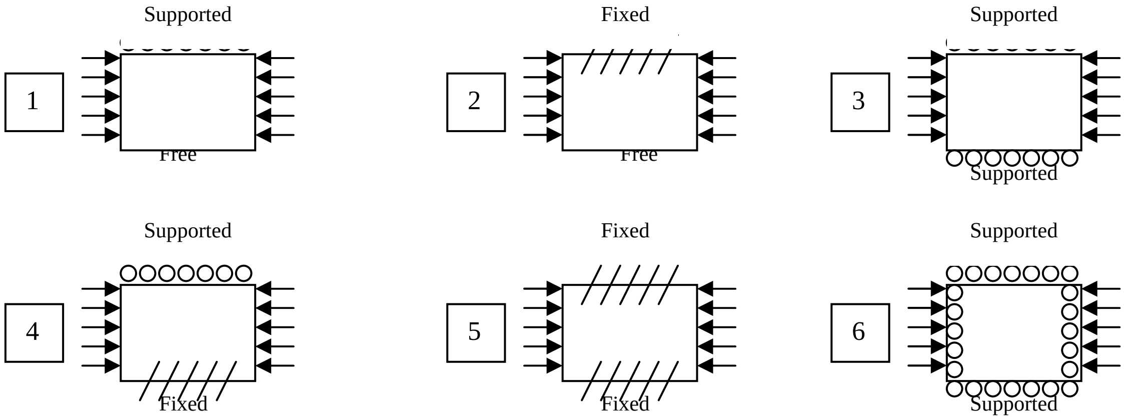
$$F_{h,stern} = F_{h,static} + F_{h,dynamic} \text{ kN}$$

3. PLATING CAPACITY

The spreadsheet ‘PLATING CAPACITY’ calculates the maximum allowable load on plates under compression. The critical buckling stress due to compression is based on the Priest – Gilligan curve as described in O.W. Blodgett’s ‘Design of welded structures’, June 1966.

Buckling resistance of plates under linear compression

The spreadsheet calculates the buckling resistance for plates supported in several ways. A selection box with various support types is placed on the right side of the spreadsheet. By default the ‘four sides supported’ loadcase is selected. Implemented support types are:



Depending on the support type, the following plate factor is used.

1. One side supported, one side free: k = 0.425
2. One side fixed, one side free: k = 1.277
3. Two sides supported: k = 4
4. One side supported, one side fixed: k = 5.42
5. Two sides fixed: k = 6.97
6. Four sides supported: k = 4 for α ≥1.0. For α ≤ 1.0: $k = (\alpha + 1/\alpha)^2$

Input:

- Modulus of elasticity, default value is $E = 2.1 * 10^5 \, N/mm^2$
- Poisson’s ratio, default value is ν = 0.3.
- Thickness of the plate, t in mm.
- Length of the plate, a in mm.
- Width of the plate, b in mm. (Loaded side). (α = a/b)
- Yield stress, σ_y in N/mm^2.

Calculation:

- The critical stress determination is based on the Priest – Gilligan curve as can be found on sheet 2.12-6 of ‘Design of Welded Structures’ by Omar W. Blodgett. This is done by determining the points B and C of the curve and selecting the proper portion of the curve.

  Point B is found at a $\frac{b/t}{\sqrt{k}} = \frac{3820}{\sqrt{\sigma_y}}$, where σ_y is entered in pound per square inch (psi).

  Point C is found at a $\frac{b/t}{\sqrt{k}} = \frac{5720}{\sqrt{\sigma_y}}$, σ_y in psi.

  By comparing the calculated factor and the factors for points B and C the proper portion of the curve is selected.

- Using the selected portion the critical stress can be calculated:

  For the portion A – B: $\sigma_{cr} = \sigma_y$, in N/mm^2.

  For the portion B – C: $\sigma_{cr} = 1.8\sigma_y - \frac{\sqrt{\sigma_y}^3}{4770} * \frac{b/t}{\sqrt{k}}$, where σ_{cr} and σ_y are in psi.

  For the portion C - D: $\sigma_{cr} = 0.75 * \frac{k * \pi^2 * E}{12 * (1 - \nu^2)} * \left(\frac{t}{b}\right)^2$ in N/mm^2.

- At the calculated critical stress the middle portion of the plate would be expected to buckle. However, the over-all plate will not collapse since the portion of the plate along the supported sides could still be loaded up to the yield point before ultimate collapse. This portion of the plate, the ‘*effective width*’, can be determined by finding the ratio b/t at the point where $\sigma_{cr} = \sigma_y$, point B of the Priest – Gilligan curve. The plate factor k is limited to a maximum of 4, i.e. a two sides supported plate or a four sides supported plate with a ≥ b:

$$\frac{b_{eff}}{t} = \frac{3820}{\sqrt{\sigma_y}} * \sqrt{k}\text{ , } \sigma_y \text{ in psi.}$$

- The effective width is calculated by multiplying the factor b_{eff}/t by the plate thickness.

- The maximum allowable load for the plate is:

$$F = \{b_{eff} * t * (0.6 * \sigma_y) + (b - b_{eff}) * t * 0.6 * \sigma_{cr}\} * 10^{-3} \text{ in kN.}$$

(0.6 to account for allowable stresses according to AISC)

The maximum specific allowable load is F/b in kN/m.

Output:

- The critical stress, and the portion of the Priest – Gilligan curve that is used.
- The k-factor depending on the type of support and plate shape factor $\alpha = a / b$.
- The effective width b_{eff} in mm.
- The maximum allowable load F in kN.
- The maximum allowable specific load in kN/m.

4. BOLLARD PULL

Wind Load

$$F_{wind} = \frac{1}{2}\rho_a \left[V.\frac{1+0.137.\ln\left(\frac{z}{10}\right)-0.047\ln\left(\frac{1}{10}\right)}{1-0.047\ln\left(\frac{1}{10}\right)} \right]^2 \times A \times C_s \times C_t \times C_\gamma$$

With:
F_{wind} : wind force [kN]
ρa : density of air 1.225 [kg/m3]
V : 1-minute mean wind velocity at reference height 10 m [m/s]
Z : height above sea surface [m]
A : longitudinal projected area [m2]
C_s : shape coefficient, user defined or see Table 5.5. [-]
C_t : truss coefficient, 0.6 for double-sided open truss work, 1 for solid bodies[-]
C_γ : shielding coefficient, subject to engineering judgement (default 1.0) [-]

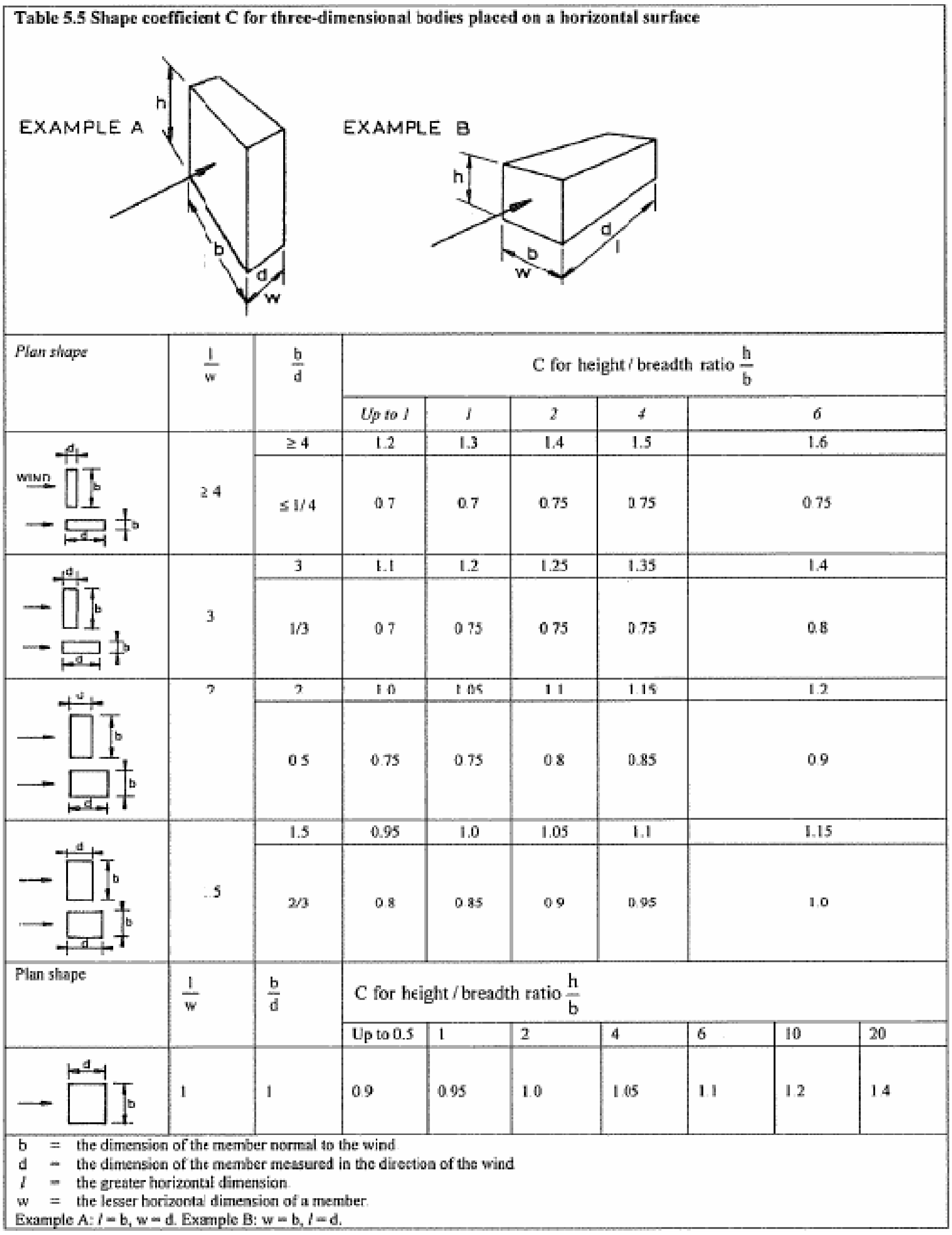


Table 5.5 Shape coefficient C for three-dimensional bodies placed on a horizontal surface

Plan shape	$\frac{l}{w}$	$\frac{b}{d}$	C for height / breadth ratio $\frac{h}{b}$				
			Up to 1	*1*	*2*	*4*	*6*
	≥ 4	≥ 4	1.2	1.3	1.4	1.5	1.6
		≤ 1/4	0.7	0.7	0.75	0.75	0.75
	3	3	1.1	1.2	1.25	1.35	1.4
		1/3	0.7	0.75	0.75	0.75	0.8
	2	2	1.0	1.05	1.1	1.15	1.2
		0.5	0.75	0.75	0.8	0.85	0.9
	1.5	1.5	0.95	1.0	1.05	1.1	1.15
		2/3	0.8	0.85	0.9	0.95	1.0

Plan shape	$\frac{l}{w}$	$\frac{b}{d}$	C for height / breadth ratio $\frac{h}{b}$						
			Up to 0.5	1	2	4	6	10	20
	1	1	0.9	0.95	1.0	1.05	1.1	1.2	1.4

b = the dimension of the member normal to the wind
d = the dimension of the member measured in the direction of the wind
l = the greater horizontal dimension
w = the lesser horizontal dimension of a member
Example A: *l* = b, w = d. Example B: w = b, *l* = d.

Hull Resistance

$$R_{Hull} = R_F + R_{TR} + R_W + R_{VP} + R_{APP} + R_{All}$$

With:

R_{Hull} = resistance due to friction
R_{TR} = Resistance due to submerge stern
R_W = Wave making resistance
R_{VP} = Viscous pressure resistance

R_{APP} = Appendage resistance
R_{All} = Additional roughness resistance

Friction resistance

$$R_F = \frac{\rho_w \times V^2 \times S \times 0.075}{[\log_{10}(R_n) - 2]^2}$$

With:
R_F = Resistance due to friction [kN]
ρ_w = Water density 1.025 [mT/m]
S = Projected longitudinal wet hull surface
$= 2 \times L \times T$ [m^3]
R_n = Reynolds number
$= \frac{V.L}{\upsilon}$
ν = Kinematic viscosity of water 1E-6 [m^2/s]

Resistance due to submerged stern

$$R_{TR} = \frac{1}{2} \times \rho_w \times V^2 \times A_{TR} \times C_{D-TR}$$

With:
R_{TR} = Resistance due to submerged stern [kN]
ρ_w = Water density 1.025 [mT/m]
A_{TR} = Submerged area of stern
$= B \times T$ [m^2]
C_{D-TR} = Drag coefficient for stern resistance, approximately by 0.213 which is an upper estimation

Wave making resistance

$$R_w = Q \times F_{nB}{}^6 \times \rho_w \times g \times B^2 \times T$$

$$Q = 0.18367 \times (1 - C_p)^{-0.32144} \times \left(\frac{B}{L}\right)^{0.562} \times \left(\frac{B}{T}\right)^{0.22314} \times \left(\frac{L}{L_{ENTR}}\right)^{0.673}$$

With:
R_w = Wave making resistance [kN]
ρ_w = Water density 1.025 [mT/m]
g = Gravitational acceleration [m/s^2]
F_{nB} = Froude number

$$= \frac{V}{\sqrt{g \times B}}$$

C_p = prismatic coefficient

$$= \frac{\nabla}{L \times A_m}$$

∇ = Displacement

$$= L \times B \times T - \frac{1}{2} L_{ENTR} \times B \times T \qquad \text{(for no scow barge)}$$

$$= L \times B \times T - L_{ENTR} \times B \times T \qquad \text{(for scow barge)}$$

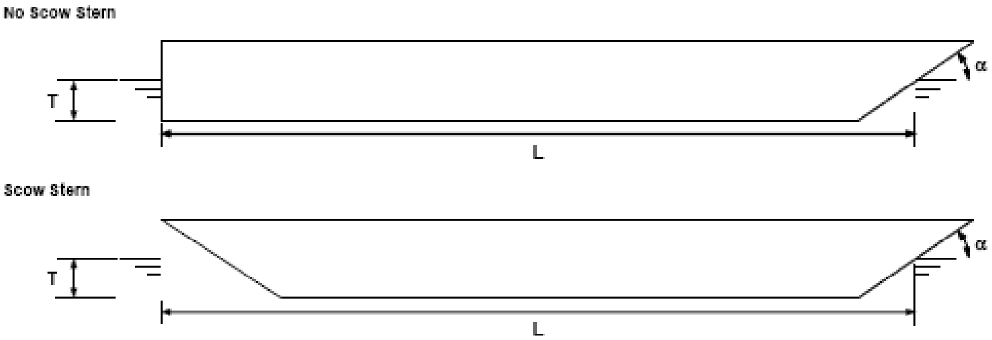


Figure 1: Explanation of input

A_m = Cross sectional area of midship

$= B \times T$ [m^2]

L_{ENTR} = Bow length

$$= \max\left(\frac{T}{\tan\alpha}, 1\right) \text{ [m]}$$

Viscous pressure resistance

$$R_{VP} = P \times \rho_w \times V^2 \times B \times T$$

$$P = 0.11712 \times \left(\frac{T}{L}\right)^{0.78203} \times (1.05 - C_{PST})^{-1.0366} \times \left(0.02 + 0.95\frac{H_{VA}}{T_A}\right)^{0.21336}$$

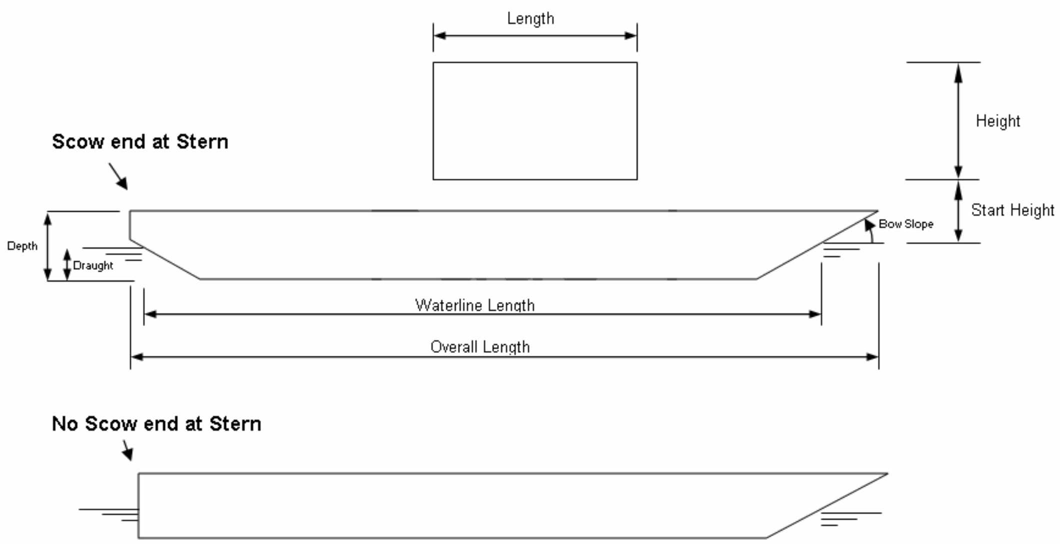
With:

R_{VP} = Viscous pressure resistance [kN]

ρ_w = Water density 1.025 [mT/m]

C_{PST} = Prismatic coefficient of aft-ship, approximately by 0.5 for barges with scow end and 1 for barges without scow end

H_{VA}/T_A = Ratio indicating pressure loss at stern, approximately by 1 for barges with scow and 0 for barge without scow end



<u>Appendage resistance</u>

$$R_{APP} = 0$$

With:
R$_{ALL}$: Resistance of appendages [kN]
Note: The appendage resistance is neglected because it is only give small contribution to the total hull resistance.

<u>Additional resistance</u>

$$R_{ALL} = 7.3 \times R_F$$

With:
R$_{ALL}$: Additional resistance for full size hull roughness, fouling and corrosion [kN]

Wave Drift Load

$$F_{wave} = C_1.g.H_s{}^2.B.e^{C2.T}.\left\lfloor C_3 + (1 - C_3) \times (1 - \cos(\alpha))^{\sqrt{2}} \right\rfloor$$

Using:

$$C_1 = 1.6183.10^3 \frac{L}{B} - 3.3304.10^{-5}.L.\left(\frac{L}{B} - 10\right) - 4.802.10^{-3}$$

$$C_2 = 0.33 - 2.7066.10^{-3}.L + 6.1392.10^{-6}.L^2$$

Barge with a scow stern (slope at stern)

$$C_3 = 1 - 0.1401.T + 0.5412.10^{-3}.L.T + 0.2736.10^{-2}.T^2$$

Barge with a no scow stern (vertical stern)

$$C_3 = 1 - 0.1036.T + 0.31457.10^{-3}.L.T + 0.3519.10^{-2}.T^2$$

With:

F_{wave} : Wave drift force [kN]
g : Gravitational acceleration [m/s^2]
H_s : Significant wave height [m]
B : Width of barge [m]
T : Draft of barge [m]
L : Length of barge at waterline [m]
α : Slope of bow w.r.t. water surface [deg]

LIST OF APPENDIXES

APPENDIX A

HEEREMA MARINE CONTRACTORS
(HMC)
REPORT

DSME DAEWOO SHIPBUILDING &
MARINE ENGINEERING CO.,LTD.

Daewoo Shipbuilding & Marine Engineering
Tombua Landana Compliant Piled Tower
Transportation & Installation

Living Quarters (LQ)
Grillage and Seafastening Design

Prepared by : Heerema Marine Contractors Nederland B.V.
Vondellaan 55
2332 AA Leiden
The Netherlands

Job No. : I/0310
HMC Doc No. :
Client Doc No. :

Rev.	Date	Prep.	Description	Check	Appr. Proj.	Appr. Eng.	Appr. Client
A	May 2007	AHa & FW	For Approval				

JOB NO. : I/0310
COMP'D BY : AHa & FW
CALC. NO :
DATE : May 2007

1.0 INTRODUCTION

Client	: DSME
Project	: Tombua Landana
Location	: Cabinda Block 14, Angola
Report contents	: Living Quarters Grillage and Seafastening Design
Barge	: Crowley C-411

1.1 General

Cabinda Gulf Oil Company (CABGOC), a Chevron Corporation affiliate, on behalf of itself and several other companies, intends to install a new Drilling and Production Platform (DPP) in Block 14, offshore Angola, West Africa, called the Tombua Landana DPP Project. They have awarded DSME (Daewoo Shipbuilding & Marine Engineering) an EPIC contract for the platform including pipelines consisting of a Compliant Piled Tower (CPT) and Topsides with process and drilling facilities.

The Platform will be located about 60 miles offshore from the Company operated Malongo shore base in approximately 1,214 feet (370 m) of water.

The offshore installation is scheduled to be performed in two phases

Phase I: Late 2007 – Early 2008
Transportation and Installation of Levelling Pile Template (LPT), 4 Levelling Piles (LP), the Tower Base Template (TBT) and 12 Foundation Piles (FP).

Phase II: Late 2008 – Early 2009
Completion of the Substructure which includes Transportation and Installation of Tower Bottom Section (TBS), Tower Top Section (TTS), barge bumpers (4x), boat landing (2x) followed by the Topsides Installations which include Transport and Installation of the Module Support Frame (MSF). The MSF supports the West, Centre and East Modules (WM, CM & EM). The second phase is completed with the installation of the Living Quarter (LQ), Flare, and ship loose items as required.

Heerema Marine Contractors BV has been contracted by Daewoo Shipbuilding & Marine Engineering CO. LTD. to transport the substructure elements and topside modules to location and perform the installation offshore.

2.0 GENERAL INFORMATION

Grillage and seafastening design is according to Noble Denton criteria for the large barge; due to the marine engineer have not done the motion analysis yet.

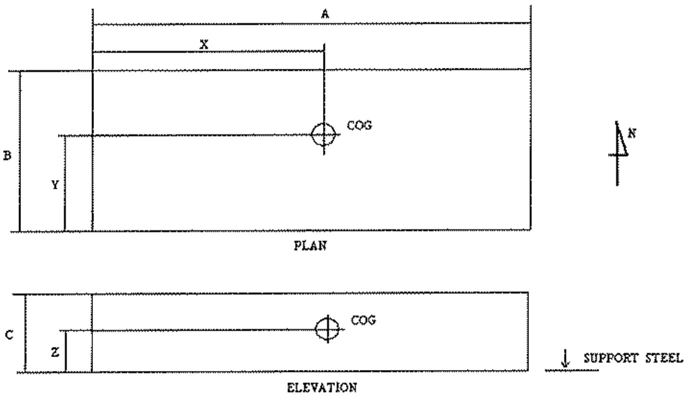
The static load distribution is based on Delta Engineering report and the dynamic load distribution is assumed the same. Once HMC gets the update report, the design must be checked in advance.

The horizontal load distribution is done by SACS model input for designing the transverse seafastening (see 4.78)

2.1 Weight and C.o.G. Information

According to the latest weight report 13 April 2007 the total Reported Lift Weight of the LQ is:

Weight = 3.650.320 lb (16242.98kN)



The C.o.G relative to centre of module is: (see 5.1)

X:	17267.24	mm from stern
Y:	7778.75	mm from starboard
Z:	9177.35	mm in vertical direction, from bottom of module steel

2.2 References

AISC	"ASD Manual of Steel Construction"	9th edition, 1989
ANSI / AWS	"Structural Welding Code"	16th edition, 1998
Noble Denton	Report 0014/NDI, "General Guidelines for Marine Transportation"	1986
Blodgett, O.W.	"Design of welded structures", ISBN 0118839527	12th edition, 1982
Straathof, Aad	"Introduction Courses for the T&I 'Junior' Engineer"	

2.3 Material Information

Item	Material type	Yield stress
Grillage	High grade	345 N/mm^2
Seafastening	High grade	345 N/mm^2
Barge	Low grade	235 N/mm^2

2.4 Allowable Stresses

Axial compression : $\sigma_a = 0.60\sigma_y$ or AISC table of slender members
Axial tension : $\sigma_t = 0.60\sigma_y$
Bending : $\sigma_b = 0.66\sigma_y$
Shear : $\tau = 0.40\sigma_y$
Combined : $\sigma_c = 0.66\sigma_y$
Bearing : $\sigma_p = 0.90\sigma_y$

2.5 Computer Programs Used

SACS	Structural Finite Element Modelling program
MS Excel	Spreadsheet calculation program
IPEX	In-house developed spreadsheet suite

2.6 Drawings / Sketches

- LQ on the Crowley C-411 lay-out
- Grillage lay-out
- Seafastening lay-out

3.0 SUMMARY AND CONCLUSIONS

3.1 Summary

Grillage detail	Load case U.C	Reference
Grillage beam PG 380x1524x38x28.58	0.42	Sheet 4.20
Grillage beam PG 190x1524x38x25.4	0.5	Sheet 4.22
Wing plates	0.89	Sheet 4.37

Seafastening detail	Load case U.C	Reference
Pitch stopper	0.74	Sheet 4.81
Roll brace	0.83	Sheet 4.84
Seafastening beam WF 30x132	0.4	Sheet 4.94

Barge capacity	Load case U.C	Reference
Bulkhead column at row 25	0.97	Sheet 4.99
Bulkhead column at row 26	0.41	Sheet 4.105

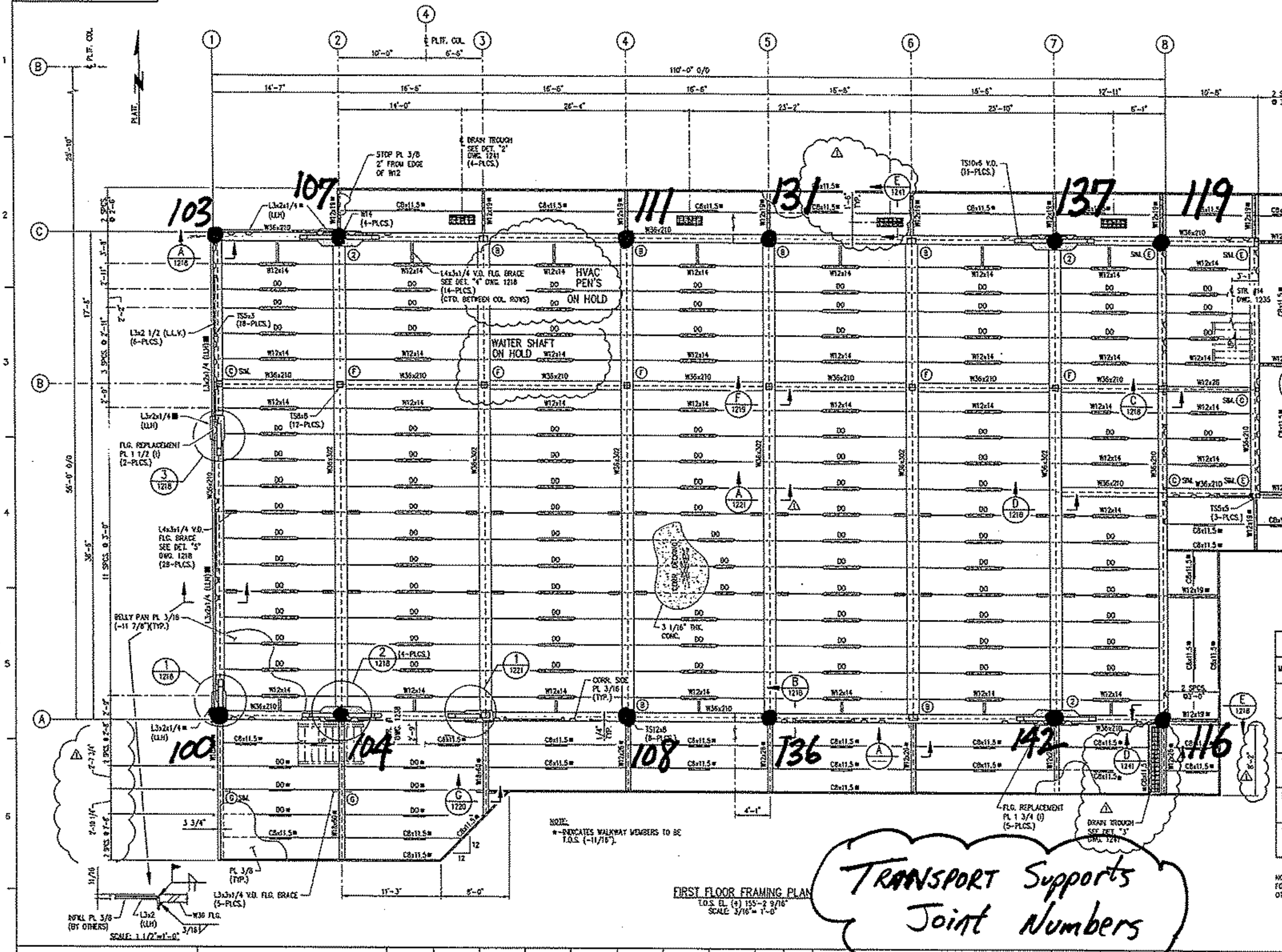
3.2 Conclusions

- Grillage and seafastening are strong enough to withstand the load
- Barge strength is sufficient

4.0 CALCULATIONS 4.0

5.0 APPENDICES

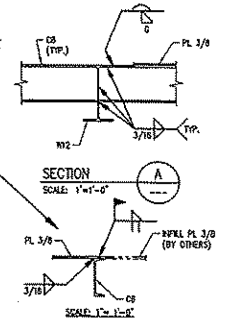
sheet 4.1



FIRST FLOOR FRAMING PLAN
T.O.S. EL. (+) 155'-2 9/16"
SCALE: 3/16" = 1'-0"

NOTE:
*-INDICATES WALKWAY MEMBERS TO BE T.O.S. (-11/16").

TRANSPORT Supports
Joint Numbers



GENERAL NOTES

1. ALL WELDING SHALL BE IN ACCORDANCE W/ AWS D1.1 LATEST EDITION.

1A. ALL WELDING INSPECTION AND QUALITY CONTROL SHALL BE IN ACCORDANCE WITH CVX TECH. REQUIREMENTS INCLUDING SPEC. CS 1.15 "STRUCTURAL WELDING & INSPECTION" AND SPEC. CS 1.19 "PLATFORM FABRICATION".

2. ALL WELDS SHALL BE FULL PENETRATION UNLESS NOTED OTHERWISE.

3. ALL FAYING EDGES SHALL BE SEAL WELDED ON BUILDING EXTERIOR.

4. ALL STRUCTURAL TUBING BE TYPE V MATERIAL.

5. ALL STRUCTURAL WIDE FLANGE SHAPES SHALL BE TYPE II MATERIAL & ALL OTHER SHAPES & PLATES SHALL BE TYPE IV MATERIAL UNLESS NOTED OTHERWISE. PIPE SHALL BE TYPE V MATERIAL UNLESS NOTED OTHERWISE.

△ 6. ALL HANDRAIL PIPE AND SOCKETS SHALL BE SCH. 40 TYPE V MATERIAL AND HOT DIPPED GALVANIZED AND PAINTED WITH PAINT SYSTEM 3.5.

7. ALL STRUCTURAL BOLTS & WASHERS SHALL BE HEAVY HEX ASTM A-325 HOT DIPPED GALVANIZED. ALL NUTS SHALL BE ASTM A194 GR. 2H.

8. FABRICATOR SHALL FIELD VERIFY ALL DOOR/WINDOW AND WALL OPENING PENETRATIONS WITH EQUIPMENT PRIOR TO FABRICATION.

9. VERTICAL SLING ANGLES WILL VARY BETWEEN 60° AND 75° DURING BUILDING LIFT.

10. STRUCTURE SHALL BE ADEQUATELY SUPPORTED DURING FABRICATION TO PREVENT EXCESS DEFLECTION.

11. ALL PAINTING SHALL CONFORM TO CABINDA GULF OIL COMPANY "PAINT AND PROTECTIVE COATINGS" GEN. SPEC. NO 2.02.

12. CORRUGATED DECKING SHALL BE 28 GA. S-3 "TENSIFORM" GALV. DECKING AND SHALL BE ATTACHED WITH HILTI STUDS AT MANUFACTURER'S RECOMMENDED SPACING. DECK SHALL BE CONTINUOUS OVER A MINIMUM OF THREE FRAMES.

13. CONCRETE SHALL BE 3,000 PSI SEMI-LIGHT WEIGHT 3 1/16" THICK SLAB REINFORCED WITH 1-LAYER 6x6-W2.0xW2.0 WWR. WWR SHALL BE INSTALLED AT CENTER OF SLAB THICKNESS.

STRUCTURAL STEEL MATERIAL SCHEDULE

MATERIAL TYPE	STEEL SPECIFICATION	MATERIAL USAGE
TYPE I	API 2H GR. 50 W/ ADDITIONAL SUPPLEMENTAL REQUIREMENTS	LIFT EYE PLATES FLANGE REPLACEMENTS
TYPE II	API 2H GR. 50 ASTM A992	PLATE GIRDERS CRITICAL MAIN FRAME STEEL SHAPES LIFT COLUMNS
TYPE III	ASTM A572 GR. 50 ASTM A992	NON CRITICAL MAIN FRAME STEEL SHAPES SECONDARY DECK FRMG. SHAPES (STRINGERS)
TYPE IV	ASTM A-36	WALKWAY FRAMING SHAPES STAIRS MISC. FRAMING SHAPES MISC. PLATES
TYPE V	API SPEC 5L GR. B ASTM A53 GR. B ASTM A500 GR. B	MISC. STRUCTURAL PIPE HANDRAIL PIPE STRUCTURAL TUBING

NOTE:
FOR THE MATERIAL SPEC. REFER TO CVX TECHNICAL SPEC. CS 1.14 "STRUCTURAL STEEL AND OTHER MATERIALS.

0 1' 2' 3' 4' 5' 10' 20'
SCALE: 3/16" = 1'-0"

DWG. NO.	TITLE	PROCESS	ELECT.	PIPING	INST.	LOSS CNT	MECH.	PROJ.	CLIENT	NO.	BY	DESCRIPTION	DATE	CHK'D	APP.
										1	PS	ADDED SECTION "A"; DRAINS; REVISED WALKWAY	4-20-07	JGC	
										0	JBJ	ISSUED APPROVED FOR CONSTRUCTION	1-25-07	TLB	
										A	JBJ	ISSUED FOR APPROVAL	11-22-06	TLB	
REFERENCES		APPROVALS								REVISIONS					

CABINDA GULF OIL COMPANY LTD

ECI
DSME
813305201

CABINDA BLOCK 14
TOMBUA LANDANA DPP PLATFORM
S3 DEVELOPMENT
CABINDA, ANGOLA

FIRST FLOOR FRAMING PLAN

DATE 9-14-06
CHKD TLB
DRAWN JBJ
SCALE 3/16" = 1'-0"
DRAWING NO. D-B14-TOL-DPP-40-1200
REV. 1

D-B14-TOL-DPP-40-1200

Apr 30, 2007 - 12:56pm F:\DWG\B100\813306 - TOMBUA LANDANA\Structural\B133-05-201 Rev 1.dwg

JOB NO. : I / 0310

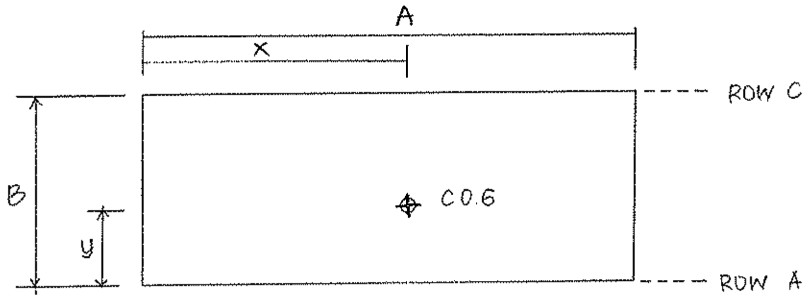
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

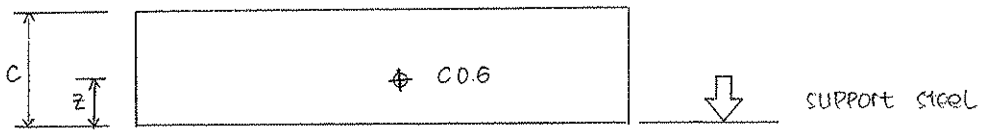
DATE : 30 May 2007

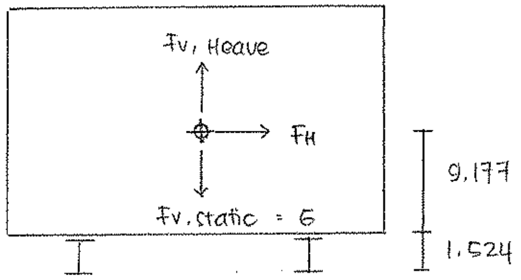
SHEET NO.: 4.3.

TRANSPORTATION LOADS



A	=	110	ft	0	in
B	=	56	ft	0	in
c	=	78	ft	7.5	in
x	=	56	ft	7 13/16	in
y	=	25	ft	6 1/4	in
z	=	30	ft	1 5/16	in





LQ weight : 16 242.98 KN (3650 320 LB)

(see sheet 5 1)

Static Load Distribution

Row C = y / B x W = 25 ft 6 1/4 in / 56 ft x 16242.98 = 9402.40 KN

Row A : (B-y) / B x W = 30 ft 5 3/4 in / 56 ft x 16 242.98 = 8840.58 KN

Dynamics

Fv, Heave : ± 0.20 g = 3268 KN (see sheet 5 4)

Row C = y / B x Fv, Heave = 25 ft 6 1/4 in / 56 ft x 3268 = 1489.32 K

Row A = (B-y) / B x Fv, Heave = 30 ft 5 3/4 in / 56 ft x 3268 = 1778.68 K

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : RT 400 - RP01

DATE : 30 May 2007

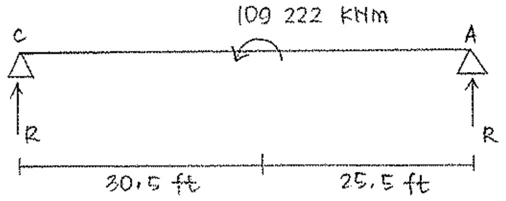
SHEET NO.: 44

FH : ± 0.54 g = 8832 KN (see sheet 54)

Moment : = 28 168 KNm

Total moment = 8832 x 9.177 + 28 168 = 109 222 KNm

DISTRIBUTION OVER ROW.



R = 109 222 / (56 x 0.3048)

= 6398.93 KN

	Fv, static (KN)	Fv, Heave (KN)	Fv, H (KN)	Z̄ Dyn max (KN)	Fv, max (KN)	Fv, min (KN)
ROW C	7402.40	1489, 32	6398, 93	7888, 26	15290, 66	- 485, 86
ROW A	8840.58	1778, 68	6398, 93	8177. 61	17018, 19	662, 97

LOAD DISTRIBUTION PER EACH SUPPORT

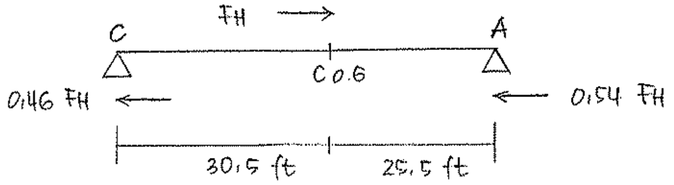
There are transverse seafastenings in the ROW 1, 3, 6, 8 of Living quarters.

These seafastenings can be used as Roll Relief for Grillage design

since the strong points of LQ are only in the ROW 1, 2, 4, 5, 7, 8, the Roll relief is only

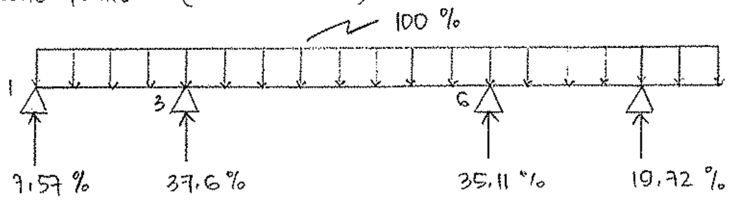
can be used in the ROW 1 & 8

ROLL RELIEF



FH = 8832 KN
(see sheet 54)

LOAD DISTRIBUTION / STRONG point (see sheet 55)



Tombua Landana - Static Reactions at Transport Supports

```
                                                  DATE 30-APR-2007  TIME 12:54:15
*********
                                   REACTION FORCES AND MOMENTS
                                                                                          |    %
       LOAD  *************** kips ****************  ************** in-kip **************  |
JOINT  COND     FORCE(X)     FORCE(Y)     FORCE(Z)    MOMENT(X)    MOMENT(Y)    MOMENT(Z) |
 100    Z        0.488       44.644      156.395       0.000        0.000        0.000    |  4,27
 103    Z       -1.778      -26.219      114.932       0.000        0.000        0.000    |  3,14
 104    Z       80.861       24.355      501.344       0.000        0.000        0.000    |  13,69
 107    Z       25.532      -33.745      366.252       0.000        0.000        0.000    |  10
 108    Z        3.413       11.501      386.201       0.000        0.000        0.000    |  10,55
 111    Z      -29.721      -12.725      296.879       0.000        0.000        0.000    |  8,11
 116    Z       -3.280       55.800      158.577       0.000        0.000        0.000    |  4,33
 119    Z       32.144      -54.405      236.193       0.000        0.000        0.000    |  6,45
 131    Z       10.357      -12.294      291.607       0.000        0.000        0.000    |  7,96
 136    Z        4.030        9.475      357.757       0.000        0.000        0.000    |  9,22
 137    Z      -51.577      -22.190      355.217       0.000        0.000        0.000    |  9,2
 142    Z      -70.469       15.802      440.487       0.000        0.000        0.000    |  12,03
                                                                                     Σ    |  100
```

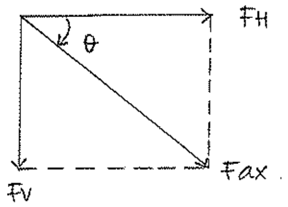
JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP01

DATE : 20 May 2007

SHEET NO.: 45



θ = 31.13

Fv = FH tan θ

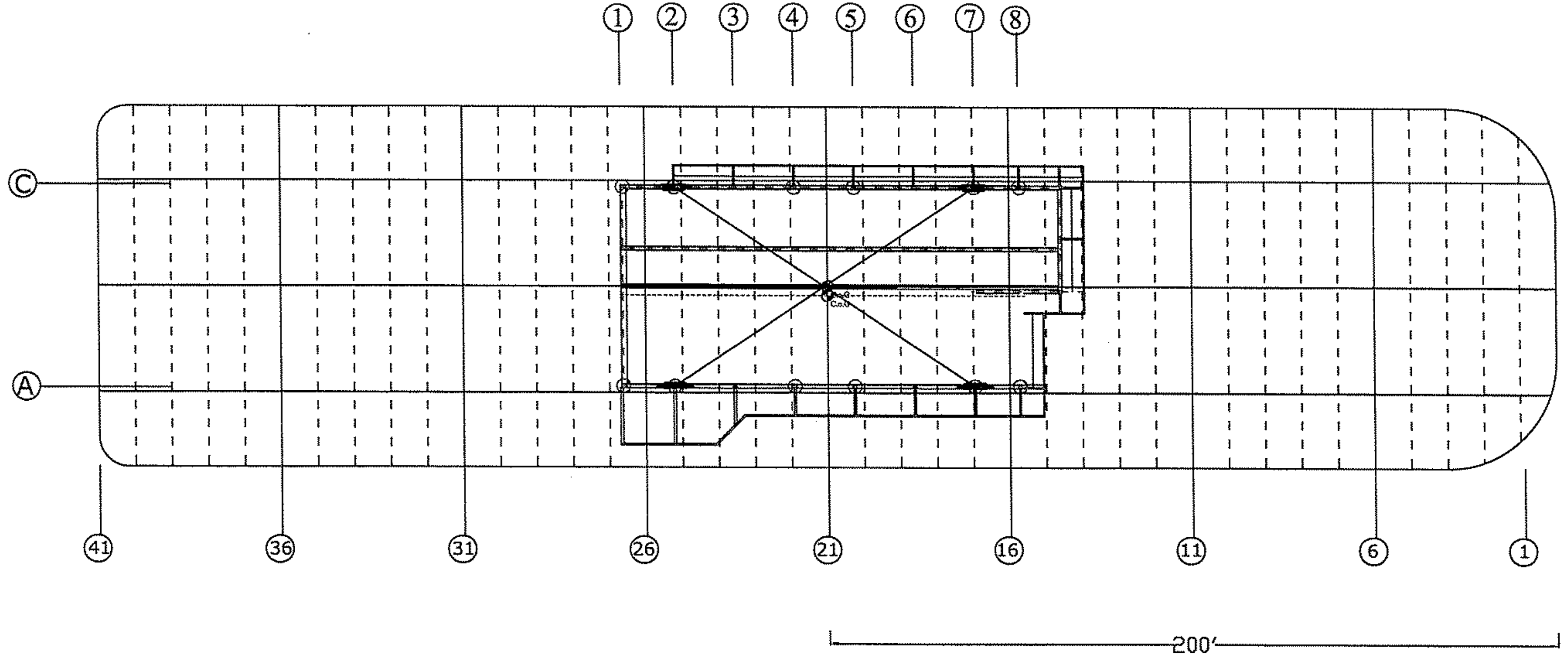
Roll relief for C - 1 : 0,46 FH tan θ 7.57 % = 185, 72 KN

C - 8 : 0,46 FH tan θ 19, 72 % = 483 , 75 KN

A - 1 : 0,54 FH tan θ 7.57 % = 218 , 02 KN

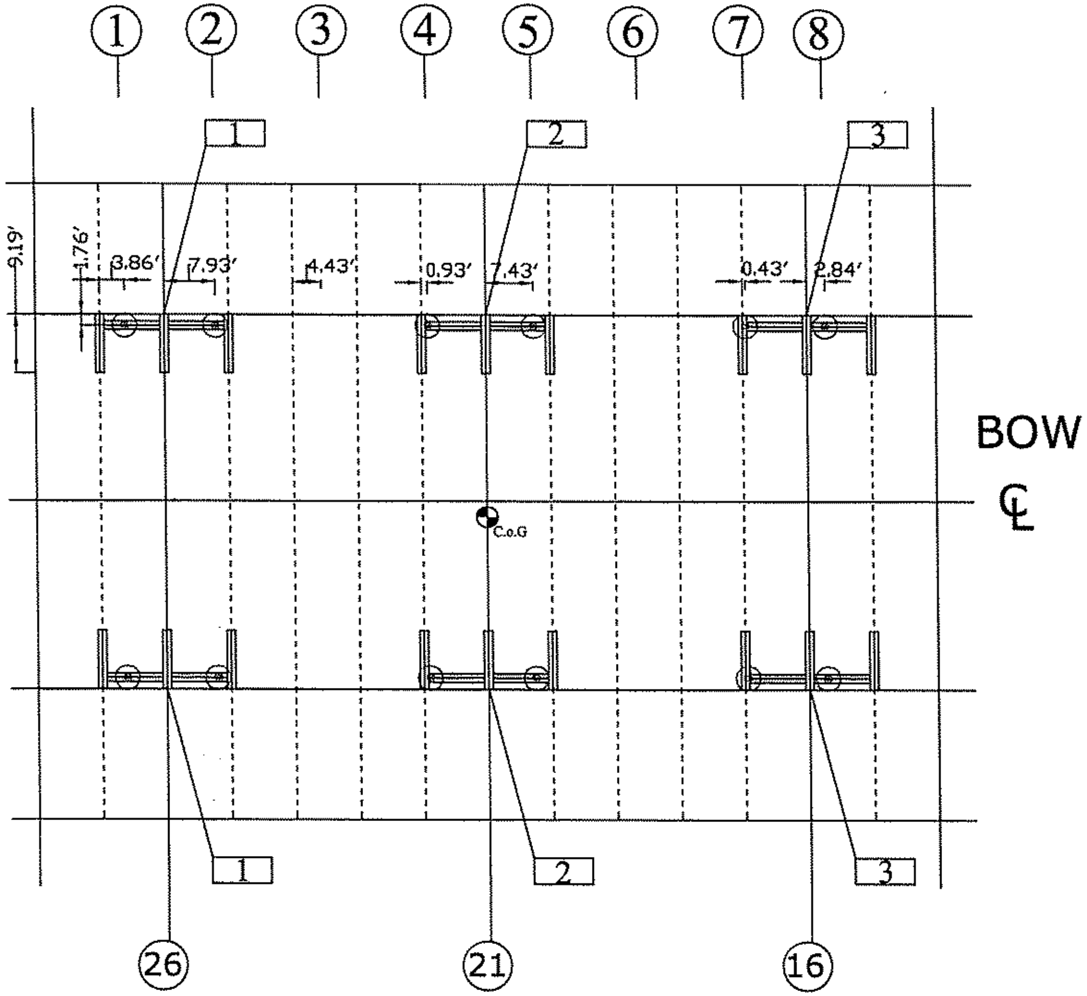
A - 8 : 0,54 FH tan θ 19.72 % = 567 . 89 KN

STRONG POINT	DISTRIBUTION LOAD (%)	Force / strong point (KN)	Roll relief (KN)	Force / strong point (Incl roll relief , KN)
C - 1	3, 14	1014, 06	185, 72	828 , 34
C - 2	10	3231 , 49	-	3231 , 49
C - 4	8 , 11	2619 , 40	-	2619 , 40
C - 5	7, 96	2572 , 88	-	2572 , 88
C - 7	9, 70	3134, 12	-	3134 , 12
C - 8	6, 45	2083 , 96	483, 75	1600 , 21
A - 1	4, 27	1379 , 89	218, 02	1161, 87
A - 2	13, 69	4423 , 42	-	4423 , 42
A - 4	10 , 55	3407 , 50	-	3407 , 50
A - 5	9, 77	3156 , 53	-	3156 , 53
A - 7	12 , 03	3886 , 47	-	3886 , 47
A - 8	4, 33	1399 , 14	567 . 89	831, 26



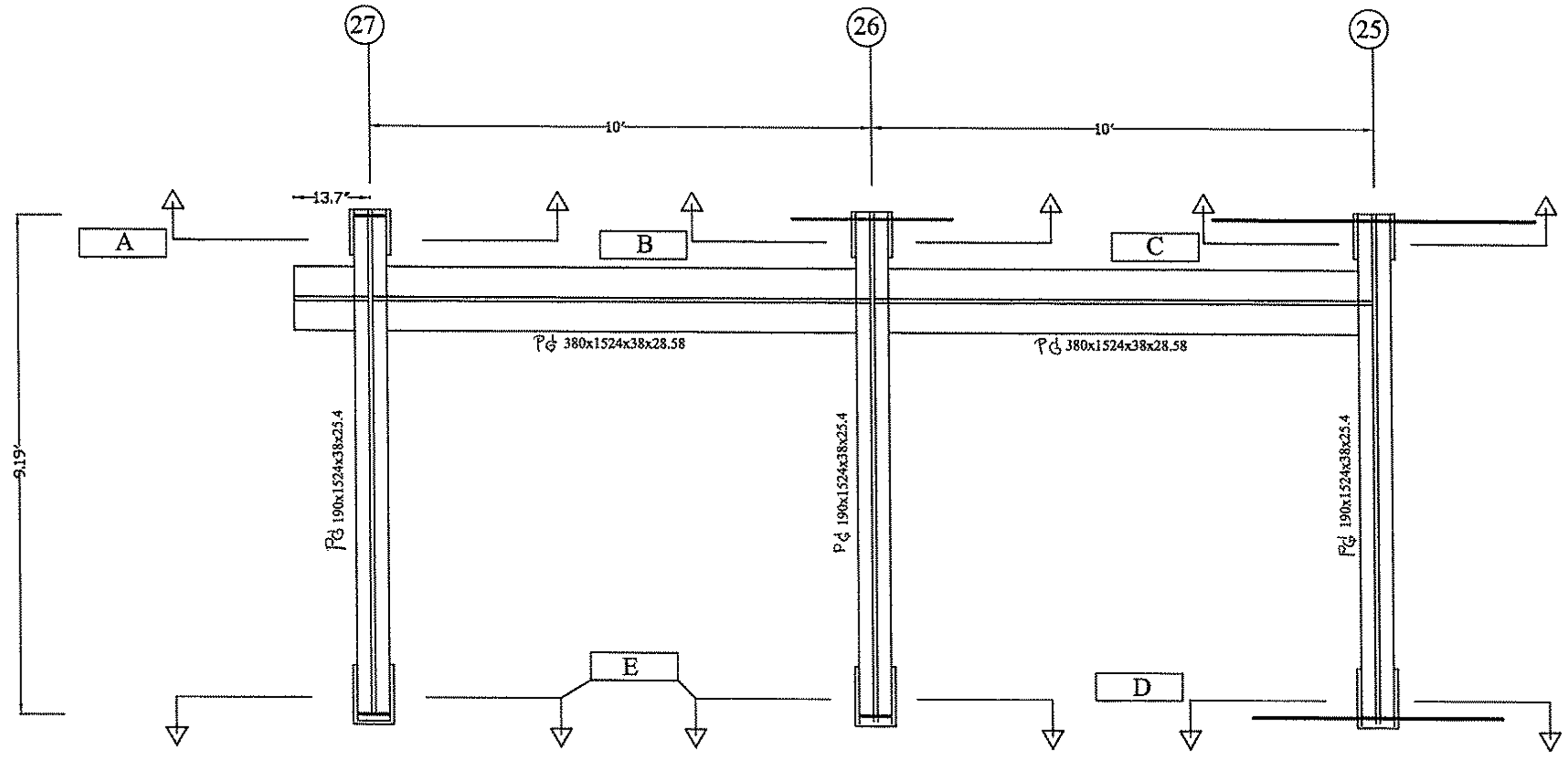
LQ lay out on Crowley-411

sheet . 4.7

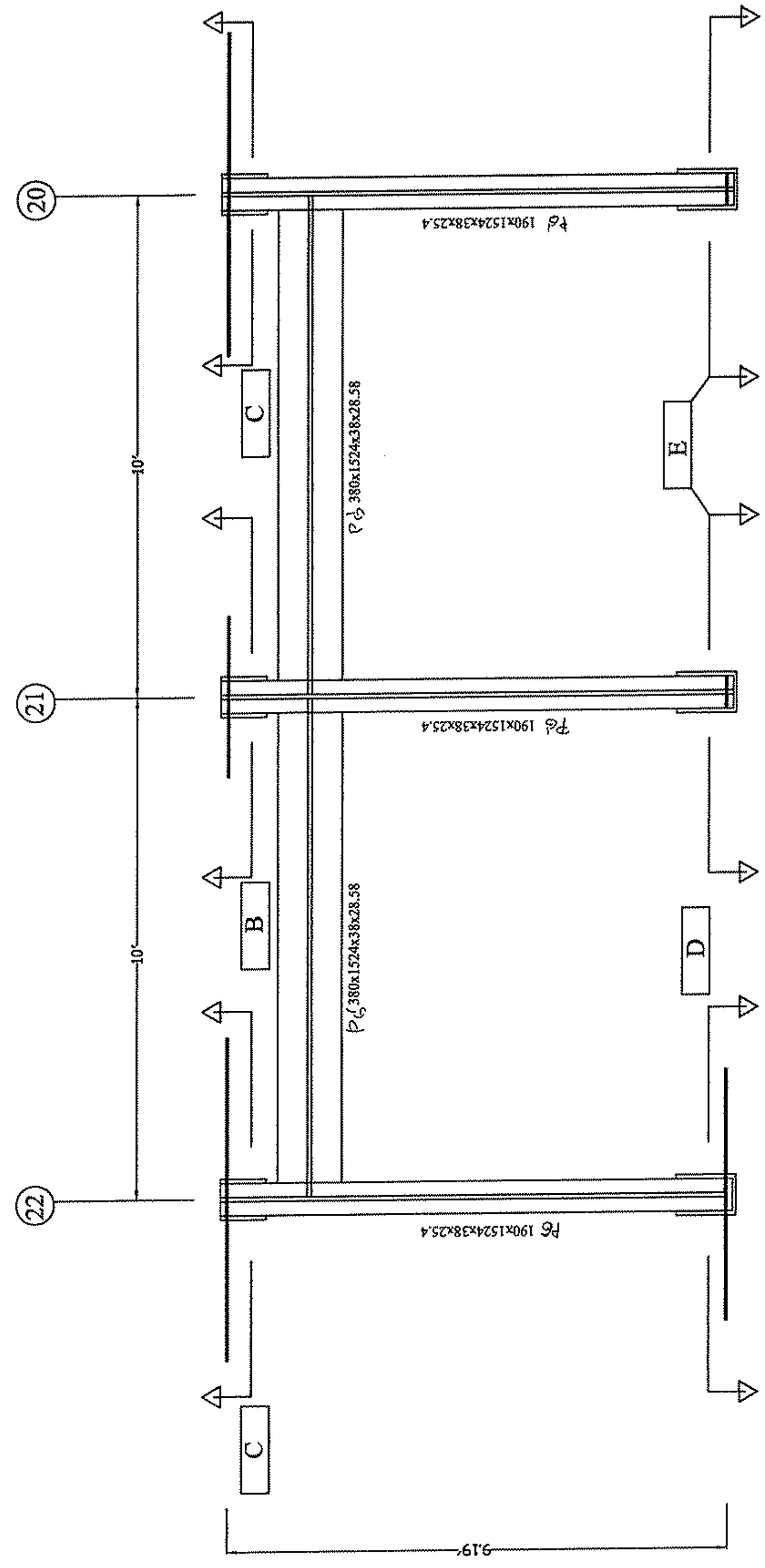


Grillage Lay out

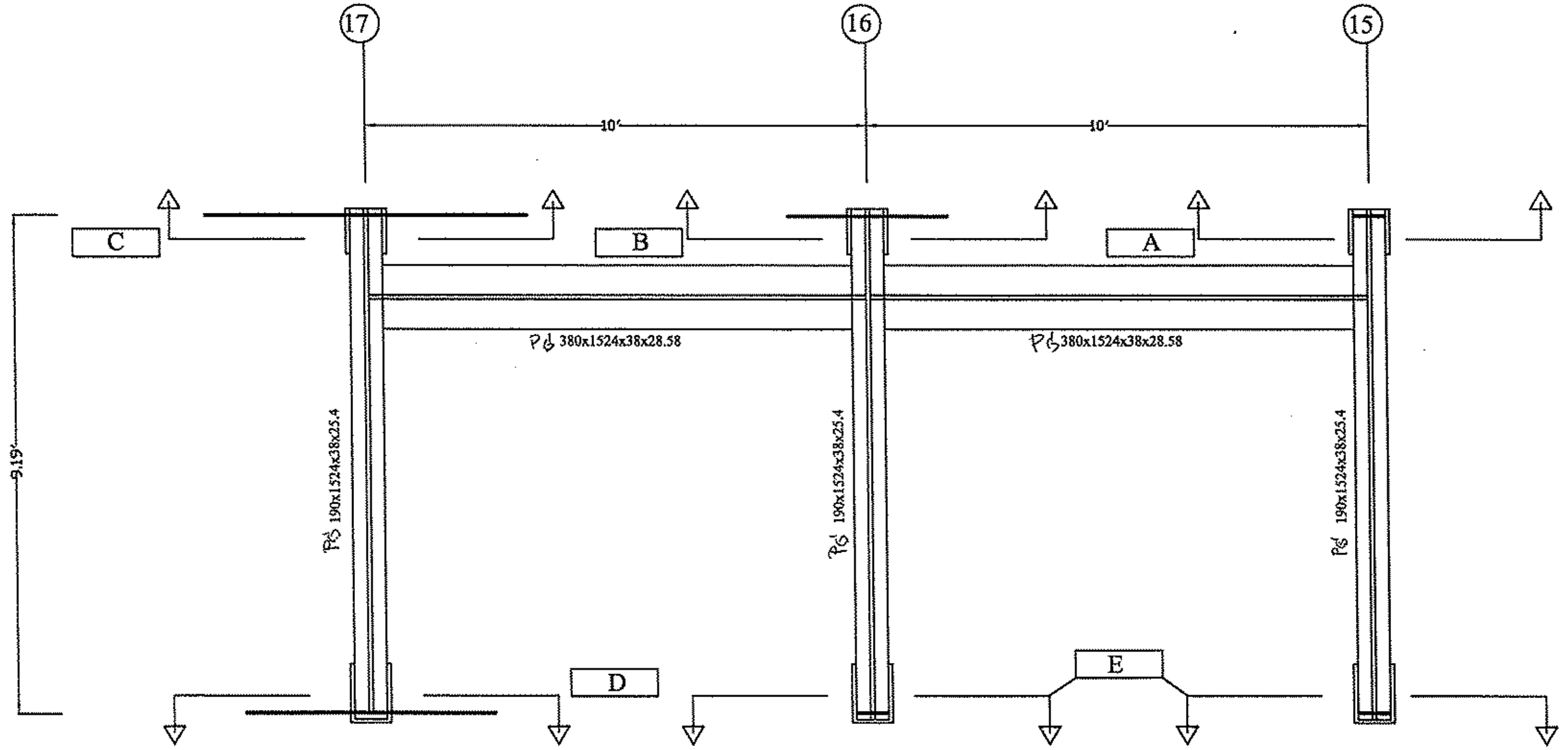
sheet 4.8



Detail 1

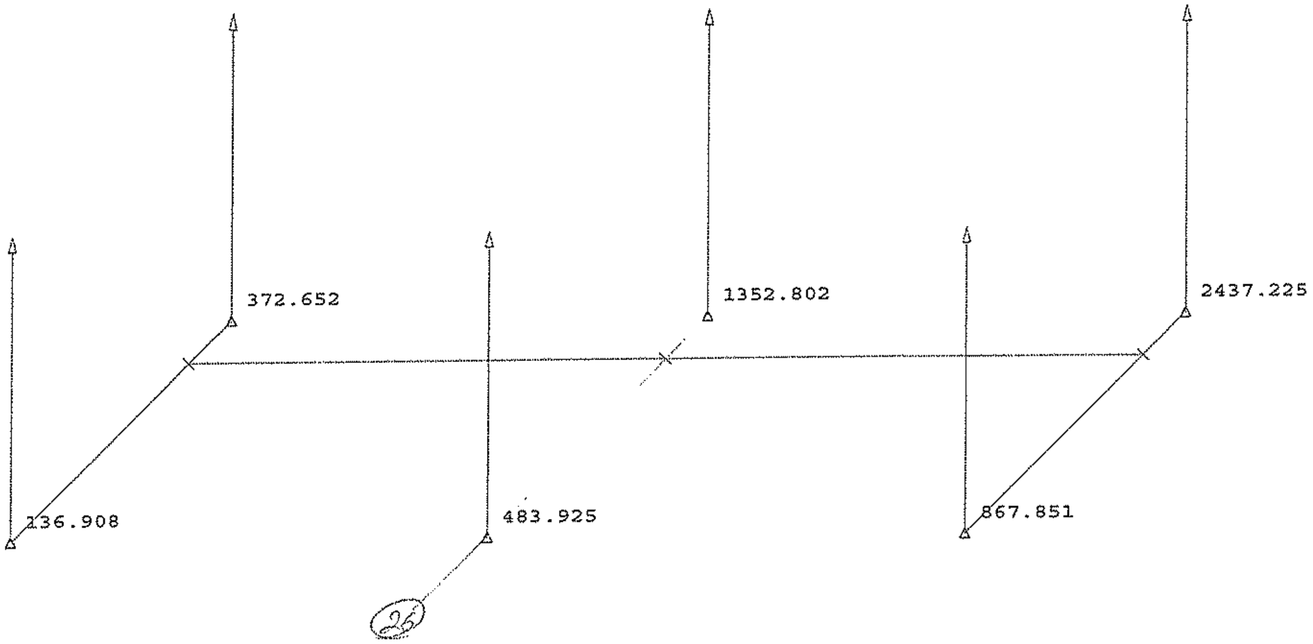

20
21
22
10'
10'
C
B
C
E
D
P6 190x1524x38x25.4
P6 190x1524x38x25.4
P6 190x1524x38x25.4
P6 380x1524x38x28.58
P6 380x1524x38x28.58
9.19'

Detail 2


17
16
15
10'
10'
9.19'
C
B
A
D
E
P6 380x1524x38x28.58
P6 380x1524x38x28.58
P5 190x1524x38x25.4
P5 190x1524x38x25.4
P5 190x1524x38x25.4

Detail 3

ISOMETRIC GRILLAGE 1

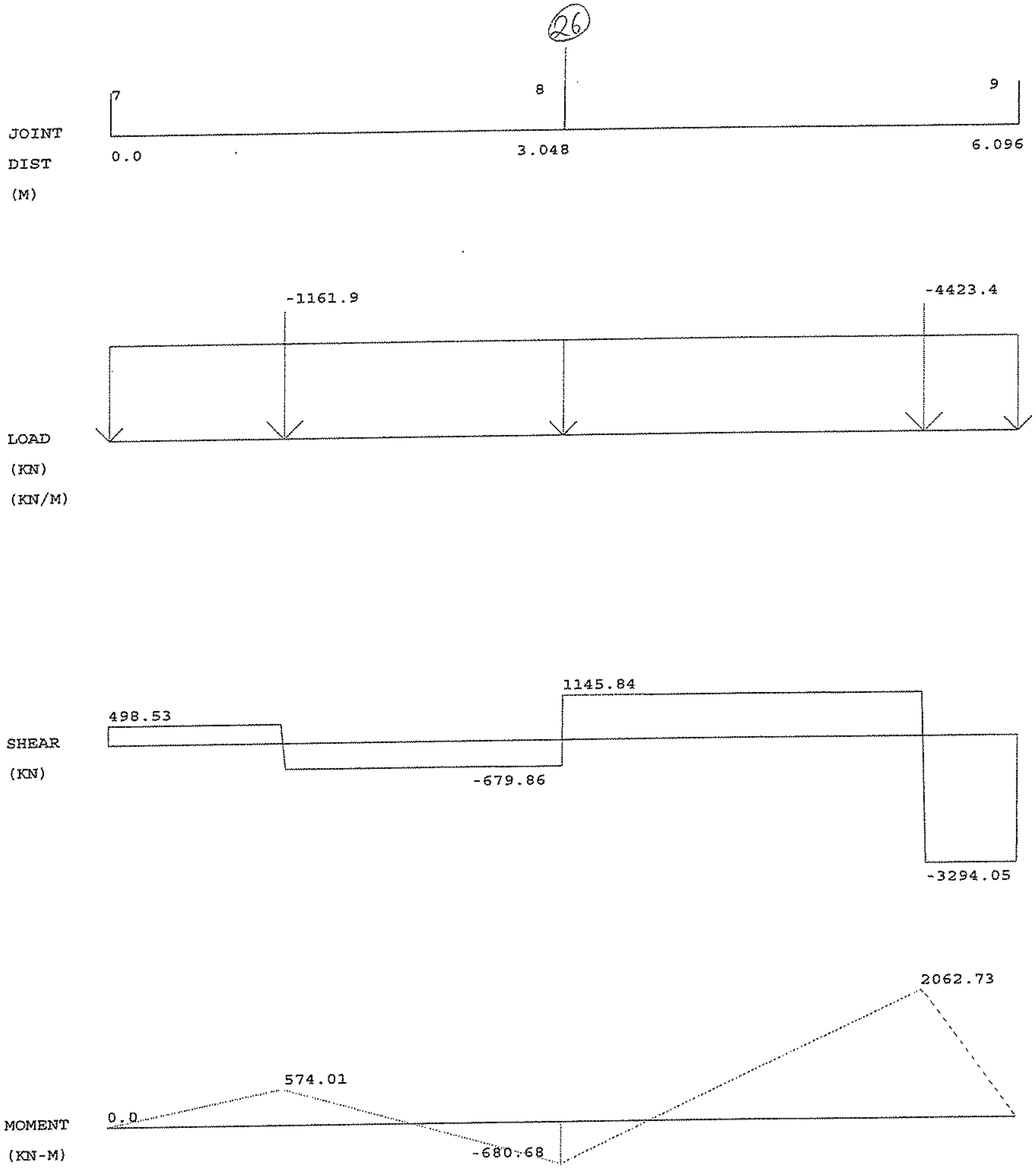


REACTION FZ

LC LIST

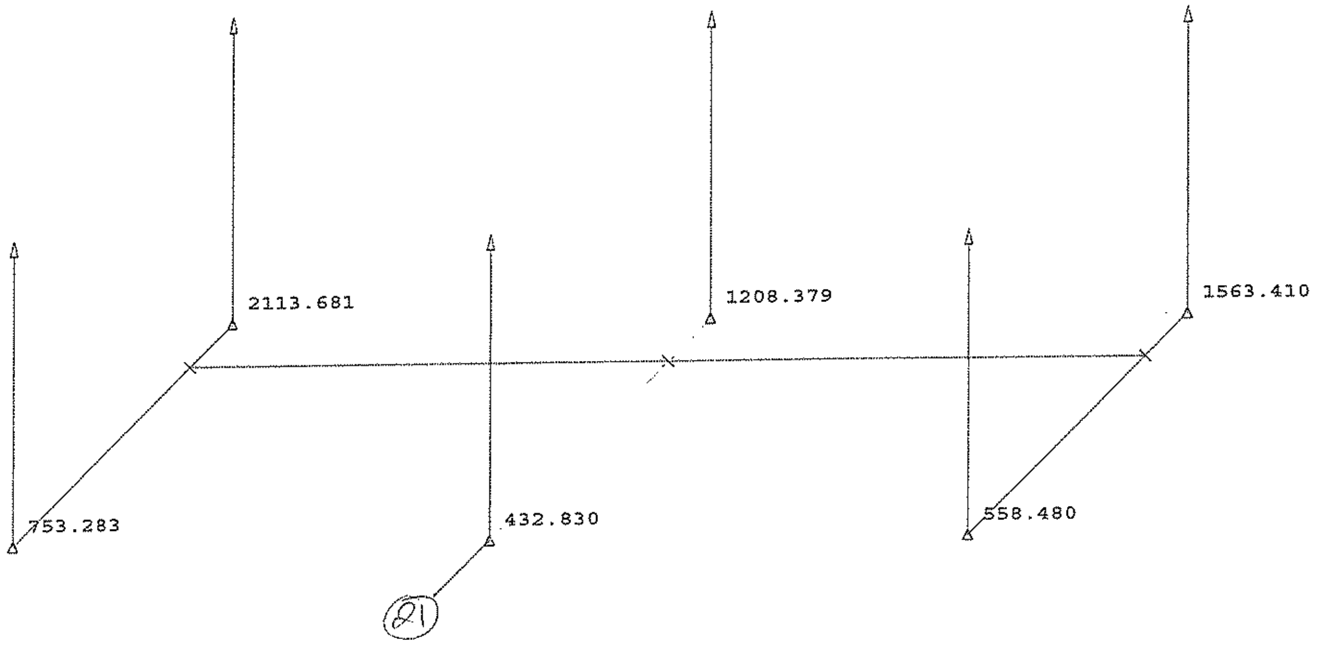
MEMBER Z SHEAR & Y MOMENT DIAGRAM FOR LOAD CONDITION 1

GRILLAGE 1



Sheet. 4 13

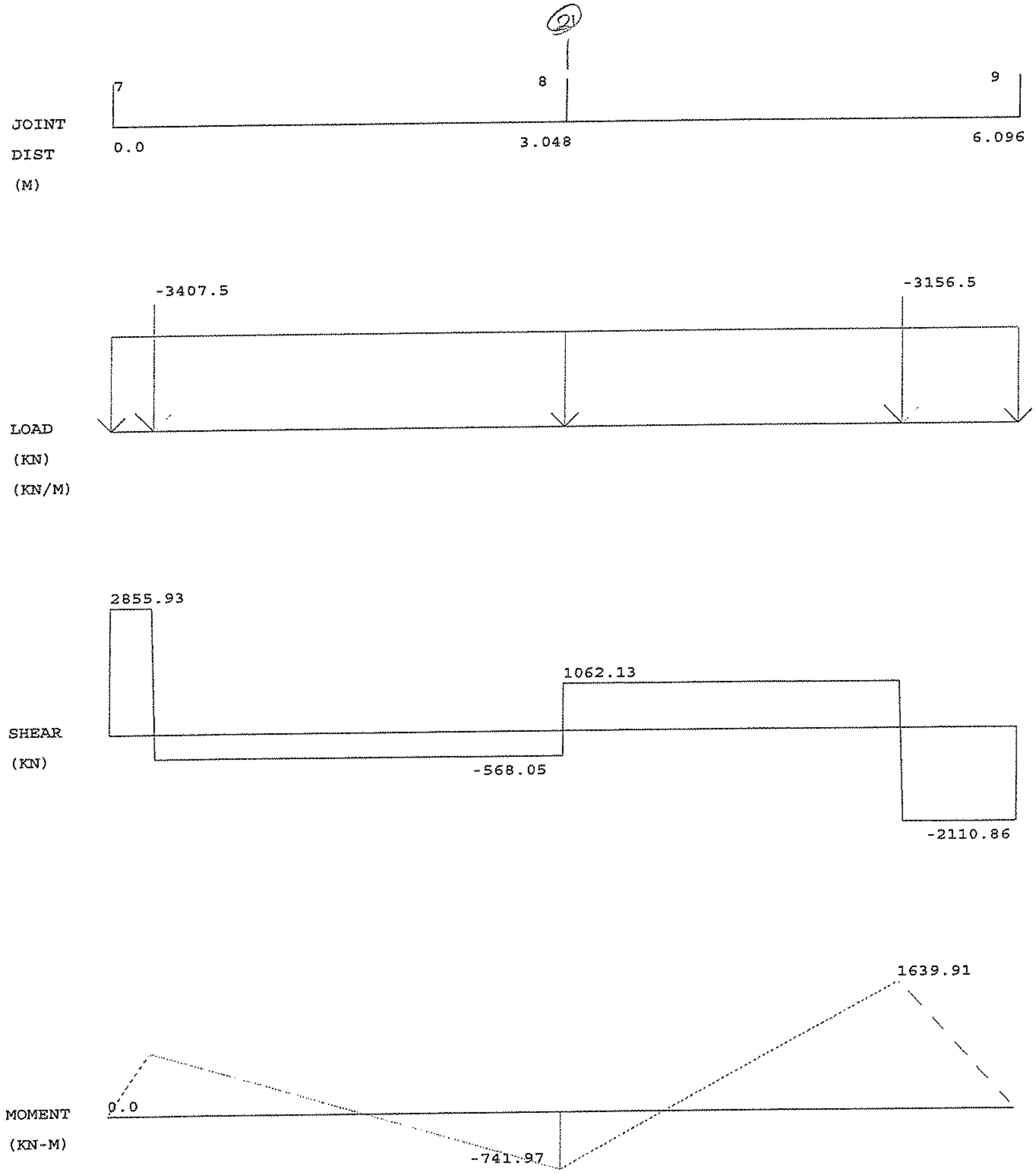
ISOMETRIC GRILLAGE 2



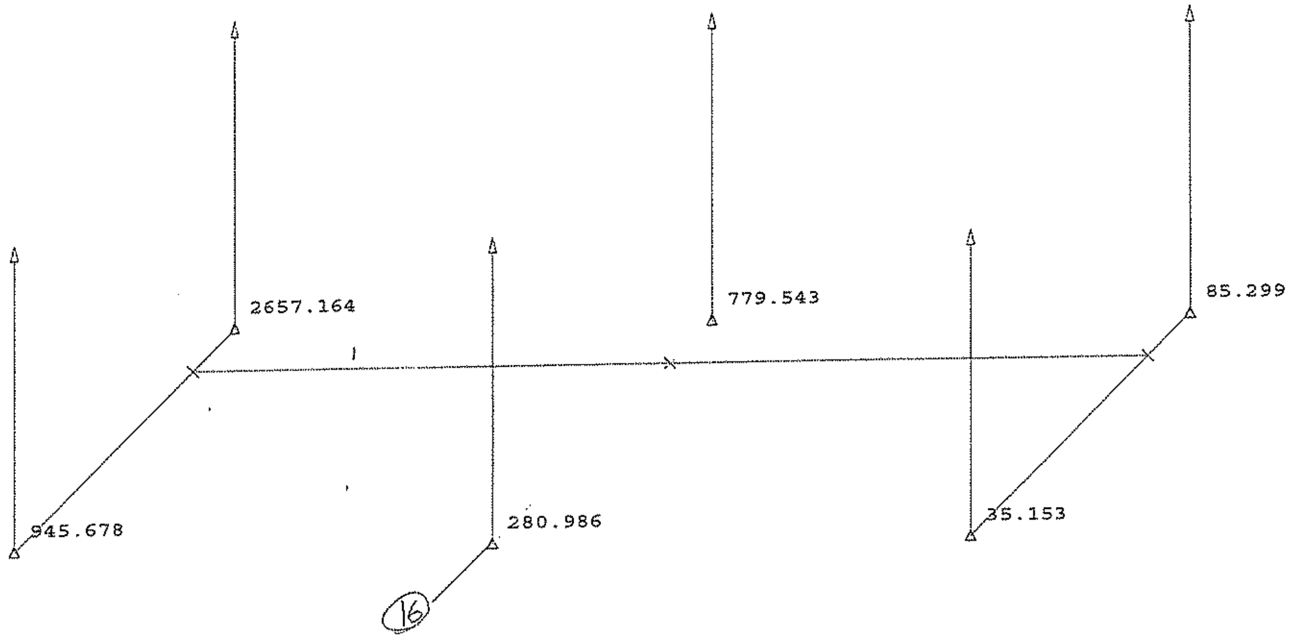
REACTION FZ LC LIST

MEMBER Z SHEAR & Y MOMENT DIAGRAM FOR LOAD CONDITION 1

GRILLage 2



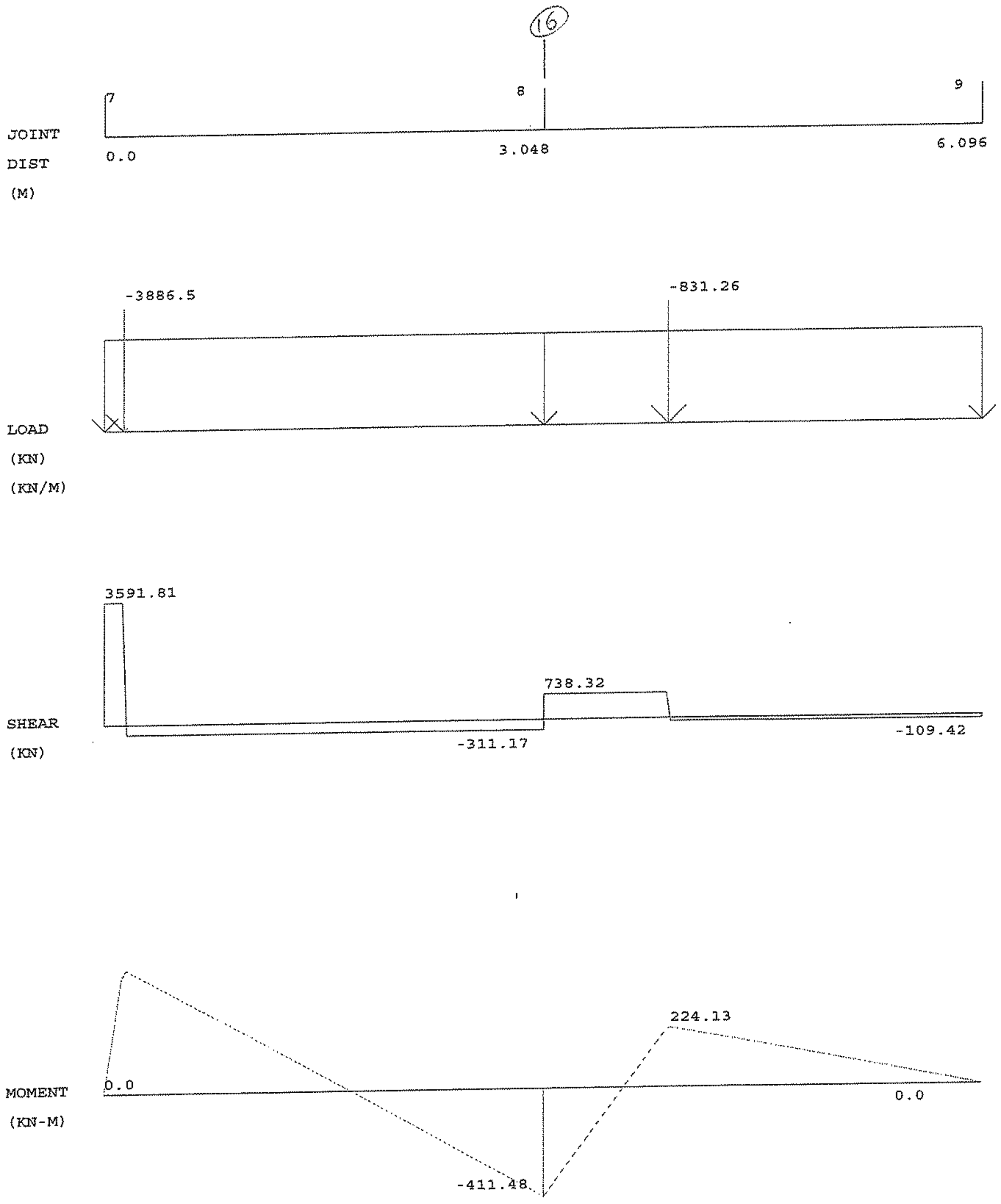
ISOMETRIC GRILLAGE 3



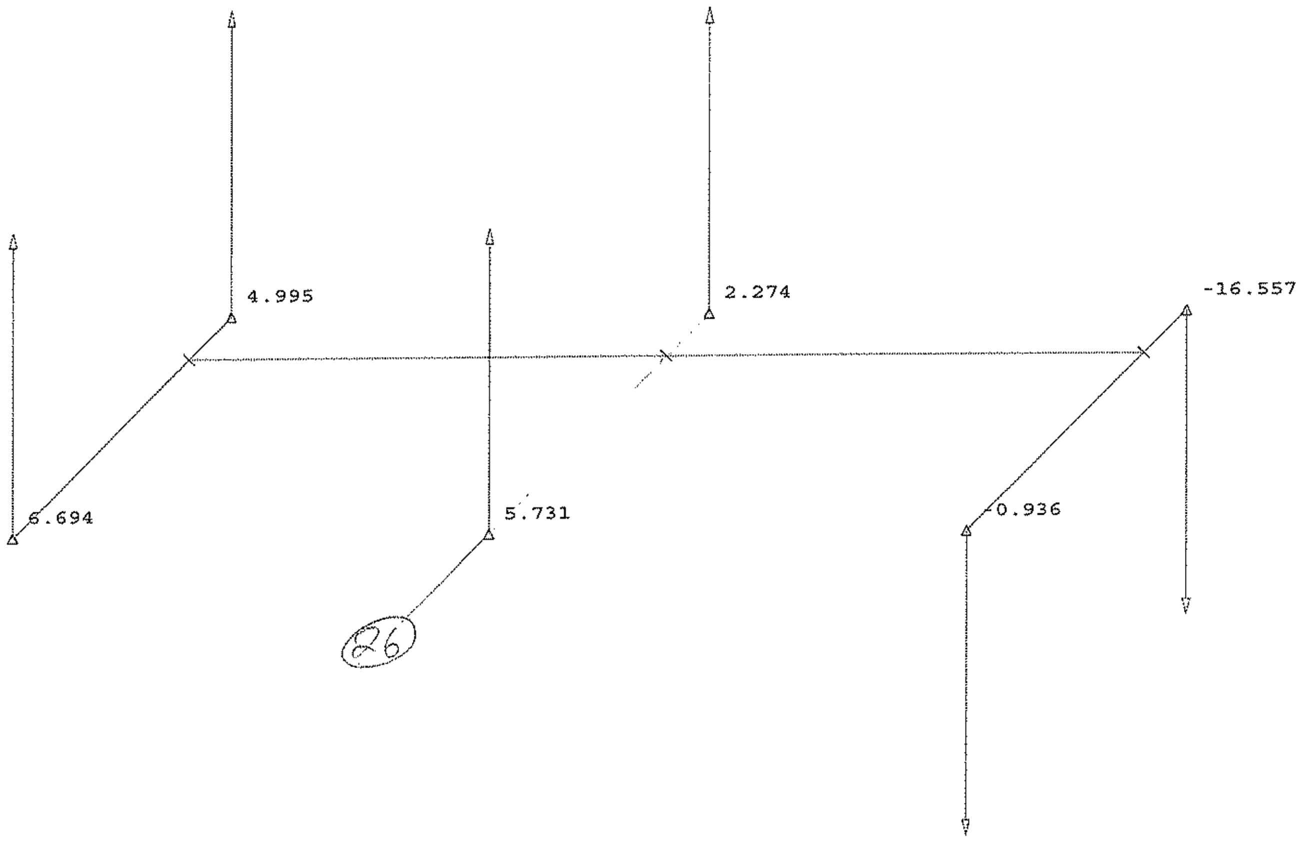
REACTION FZ LC LIST

MEMBER Z SHEAR & Y MOMENT DIAGRAM FOR LOAD CONDITION 1

GRILLAGE 3

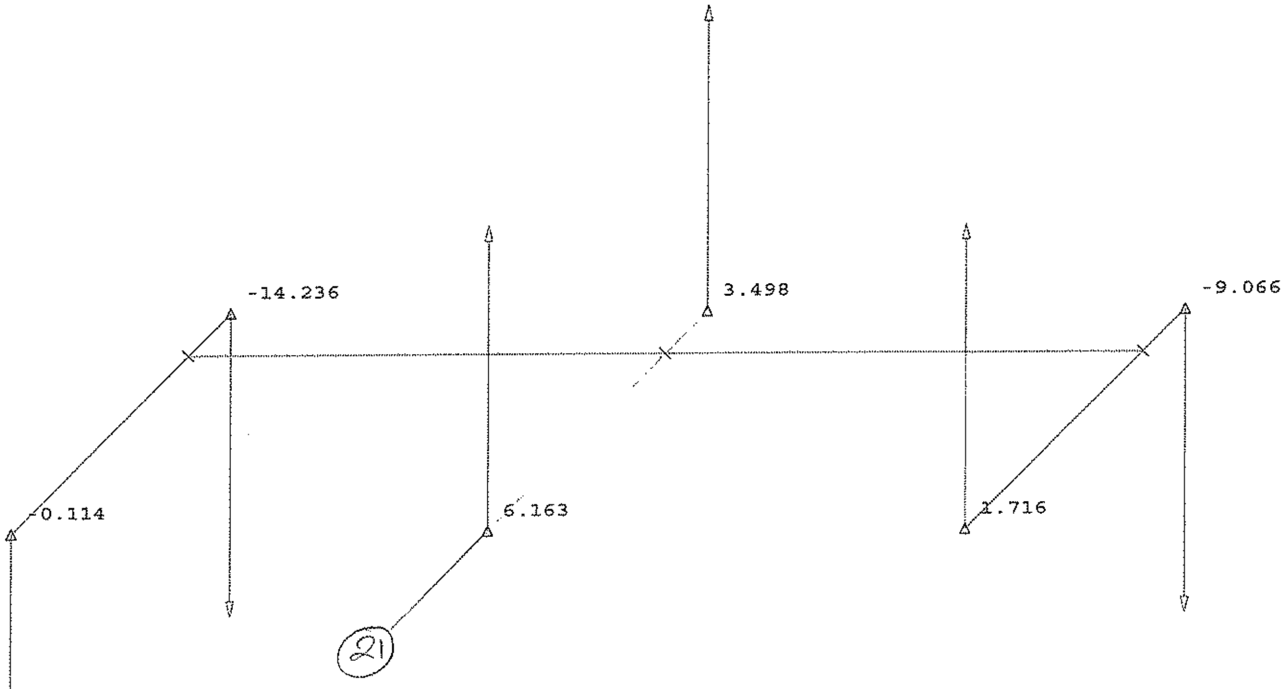


ISOMETRIC GRILLAGE1 UPLIFT



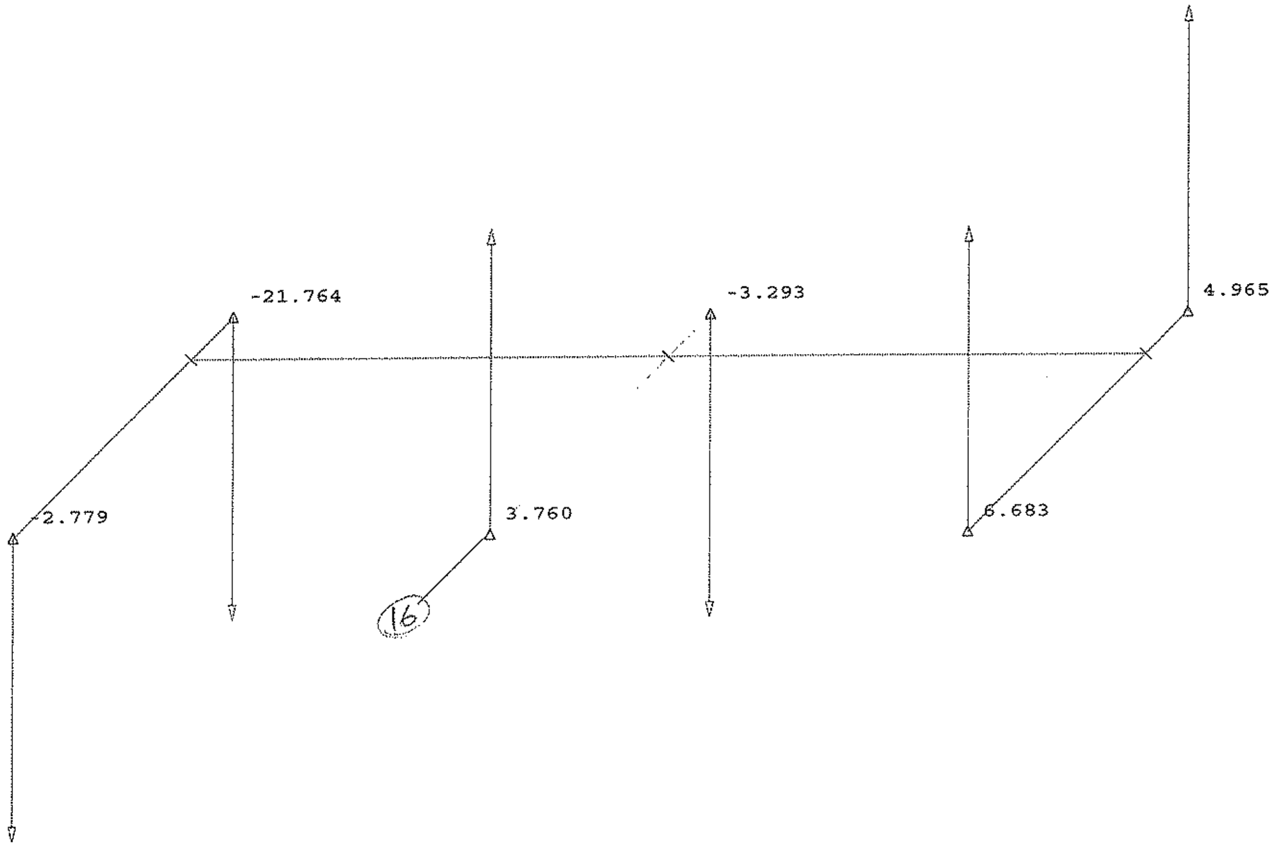
REACTION FZ LC LIST

ISOMETRIC GRILLAGE 2 UPLIFT



REACTION FZ LC LIST

ISOMETRIC GRILLAGE 3 UPLIFT



REACTION FZ LC LIST

JOB NO. : I/0310

COMP'D BY : Fenny

CALC. NO. : QT400-RV01

DATE : 30th May '07

SHEET NO.: 4 20

4.3 GRILLAGE DESIGN

4.3.1 Beam capacity Check.

- PG 280 x 1524 x 38 x 28.58

M max = 2062.78 KNm (GRILLAGE 1) → see sheet 4.12

V max = 3591.81 KN (GRILLAGE 3) → see sheet 4.16

- Check Bending

$$\sigma = \frac{M}{W} = \frac{2062.78 \quad 10^{6}}{3.04 \quad 10^{7}} = 67.85 \quad N/mm^2$$

$$U.C = \frac{67.85}{0.66 \quad 345} = 0.297 \longrightarrow O.K$$

- Check Shear

$$\tau = \frac{V . S}{I_y \quad t_w} = \frac{3591.81 \quad 10^{3} \quad 1.07 \quad 10^{7}}{2.32 . 10^{10} . 28.58} = 57.96 \quad N/mm^2$$

$$U.C. = \frac{57.96}{0.4 . 345} = 0.42 \longrightarrow O.K.$$

Sheet 4.21

Project	Tombua Landana		
Subject	Living Quarters		
Job / Bid no.	I/0310		
Date	30-May-07	Sheet	1

PLATE GIRDER PROPERTIES

Plategirder Description

section no	Section breadth [mm]	Section height [mm]	Offset ey [mm]	Axial area [mm^2]	Shear area [mm^2]	Statical moment [mm^3]
1	*380.0*	*38.0*	*0.0*	14440	1087	1.07E+07
2	*28.6*	*1448.0*	*0.0*	41413	41413	1.07E+07
3	*380.0*	*38.0*	*0.0*	14440	1087	0.00E+00
4	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
5	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
6	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
7	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
8	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
9	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
10	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
11	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
12	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
13	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
14	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
15	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
	380	1524		70293	43586	

Section Properties

Areas:	AX	70293	[mm^2]
	AY	28880	[mm^2]
	AZ	43586	[mm^2]
Dimensions:	Y	380.0	[mm]
	Z	1524.0	[mm]
	Weight	5.4	[kN/m]
Distances to neutral axis:	ez (From bottom)	762.0	[mm]
	Z-ez	762.0	[mm]
	ey (From left)	190.0	[mm]
	Y-ey	190.0	[mm]
Section moduli:	Wy,min	3.04E+07	[mm^3]
	Wy,max	3.04E+07	[mm^3]
	Wz,min	1.84E+06	[mm^3]
	Wz,max	1.84E+06	[mm^3]
Moments of inertia:	Iy	2.32E+10	[mm^4]
	Iz	3.50E+08	[mm^4]
Torsional constant (torsional resistance):	It	2.52E+07	[mm^4]
Radii of gyration:	ry	574.3	[mm]
	rz	70.6	[mm]

Note: -Torsional Constant / Resistance is only valid for open girders

Last Revision: May 98

JOB NO. : I/0310

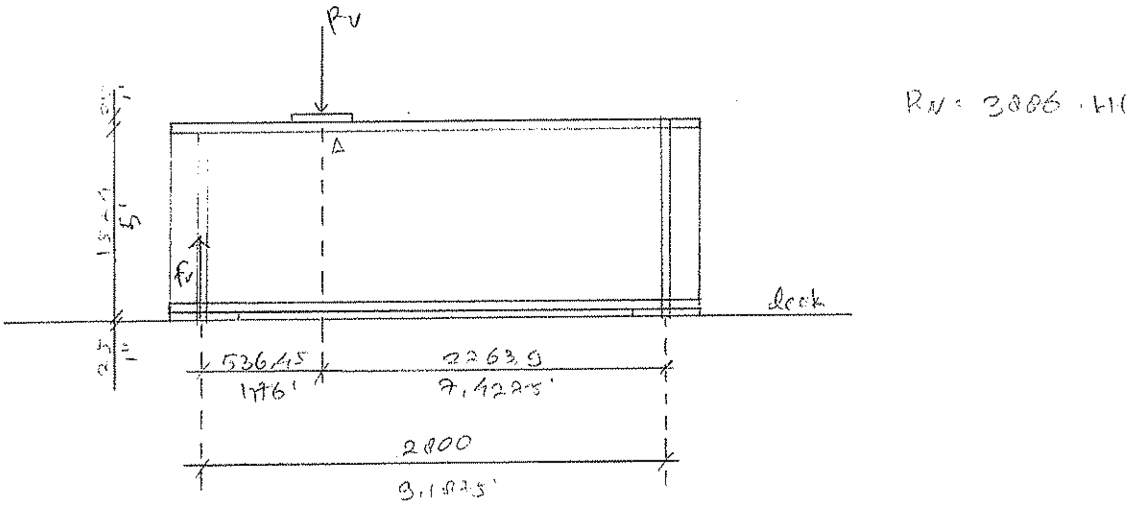
COMP'D BY : Andrew.H.

CALC. NO. : RT400-RB02

DATE : 23rd May '07

SHEET NO.: 4.22

- Grillage Beam Capacity Check
  - Grillage 3
  - Beam $^{1/2}$G190 × 1524 × 38 × 25,4



Rv : 3886 kN

$W_{y,min} = 1,94.10^7\ mm^3$

$A_{shear} = 39345\ mm^2$

Reaction and moments

$F_v : 2657,16\ kN$ (see sheet 4.15)

$M_\Delta : 2657,16 . 536,45 . 10^{-3}$

$= 1425,43\ kNm$

$$\sigma_b = \frac{M}{W_{ymin}} = \frac{1425,43 . 10^6}{1,89 . 10^7} = 75,42\ N/mm^2$$

$$UC = \frac{\sigma_b}{0,66 F_y} = \frac{75,42}{0,66 . 345} = 0,33$$

$$\tau_v = \frac{F_v}{A_{shear}} = \frac{2657,16 . 10^3}{30710} = 68,64\ N/mm^2$$

$$UC = \frac{\tau_v}{0,4 F_y} = \frac{68,64}{0,4 . 345} = 0,5$$

sheet 4.23

Project	Tombua Landana		
Subject	Living Quarters		
Job / Bid no.	I/0310		
Date	30-May-07	Sheet	1

PLATE GIRDER PROPERTIES

Plategirder Description

section no	Section breadth [mm]	Section height [mm]	Offset ey [mm]	Axial area [mm²]	Shear area [mm²]	Statical moment [mm³]
1	*190.0*	*38.0*	*0.0*	7220	965	5.36E+06
2	*25.4*	*1448.0*	*0.0*	36779	36779	5.36E+06
3	*190.0*	*38.0*	*0.0*	7220	965	0.00E+00
4	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
5	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
6	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
7	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
8	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
9	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
10	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
11	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
12	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
13	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
14	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
15	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
	190	1524		51219	38710	

Section Properties

Areas:	AX	51219	[mm²]
	AY	14440	[mm²]
	AZ	38710	[mm²]
Dimensions:	Y	190.0	[mm]
	Z	1524.0	[mm]
	Weight	3.9	[kN/m]
Distances to neutral axis:	ez (From bottom)	762.0	[mm]
	Z-ez	762.0	[mm]
	ey (From left)	95.0	[mm]
	Y-ey	95.0	[mm]
Section moduli:	Wy,min	1.89E+07	[mm³]
	Wy,max	1.89E+07	[mm³]
	Wz,min	4.78E+05	[mm³]
	Wz,max	4.78E+05	[mm³]
Moments of inertia:	Iy	1.44E+10	[mm^4]
	Iz	4.54E+07	[mm^4]
Torsional constant (torsional resistance):	It	1.49E+07	[mm^4]
Radii of gyration:	ry	530.2	[mm]
	rz	29.8	[mm]

Note: -Torsional Constant / Resistance is only valid for open girders

Last Revision: May 98

JOB NO. : I / 0310

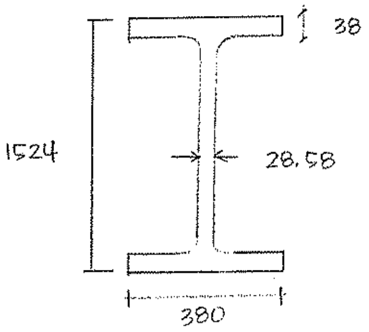
COMP'D BY : Fenny

CALC. NO. : ST 400 - RP01

DATE : 30 May 2007

SHEET NO.: 4 24

4.3.2 PLATE GIRDER



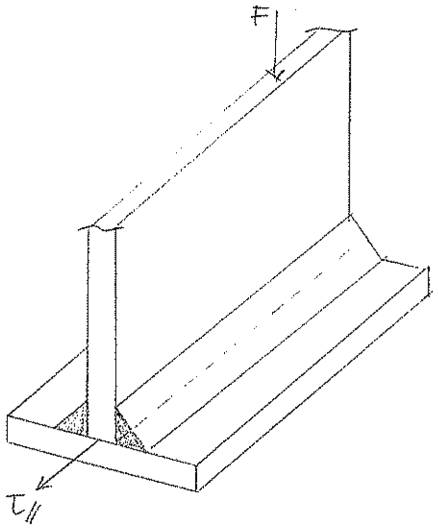
statical moment (S) = $1.07 . 10^{7}$ mm^3

Iy = $2.32 . 10^{10}$ mm^4

Wy = $3 \ 10^{7}$ mm^3

(see sheet 4)

FILLET WELD CALCULATION



PG . 380 x 1524 x 38 x 28.58

Fy = 345 N / mm^2

n = 2 (Both side)

σc all = 0.66 Fy = 227.7 N/mm^2

σ all = 0.6 Fy = 207 N/mm^2

τ all = 0.4 Fy = 138 N/mm^2

GRILLAGE I

Shear force (F) = 3294.05 kN (see sheet 4 12)

L = 10 ft = 3048 mm

Shear force between flange and web

$$\tau = \frac{V . S}{Iy \ tw}$$

$$= \frac{3294.05 \ 10^{3} \ 1.07 . 10^{7}}{2.32 \ 10^{10} \ . \ 28.58}$$

= 53.16 N/mm^2

$$u.c. = \frac{53,16}{0,4 \cdot 345}$$

$$= 0,39 < 1 \longrightarrow O.K.$$

Weld

$$\tau = \frac{F}{2\ a \cdot l}$$

$$53,16 = \frac{3294.05\ 10^{3}}{2\ a\ 3048}$$

$$a = 10,16\ \text{mm}$$

$$w = a\sqrt{2} = 14,37\ \text{mm}$$

min w = 3/8 in (9,53 mm)
max w = 28,58 mm (1,13 in)

w = 0,75 in (19,05 mm)
a = 0,53 in (13,47 mm)

GRILLAGE 2

Shear Force (F) = 2855.93 kN (see sheet 4.14)

Length = 10 ft = 3048 mm

Shear Force Between Flange and web

$$\tau = \frac{V \cdot S}{I_y\ t_w}$$

$$= \frac{2855,93\ 10^{3}\ 1,07 \cdot 10^{7}}{2,32\ 10^{10} \cdot 28,58}$$

$$= 46,09\ \text{N/mm}^2$$

JOB NO. : I / 0310

SHEET NO.: 4.26

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

$$U.C = \frac{46,09}{0,4 \quad 345}$$

$$= 0,33 \quad < 1 \quad \longrightarrow \quad O.K$$

Weld

$$\tau = \frac{F}{2 \quad a \quad l}$$

$$46,09 = \frac{2855,93 . 10^3}{2 \quad a \quad 3048}$$

$$a = 10,16 \text{ mm}$$

$$\left.\begin{array}{l} \min w = 3/8 \text{ in} \quad (0,53 \text{ mm}) \\ \max w = 28,58 \text{ mm} \quad (1,13 \text{ in}) \end{array}\right\} \quad \begin{array}{l} w = 0,75 \text{ in} \quad (19,05 \text{ mm}) \\ a = 0,53 \text{ in} \quad (13.47 \text{ mm}) \end{array}$$

GRILLAGE 3

Shear Force (F) : 3591 . 81 KN (see sheet 4 16)

L : 10 ft 3048 mm

Shear Force Between Flange and web

$$\tau = \frac{V . S}{Jy \quad tw}$$

$$= \frac{3591.81 . 10^3 . \quad 1,07 \; 10^7}{2,32 \quad 10^{10} \qquad 28,58}$$

$$= 57,96 \text{ N/mm}^2$$

$$U.C = \frac{57,96}{0,4 \cdot 345}$$

$$= 0,42 \quad < 1 \quad \longrightarrow \quad O.K$$

JOB NO. : I / 0310

SHEET NO.: 4.27

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP01

DATE : 20 May 2007

Weld

$$\tau = \frac{F}{2 . a\ l}$$

$$57.06 = \frac{3591 . 81 . 10^3}{2\ a\ 3048}$$

$$a = 10{,}17\ \text{mm}$$

min w = 3/8 in (9,53 mm)
max w = 28,58 mm (1,13 in)

} w = 0,75 in (19,05 mm)
a = 0,53 in (13.47 mm)

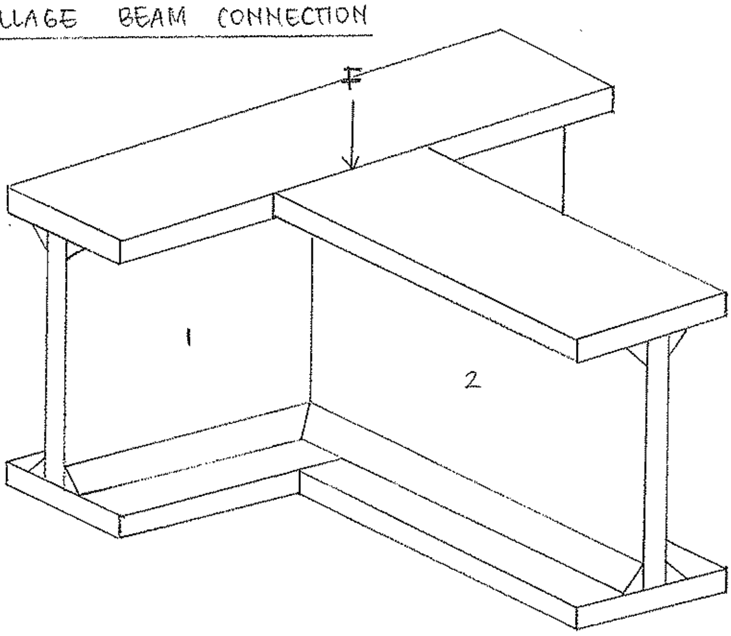
Note Fillet weld of PG 190 x 1524 x 38 x 25,4 is the same as fillet weld of PG 380 x 1524 x 38 x 28,58

Fillet Weld Minimum Size (AWS)

Thickness of thicker plate to be joined	Minimum leg size of fillet weld *
0 - 1/2 in	3/16 in
1/2 in - 3/4 in	1/4 in
3/4 in - 1 1/2 in	5/16 in
1 1/2 in - 2 1/4 in	3/8 in
2 1/4 in - 6 in	1/2 in
> 6 in	5/8 in

* Do not need exceed the thickness of the thinner plate

4.3.3. GRILLAGE BEAM CONNECTION



1. PG 380 x 1524 x 38 x 28.58
2. PG 190 x 1524 x 38 x 25,4

GRILLAGE 3 (the maximum)

Length of fillet weld = dw - 2w = 1448 - 2 12,7 = 1422, 6 mm

F = 3591, 81 KN (see sheet 4.15)

$$\tau_{//} = \frac{F}{2aL}$$

$$= \frac{3591,81 \quad 10^3}{2 \cdot a \quad 1422,6}$$

$$= 1262,41 \ / a$$

Check shear

$\tau_{//}$ = 1262. 41 / a

0,4 . 345 = 1262, 41 / a

a = 9,15 mm

$w = a\sqrt{2}$ = 12. 94 mm

w min = 3/6 in (9. 53 mm)

w max = 25,4 mm (1 in)

w = 0,75 in (19,05 mm)

a = 0,53 in (13.5 mm)

JOB NO. J/0310

COMP'D BY : Andreas H.

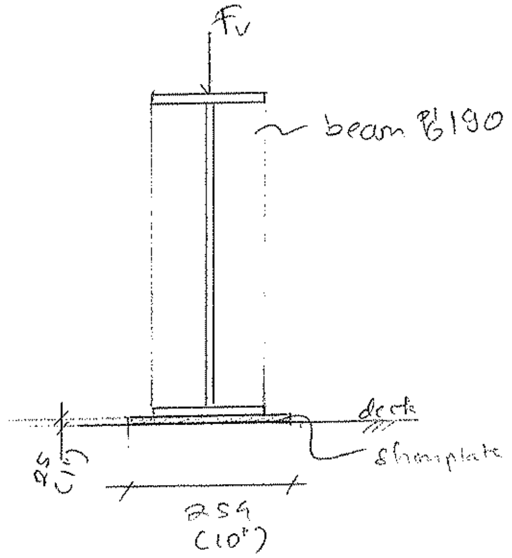
CALC. NO. : QT400-RP01

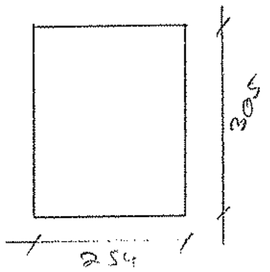
DATE : 24th May'07

SHEET NO.: 4 29

4 34 WING PLATE

Detail A





Fv : 372 kN
(see sheet 4.11)

Check whether need the wingplate or the end stiffener

A. Barge capacity without wingplate against Fv

barge capacity : 2285,74 kN

$$UC = \frac{372}{2285,74}$$

$$= 0{,}16 < 1{,}0 \rightarrow ok!$$

B. check whether the uplift reaction can be occured caused by dynamic forces

- see sheet

→ no uplift reaction in detail A

Conclusion = only the end stiffener which is needed.

Reference : - sheet 4.8 , 4.10
- sheet 4.17
- sheet 4.99

JOB NO. : T/0310

SHEET NO.: 4.30

COMP'D BY : Andrew H.

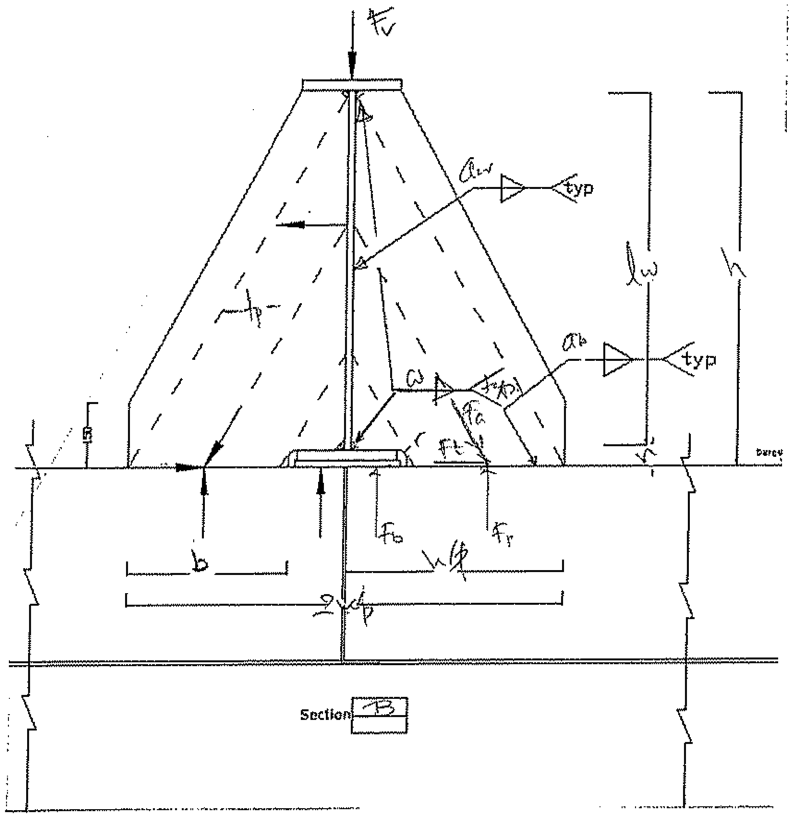
CALC. NO. : QT400-RP01

DATE : 24th May '07

Wingplate

To deck from PL 190 x 1524 x 38 x 25,4
plate thickness 25 mm

Detail B



Forces quality
F_v : 1352,8 kN (see sheet 41
f_y : 295 N/mm²

Dimensional Aspects

h : 1498 mm
b : 350 mm
t_p = 25,4 mm
n = 63 mm
w_f = 190 mm
r : 63 mm
w : 19,05 mm

Design Considerations

$$W_p : \frac{w_f + 2 r_{rathole} + 2b}{2} = \frac{190+2.63+2.350}{2} : 508 \text{ mm}$$

$$\theta : \text{atan}\left(\frac{h}{w_p}\right) : \text{atan}\left(\frac{1492}{508}\right) : 71{,}20°$$

$$Sb : \left(b - \frac{n}{\tan\theta}\right)\sin\theta : \left(350 - \frac{63}{\tan 71{,}20°}\right)\cdot\sin 71{,}20° : 311{,}02 \text{ mm}$$

$$Wd : \frac{Sb}{\sin\theta} : \frac{311{,}02}{\sin 71{,}20} : 320{,}55 \text{ mm}$$

JOB NO. : I/0310

COMP'D BY : Andrew. H.

CALC. NO. : QT 400 - RP01

DATE : 24th May'07

SHEET NO.: 4.31

$$W_b = \frac{S_b}{\cos\theta} = \frac{311,02}{\cos 71,20^\circ} = 964,95 \text{ mm}$$

$$l_b = \frac{W_p - 0,5\,W_d}{\sin\theta} = \frac{500-(0,5 \cdot 328,55)}{\sin 71,20^\circ} = 363,10 \text{ mm}$$

Design Calculations

Description of loads

1. Uniform load

$$Q = \frac{F_v}{2W_p} = \frac{1352,8}{2 \cdot 500 \cdot 10^{-3}} = 1331.5 \text{ kN/m}$$

2. Plate load

$$F_p = Q \cdot b = 1352,8 \cdot 350 \cdot 10^{-3} = 466,02 \text{ kN}$$

3. Direct bearing

$$F_b = 0,5 F_v - F_p = (0,5 \cdot 1352,8) - 466,02 = 210,38 \text{ kN}$$

4. Strut force

$$F_a = \frac{F_p}{\sin\theta} = \frac{466,02}{\sin 71,20^\circ} = 492,80 \text{ kN}$$

5. Horizontal Component

$$F_t = \frac{F_p}{\tan\theta} = \frac{466,02}{\tan 71{,}20} = 158,67 \text{ kN}$$

Plate Design

6. Acting stress in plate strut

$$f_c = \frac{F_a}{S_b \cdot t_p} = \frac{492,08 \cdot 10^3}{311,02 \cdot 25,4} = 62,32 \text{ N/mm}^2$$

7. Allowable stress in slenderness plate strut

$$sl = \frac{0,7\, l_b \sqrt{12}}{t_p} = \frac{0,7 \cdot 363,10\sqrt{12}}{25,4} = 35$$

$$F_c(C_c) = 26,51 \text{ Ksi} = 106,38 \text{ N/mm}^2$$

8. Stress ratio

$$UC_1 = \frac{f_c}{F_c(C_c)} = \frac{62,25}{186,38} = \underline{\underline{0,33}}$$

Weld design

A. Weld to web

weld to web size, aw : 8 mm
length of web , lw : 1410 mm

9. Vertical

$$f_{vweld,v} = \frac{F_p\sqrt{2}}{2.a_w.w_b} + \frac{F_b\sqrt{2}}{2a_w.l_w} = \left(\frac{466,02\sqrt{2}}{2.8.964,95} + \frac{210,38\sqrt{2}}{2.8.1410}\right).10^3 = 55,88 \ N/m$$

10. Horizontal

$$f_{vweld,h} = \frac{F_t}{2a_w.w_b} = \frac{150,67.10^3}{2.8.964,95} = 10,28 \ N/m$$

11. Shear in the weld

$$f_{vweld} = \sqrt{f_{vweld,v}^2 + f_{vweld,h}^2} = \sqrt{55,88^2 + 10,19^2} = 56,81 \ N/m$$

12. Stress ratio

$$UC_2 = \frac{f_{vweld}}{0,4F_{yield}} = \frac{56,81}{0,4.345} = \underline{\underline{0,41}}$$

B. Weld to barge deck

bottom weld size, ab = 12 mm

13. Vertical

$$f_{vweld,v_2} = \frac{F_p}{2a_b.W_d} = \frac{466,02.10^3}{2.12.328,55} = 59,10 \ N/m$$

14. Horizontal

$$f_{vweld,h_2} = \frac{F_t\sqrt{2}}{2a_b.W_d} = \frac{150,67\sqrt{2}.10^3}{2.12.328,55} = 28,46 \ N/m$$

15. Shear in weld

$$f_{vweld,b} = \sqrt{f_{vweld,v_2}^2 + f_{hweld,h}^2} = \sqrt{59,10^2 + 28,46^2} = 65,60 \ N/mm$$

JOB NO. : I/0310

COMP'D BY : Andraw .K.

CALC. NO. : QT400-R01

DATE : 24th May '07

16. Stress ratio

$$UC_3 = \frac{f_{vweld,b}}{0{,}4 F_{yield}} = \frac{65{,}60}{0{,}4 . 345} = \underline{\underline{0{,}7}}$$

Check bearing on the deck

$F_{v,max}$ = 1352,8 kN

F_y barge = 235 N/mm^2

plate thick. barge: t_p = 11 mm

$$\sigma_c = \frac{F_{v,max}}{2 W_p . t_p} = \frac{1352{,}8 . 10^3}{2 . 508 . 11} = 121{,}05 \, {}^{N}/_{m}$$

Stress ratio

$$UC = \frac{\sigma_c}{0{,}6 F_y \text{ barge}} = \frac{121{,}05}{0{,}6 . 235} = \underline{\underline{0{,}86}}$$

JOB NO. : I/0310

COMP'D BY : Andrew, H.

CALC. NO. : QT400-RP01

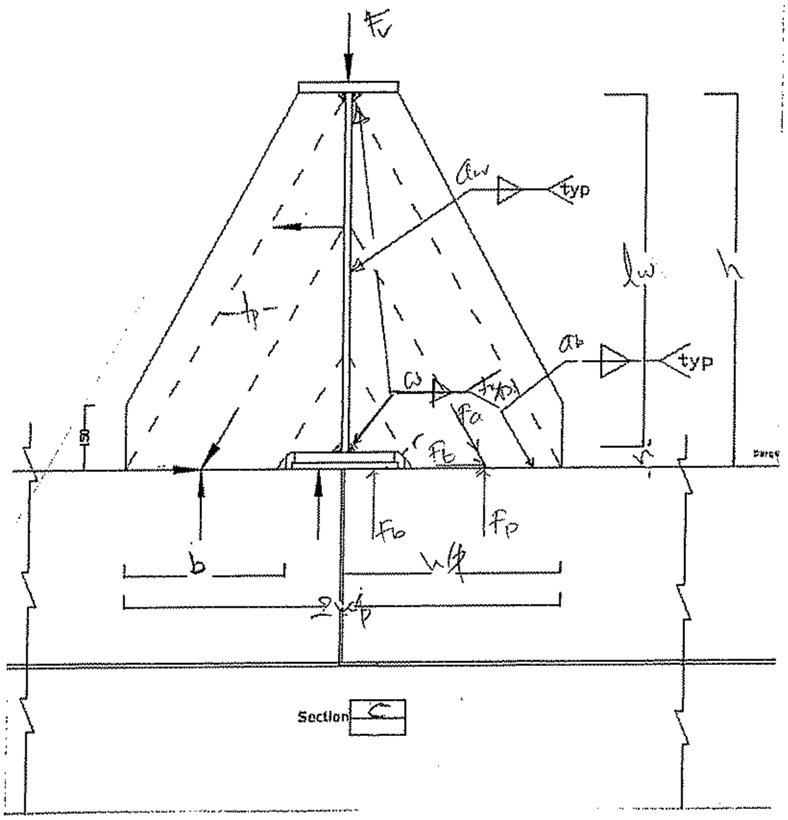
DATE : 24th May '07

SHEET NO.: 4 34

Wingplate

To deck from PG 190 x 1524 x 38 x 25,4
plate thickness 25 mm

Detail C



Forces quality
F_v = 2657,16 kN (sheet 4 15
f_y = 295 N/mm²

Dimensional Aspects

h : 1492 mm
b : 800 mm
tp : 25,4 mm
n = 63 mm
wf = 190 mm
r : 63 mm
w : 19,05 mm

Design Considerations

$$W_p = \frac{w_f + 2r_{ratHole} + 2b}{2} = \frac{190 + 2 \cdot 63 + 2 \cdot 800}{2} = 958 \text{ mm}$$

$$\theta = \operatorname{atan}\left(\frac{h}{w_p}\right) = \operatorname{atan}\left(\frac{1492}{958}\right) = 57{,}29°$$

$$S_b = \left(b - \frac{n}{\tan\theta}\right)\sin\theta = \left(800 - \frac{63}{\tan 57{,}29}\right)\sin 57{,}29° = 639{,}13 \text{ mm}$$

$$W_d = \frac{S_b}{\sin\theta} = \frac{640{,}07}{\sin 57{,}29°} = 759{,}55 \text{ mm}$$

JOB NO. : I/0310

COMP'D BY : Andrew. H.

CALC. NO. : QT400 - RP01

DATE : 24th May '07

SHEET NO.: 435

$W_b : \frac{S_b}{\cos\theta} = \frac{639,13}{\cos 57\ 29''} = 1182,89$ mm

$l_b = \frac{W_p - 0,5\, W_d}{\sin\theta} = \frac{958-(0,5 . 759,55)}{\sin 57,29'} = 682.17$ mm

Design Calculations

Description of loads

1. Uniform load

$Q = \frac{F_v}{2W_p} = \frac{2657,16}{2 . 958 . 10^{-3}} = 1386,83$ kN/m

2. Plate load

$F_p = Q . b = 1306,83 . 800 . 10^{-3} = 1109,46$ kN

3. Direct bearing

$F_b = 0,5 F_v - F_p = (0,5 . 2657,16) - 1109,46 = 219,12$ kN

4. Strut force

$F_a = \frac{F_p}{\sin\theta} = \frac{1109,46}{\sin 57\ 29°} = 1318,49$ kN

5. Horizontal Component

$F_t = \frac{F_p}{\tan\theta} = \frac{1109,46}{\tan 57,29°} = 712,10$ kN

Plate Design

6. Acting stress in plate strut

$f_c = \frac{F_a}{S_b . t_p} = \frac{1318,49 . 10^3}{639,13 . 25,4} = 81,22$ N/mm²

7. Allowable stress in slenderness plate strut

$sl = \frac{0,7 . l_b \sqrt{12}}{t_p} = \frac{0,7 . 682,17 \sqrt{12}}{25,4} = 66$

$F_c(C_c) = 21,67$ Ksi $= 152,36$ N/mm2

8. Stress ratio.

$UC_1 = \frac{f_c}{F_c(C_c)} = \frac{81,22}{152,36} = \underline{0,53}$

JOB NO. : I/0310

COMP'D BY : Andrew .H.

CALC. NO. : QT400-RP01

DATE : 24th May '07

SHEET NO.: 4.36

Weld design

A. Weld to web

weld to web size a_w : 8 mm

length of web, l_w : 1410 mm

9. Vertical

$$f_{v weld,v} = \frac{F_p\sqrt{2}}{2.a_w.w_b} + \frac{F_b\sqrt{2}}{2a_w.l_w} = \left(\frac{1109,46\sqrt{2}}{2.8.1182,09} + \frac{219,12\sqrt{2}}{2.8.1410}\right).10^3 = 96,64 \ N/m$$

10. Horizontal

$$f_{v weld,h} = \frac{F_t}{2a_w.w_b} = \frac{712,40.10^2}{2.8.1182,09} = 37,64 \ N/m$$

11. Shear in fv weld

$$f_{v weld} = \sqrt{f_{v weld,v}^2 + f_{v weld,h}^2} = \sqrt{96.64^2 + 37.64^2} = 103,71 \ N/m$$

12. Stress ratio

$$UC_2 = \frac{f_{v weld}}{0,4 F_{yield}} = \frac{103,71}{0,4.345} = \underline{\underline{0,75}}$$

B. Weld to barge deck

bottom weld size, a_b = 12 mm

13. Vertical

$$f_{v weld,v_2} = \frac{F_p}{2a_b.w_d} = \frac{1109,46.10^3}{2.12.759,55} = 60,86 \ N/m$$

14. Horizontal

$$f_{v weld,h_2} = \frac{F_t\sqrt{2}}{2a_b.w_d} = \frac{712,40\sqrt{2}.10^2}{2.12.759,55} = 55,27 \ N/m$$

15. Shear in weld

$$f_{v weld,b} = \sqrt{f_{v weld,v_2}^2 + f_{h weld,h}^2} = \sqrt{60,86^2 + 55,27^2} = 82,21 \ N/m$$

JOB NO. : I/0310

COMP'D BY : Andrew K.

CALC. NO. : QT402-R01

DATE : 24th May '07

SHEET NO.: 4 37

16. Stress ratio

$$UC_3 = \frac{f_{vweld,b}}{0{,}4F_{yield}} = \frac{82{,}21}{0{,}4 . 345} = \underline{\underline{0{,}87}}$$

Check bearing on the deck

$F_{v,max}$ = 2657,16 kN

F_y barge = 235 N/mm2

plate thick. barge, t_p = 11 mm

$$\sigma_c = \frac{F_{v,max}}{2\,W_p . t_p} = \frac{2657{,}16 . 10^3}{2 . 958 . 11} = 126{,}08\ ^{N}/_{m}$$

Stress ratio

$$UC = \frac{\sigma_c}{0{,}6F_{y\ barge}} = \frac{126{,}08}{0{,}6 . 235} = \underline{\underline{0{,}89}}$$

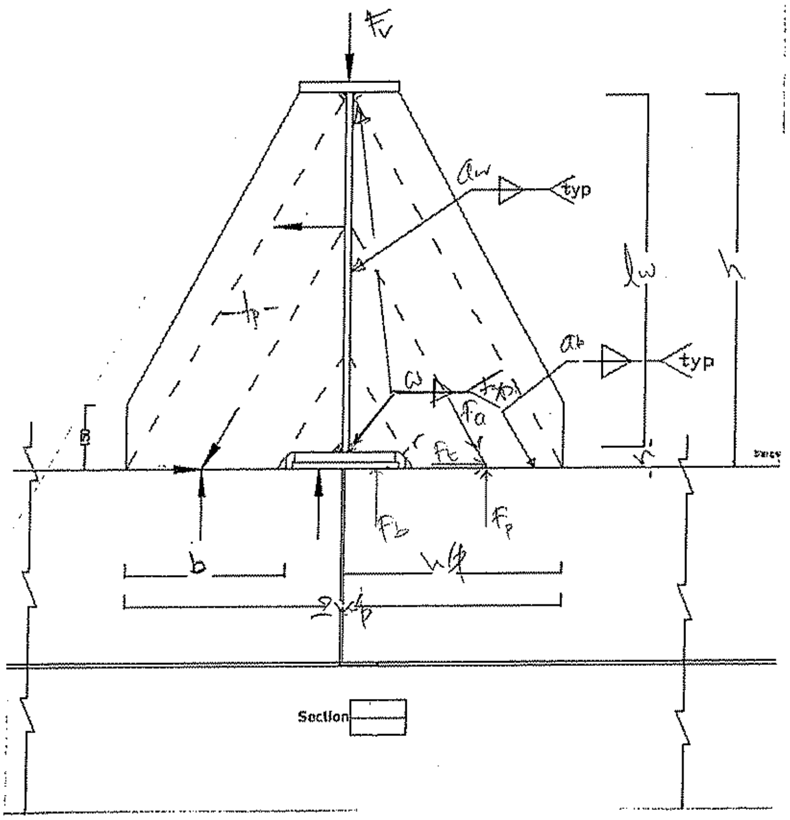
JOB NO. : T/0310
COMP'D BY : Andrew, H.
CALC. NO. : QT400-RP01
DATE : 24th May '02

SHEET NO.: 4.38

Wingplate

To deck from PB 190 x 1524 x 38 x 25,4
plate thickness 25 mm

Detail D



Forces quality
F_v : 945,68 (sheet 4.15)
f_y = 245 N/mm²
Rail girder capacity : 591 kN
(see sheet 4.42)
→ need the wingplate

Dimensional Aspects

h : 1492 mm
b : 570,6 mm
t_p = 25,4 mm
n = 63 mm
w_f = 190 mm
r : 63 mm
w : 19,05 mm

Design Considerations

$$W_p : \frac{w_f + 2r_{rathole} + 2b}{2} = \frac{190 + 2.63 + 2.570,6}{2} : 736,6 \text{ mm}$$

$$\theta : \operatorname{atan}\left(\frac{h}{w_p}\right) : \operatorname{atan}\left(\frac{1492}{736,6}\right) : 63,72$$

$$Sb : \left(b - \frac{n}{\tan\theta}\right)\sin\theta : \left(570,6 - \left(\frac{63}{\tan 63,72^\circ}\right)\right)\sin 63,72^\circ : 450,92 \text{ mm}$$

$$Wd : \frac{Sb}{\sin\theta} : \frac{491,45}{\sin 63,72^\circ} : 547,49 \text{ mm}$$

JOB NO. : I/0310

SHEET NO.: 4.39

COMP'D BY : Andrew. H.

CALC. NO. : QT 400 - RP01

DATE : 24th May'07

$W_b : \frac{S_b}{\cos \theta} = \frac{490,92}{\cos 63,72'} = 1108,87$ mm

$l_b = \frac{W_p - 0,5\, W_d}{\sin \theta} = \frac{736,6 - (0,5 . 547,48)}{\sin 63,72°} : 516,19$ mm

Design Calculation =

Description of loads

1. Uniform load

$Q = \frac{F_v}{2 W_p} = \frac{945,60}{2 . 736,6 . 10^{-3}} = 641,92$ kN/m

2. Plate load

$F_p = Q . b = 641,92 . 578,6 . 10^{-3} = 371.42$ kN

3. Direct bearing

$F_b : 0,5 F_v - F_p = (0,5 . 641,92) - 371.42 = 101.42$ kN

4. Strut force

$F_a = \frac{F_p}{\sin \theta} = \frac{371,42}{\sin 63,72} = 414,22$ kN

5. Horizontal Component

$F_t = \frac{F_p}{\tan \theta} = \frac{371.42}{\tan 63,72°} = 183,85$ kN

Plate Design

6. Acting stress in plate strut

$f_c = \frac{F_a}{S_b . t_p} = \frac{414,22 . 10^3}{490,92 . 25,4} = 33,22$ N/mm²

7. Allowable stress in slenderness plate strut

$sl = \frac{0,7\, l_b \sqrt{12}}{t_p} = \frac{0,7 . 516,19 \sqrt{12}}{25,4} = 49$

$F_c(C_c) = 24,51$ Ksi $= 173,32$ N/mm2

8. Stress ratio

$UC_1 = \frac{f_c}{F_c(C_c)} = \frac{33,22}{173,32} = \underline{\underline{0,19}}$

JOB NO. : I/0310

COMP'D BY : Andrew .H.

CALC. NO. : QT900-RP01

DATE : 24th May '07

SHEET NO.: 4.40

Weld design

A. Weld to web

weld to web size, a_w : 8 mm

length of web, l_w : 1410 mm

9. Vertical

$$fvweld,v = \frac{F_p\sqrt{2}}{2.a_w.w_b} + \frac{F_b\sqrt{2}}{2a_w.l_w} = \left(\frac{371,42\sqrt{2}}{2.8.1108,09} + \frac{101,42\sqrt{2}}{2.8.1410}\right).10^3 = 35,96 \quad N/m$$

10. Horizontal

$$fvweld,h = \frac{F_t}{2a_w.w_b} = \frac{183,38.10^3}{2.8.1108,09} = 10,34 \quad N/m$$

11. Shear in fv weld

$$fvweld = \sqrt{fvweld,v^2 + fvweld,h^2} = \sqrt{35,96^2 + 10,34^2} = 37,42 \quad N/m$$

12. Stress ratio

$$UC_2 = \frac{fvweld}{0,4.Fyield} = \frac{37,21}{0,4.345} = 0,27$$

B. Weld to barge deck

bottom weld size, a_b = 8 mm

13. Vertical

$$fvweld,v_2 = \frac{F_p}{2a_b.w_d} = \frac{371,42.10^3}{2.8.547,49} = 42,39 \quad N/m$$

14. Horizontal

$$fvweld,h_2 = \frac{F_t\sqrt{2}}{2a_b.w_d} = \frac{183,38.10^3\sqrt{2}}{2.8.547,49} = 29,61 \quad N/m$$

15. Shear in weld

$$fvweld,b = \sqrt{fvweld,v_2^2 + fhweld,h^2} = \sqrt{42,39^2 + 29,61^2} = 51,71 \quad N/mm$$

JOB NO. : I/0310

COMP'D BY : Andrew K.

CALC. NO. : QT400-R01

DATE : 24th May '07

SHEET NO.: 4.41

16. Stress ratio

$$UC_3 = \frac{f_{v weld,b}}{0{,}4 F_{yield}} = \frac{51{,}71}{0{,}4 \cdot 345} = \underline{\underline{0{,}37}}$$

Check bearing on the deck

$F_{v,max} = 945{,}68$ kN

F_y barge $= 235$ N/mm²

plate thick. barge, $t_p = 16{,}5$ mm

$$\sigma_c = \frac{F_{v,max}}{2 W_p \cdot t_p} = \frac{945{,}60 \cdot 10^3}{2 \cdot 436{,}6 \cdot 16{,}5} = 30{,}9 \ N/mm$$

Stress ratio

$$UC = \frac{\sigma_c}{0{,}6 F_y \text{ barge}} = \frac{30{,}9}{0{,}6 \cdot 235} = \underline{\underline{0{,}28}}$$

JOB NO. : I/0310

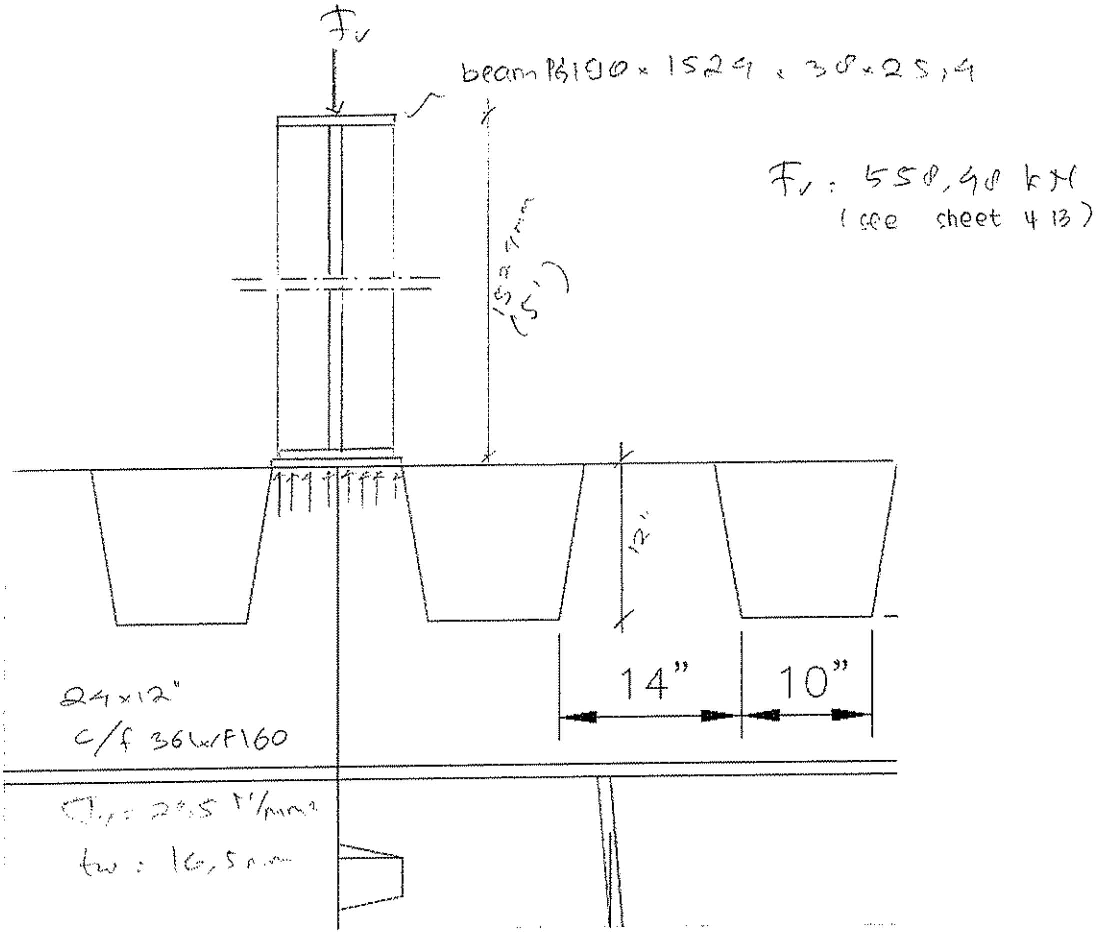
COMP'D BY : Andrew. H.

CALC. NO. : QT-100-RP01

DATE : 24th May '07

SHEET NO.: 4.42

Detail E



F_v : 550,40 kN
(see sheet 4.13)

Check whether in detail E needs the wingplate or end stiffener :

A. Rail girder capacity

Rail girder capacity : $0,6\ \sigma_y \cdot t_w \cdot 10"$

$= 0,6 \cdot 235 \cdot 16,5 \cdot (25,4 \cdot 10)$

$= 590,93 \cdot 10^3\ N$

$= 590,93\ kN$

$$UC : \frac{550,40}{590,93}$$

$= 0,95 \quad < 1,0 \rightarrow ok$

JOB NO. : I/0310

COMP'D BY : Andrau. H.

CALC. NO. : QT400-RP01

DATE : 24th May '07

SHEET NO.: 4 43

B. check whether the uplift reaction caused by dynamic force.

→ see sheet 4.11 - 4.19

→ no uplift reaction occured in detail E (do not need wingplate)

Conclusion :

- only need the end stiffener
- for end stiffener calculation detail E, see sheet 4.73

JOB NO. : I/0310

COMP'D BY : Andrew. H

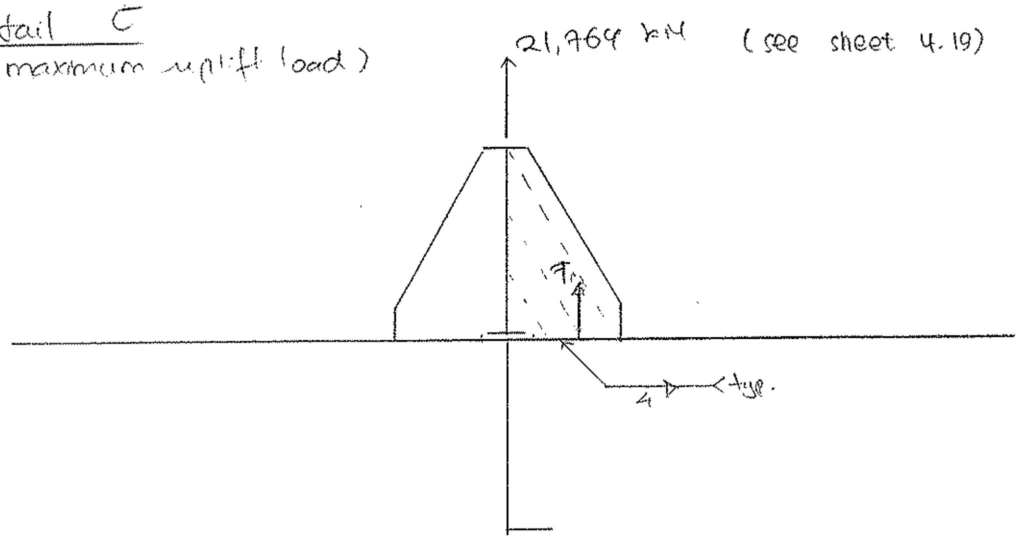
CALC. NO. : QT400-RP01

DATE : 21st May '07

SHEET NO.: 4.44

4.3.5 Uplift Capacity Check

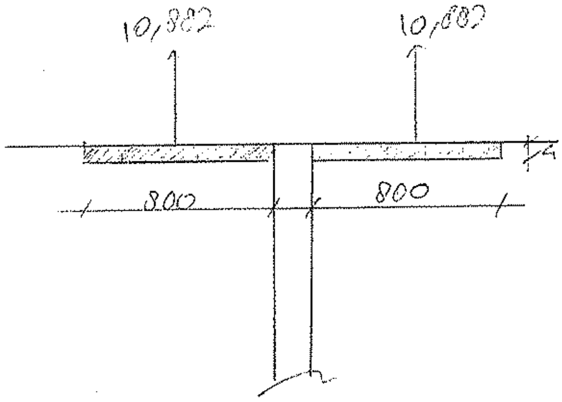
Detail C
(maximum uplift load)



$F_p = \frac{1}{2} \cdot 21{,}764$

$= 10{,}882$ kN (↑)

Weld deck resistance due to uplift



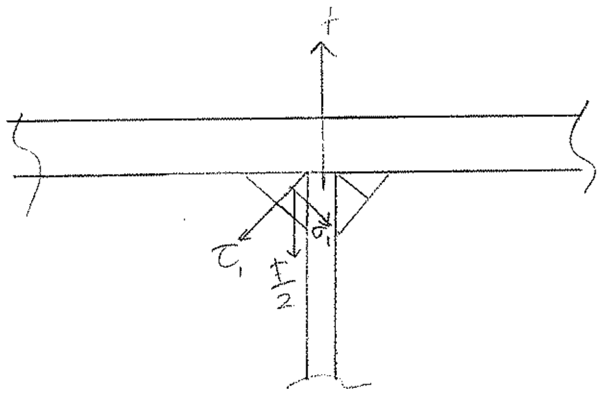
JOB NO. : I/0310

COMP'D BY : Andrew.H

CALC. NO. : QT400-RP01

DATE : 21st May '07

SHEET NO.: 4.45



$$\tau_1 = \sigma_1 = \frac{F\sqrt{2}}{4.a.l}$$

$$a = \frac{1}{2}\sqrt{2}\,w$$

$$= \frac{1}{2}\sqrt{2}\,.\,4$$

$$= 2{,}83\text{ mm}$$

$$l = b = 800\text{ mm}$$

$$\tau_1 = \sigma_1 = \frac{21{,}764\sqrt{2}}{4\,.\,2{,}83\,.\,800}$$

$$= 3{,}4\,.\,10^{-3}\text{ kN}$$

Unity Check

$$UC = \frac{\tau_1}{0{,}4\,.\,\sigma_y\text{ barge}}$$

$$= \frac{3{,}4}{0{,}4\,.\,235}$$

$$= 0{,}04$$ (ok ... barge welding governs for uplift force)

JOB NO. : I/0310

SHEET NO.: 4.46

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP01

DATE : 30 May 2007

4 3 6 STIFFENER

Stiffened Webs and Flanges Under Concentrated Forces

GRILLAGE 1 PART 1

Input Data

Compressive Force	R	1161 . 87	KN	261 . 20	kips	(sheet 4.5
Enhancement factor (for Pbf)		1. 33				
Web thickness	tw	28 . 58	mm	1. 12	in	
Flange thickness	tf	38	mm	1. 50	in	
overall member depth	d	1524	mm	60	in	
Flange Breadth	bf	380	mm	14 . 96	in	
Root radius / weld size	r	19. 05	mm	0. 75	in	
Unbraced length of flange	l	3048	mm	120	in	
End distance	e	1175. 45	mm	46. 28	in	
Stiff bearing length	N	1324	mm	52, 13	in	
Yield stress	Fy	345	N/mm2	50	ksi	
Include One - third overstress ?	yes					
Factored load	Pbf	1549 . 16	KN	348 . 27	lbf	
Web Depth	h	1448	mm	57 . 01	in	
Clear web depth	dc	1409. 9	mm	55. 51	in	
(d - dc) / 2	K	57. 05	mm	2 . 25	in	

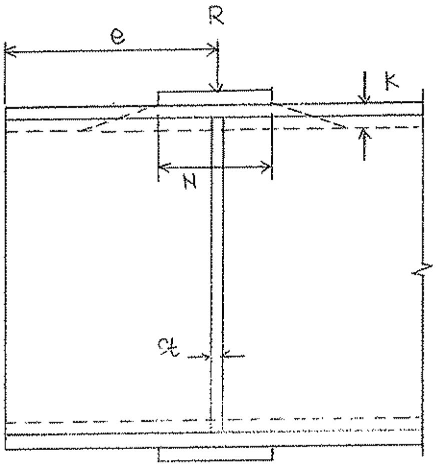
JOB NO. : I / 0310

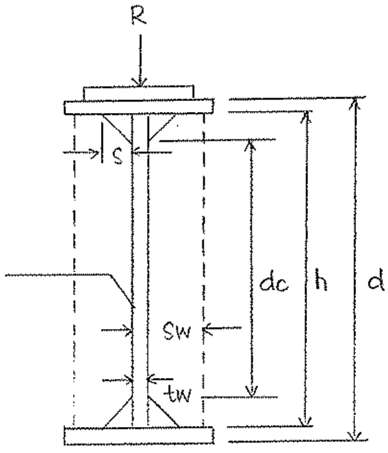
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.47





Flange restraint

☑ Rotationally unrestraint
☐ Rotationally restraint

Design Basis

☑ Load applied to one flange
☐ Load applied to both flange

LOCAL MEMBER CHECKS

K 1 2 Local Flange Bending

$0.4 \times \sqrt{Pbf / Fy}$ = 1.06 in

= 26.8 mm < 38 mm (tf)

No stiffener Required

K.1 3 Local Web yielding (Bearing)

→ concentrated load applied at or near the end of the member (less than member dep

$\frac{R}{tw \times (N + 2.5 K)}$ = 4.02 ksi

= 27.75 N/mm² < 228 N/mm² (0.66 Fy)

. UC = 0.12

No stiffener required

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : RT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.48

K 1.4 Web Crippling (Buckling)

→ concentrated load is applied more than a distance d/2 from the end of the member

$$R = 67.5\ tw^2 \left(1 + 3 \left(\frac{N}{d}\right)\left(\frac{tw}{tf}\right)^{1.5}\right) \sqrt{Fy \cdot tf / tw}$$

$= 1881.24$ kips

$= 8368.17$ KN $>$ 1161.87 KN (R)

UC = 0.14 → No stiffener Required

K 1.5 Sideway web buckling

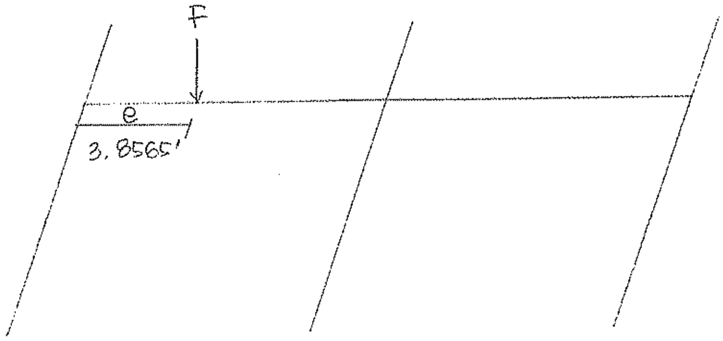
$$\frac{dc / tw}{l / bf} = 6.2 > 1.7$$ → No stiffener Required

K.1.6 Compression Buckling of the web

$$\frac{4100\ tw^3 \sqrt{Fy}}{Pbf} = 118.57 \text{ in}$$

$= 3011.7$ mm $>$ 1409.9 mm (dc)

stiffener Required



JOB NO. : I / 0310

SHEET NO.: 4.49

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

Stiffened Webs and Flanges Under Concentrated Forces

GRILLAGE 1 PART 2

Input Data

Compressive Force	R	4423, 42	KN	994, 42	kips	(sheet 4.5)
Enhancement factor (for Pbf)		1, 33				
Web thickness	tw	28 , 58	mm	1, 12	in	
Flange thickness	tf	38	mm	1, 50	in	
Overall member depth	d	1524	mm	60	in	
Flange Breadth	bf	380	mm	14, 96	in	
Root radius / weld size	r	19, 05	mm	0,75	in	
Unbraced length of flange	l	3048	mm	120	in	
End distance	e	630, 24	mm	24, 81	in	
Stiff bearing length	N	1324	mm	52, 13	in	
Yield stress	Fy	345	N/mm2	50	ksi	
Include One - third overstress ?	yes					
Factored load	Pbf	5897 , 89	KN	1325. 90	lbf	
Web Depth	h	1448	mm	57 , 01	in	
Clear web depth	dc	1409, 9	mm	55, 51	in	
(d - dc) / 2	k	57, 05	mm	2 , 25	in	

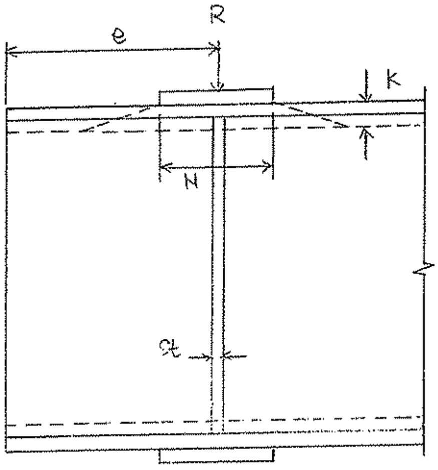
JOB NO. : I / 0310

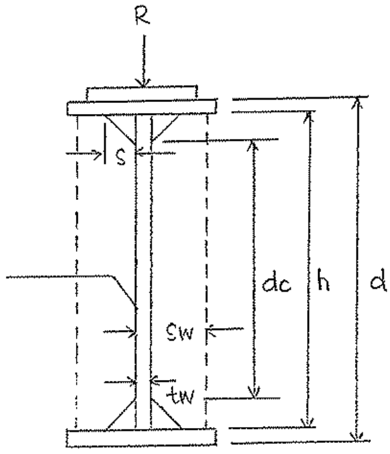
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4 50





Flange restraint

☑ Rotationally unrestraint
☐ Rotationally restraint

Design Basis

☑ Load applied to one flange
☐ Load applied to both flange

LOCAL MEMBER CHECKS

K 1 2 Local Flange Bending

$0.4 \times \sqrt{Pbf / Fy}$ = 2.06 in

= 52.3 mm > 38 mm (tf)

Stiffener Required

K.1 3 Local Web Yielding (Bearing)

→ concentrated load applied at or near the end of the member (less than member dep

$\frac{R}{tw \times (N + 2.5 K)}$ = 15.31 ksi

105.63 N/mm² < 228 N/mm² (0.66 Fy)

UC = 0.46

No stiffener required

K 1.4 Web Crippling (Buckling)

→ concentrated load is applied less than a distance d/2 from the end of the member

$R = 34\ tw^2 \left(1 + 3 \left(\frac{N}{d}\right)\left(\frac{tw}{tf}\right)^{1.5}\right) \sqrt{Fy \cdot tf / tw}$

= 949. 59 kips

= 4215 . 08 KN < 4423. 42 KN (R)

UC = 1.05 → stiffener Required

K 1.5 Sideway web buckling

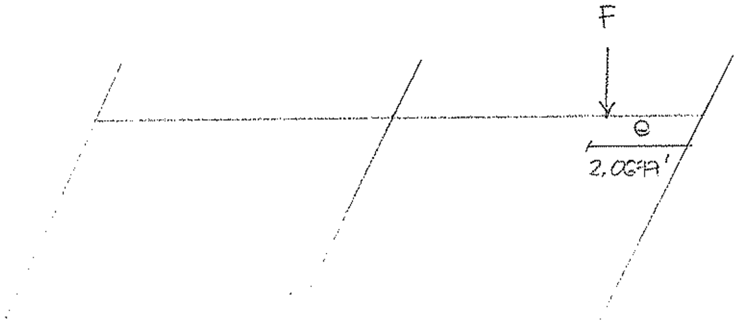
$\frac{dc / tw}{l / bf}$ = 6.2 > 1.7 → No stiffener Required

K.1.6 Compression Buckling of the web

$\frac{4100\ tw^3 \sqrt{Fy}}{Pbf}$ = 31. 14 in

= 791. 06 mm < 1409.9 mm (dc)

stiffener Required



JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : RT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4 52

Stiffened Webs and Flanges Under Concentrated Forces

GRILLAGE 2 PART 1

Input Data

Compressive Force	R	3407.50	KN	766,04	kips	(sheet 4 5)
Enhancement factor (for Pbf)		1,33				
Web thickness	tw	28.58	mm	1,12	in	
Flange thickness	tf	38	mm	1,50	in	
Overall member depth	d	1524	mm	60	in	
Flange Breadth	bf	380	mm	14,96	in	
Root radius / weld size	r	19,05	mm	0,75	in	
Unbraced length of flange	l	3048	mm	120	in	
End distance	e	300,04	mm	11,81	in	
Stiff bearing length	N	1324	mm	52,13	in	
Yield stress	Fy	345	N/mm2	50	ksi	
Include One-third overstress ?	yes					
Factored load	Pbf	4543.33	KN	1021,38	lbf	
Web Depth	h	1448	mm	57,01	in	
Clear web depth	dc	1409,9	mm	55,51	in	
(d-dc)/2	K	57,05	mm	2,25	in	

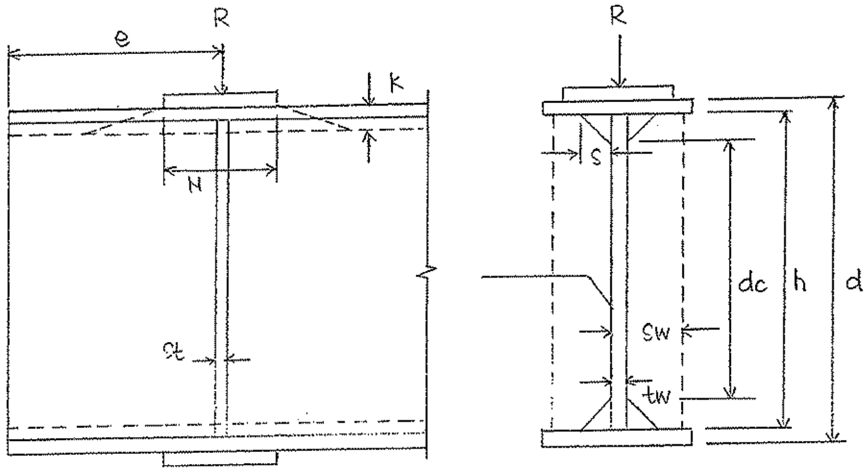
JOB NO. : I /0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4 53



Flange restraint

☑ Rotationally unrestraint
☐ Rotationally restraint

Design Basis

☑ Load applied to one flange
☐ Load applied to both flange

LOCAL MEMBER CHECKS

K 1 2 Local Flange Bending

$0,4 \times \sqrt{Pbf / Fy}$ = 1.81 in

= 45.90 mm > 38 mm (tf)

stiffener required

K.1 3 Local Web Yielding (Bearing)

→ concentrated load applied at or near the end of the member (less than member dep

$\frac{R}{tw \times (N + 2.5 k)}$ = 11.79 ksi

= 81.37 N/mm^2 < 228 N/mm^2 (0,66 Fy)

UC = 0,36 → No stiffener Required

K 1.4 Web Crippling (Buckling)

→ concentrated load is applied less than a distance d/2 from the end of the member

$R = 34\ tw^2 \left(1 + 3 \left(\frac{N}{d}\right)\left(\frac{tw}{tf}\right)^{1.5} \right) \sqrt{Fy \cdot tf / tw}$

$= 947.59$ kips

$= 4215.08$ KN > 3409.5 KN (R)

UC = 0.81 → No stiffener required

K 1.5 Sideway web buckling

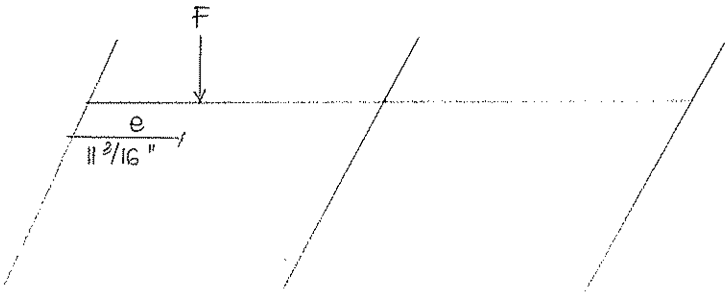
$\frac{dc / tw}{l / bf} = 6.2 > 1.7$ → No stiffener required

K.1.6 Compression Buckling of the web

$\frac{4100\ tw^3 \sqrt{Fy}}{Pbf} = 40.43$ in

$= 1026.92$ mm < 1409.9 mm (dc)

No stiffener Required



JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : ST 400 - RP01

DATE : 30 May 2007

SHEET NO.: 4 55

Stiffened Webs and Flanges Under Concentrated Forces

GRILLAGE 2 part 2

Input Data

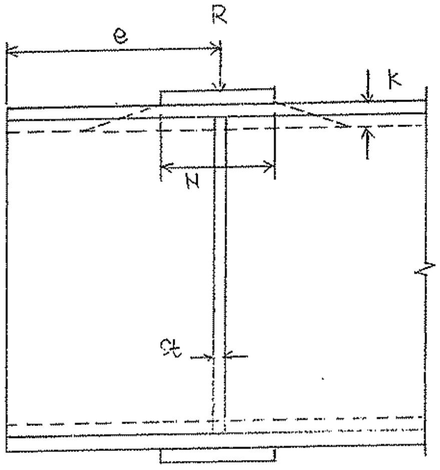
Compressive Force	R	3156. 53	KN	709. 62	kips	(sheet 4 5)
Enhancement factor (for Pbf)		1. 33				
Web thickness	tw	28 . 58	mm	1. 12	in	
Flange thickness	tf	38	mm	1. 50	in	
Overall member depth	d	1524	mm	60	in	
Flange Breadth	bf	380	mm	14, 96	in	
Root radius / weld size	r	19, 05	mm	075	in	
Unbraced length of flange	l	3048	mm	120	in	
End distance	e	782. 64	mm	30. 81	in	
Stiff bearing length	N	1324	mm	52, 13	in	
Yield stress	Fy	345	N/mm^2	50	ksi	
Include One - third overstress ?	yes					
Factored load	Pbf	4208. 71	KN	946. 16	lbf	
Web Depth	h	1448	mm	57 , 01	in	
Clear web depth	dc	1409. 9	mm	55. 51	in	
(d-dc)/2	k	57, 05	mm	2. 25	in	

JOB NO. : I / 0310

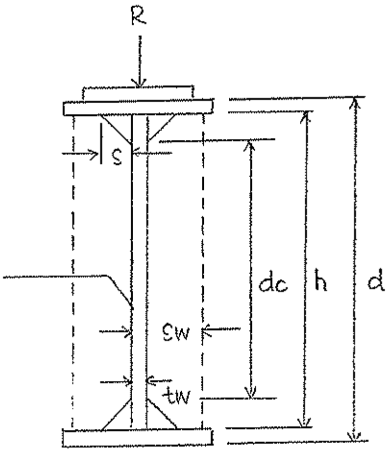
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP01

DATE : 30 May 2007



Flange restraint



Design Basis

☑ Rotationally unrestraint
☐ Rotationally restraint

☑ Load applied to one flange
☐ Load applied to both flange

LOCAL MEMBER CHECKS

K 1 2 Local Flange Bending

$0{,}4 \times \sqrt{Pbf / Fy} = 1{,}74$ in

$= 44{,}18$ mm $>$ 38 mm (tf)

stiffener Required

K.1 3 Local Web Yielding (Bearing)

→ concentrated load applied at or near the end of the member (less than member de

$\frac{R}{tw \times (N + 2{,}5k)} = 10{,}92$ ksi

$= 75{,}38$ N/mm² $<$ 228 N/mm² (0,66 Fy)

UC = 0,33 → No stiffener required

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 20 May 2007

SHEET NO.: 4.57

K 1.4 Web Crippling (Buckling)

→ concentrated load is applied less than a distance d/2 from the end of the member

$$R = 69.5\ tw^2 \left(1 + 3 \left(\frac{N}{d}\right)\left(\frac{tw}{tf}\right)^{1.5} \right) \sqrt{Fy\ \ tf/tw}$$

$= 1881.24$ kips

$= 8368.17$ KN $>$ 3156.53 KN (R)

UC $= 0.38$ → No stiffener required

K 1.5 Sideway web buckling

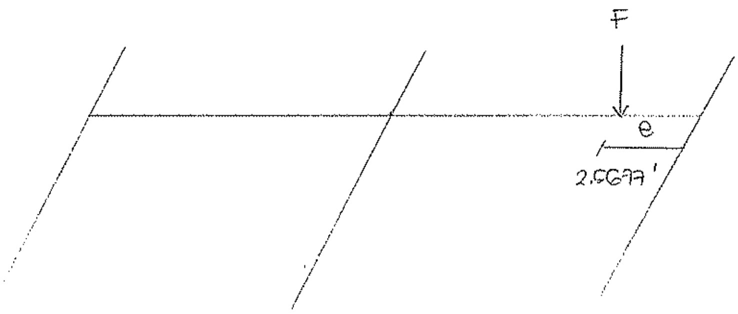
$$\frac{dc/tw}{l/bf} = 6.2 > 1.7$$ → No stiffener required

K.1.6 Compression Buckling of the web

$$\frac{4100\ tw^3 \sqrt{Fy}}{Pbf} = 43.64 \text{ in}$$

$= 1108.56$ mm $<$ 1409.9 mm

No stiffener required



JOB NO. : I / 0310

SHEET NO.: 4.58

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2009

Stiffened Webs and Flanges Under Concentrated Forces

GRILLAGE 3 PART 1

Input Data

Compressive Force	R	3886,47	KN	873,71	kips	(sheet 4.5
Enhancement factor (for Pbf)		1,33				
Web thickness	tw	28,58	mm	1,12	in	
Flange thickness	tf	38	mm	1.50	in	
Overall member depth	d	1524	mm	60	in	
Flange Breadth	bf	380	mm	14,96	in	
Root radius / weld size	r	19,05	mm	0.75	in	
Unbraced length of flange	l	3048	mm	120	in	
End distance	e	147,64	mm	5,81	in	
Stiff bearing length	N	1324	mm	52,13	in	
Yield stress	Fy	345	N/mm2	50	ksi	
Include One-third overstress ?	yes					
Factored load	Pbf	5181,96	kN	1164.95	lbf	
Web Depth	h	1448	mm	57,01	in	
Clear web depth	dc	1409.9	mm	55,51	in	
(d-dc)/2	k	57,05	mm	2,25	in	

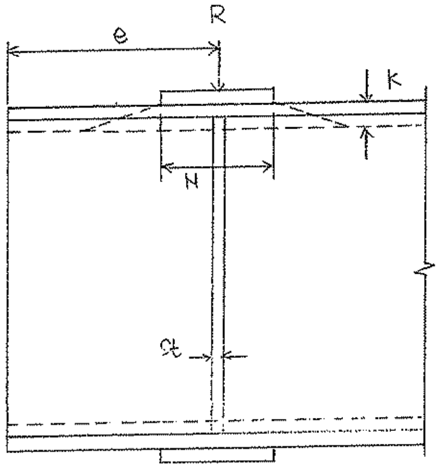
JOB NO. : I / 0310

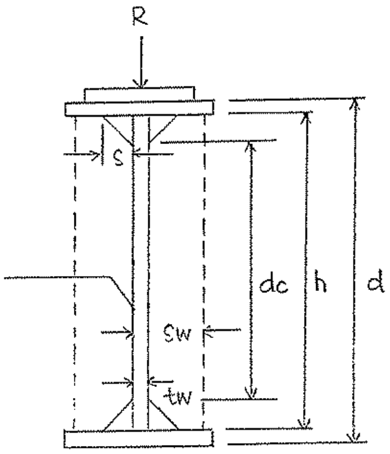
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.59





Flange restraint

Design Basis

☑ Rotationally unrestraint
☐ Rotationally restraint

☑ Load applied to one flange
☐ Load applied to both flange

LOCAL MEMBER CHECKS

K 1 2 Local Flange Bending

$0.4 \times \sqrt{Pbf / Fy}$ = 1.93 in

= 49.02 mm > 38 mm (tf)

Stiffener required

K.1 3 Local Web Yielding (Bearing)

→ concentrated load applied at or near the end of the member (less than member dep

$\frac{R}{tw \times (N + 2.5 k)}$ = 13.45 ksi

= 92.81 N/mm² < 228 N/mm² (0.66 Fy)

UC = 0.41 → No stiffener required

K 1.4 Web Crippling (Buckling)

→ concentrated load is applied less than a distance d/2 from the end of the member

$R = 34\ tw^2 \left(1 + 3 \left(\frac{N}{d}\right)\left(\frac{tw}{tf}\right)^{1.5} \right) \sqrt{Fy \cdot tf / tw}$

$= 947.59$ kips

$= 4215.06$ kN > 3886.47 kN (R)

UC = 0.92 → No stiffener required

K 1.5 Sideway web buckling

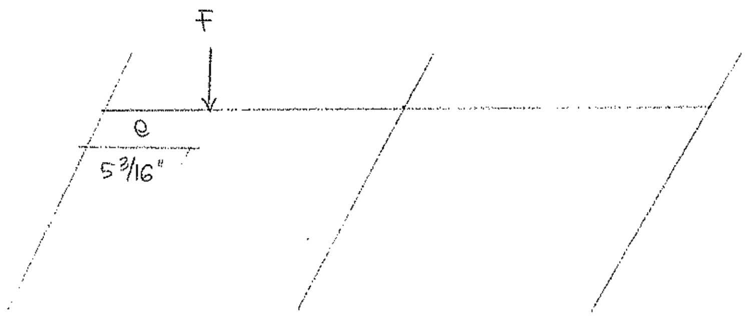
$\frac{dc / tw}{l / bf} = 6.2 > 1.7$ → No stiffener required

K.1.6 Compression Buckling of the web

$\frac{4100\ tw^3 \sqrt{Fy}}{Pbf} = 35.45$ in

$= 900.36$ mm < 1409.9 mm (dc)

No stiffener required



JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.61

Stiffened Webs and Flanges Under Concentrated Forces

GRILLAGE 3 part 2

Input Data

Compressive Force	R	1600,21	KN	359,94	kips	(sheet 4.5)
Enhancement factor (for Pbf)		1,33				
Web thickness	tw	28,58	mm	1,12	in	
Flange thickness	tf	38	mm	1,50	in	
Overall member depth	d	1524	mm	60	in	
Flange Breadth	bf	380	mm	14,96	in	
Root radius / weld size	r	19,05	mm	0,75	in	
Unbraced length of flange	l	3048	mm	120	in	
End distance	e	2181.92	mm	85,9	in	
Stiff bearing length	N	1324	mm	52,13	in	
Yield stress	Fy	345	N/mm2	50	ksi	
Include One-third overstress ?	yes					
Factored load	Pbf	2133.61	KN	479.65	lbf	
Web Depth	h	1448	mm	57,01	in	
Clear web depth	dc	1409,9	mm	55,51	in	
(d-dc)/2	k	57,05	mm	2,25	in	

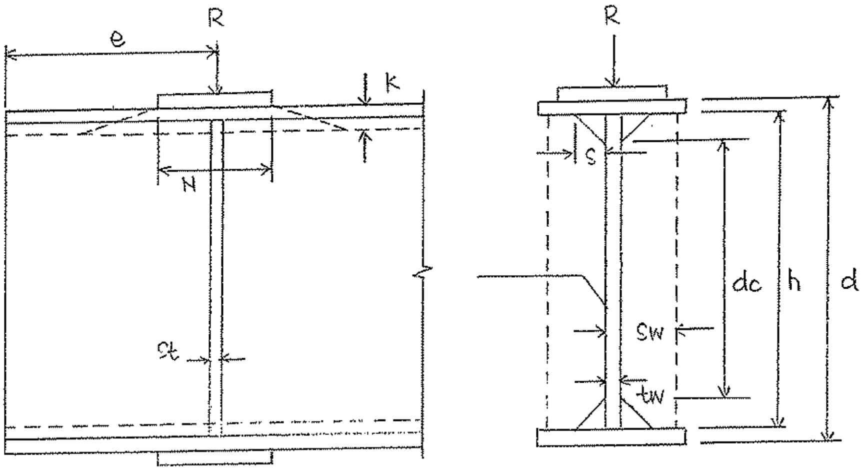
JOB NO. : 1 / 0310

SHEET NO.: 4.62

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007



Flange restraint

☑ Rotationally unrestraint
☐ Rotationally restraint

Design Basis

☑ Load applied to one flange
☐ Load applied to both flange

LOCAL MEMBER CHECKS

K 1 2 Local Flange Bending

$0.4 \times \sqrt{Pbf / Fy}$ = 1.24 in

= 31.46 mm < 38 mm (tf)

No stiffener required

K.1 3 Local Web Yielding (Bearing)

→ concentrated load applied at a distance from the member end (more than member dep

$\frac{R}{tw \times (N + 5k)}$ = 5.05 ksi

= 34.83 N/mm² < 228 N/mm² (0.66 Fy)

UC = 0.15 → No stiffener required

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.63

K.1.4 Web Crippling (Buckling)

→ concentrated load is applied more than a distance d/2 from the end of the member

$R = 67.5\ tw^2 \left(1 + 3 \left(\frac{N}{d}\right)\left(\frac{tw}{tf}\right)^{1.5} \right) \sqrt{Fy \cdot tf / tw}$

= 1881.24 kips

= 8368.17 kN > 1600.21 kN (R)

UC = 0.19 → No stiffener required

K.1.5 Sideway web buckling

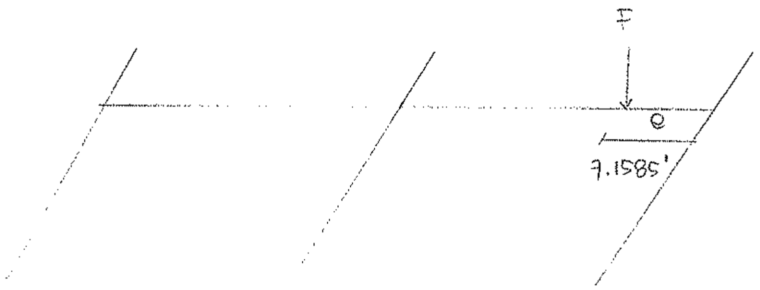
$\frac{dc / tw}{l / bf} = 6.2 > 1.7$ → No stiffener required

K.1.6 Compression Buckling of the web

$\frac{4100\ tw^3 \sqrt{Fy}}{Pbf} = 86.09$ in

= 2186.73 mm > 1409.9 mm (dc)

stiffener required



JOB NO. : I / 0310

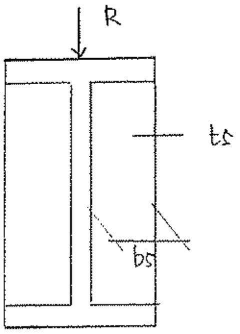
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.64

STIFFENERS



$bf = 380$ mm (15 in)

$tf = 38$ mm (1,5 in)

$tw = 28,58$ mm (1,125 in)

$H = 1524$ mm (60 in)

$dw = 1448$ mm (57 in)

$Fy = 50$ mm (345 N/mm^2)

$bs = (380 - 28,58)/2 = 175,71$ mm

Check shear

$H/tw = 1524 / 28.58 = 53.33$

Type	Shear Force (KN)	$\tau = V.S/(tw\ I)$ (N/mm^2)	a (mm)	a/H	τall (N/mm^2)	U.C	
GRILLAGE 1	3294.05	53,36	2434	1,60	137,90	0,39	No stiffener required
GRILLAGE 2	2855,93	46,26	2764	1.81	134,45	0,34	No stiffener required
GRILLAGE 3	3591,81	58,19	2916	1,91	134.45	0,43	No stiffener required

↓
Table AISC
(allowable shear stress in web of plate gird

Type	Shear force (KN)	$\tau_1 = V.S (tw\ 1)$ (N/mm^2)	τall = 0,4 Fy (N/mm^2)	U.C	
GRILLAGE 1	3294,05	53,36	138	0,39	No stiffener required
GRILLAGE 2	2855,93	46,26	138	0,34	No stiffener required
GRILLAGE 3	3591,81	58,19	138	0,42	No stiffener required

Transverse Intermediate stiffeners

$dw / tw = 1448 / 28.58 = 50,67 < 260$ → No stiffener required

Bearing stiffeners

actual bending stress in girder :

Type	Moment (kNm)	$\sigma = M/w$ (N/mm²)	$\sigma_{all} = 0.66 Fy$ (N/mm²)	UC	
Grillage 1	2062.73	67.82	227,6	0,30	No stiffener required
Grillage 2	1693.91	53,91	227.6	0,24	No stiffener required
Grillage 3	224. 13	7.37	227,6	0,03	No stiffener required

Check if bearing stiffeners are needed at the point of load :

compressive stress at web toe of girder fillet :

$N = 423$ mm
$K = tf + w = 38 + 19.05 = 57,1$ mm

Grillage 1
$$\sigma = \frac{R}{tw\ (N + 2K)} \leq 0,75\ Fy$$

$$= \frac{3294.05 \quad 10^{3}}{28.58\ (423 + 2 \quad 57,1)} \leq 0,75 \quad 345$$

$$= 214.63 \text{ N/mm}^2 \leq 258,64 \text{ N/mm}^2$$

$$UC = \frac{214,63}{258,64}$$

$= 0,83$ → No stiffener required

Grillage 2
$$\sigma = \frac{R}{tw\ (N + 2K)} \leq 0,75\ Fy$$

$$= \frac{2855.93 \quad 10^{3}}{28.58\ (423 + 2 \quad 57,01)} \leq 0,75 \quad 345$$

$$= 186.08 \text{ N/mm}^2 \leq 258,64 \text{ N/mm}^2$$

$$U.C = \frac{186.08}{258.64}$$

$$= 0.72 \rightarrow \text{No stiffener Required}$$

Grillage 3 :

$$\sigma = \frac{R}{tw\ (N + 2K)} \leq 0.75\ Fy$$

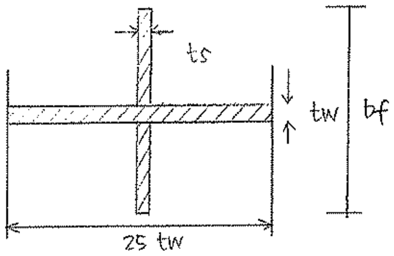
$$= \frac{3591.81\ \ 10^{3}}{28.58\ \ (423 + 2\ \ 57.1)} \leq 0.75\ \ 345$$

$$= 224.03\ N/mm^{2} < 258.64\ N/mm^{2}$$

$$U\ C = \frac{}{258.64}$$

$$= 0.90 \rightarrow \text{No stiffener required}$$

Stiffener Dimensions



$$\sigma all = 0.66\ Fy$$

$$= 0.66\ \ 345$$

$$= 227.6\ N/mm^{2}$$

Type	Shear Force (KN)	A = R / σall (mm²)	25 tw (mm)	A web (mm²)	As (mm²)	ts = As / 2bs (mm)
Grillage 1	3294.05	14472.68	714.38	20413.27	13358.68	38.01
Grillage 2	2855.93	12547.76	714.38	20413.27	-7865.50	-22.38
Grillage 3	3591.81	15780.91	714.38	20413.27	-4632.35	-13.18

To prevent local stiffener buckling

$$\frac{bs}{ts} \leq \frac{R}{\sigma}$$

$$\frac{175.71}{ts} \leq \frac{95}{\sqrt{50}}$$

$$ts \geq 13.08 \rightarrow ts = 28.58\ mm$$

$A_{web + stiffener} = 25\ tw\ \ tw + 2\ bc \cdot ts$

$= 914.38 \cdot 28.6 + 2\ \ 175.71\ \ 28.58$

$= 30\,456.99\ mm^2$

Type	Shear force (KN)	$\sigma_{actual} = V / A_{web+stiff}$ (N/mm²)	$\sigma_{all} = 0.66\ Fy$ (N/mm²)	U.C	
Grillage 1	3294.05	108.15	227.6	0.48	OK
Grillage 2	2855.93	93.77	227.6	0.41	OK
Grillage 3	3591.81	117.93	227.6	0.52	OK

Check stiffener profile area as a column

$$I_x = \frac{ts\ \ bf^3}{12} + \frac{(25\ tw - ts)\ \ tw^3}{12}$$

$$= \frac{28.58 \cdot 380^2}{12} + \frac{(25\ \ 28.58 - 28.58)\ \ 28.58^2}{12}$$

$$= 132\,020\,248.1\ mm^4$$

$$r_x = \sqrt{\frac{I_x}{A}}$$

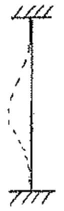
$$= \sqrt{\frac{132\,020\,248.1}{30\,456.99}}$$

$$= 65.84\ mm$$

Slenderness Ratio

$$\frac{K\ Le}{r_x} = \frac{0,65 \times 1448}{65,84}$$

$$= 14,3$$



K = 0,65 ; Le = dw.

→ allowable compressive stress = 28780 psi = 198,43 N/mm²
(Table II AISC - 50 000 psi yield members)

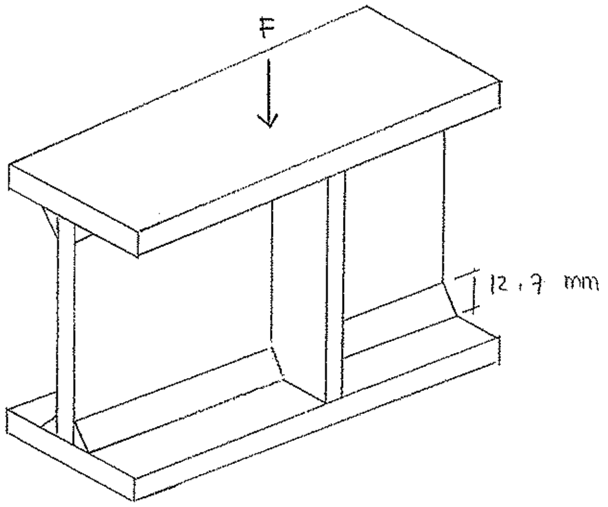
$F = \sigma \times A$

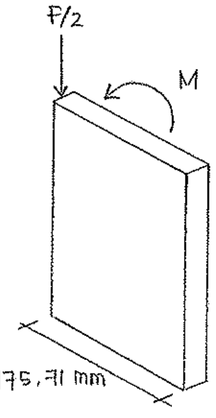
$= 198,431 \times 30456,99$

$= 6043615$ N

: 6043,615 kN > 3591,81 kN (max shear force) → OK

Determine the size of fillet weld joining stiffeners to the beam web





GRILLAGE 1

Length of fillet weld = dw - 2 w = 1448 - 2. 19,05 = 1409,9 mm

F = 3294 ,05 kN

M = F/2 1/2 bs

= 3294 ,05 10^3 / 2 . 1/2 175.71

= 144 701 440, 2 Nmm

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : RT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4 69

$$\tau_{/\!/} = \frac{F}{2aL}$$

$$= \frac{3294,05 \cdot 10^3}{2 \;\; a \;\; 1409,9}$$

$$= 1168,19 \,/ a$$

$$\tau_{\perp} = \frac{M}{2 . a L^2}$$

$$= \frac{144\;701\;440,2}{2 \;\; a \;\; 1409,9^2}$$

$$= 36,40 \,/ a$$

Check shear

$\tau_{/\!/} = 1168,19 \,/ a$; $\tau_{all} = 0,4\ Fy = 138\ N/mm^2$

$138 = 1168,19 \,/ a$

$a = 8,5$ mm

$\tau_{\perp} = 36,4 \,/ a$

$138 = 36,4 \,/ a$

$a = 0,26$ mm

Check combine stress

$$\tau_c = \sqrt{\tau_{\perp}^2 + \tau_{/\!/}^2}$$

$$138 = \sqrt{(1168,19/a)^2 + (36,40/a)^2}$$

$a = 8.5$ mm

$$\left.\begin{array}{l} \rightarrow \quad a = 8,47 \text{ mm} \\ w = a\sqrt{2} = 11,98 \text{ mm} \\ w \text{ min} = 3/8 \text{ in} \quad (9.53 \text{ mm}) \\ w \text{ max} = 28,58 \text{ mm} \quad (1,13 \text{ in}) \end{array}\right\} \begin{array}{l} w = 0,75 \text{ in} \quad (19,05 \text{ mm}) \\ a = 0,53 \text{ in} \quad (13,5 \text{ mm}) \end{array}$$

JOB NO. : I / 0310

SHEET NO.: 4 70

COMP'D BY : Fenny

CALC. NO. : RT 400 - RP 01

DATE : 30 May 2007

GRILLAGE 2

Length of fillet weld $= dw - 2 W = 1448 - 2 . 19,05 = 1409.9$ mm

$F = 2855.93$ KN

$M = F/2 \times 1/2 \ bs$

$= 2855.93 \cdot 10^3 /2 \quad 1/2 \quad 175.71$

$= 125\ 455\ 650$ Nmm

$$\tau_{//} = \frac{F}{2 a L}$$

$$= \frac{2855.93 \quad 10^3}{2 \quad a \quad 1409.9}$$

$$= 1012.81 \ / a$$

$$\tau_{\perp} = \frac{M}{2 a L^2}$$

$$= \frac{125\ 455\ 650}{2 \quad a \quad 1409.9^2}$$

$$= 31.56 \ / a$$

Check shear

$\tau_{//} = 1012.81 \ / a$; τ all $= 0.4$ Fy $= 138$ N / mm^2

$138 = 1012.81 \ / a$

$a = 7.34$ mm

$\tau_{\perp} = 31.56 \ / a$

$138 = 31.56 \ / a$

$a = 0.23$ mm

Check combine stress

$$\tau_c = \sqrt{\tau_{\perp}^2 + \tau_{//}^2}$$

$$138 = \sqrt{(1012.81 / a)^2 + (31.56 \ / a)^2} \longrightarrow a = 7.34 \text{ mm}$$

$$\left.\begin{array}{lll} \rightarrow a & = & 7,34 \\ w & = & 10,38 \\ w\ \text{min} & : & 3/8\ \text{in} \\ w\ \text{max} & = & 28,58\ \text{mm} \end{array}\right\} \begin{array}{llll} w & = & 0,75\ \text{in} & (19,05\ \text{mm}) \\ a & = & 0,53\ \text{in} & (13,5\ \text{mm}) \end{array}$$

Grillage 3

Length of fillet weld = dw - 2 w = 1448 - 2 19,05 = 1409,9 mm

$F = 3591 , 81\ \text{kN}$

$M = F/2 \quad . \quad 1/2\ bs$

$= 3591,81 /2 \quad 10^3 \quad 1/2 \quad 175,71$

$= 157\ 781\ 478 , 7\ \text{Nmm}$

$$\tau_{//} = \frac{F}{2\,a\,L} = \frac{3591,81 \quad 10^3}{2 \quad a \quad 1409,9} = 1273,78 \ /a$$

$$\tau_{\perp} = \frac{M}{2\,a\,L^2} = \frac{157\ 781\ 478,7}{2 \quad a \quad 1409,9} = 39,69 \ /a$$

Check shear

$\tau_{//} = 1273,78 \ /a$

$138 = 1273,78 \ /a$

$a = 9,23 \ \text{mm}$

$\tau_{\perp} = 39,69 \ /a$

$138 = 39,69 \ /a$

$a = 0,29 \ \text{mm}$

Check combined stress

$\tau_c = \sqrt{\tau_{\perp}^{\,2} + \tau_{//}^{\,2}}$

$138 = \sqrt{(1273,78\ /a)^2 + (39,69\ /a)^2}$

$138 \quad 1274\ /a$

$a \quad 9,23\ \text{mm}$

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COMP'D BY : Fenny

CALC. NO. : QT 400 – RP 01

DATE : 30 May 2007

SHEET NO.: 4 72

$$\left.\begin{array}{llll} \rightarrow & a & = & 9.23 \text{ mm} \\ & w & = & a\sqrt{2} = 13,06 \text{ mm} \\ & w \text{ min} & = & 3/8 \text{ in} \\ & w \text{ max} & = & 28,58 \text{ mm} \end{array}\right\} \begin{array}{llll} w & = & 0.75 \text{ in} & (19,05 \text{ mm}) \\ a & = & 0.53 \text{ in} & (13,5 \text{ mm}) \end{array}$$

JOB NO. : I /0310

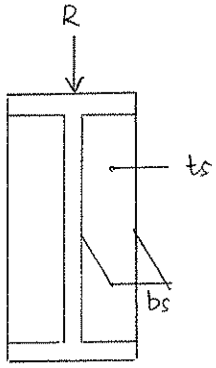
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.73

END STIFFENER (DETAIL A & E)



PG 190 x 1524 x 38 x 25,4

$dw = 1524 - 2 \cdot 38 = 1448$ mm

$bs = (190 - 25,4)/2 = 82,3$ mm

section modulus (S) = $5,36 \cdot 10^6$ mm^3

W = $1,89 \cdot 10^7$ mm^3

Iy = $1,44 \cdot 10^{10}$ mm^4

Check IF bearing stiffener are needed at the girder end :

N = 423 mm

K = tf + w = 38 + 19,05 = 57,1 mm

vertical Reaction (R) = 558 , 48 KN (SACS output)

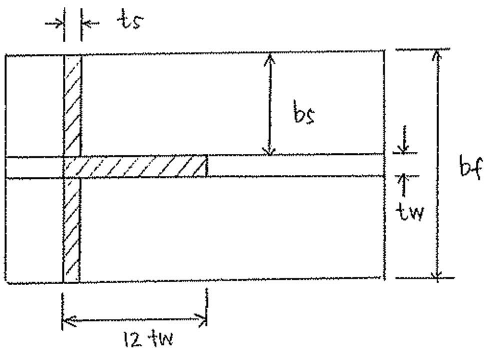
$$\sigma = \frac{R}{tw\,(N + K)} \leq 0,75\ Fy$$

$$= \frac{558,48 \cdot 10^3}{25,4\ (423 + 57,1)} \leq 259\ N/mm^2$$

$$= 45.80\ N/mm^2 \leq 259\ N/mm^2$$

U C = 0,18 / 259 = → no stiffener required

Stiffener Dimensions



$$A\ tot = \frac{R}{\sigma all}$$

$$= \frac{558,48 \cdot 10^3}{0,66 \cdot 345}$$

$= 2452.7$ mm^2

A web = 12 tw . tw

$= 12 \cdot 25,4 \cdot 25,4 = 7741.92$ mm^2

JOB NO. : I / 0310

COMP'D BY : Jenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.74

A stiffener = A tot - A web

= -5289,22 mm ^{2}

ts = A stiff / 2 bs

= - 5289.22 / 2 82.3

= - 32,13 mm

To prevent local stiffener buckling

$$\frac{bs}{ts} \leqslant \frac{95}{\sqrt{Fy}}$$

$$\frac{82,30}{ts} \leqslant \frac{95}{\sqrt{50}}$$

$ts \geqslant 6,13$ mm $\longrightarrow$ $ts = 25,40$ mm

A web + stiffener = 25 tw . tw. + 2 bs ts

= 25 . 25,4 25,4 + 2 82.3 . 25,4

= 20309 . 84 mm ^{2}

σ actual = R / A web + stiff

= 558,48 . 10 ^{3} / 20309 . 84

= 27,5 N/mm ^{2}

U C = σ actual / σall

= 24,74 /(0,66 345)

= 0,12 (OK)

Check stiffener profile area as a column

$$Ix = \frac{ts \cdot bf^3}{12} + \frac{(12\,tw - ts) \cdot tw^3}{12}$$

$$= \frac{25.4 \cdot 190^3}{12} + \frac{(12 \quad 25.4 - 25.4) \cdot 25.4^3}{12}$$

= 14 899 762, 14 mm ^{4}

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : RT 400 - RP 01

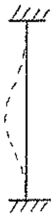
DATE : 30 May 2007

SHEET NO.: 4 75

$$r_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{14\ 889\ 762,14}{20\,309,84}} = 27,09 \text{ mm}$$

Slenderness ratio

$$\frac{K \times L_e}{r_x} = \frac{0,65 \quad 1448}{27,09} = 34,75$$



K = 0,65

$\longrightarrow$ allowable compressive stress = 26490 psi = 182,64 N/mm^2

$F = \sigma \times A$

$= 182,64 \times 20309,84$

$= 3\ 709\ 433$ N

$= 3709,433$ kN $>$ 558,48 kN (OK)

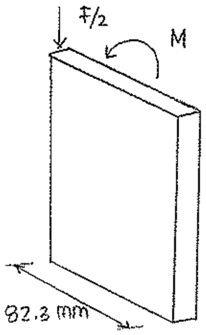
Bearing stress in center stiffener

$\sigma = F / A$

$$= \frac{558,48 \cdot 10^3}{20309,84}$$

$= 27,5 \quad < \quad 0,75\ F_y$ (259 N/mm^2) (OK)

Fillet weld size joining stiffener to the beam web



Length of fillet weld = $d_w - 2w$

$= 1448 - 2 \quad 19,05$

$= 1409,9$ mm

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : RT 400 - RPa

DATE : 30 May 2007

F : 558, 48 kN

M : $F/2 \quad 1/2 \ bc$

: $558,48 . 10^3 / 2 \quad 1/2 \quad 82,3$

: 11 490 726 Nmm

$\tau_{//}$: $\frac{F}{2aL}$

: $\frac{558,48 \ 10^3}{2 \ a \ 1409.9}$

: $198,06 / a$

$\tau_{\perp}$: $\frac{M}{2 \ a \ L^2}$

: $\frac{11 \ 490 \ 726}{2 \ a \ 1409,9^2}$

: $2.89 / a$

Check shear

$\tau_{//}$: $198,06 / a$

$138 = 198.06 / a$

a : 1.44 mm

$\tau_{\perp}$: $2,89 / a$

138 : $2.89 / a$

a = 0,02 mm

Check combine stress

τ_c : $\sqrt{\tau_{//}^2 + \tau_{\perp}^2}$

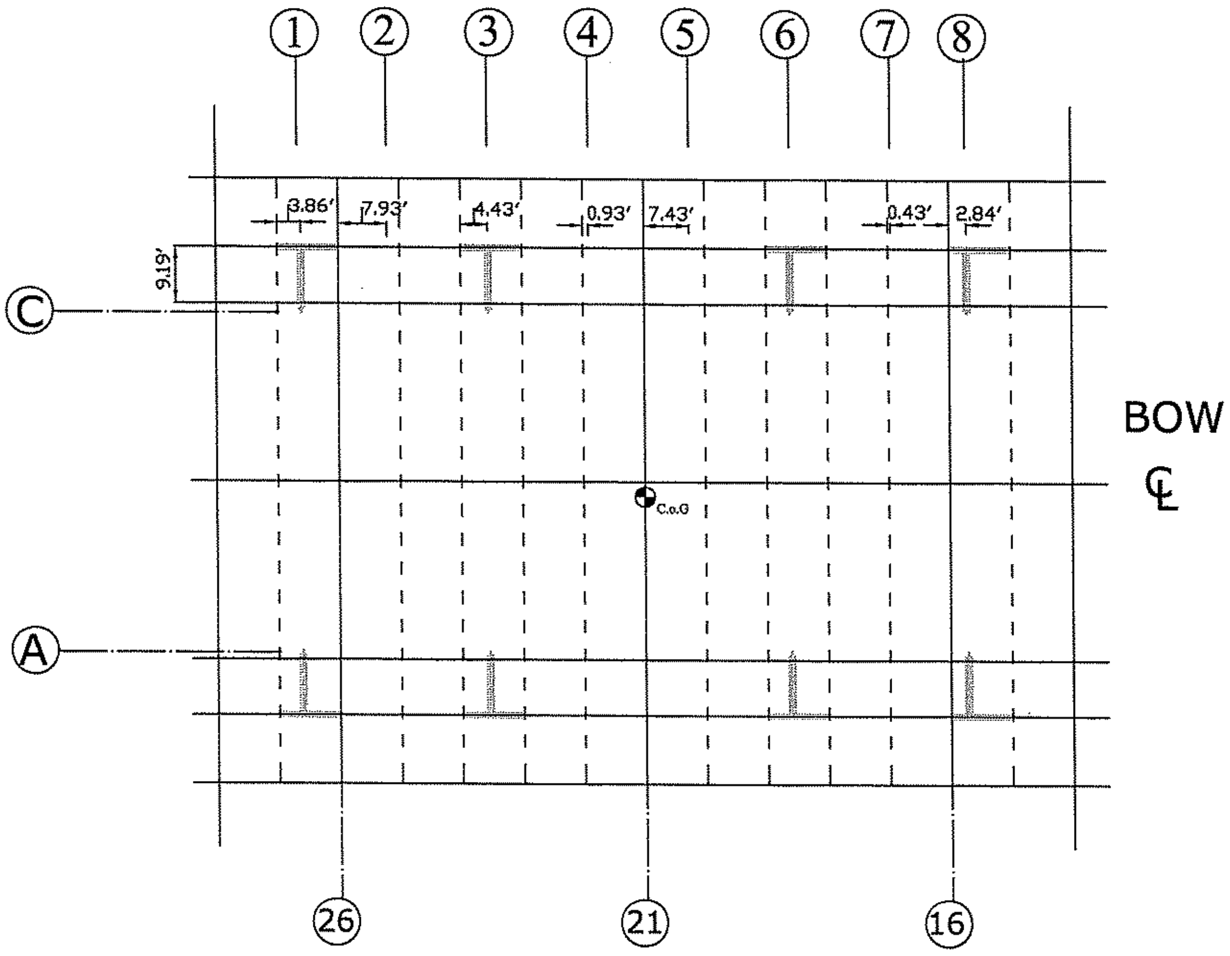
$138 = \sqrt{(198,06 / a)^2 + (2.89 / a)^2}$

a : 1 ,44

→ a : 1.44 mm
w : 2,03 mm
w min : 3/8 in (9,53 mm)
w max : 25,4 mm (1 in)

} w : 0,75 in (19,05 mm)
a : 0,53 in (13,5 mm)

cheet 4.77



Transverse Seafastening Lay out

JOB NO. : I/0310

COMP'D BY : Andrew H.

CALC. NO. : QT400-RP01

DATE : 10th May

SHEET NO.: 4.78

4.4 Seafastening Concept design.

Considerations :

① COG of LQ is located 200' from bow

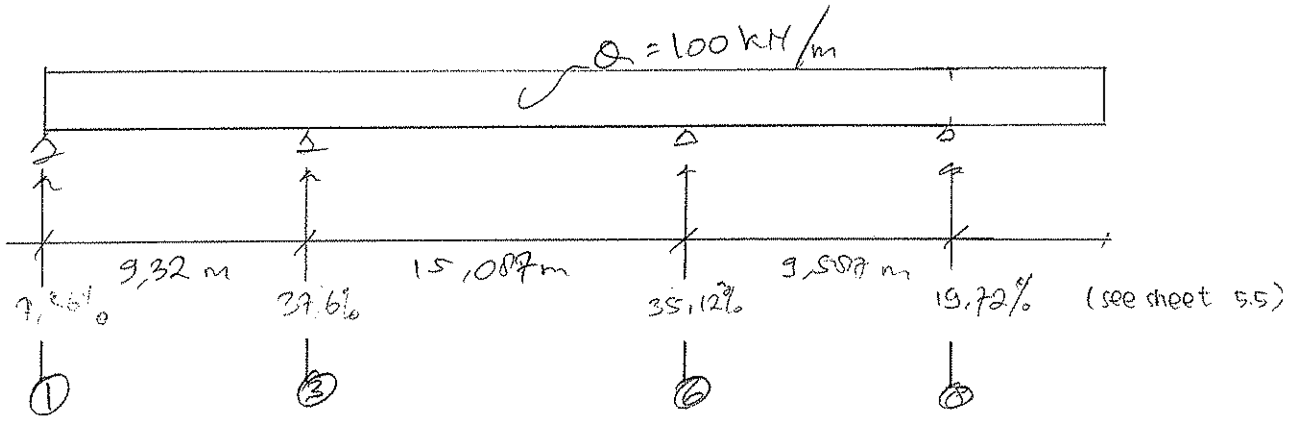
② Roll braces are connected to rows : 1, 3, 6, 8 of LQ

③ Then will be connected to a beam for transfering the load to web frame

④ There are 8 roll braces, 4 in each side.

A. Load distribution

Roll forces



B. Roll forces for each support

Fh = 8832 kN (see sheet 5.4)

Fh in row A = 54% . 8832 = 4808,56 kN

Fh in row C = 46% . 8832 = 4024,08 kN

Design is based on max. load dist. in row 3A

$Fh_{(3A)}$ = 4808,56 . 37,6 %

= 1808,02 kN

JOB NO. : I/0310

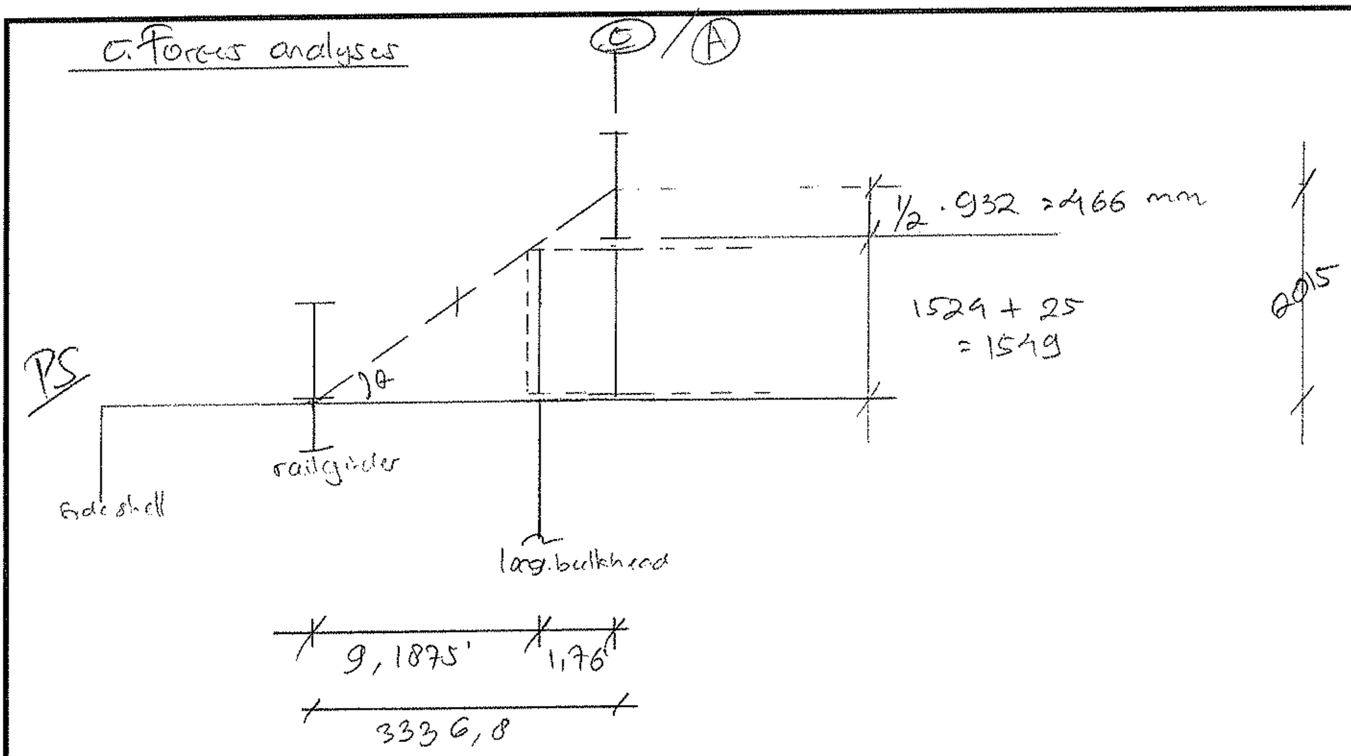
SHEET NO.: 4.79

COMP'D BY : Andrao .H.

CALC. NO. : QT 400-RP01

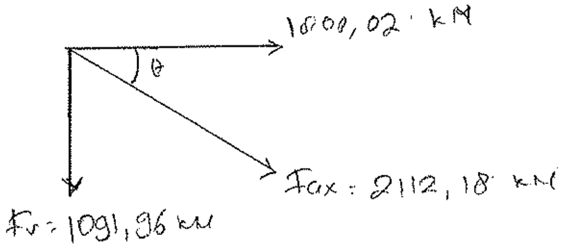
DATE : 10th May

c. Forces analyses



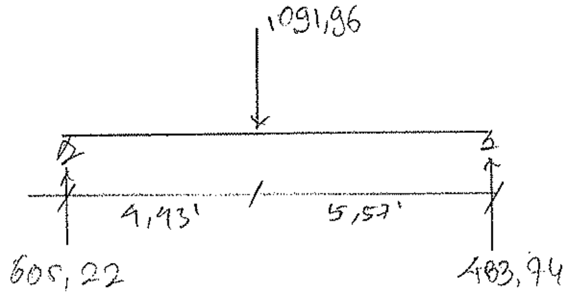
$$\theta = arc.tan \frac{2015}{3336,8}$$

$$= 31,13°$$



notice: Fv can be used as the roll relief

D. Webframe capacity check



(see sheet)

$$uc = \frac{608,22}{926}$$

$$= \underline{\underline{0,66}} \quad \underline{ok!!!}$$

JOB NO. : I/0310

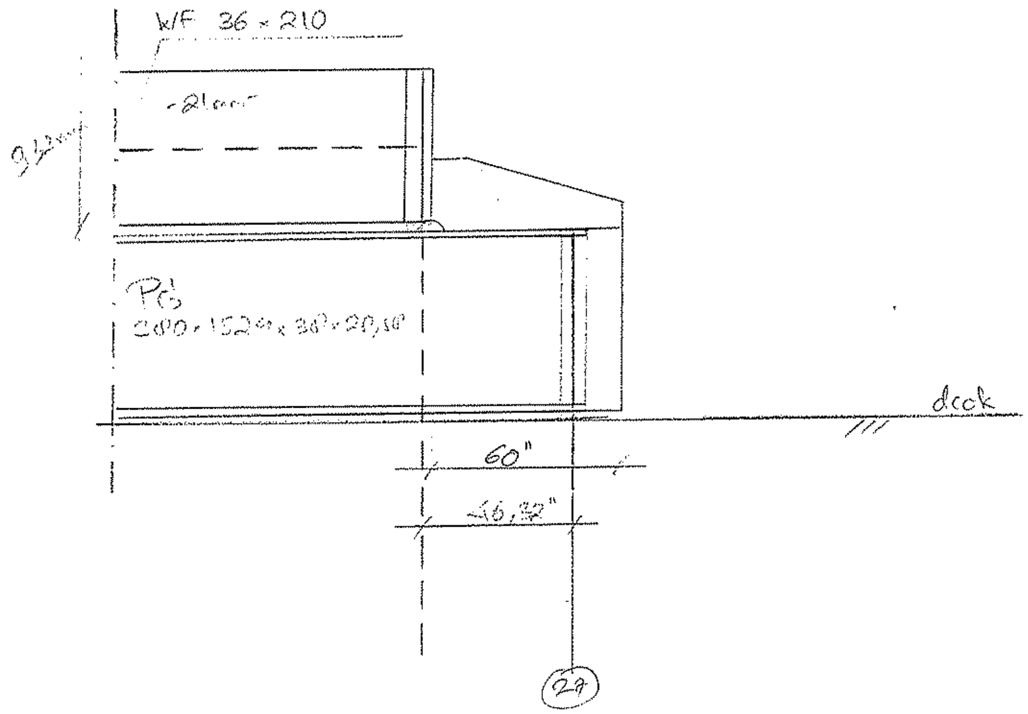
COMP'D BY : Andrew.H.

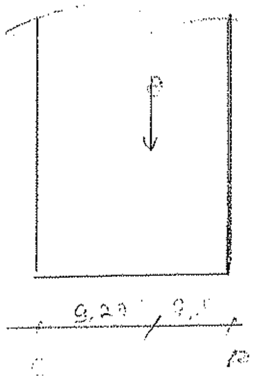
CALC. NO. : QT400-RP01

DATE : 25th Vg., '02

SHEET NO.: 4 80

4 4.1. Pitch stopper design





$$F_{hC} = \frac{5563 \cdot 7,8}{17,07} = 2541,97 \text{ kN}$$

$$F_{hA} = \frac{5563 \cdot 9,29}{17,07} = 3021,03 \text{ kN}$$

JOB NO. : I/0310

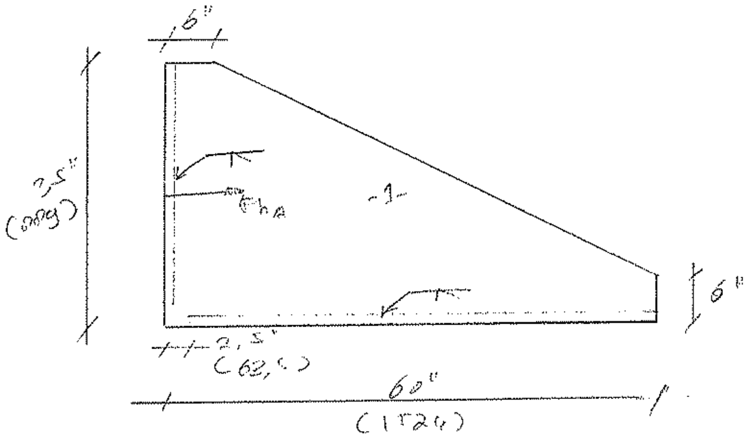
COMP'D BY : Andrew .H.

CALC. NO. : QT400-RP01

DATE : 25th May '02

SHEET NO.: 4.81

Check weld to grillage



$$\tau_{\parallel} = \frac{F_{hA}}{w . l}$$

$$= \frac{3021.10^3}{25,4\ (1524 - 63,5)}$$

$$= 81,44\ N/mm^2$$

$$\tau_{\perp} = \frac{F_{hA} . \frac{1}{2} . 889 . 6}{w . l^2}$$

$$= \frac{3021.10^3 . \frac{1}{6} . 889 . 6}{25,4 . 1460,5^2}$$

$$= 148,71\ N/mm^2$$

$$\tau_c = \sqrt{\tau_{\parallel}^2 + \tau_{\perp}^2}$$

$$= \sqrt{81,44^2 + 148,71^2}$$

$$= 169,55\ N/mm^2$$

Unity Check

$$UC = \frac{\tau_c}{0,66 \sigma_y}$$

$$= \frac{169,55}{0,66 . 345} = \underline{0,74}$$

JOB NO. : I/0310

COMP'D BY : Andrew.H

CALC. NO. : OT400-RP01

DATE : 25th May '07

SHEET NO.: 4 82

Check weld to 2a beam

$w = 21mm$

$l = 35'' = 889\ mm$

$$\tau_{\perp} = \frac{Fha}{w.l}$$

$$= \frac{3021.10^3}{21.889}$$

$$= 161,82\ N/mm^2$$

Unity check

$$UC = \frac{\tau_{\perp}}{0,6\,f_y}$$

$$= \frac{161,82}{0,6.345}$$

$$= \underline{\underline{0,78}} < 1.0\ Ok!$$

JOB NO. : I/0310

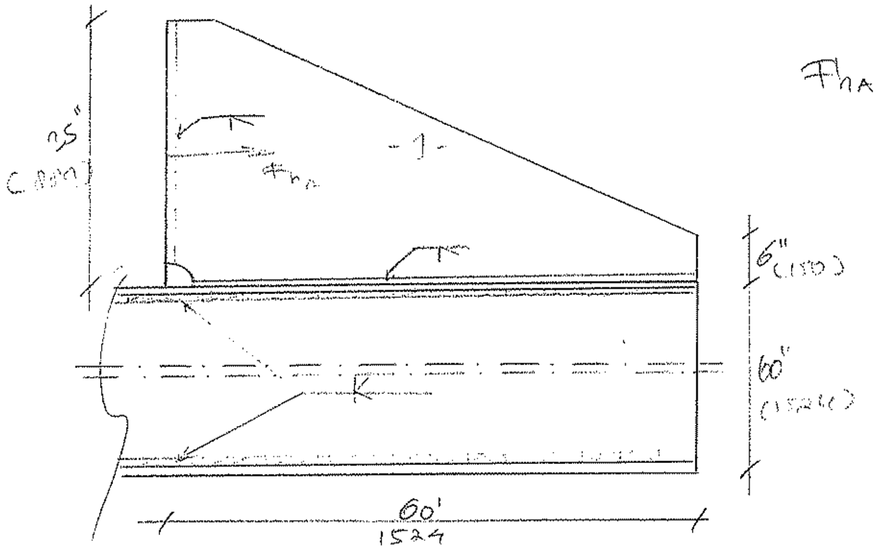
COMP'D BY : Andrew H.

CALC. NO. : QT402-RP01

DATE : 25th May '07

SHEET NO.: 483

Check the welding on grillage beam against the horizontal forces in bracket.



Fha = 3021,03 kN

$$\tau_{\parallel} = \frac{3021,03 \cdot 10^3}{25,4 \cdot 1524}$$

$$= 78,04 \ N/mm^2$$

$$\tau_{\perp} = \frac{3021,03 \cdot 10^3 \cdot 6 \cdot 444,5}{25,4 \cdot 1524^2}$$

$$= 136,58 \ N/mm^2$$

$$\sigma_c \quad \sqrt{78,04^2 + 136,58^2}$$

$$157,3 \ N/mm^2$$

Unity Check

$$UC = \frac{157,3}{0,66 \cdot 345}$$

$$= 0,69 \quad < 1,0 \rightarrow ok!$$

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4 84

4.4.2 ROLL BRACE

Buckling check FOR axially loaded pipes (according AISC WSD 9 th, 1989)

Buckling length	K x L	3898, 01	mm
Axial design load	Fax	2111 , 4	kN
Yield stress	Fy	345	N/mm ^{2}

TUBE PROPERTIES

O.D.	10.75	in	273, 05	mm
w t	0, 718	in	18, 24	mm
G	77, 01	lbs/ft	114, 60	kg/m
A	22, 63	in ^{2}	14599	mm ^{2}
W	53, 23	in ^{3}	872 345, 5	mm ^{3}
I	286, 13	in ^{4}	$1{,}2 \; 10^8$	mm ^{4}
r	3, 56	in	90, 32	mm

Calculation Results

Slenderness	KL / r	43, 16		
Cc		106, 97		
Allowable stress		173, 54	N/mm ^{2}	
Actual stress	Fax / A	144, 62	N / mm ^{2}	
U.C.		0, 83	→	O.K

Dimensions of Welded and Seamless Steel Pipe (ASA B36.10)*

(Listed by Schedule Numbers)

Nom. Pipe Size	Outside Diameter	Nominal Wall Thickness (all in inches)									
		Sched 10	Sched 20	Sched 30	Sched 40	Sched 60	Sched 80	Sched 100	Sched 120	Sched 140	Sched 160
1/8	0.405	-	-	-	0.068	-	0.095	-	-	-	-
1/4	0.540	-	-	-	0.088	-	0.119	-	-	-	-
3/8	0.675	-	-	-	0.091	-	0.126	-	-	-	-
1/2	0.840	-	-	-	0.109	-	0.147	-	-	-	0.187
3/4	1.050	-	-	-	0.113	-	0.154	-	-	-	0.218
1	1.315	-	-	-	0.133	-	0.179	-	-	-	0.250
1 1/4	1.660	-	-	-	0.140	-	0.191	-	-	-	0.250
1 1/2	1.900	-	-	-	0.145	-	0.200	-	-	-	0.281
2	2.375	-	-	-	0.154	-	0.218	-	-	-	0.343
2 1/2	2.875	-	-	-	0.203	-	0.276	-	-	-	0.375
3	3.500	-	-	-	0.216	-	0.300	-	-	-	0.438
3 1/2	4.000	-	-	-	0.226	-	0.318	-	-	-	-
4	4.500	-	-	-	0.237	-	0.337	-	0.438	-	0.531
5	5.563	-	-	-	0.258	-	0.375	-	0.500	-	0.625
6	6.625	-	-	-	0.280	-	0.432	-	0.562	-	0.718
8	8.625	-	0.250	0.277	0.322	0.406	0.500	0.593	0.718	0.812	0.906
10	10.750	-	0.250	0.307	0.365	0.500	0.593	0.718	0.843	1.000	1.125
12	12.750	-	0.250	0.330	0.406	0.562	0.687	0.843	1.000	1.125	1.312
14	14.000	0.250	0.312	0.375	0.438	0.593	0.750	0.937	1.093	1.250	1.406
16	16.000	0.250	0.312	0.375	0.500	0.656	0.843	1.031	1.218	1.438	1.593
18	18.000	0.250	0.312	0.438	0.562	0.750	0.937	1.156	1.375	1.562	1.781
20	20.000	0.250	0.375	0.500	0.593	0.812	1.031	1.281	1.500	1.750	1.968
24	24.000	0.250	0.375	0.562	0.687	0.968	1.218	1.531	1.812	2.062	2.343
30	30.000	0.312	0.500	0.625	-	-	-	-	-	-	-

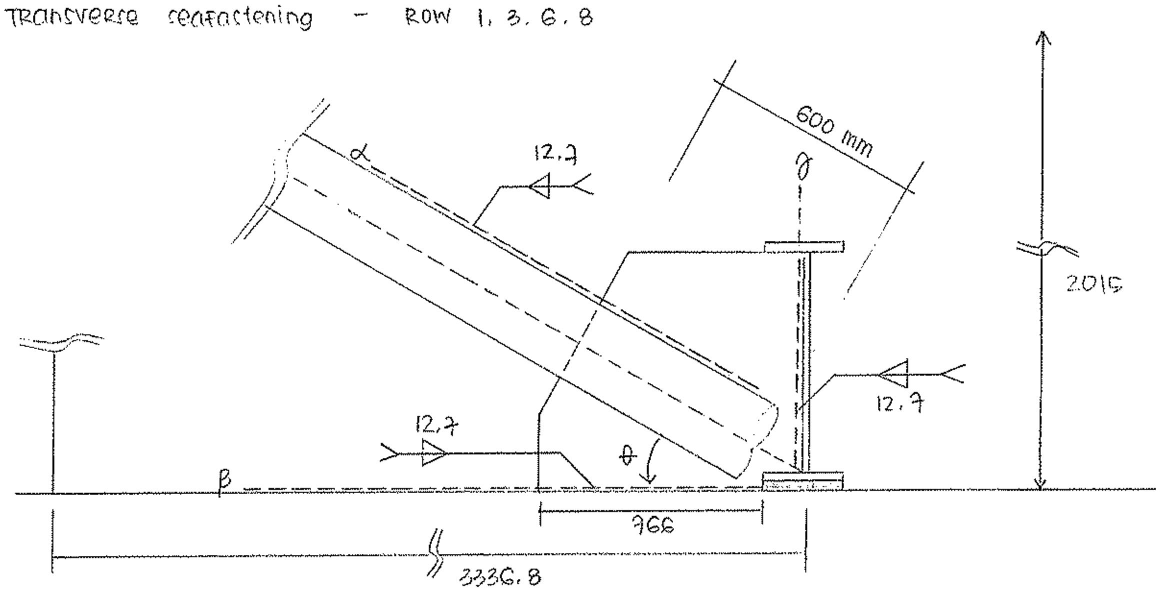
All dimensions given in inches.

The decimal thicknesses listed for the respective pipe size represent their nominal or average wall dimensions. For tolerances on wall thicknesses, see appropriate material specifications.

* A.S.A. = American Standard Association

4.4.3. PLATE CONNECTION TO THE DECK

Transverse seafastening - Row 1, 3, 6, 8



Properties

weld length brace - plate : 600 mm

weld length plate - deck : 900 mm ⟶ eff : 900 − 1/2 268 : 766 mm

weld length plate - web : 719.2 mm

weld size to brace : 12.7 mm

weld size to deck : 19.05 mm

weld size to web : 12.7 mm

Horizontal length, l_1 : 3336.8 mm

vertical length, l_2 : 2015 mm

plate thickness : 25.4 mm

Fy : 345 mm

Fy barge : 235 mm

seafastening beam properties : profile = WF 268 x 770 x 25.4 x 15.6

plate : 25.4 mm

Roll brace : 10.75 in O.D 0.718 WT

JOB NO. : I/0310

SHEET NO.: 4.87

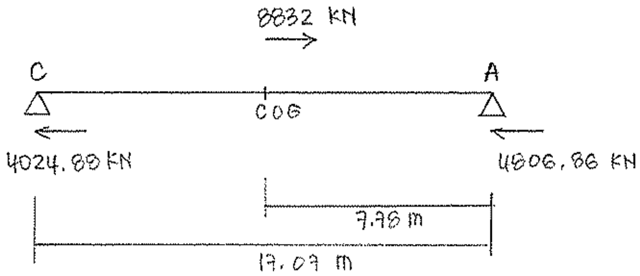
COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

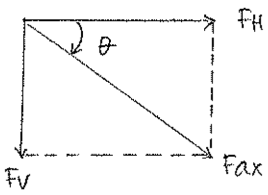
DATE : 30 May 2007

FORCES DISTRIBUTION

(Roll to portside or Roll to starboard)



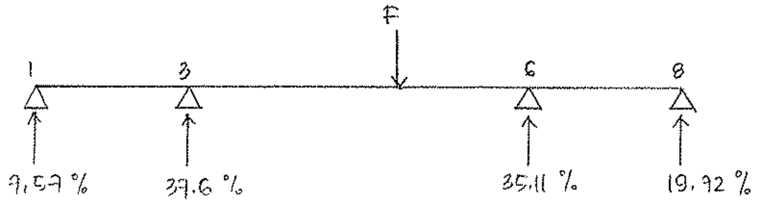
Maximum force in one support



F_H = 4806.86 KN (per row)

$\theta = \text{arc tan} \frac{2015}{3336.8} = 31.13° > 20°$ (O.K)

(see sheet 56)



F_H = 37.6 % x F_H (per row)

= 37.6 % x 4806.86

= 1807.38 KN

$$F_{ax} = \frac{F_H}{\cos\theta} = \frac{1807.38}{\cos 31.13°} = 2111.4 \text{ KN}$$

$$F_v = F_H \tan\theta = 1807.38 \tan 31.13° = 1091.43 \text{ KN}$$

* Check α-x brace weld - plate

$$\tau_{/\!/} = \frac{F_{ax}}{t_0\ L} = \frac{2111,4 \cdot 10^3 \quad \sqrt{2}}{4 \cdot 12,07 \quad 600} = 97.96 \text{ N/mm}^2$$

$$U.C = \frac{\tau_{/\!/}}{0.4\ F_y} = \frac{97.96}{0.4 \cdot 345} = 0.71 \quad (O.K)$$

* Check β-β deck-weld

$$\tau_{/\!/} = \frac{F_H}{w \cdot L} = \frac{1807{,}38 \ 10^3 \ \sqrt{2}}{2 \ 19.05 \ 766} = 87.58 \ N/mm^2$$

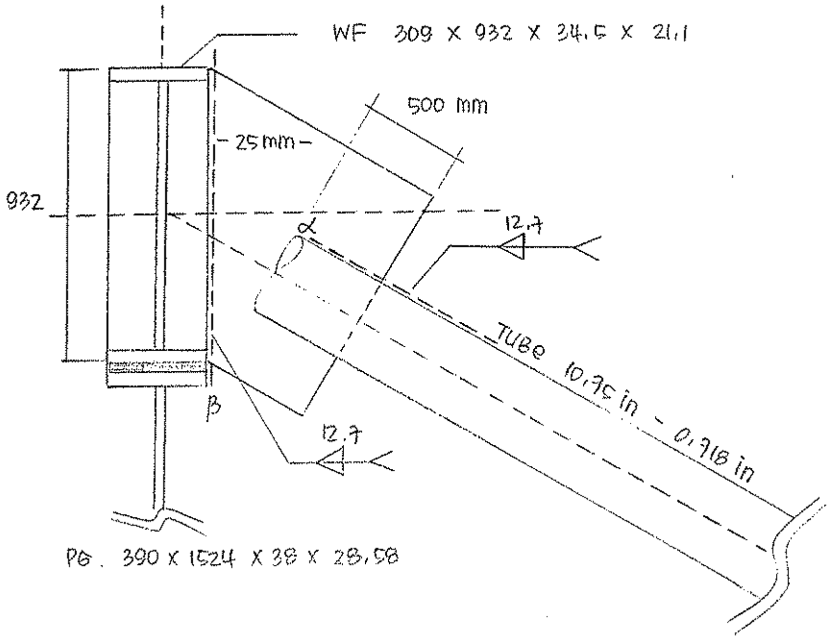
$$u.c = \frac{\tau_{/\!/}}{0{,}4 \ F_y} = \frac{87.58}{0{,}4 \ 235} = 0{,}93 \quad (O.K).$$

* Check ∂-∂ plate - web

$$\tau_{/\!/} = \frac{F_V}{w \cdot L} \quad \frac{1091{,}43 \cdot 10^2 \cdot \sqrt{2}}{2 \ 12.07 \ 719{,}2} = 84.49 \ N/mm^2$$

$$u.c. = \frac{\tau_{/\!/}}{0{,}4 \ F_y} = \frac{84.49}{0{,}4 \cdot 345} = 0{,}61 \quad (O.K).$$

4.4.4 PLATE CONNECTION TO LQ BEAM. (ROW C)



PROPERTIES

Weld length brace - plate = 500 mm

Weld length plate - web = 932 mm

Weld size to brace = 12,7 mm

Weld size to web = 12,7 mm

Plate thickness = 25,4 mm

Fy = 345 N/mm²

Fy barge = 235 N/mm²

Seafastening beam properties

Profile WF 268 X 770 X 25,4 X 15,6

Plate 25.4 mm

Roll brace 10,75 OD 0,718 WT

Forces : Fax = 2111,4 KN

FH = 1607,38 KN

Fv = 1001,43 KN

JOB NO. : I / 0310

SHEET NO.: 4 90

COMP'D BY : Fenny

CALC. NO. : QT 400 – RP 01

DATE : 30 May 2007

Check x-x brace weld – plate

$$\tau_{//} = \frac{Fax}{w\ L} = \frac{2111,4 \cdot 10^3 \cdot \sqrt{2}}{4 \cdot 12,7 \ 500} = 117,56\ N/mm^2$$

$$U.C. = \frac{\tau_{//}}{0,4\ Fy} = \frac{117,56}{0,4 \cdot 345} = 0,85 \quad (O.K)$$

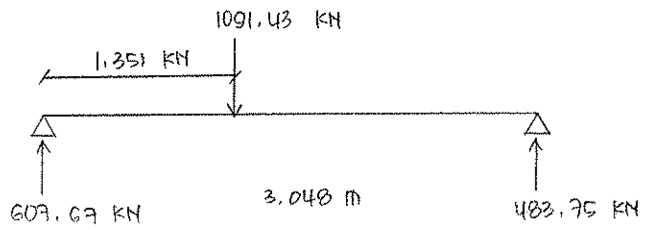
Check β-β brace weld – Web

$$\tau_{//} = \frac{Fv}{w\ L} = \frac{1091,38\ 10^3 \sqrt{2}}{2 \ 12,7 \cdot 932} = 65,2\ N/mm^2$$

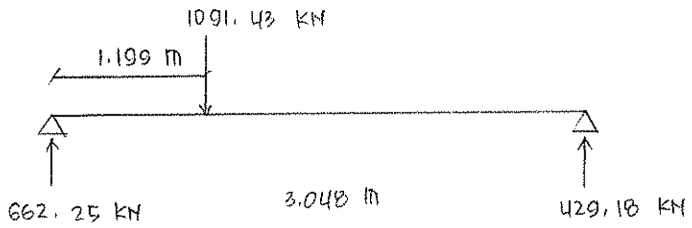
$$U.C. = \frac{\tau_{//}}{0,4\ Fy} = \frac{65,2}{0,4 \cdot 345} = 0,47 \quad (O.K)$$

Seafastening Beam

ROW 3



ROW 6



→ all the reaction force in ROW 3 and ROW 6 less than the Bulkhead capacity (926 KN)

JOB NO. : I/0310

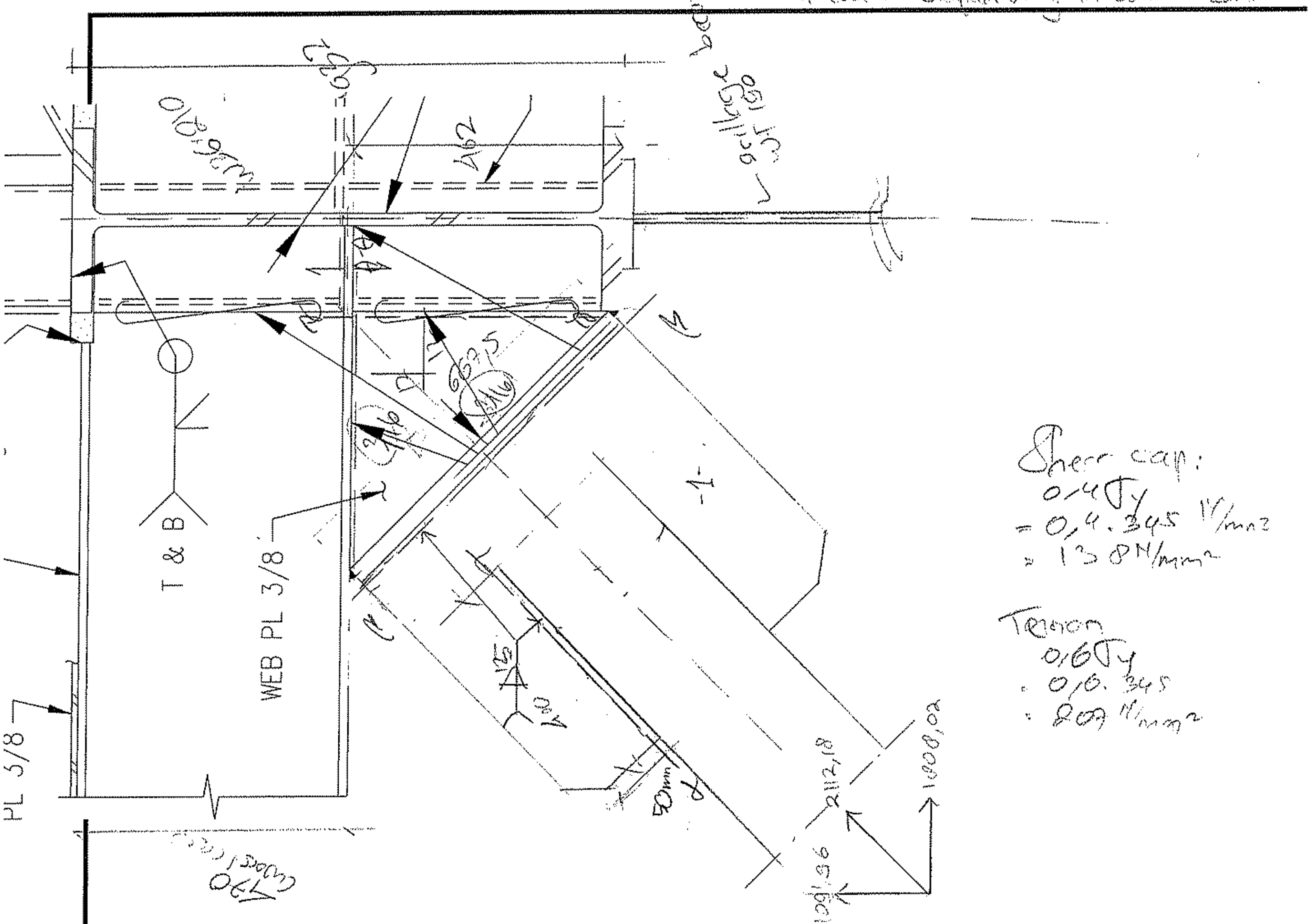
COMP'D BY : Andrew H.

CALC. NO. : AT400-RP07

DATE : 25th May '07

SHEET NO.: 4.91

Detail Seafastening in column 3A



Shear cap:
0,4 σy
= 0,4 . 345 N/mm²
= 138 N/mm²

Tension
0,6 σy
= 0,6 . 345
= 207 N/mm²

Check Shear

α-α

w = 15 mm
L = 400 mm

$$\tau_{//} = \frac{F_{ax}}{\Sigma a.l}$$

$$= \frac{2112,18 . 10^3}{4 . (\frac{1}{2}\sqrt{2} . 15 . 400)}$$

$$U_c = \frac{124,5}{138 N/mm^2} = 0.9$$

β-β

w = 15 mm
L = 667,5 mm

$$\tau_{\perp} = \frac{F_{ax}}{\Sigma a.l}$$

$$= \frac{2112,18 . 10^3 . \frac{1}{2}\sqrt{2}}{2 . \frac{1}{2}\sqrt{2} . 15 . 667,5}$$

$$= 105,48 N/mm^2$$

$$U_c = \frac{105,48}{207}$$

$$= 0,51$$

JOB NO. : I/0310

COMP'D BY : Andreas H.

CALC. NO. : QT400-RP01

DATE : 25th May '07

SHEET NO.: 4 92

Check shear X-X

$w = 3/16"$ (according to Delta design)

$= 4{,}76$ mm

$L = 1' - 4\,3/8"$

$= 422$ mm

$$\tau_{\parallel} = \frac{F_v}{\Sigma\, a.l}$$

$$= \frac{1091{,}96 . 10^3}{2\left(\frac{1}{2}\sqrt{2} . 4{,}76\right) 422}$$

$$= 384{,}4 \text{ N/mm}^2$$

$$UC = \frac{384{,}4}{138}$$

$$= 2{,}79$$

∴ for getting UC = 0,05

- the weld size should be : 16,6 mm
- thicker plate ~ 25,4 mm

JOB NO. : I/0310

COMP'D BY : Andrew H

CALC. NO. : QT400-RP01

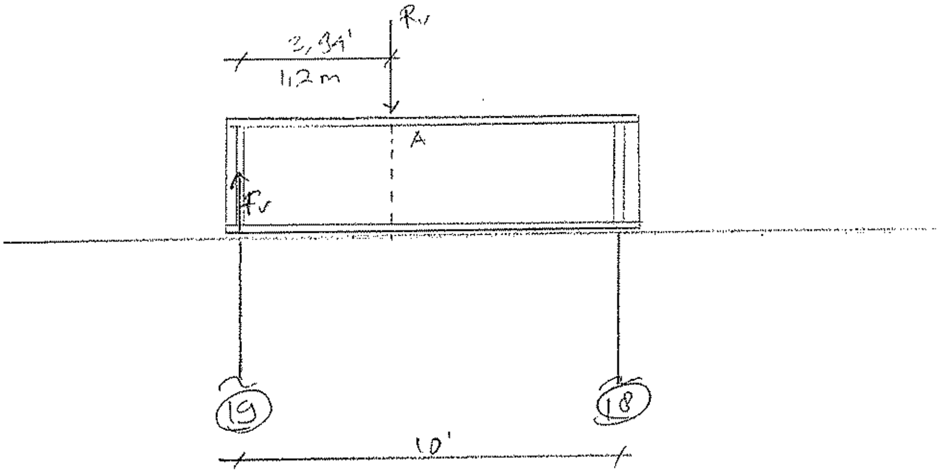
DATE : 29th May '07

SHEET NO.: 4.93

44.5 Seafastening Beam Capacity Check

· Beam WF 260 × 770 × 25,4 × 15,6 / WF 30 × 132

Check is according to seafastening in column 6



For seafastening layout, see sheet 4.77

$W_{y,min}$: $6,16 \cdot 10^6$ mm^3

A_{shear} : 12012 mm^2

Reaction and moments

F_v : 662,25 kN

$M_A = 662,25 \cdot 1,2$

$= 794,7$ kNm

JOB NO. : I/0310

COMP'D BY : Andrew.K

CALC. NO. : QT400-RP02

DATE : 20th May '07

SHEET NO.: 4.94

- $\sigma_b : \frac{M}{W_{ymin}} = \frac{794,7.10^6}{6,16.10^6}$

$= 129 \ N/mm^2$

$UC = \frac{\sigma_b}{0,66F_y} = \frac{129}{0,6.345}$

$= 0,52$ $(< 1,0)$

- $\tau_v = \frac{F_v}{A_{shear}} = \frac{662,25.10^3}{12012}$

$= 55,13 \ N/mm^2$

$UC = \frac{\tau_v}{0,4 \ F_y} = \frac{55,13}{0,4.345}$

$= 0,4$ $(< 1,0)$

- Conclusion : the seafastening beam is sufficient cheet 4.95

Project	Tombua Landana		
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PLATE GIRDER PROPERTIES

Plategirder Description

section no	Section breadth [mm]	Section height [mm]	Offset ey [mm]	Axial area [mm²]	Shear area [mm²]	Statical moment [mm³]
1	*268.0*	*25.4*	*0.0*	6807	396	2.53E+06
2	*15.6*	*719.2*	*0.0*	11220	11220	2.53E+06
3	*268.0*	*25.4*	*0.0*	6807	396	0.00E+00
4	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
5	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
6	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
7	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
8	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
9	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
10	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
11	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
12	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
13	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
14	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
15	*0.0*	*0.0*	*0.0*	0	0	0.00E+00
	268	770		24834	12012	

Section Properties

Areas:		AX	24834	[mm²]
		AY	13614	[mm²]
		AZ	12012	[mm²]
Dimensions:		Y	268.0	[mm]
		Z	770.0	[mm]
		Weight	1.9	[kN/m]
Distances to neutral axis:	ez (From bottom)		385.0	[mm]
	Z-ez		385.0	[mm]
	ey (From left)		134.0	[mm]
	Y-ey		134.0	[mm]
Section moduli:		Wy,min	6.16E+06	[mm³]
		Wy,max	6.16E+06	[mm³]
		Wz,min	6.10E+05	[mm³]
		Wz,max	6.10E+05	[mm³]
Moments of inertia:		Iy	2.37E+09	[mm^4]
		Iz	8.17E+07	[mm^4]
Torsional constant (torsional resistance):		It	3.84E+06	[mm^4]
Radii of gyration:		ry	309.0	[mm]
		rz	57.4	[mm]

Note: -Torsional Constant / Resistance is only valid for open girders

Last Revision: May 98

JOB NO. : I/0310

COMP'D BY : Andrea. Hr

CALC. NO. : 10I-120-R002

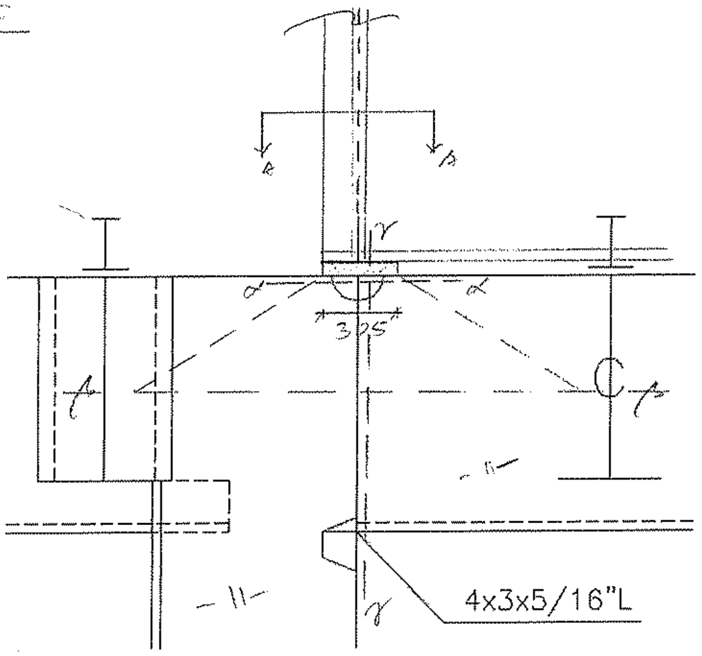
DATE : 21st May '02

SHEET NO.: 4.96

4.5 BARGE CAPACITY CHECK

4.5.1 CAPACITY OF BULKHEAD COLUMNS at TRANSVERSE WEBFRAMES

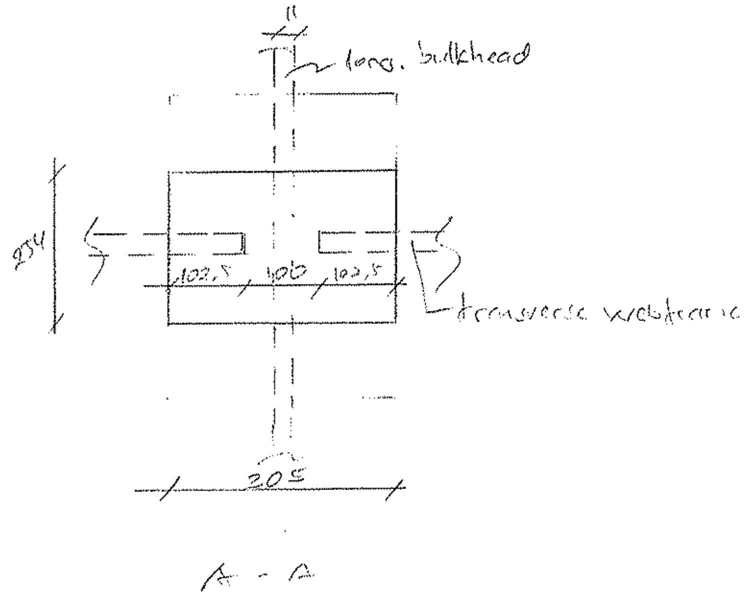
Detail c



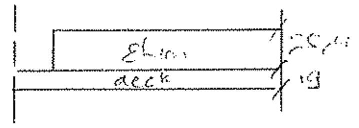
$\alpha\alpha$ - yield below deck

$\beta\beta$ - plate buckling resistance

$\gamma\gamma$ - shear capacity



Shim plate
305 × 254 × 25.4



JOB NO. : I/0310
COMP'D BY : Andrew. H
CALC. NO. : QT400-RP09
DATE : 21st May'02

① Activated areas at loadout

- Longitudinal :

$H = 254$ mm
$k = 19 + 25,4$
$= 44.4$ mm

$A_1 = t_w . (H + 5k)$
$= 11 \ (254 + 5 . 44.4)$
$= 5236$ mm²

- Transverse

$H = 102,5 \times 2 = 205$ mm
$k = 19$ mm

$A_2 = t_w \ (H + 5k)$
$= 11 \ (205 + 5 . 19)$
$= 3300$ mm²

Capacity of area : $(A_1 + A_2) . 0,66 . \sigma_{yield}$
$= (5236 + 3300) . 0,66 . 235$
$= 1323,93$ kN

② during transportation

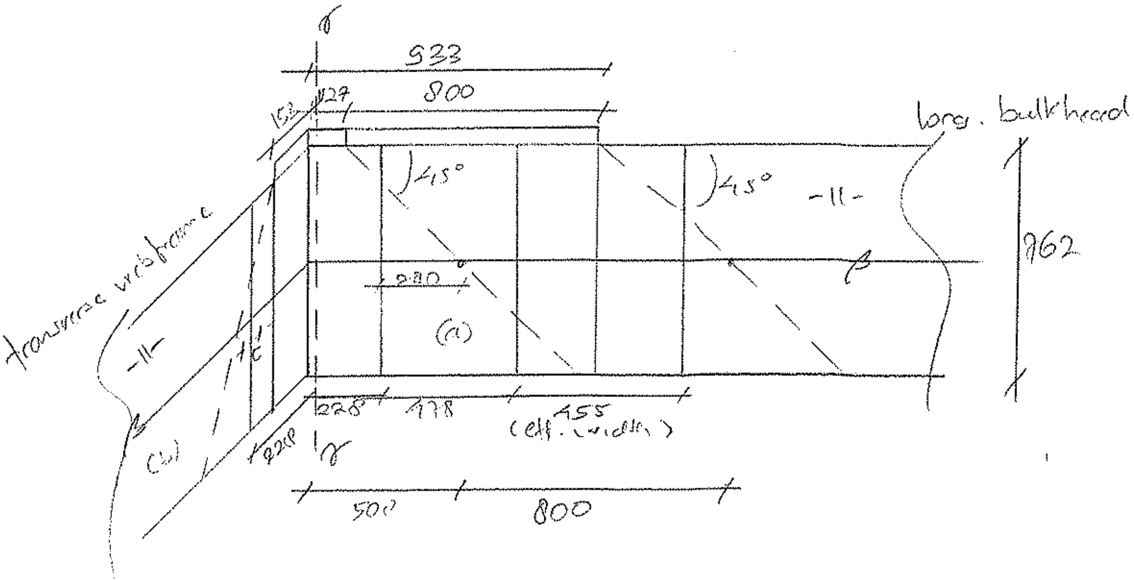
b : 800 mm
k : 19 mm
t_w : 11 mm

$A_3 = (t_w . (H + 2,5k)) \ 2$
$= (11 . (800 + 2,5 . 19)) . 2$
$= 18645$ mm²

Add capacity (WP) : $A_3 . 0,66 \ \sigma_{yield}$
$= 18645 . 0,66 . 235$
$= 2891,84$ kN

Total Capacity $= 1323,93 + 2891,84$
$= 4215,77$ kN

longitudinal bulkhead.
t_w : 11mm
σ_y : 235 N/mm²
σ_{cr} = 83 N/mm²



C = 306mm
a = 778

Capacity plate (a)

- ββ without W/P:
  0,6 σ_y . ½ eff. width . t_w = 0,6 . 235 . 228 . 11 = 353,63 kN
  0,6 σ_{cr} . 280 . t_w = 0,6 . 83 . 280 . 11 = 153,38 kN
  507,01 kN

- ββ with the wing plates
  : 966 kN
  Can use the design allowable load from IPEX (ref. sh 5.)

- γγ shear capacity

  h = 762 - (½ gap) = 762 - (½ . 100) = 712 mm
  t_w = 11 mm
  A = 712 . 11 = 7832 mm²

  Fmax = 0,4 σ_y . A
  = 0,4 . 235 . 7832
  = 736,21 kN

JOB NO. : I/0310
COMP'D BY : Andreas H
CALC. NO. : QT400-RP01
DATE : 21st May '07

SHEET NO.: 4.99

Capacity plate (b)

· P/P without the wingplate ·

$0{,}6\,\sigma_y \cdot \frac{1}{2}$ eff. width t_w = 0,6.235.228.11 = 353,63 kN

$0{,}6\,\sigma_{cr} \cdot c \cdot t_w$ = 0,6. 83. 306. 11 = 167,63 kN

521,26 kN +

Capacity P/P without the wingplate :

plate (a) = 507,01 kN
plate (c) = 2. 521,26 kN
plate (a) shear = 736,21 kN
2285,74 kN +

Capacity P/P with the wingplate

plate (a) = 966 kN
plate (b) = 2.521,26 kN
plate (a) shear = 736,21 kN
2744,73 kN +

Unity Check

$$UC = \frac{2652{,}16}{2744{,}73}$$

$$= 0{,}97$$

note : the load can be less, caused by roll relief influence from transverse seafastening in column 6 sheet 4 100

Project	Tombua landana
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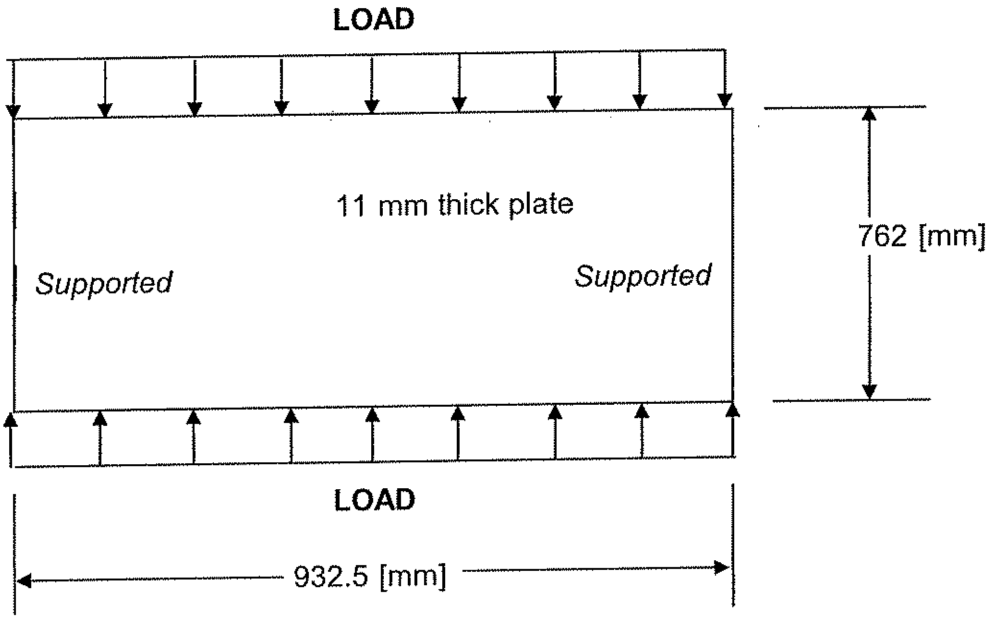
PLATING CAPACITY

BUCKLING RESISTANCE OF PLATES UNDER COMPRESSION

Support type: **Four sides supported**

Modulus of elasticity:	*210000*	[N/mm²]	
Poisson's ratio:	*0.3*	[-]	
Plate thickness:	*11*	[mm]	
Plate length:	*762*	[mm]	
Plate width:	*932.5*	[mm]	(Loaded)
Yield stress:	*235*	[N/mm²]	
Plate factor k:	4.165		
Design stress:	141.0	[N/mm²]	
b(eff)/t:	41.4		
Effective width:	455.2	[mm]	
Section of curve:	**C - D**		
Critical stress:	**83**	**[N/mm²]**	
Design allowable load:	**966**	**[kN]**	
Design specific allowable load:	**1036**	**[kN/m]**	



Calc. Acc. To Blodgett's Design of Welded Structures, Priest-Gilligan curve.

Allowable stress according to AISC

Last Revision: July 99

Sheet 4.101

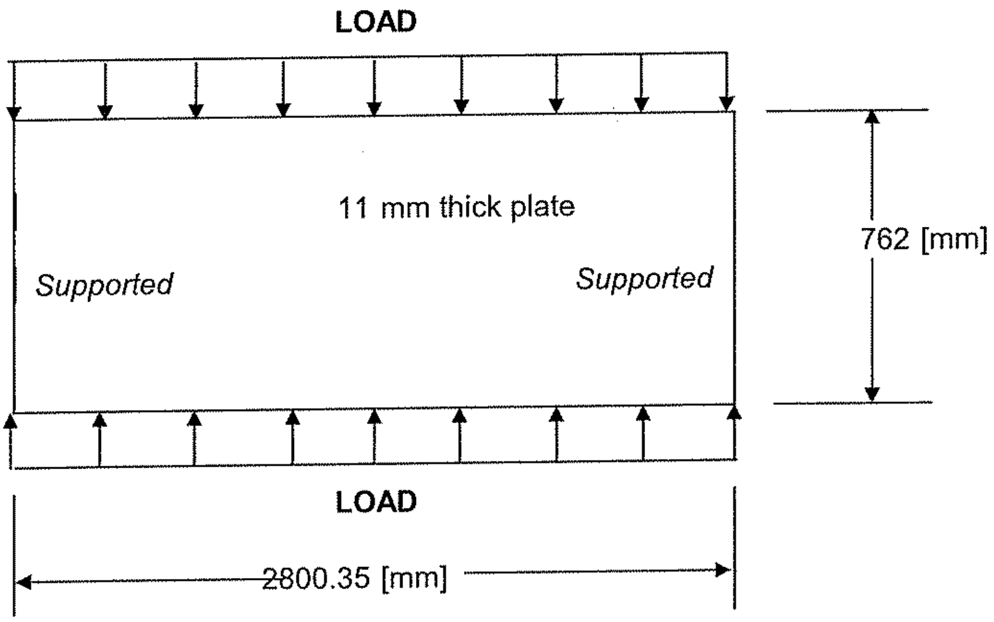
Project Tombua landana
Subject Living Quarters
Job / Bid no. I/0310
Date 30-May-07 Sheet

PLATING CAPACITY

BUCKLING RESISTANCE OF PLATES UNDER COMPRESSION

Support type: **Four sides supported**

Modulus of elasticity:	*210000*	[N/mm²]	
Poisson's ratio:	*0.3*	[-]	
Plate thickness:	*11*	[mm]	
Plate length:	*762*	[mm]	
Plate width:	*2800.35*	[mm]	(Loaded)
Yield stress:	*235*	[N/mm²]	
Plate factor k:	15.580		
Design stress:	141.0	[N/mm²]	
b(eff)/t:	41.4		
Effective width:	455.2	[mm]	
Section of curve:	**C - D**		
Critical stress:	**34**	**[N/mm²]**	
Design allowable load:	**1236**	**[kN]**	
Design specific allowable load:	**441**	**[kN/m]**	



Calc. Acc. To Blodgett's Design of Welded Structures, Priest-Gilligan curve.
Allowable stress according to AISC

Last Revision: July 99

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

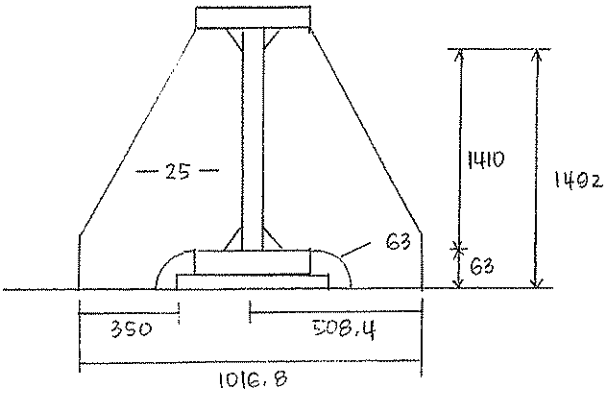
DATE : 30 May 2007

SHEET NO.: 4.102

4.5 2 CAPACITY OF BULKHEAD COLUMNS at TRANSVERSE BULKHEAD

Detail B

crossing of transverse bulkhead with longitudinal bulkhead



WF 190 x 1524 x 38 x 25.4

w : 19.05 mm

b : 350 mm

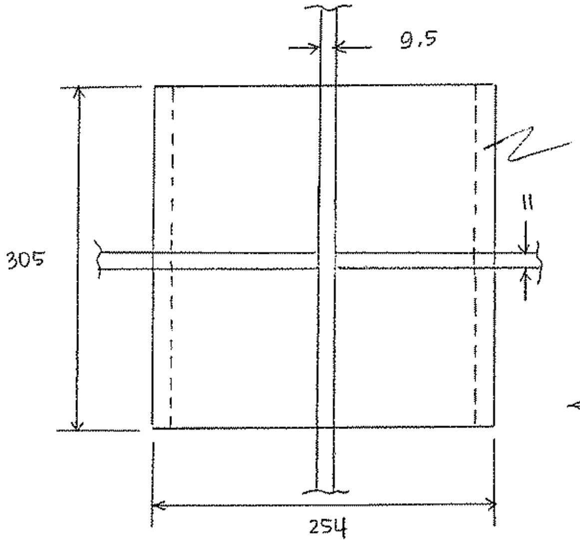
twp : 25.4 mm

t shimplate : 25.4 mm

n : 63.4 mm

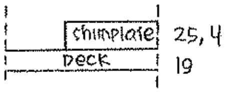
r : 63.4 mm

fy deck : 235 N/mm²



shimplate 254 x 305 x 25.4

⟷ Longitudinal Bulkhead



1. Activated areas at loadout

(without wing plate)

Longitudinal
N : 254 mm
K : 44 mm
tw : 11 mm
A_1 : tw (N + 5k) : 5236 mm²

Tranrverse
N : 305 mm
K : 19.05 mm
tw : 9.5 mm
A_2 : tw · (N + 5k) : 3800 mm²

JOB NO. : I / 0310

SHEET NO.: 4.103

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

Capacity section a-a at load out = $(A_1 + A_2) \cdot 0.6\ F_y$

$= 1274.08$ KN

2 Additional area during transportation

Longitudinal, beneath 2 wing plates $b = 350$ mm

$N = 350$ mm

$k = 19$ mm

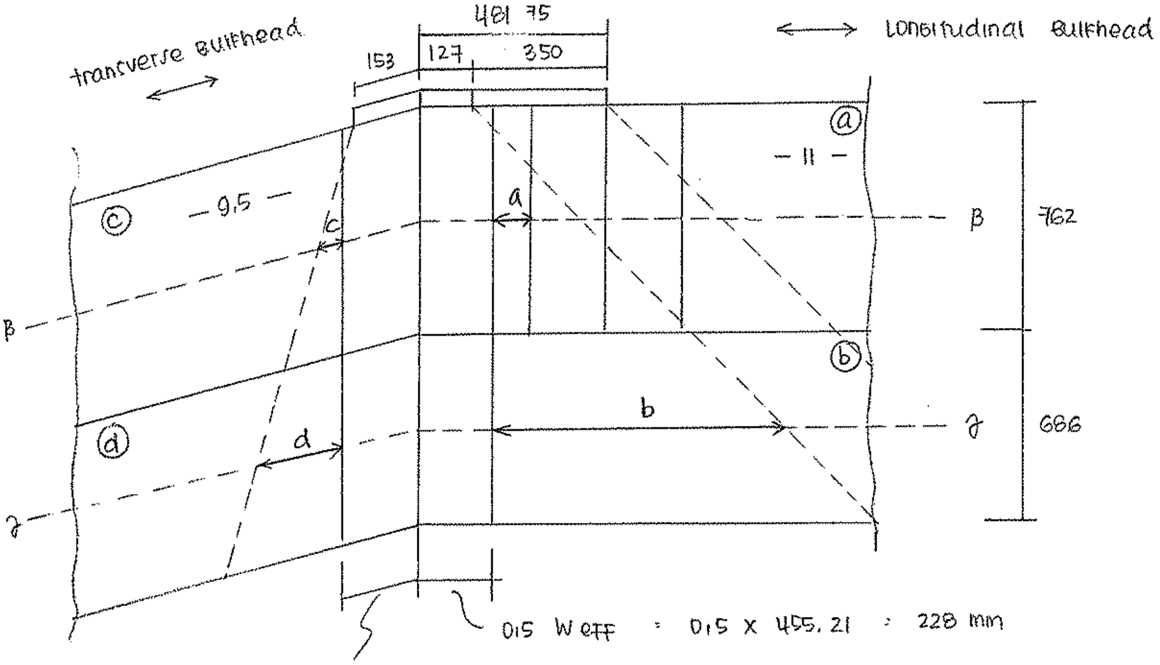
$t_w = 11$ mm

$A_3 = t_w \cdot (N + 2.5\,k) = 4372.5\ \text{mm}^2$

Additional capacity : $A_3 \times 0.6\ F_y \times 2 = 1356.35$ KN

Total capacity during transportation = 2630.43 KN

Capacity at section $\beta - \beta$ and $\alpha - \alpha$



0.5 Weff = 0.5 x 455.21 = 228 mm

0.5 Weff = 0.5 x 393.14 = 197 mm

assume 45° load distribution

a = 26.55 mm → Fcr = 224 N/mm²

b = 1004.3 mm → Fcr = 224 N/mm²

c = 336.95 mm → Fcr = 26 N/mm²

d = 1060.85 mm → Fcr = 31 N/mm²

JOB NO. : I / 0310

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

SHEET NO.: 4.104

Capacity plate a

- at section β-β , without wing plates

Loaded area = (127 + 0.5 762) x 11 = 5588 mm^2

0.6 Fy x (508 - 27) x tw = 448.04 KN

0.6 Fcr x 27 x tw = 39, 23 KN +

Fmax ; a , at loadout = 487, 27 KN

- at section ∂-∂ , with wing plates

0.6 Fy x 1.5 W eff x tw = 1059.05 KN

0.6 Fcr x (481.75 + 0.5 x 762 - 1.5 W eff) x tw = 265.88 KN +

Fmax ; a . at transport = 1324, 90 KN

Capacity plate b

- at section β-β , without wing plates

0.6 Fy x 0.5 W eff x tw = 353, 02 KN

0.6 Fcr x b x tw = 1281 .51 KN +

Fmax ; b , at loadout = 1234, 52 KN

- at section ∂-∂ , with wing plates

0.6 Fy x 0.5 W eff x tw = 353, 02 KN

0.6 Fcr x (b + 350) x tw = 2000. 99 KN +

Fmax ; b , at transport = 2353 . 99 KN

Capacity plate c

0.6 Fy x 0.5 W eff x tw = 263.3 KN

0.6 Fcr x c x tw = 49 ,02 KN +

Fmax ; c , at transport = 312 , 30 KN

JOB NO. : I / 0310

SHEET NO.: 4.105

COMP'D BY : Fenny

CALC. NO. : QT 400 - RP 01

DATE : 30 May 2007

Capacity plate d

0,6 Fy x 0,5 Weff x tw = 263,3 KN

0,6 Fcr x d x tw = 185,48 KN +

Fmax ; d, at transport = 448.76 KN

Capacity section B-B

without wing plates ; Fmax = 2 x 489,27 + 2 x 312,3 = 1599,13 KN

with wing plates ; Fmax = 2 x 1324,9 + 2 x 312,3 = 3274.40 KN

capacity section ∂-∂

Without wing plates ; Fmax = 2x 1634,52 + 2 x 448,76 = 4166.57 KN

With wing plates ; Fmax = 2x 2353.99 + 2 x 448,76 = 5605.51 KN

$$U.C. = \frac{F\ occured}{F\ allowable}$$

$$= \frac{1352.8}{3274,40}$$ (see sheet 4.10)

$$= 0,413 < 1 \longrightarrow O.K$$

sheet 4.106

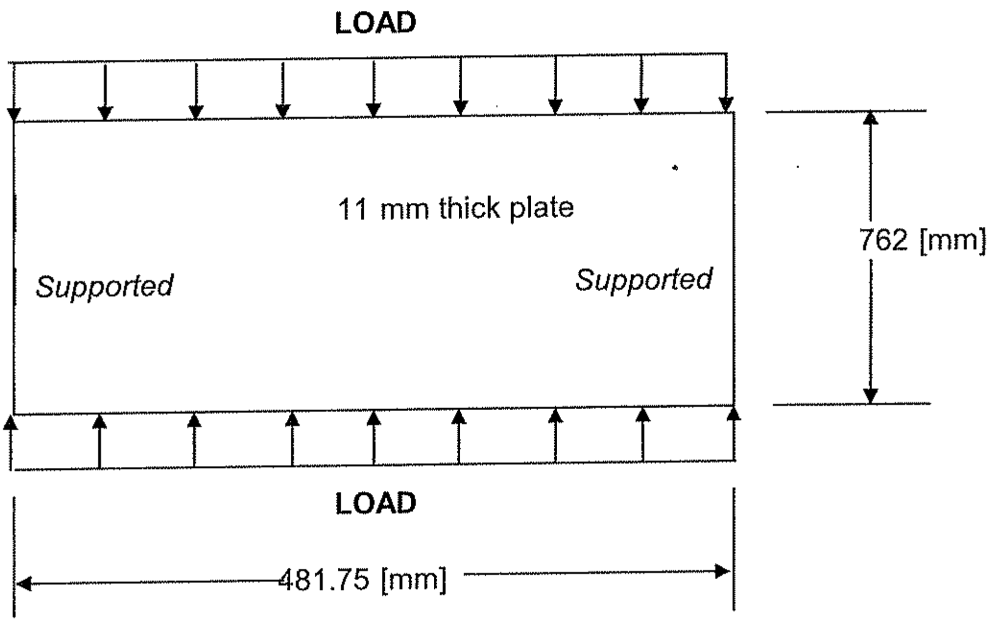
Project	Tombua landana		
Subject	Living Quarters		
Job / Bid no.	I/0310		
Date	30-May-07	Sheet	

PLATING CAPACITY

BUCKLING RESISTANCE OF PLATES UNDER COMPRESSION

Support type: **Four sides supported**

Modulus of elasticity:	*210000*	[N/mm²]	
Poisson's ratio:	*0.3*	[-]	
Plate thickness:	*11*	[mm]	
Plate length:	*762*	[mm]	
Plate width:	*481.75*	[mm]	(Loaded)
Yield stress:	*235*	[N/mm²]	
Plate factor k:	4.000		
Design stress:	141.0	[N/mm²]	
b(eff)/t:	41.4		
Effective width:	455.2	[mm]	
Section of curve:	**B - C**		
Critical stress:	**224**	**[N/mm²]**	
Design allowable load:	**745**	**[kN]**	
Design specific allowable load:	**1547**	**[kN/m]**	



Calc. Acc. To Blodgett's Design of Welded Structures, Priest-Gilligan curve.

Allowable stress according to AISC

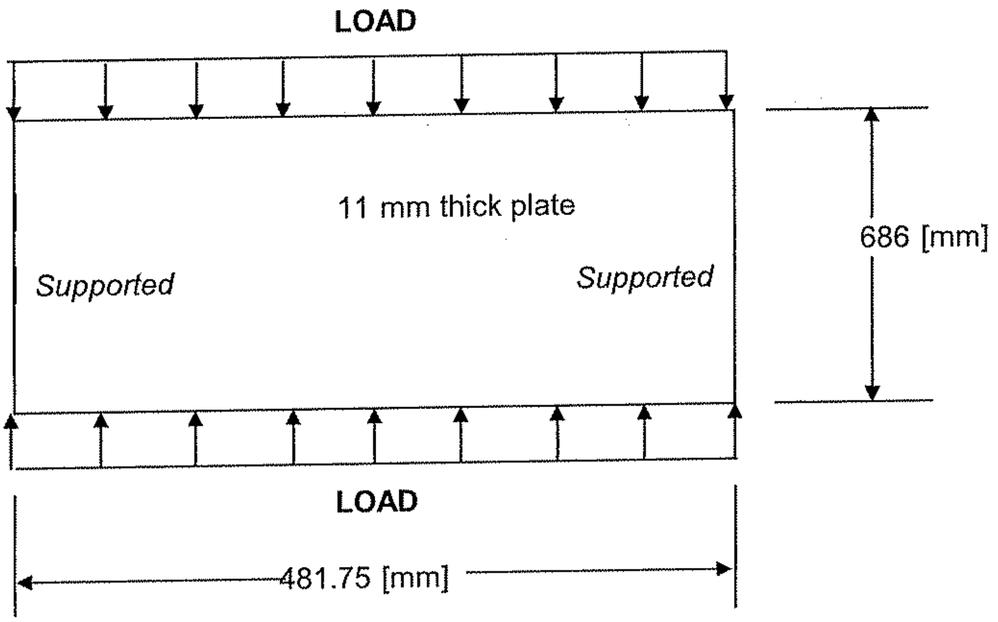
Project Tombua landana
Subject Living Quarters
Job / Bid no. I/0310
Date 30-May-07 Sheet

PLATING CAPACITY

BUCKLING RESISTANCE OF PLATES UNDER COMPRESSION

Support type: **Four sides supported**

Modulus of elasticity:	*210000*	[N/mm²]	
Poisson's ratio:	*0.3*	[-]	
Plate thickness:	*11*	[mm]	
Plate length:	*686*	[mm]	
Plate width:	*481.75*	[mm]	(Loaded)
Yield stress:	*235*	[N/mm²]	
Plate factor k:	4.000		
Design stress:	141.0	[N/mm²]	
b(eff)/t:	41.4		
Effective width:	455.2	[mm]	
Section of curve:	**B - C**		
Critical stress:	**224**	**[N/mm²]**	
Design allowable load:	**745**	**[kN]**	
Design specific allowable load:	**1547**	**[kN/m]**	



Calc. Acc. To Blodgett's Design of Welded Structures, Priest-Gilligan curve.
Allowable stress according to AISC

Last Revision: July 99

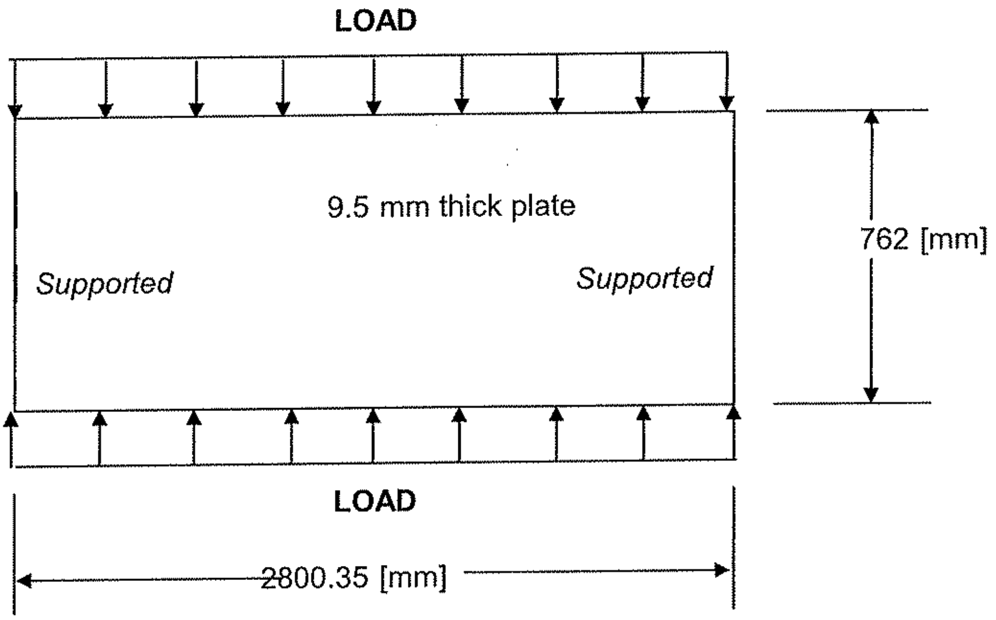
Project	Tombua landana		
Subject	Living Quarters		
Job / Bid no.	I/0310		
Date	30-May-07	Sheet	

PLATING CAPACITY

BUCKLING RESISTANCE OF PLATES UNDER COMPRESSION

Support type: **Four sides supported**

Modulus of elasticity:	*210000*	[N/mm²]	
Poisson's ratio:	*0.3*	[-]	
Plate thickness:	*9.5*	[mm]	
Plate length:	*762*	[mm]	
Plate width:	*2800.35*	[mm]	(Loaded)
Yield stress:	*235*	[N/mm²]	
Plate factor k:	15.580		
Design stress:	141.0	[N/mm²]	
b(eff)/t:	41.4		
Effective width:	393.1	[mm]	
Section of curve:	**C - D**		
Critical stress:	**26**	**[N/mm²]**	
Design allowable load:	**877**	**[kN]**	
Design specific allowable load:	**313**	**[kN/m]**	



Calc. Acc. To Blodgett's Design of Welded Structures, Priest-Gilligan curve.

Allowable stress according to AISC

sheet 4.109

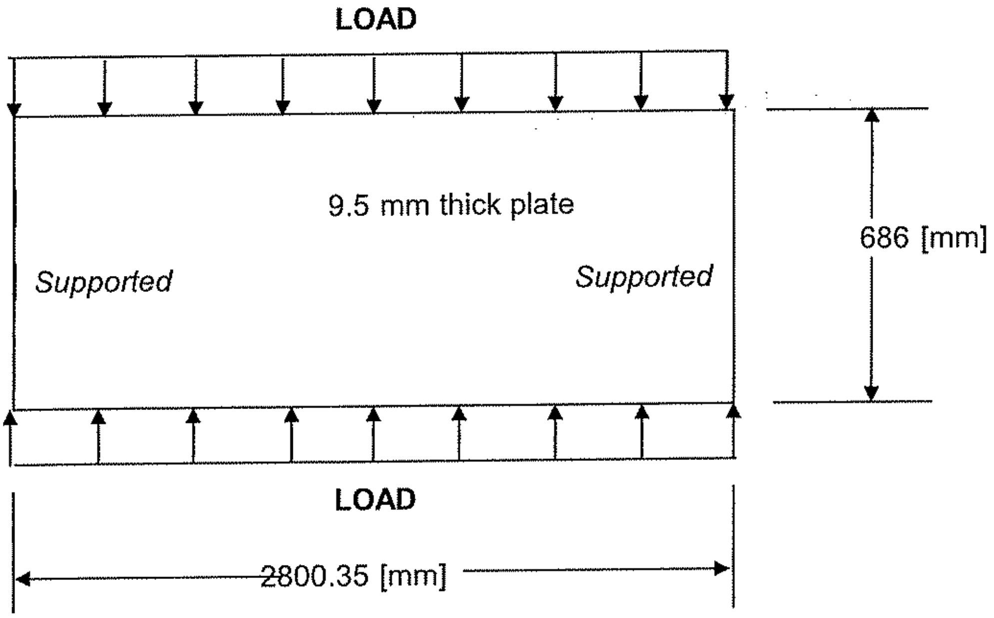
Project	Tombua landana
Subject	Living Quarters
Job / Bid no.	I/0310
Date	30-May-07
Sheet	

PLATING CAPACITY

BUCKLING RESISTANCE OF PLATES UNDER COMPRESSION

Support type: **Four sides supported**

Modulus of elasticity:	*210000*	[N/mm²]	
Poisson's ratio:	*0.3*	[-]	
Plate thickness:	*9.5*	[mm]	
Plate length:	*686*	[mm]	
Plate width:	*2800.35*	[mm]	(Loaded)
Yield stress:	*235*	[N/mm²]	
Plate factor k:	18.724		
Design stress:	141.0	[N/mm²]	
b(eff)/t:	41.4		
Effective width:	393.1	[mm]	
Section of curve:	**C - D**		
Critical stress:	**31**	**[N/mm²]**	
Design allowable load:	**947**	**[kN]**	
Design specific allowable load:	**338**	**[kN/m]**	



Calc. Acc. To Blodgett's Design of Welded Structures, Priest-Gilligan curve.

Allowable stress according to AISC

Project	PROJECT		
Subject	SUBJECT		
Job / Bid no.	JOBNO		
Date	25-Apr-07	Sheet	4.1/0

BOLLARD PULL FOR SEAGOING BARGES

INPUT

Barge:	BARGE
Cargo:	CARGO

Environmental conditions

Wind Speed	*20.0*	[m/s]
Sign. Wave Height	*5.0*	[m]
Current Speed	*0.5*	[m/s]

Barge specification

Overall Length:	*121.92*	[m]
Waterline length:	*114.43*	[m]
Beam (moulded):	*30.33*	[m]
Depth:	*6.10*	[m]
Draught (mean):	*2.44*	[m]
Bow slope:	*48*	[deg]
Scow end at stern:	*y*	[YES/no]

Wind Input

Description	Type	Length [m]	Width [m]	Height [m]	Start Height [m]
Barge	Solid Box ▼	*121.92*	*30.33*	*7.01*	*0*
LQ	Solid Box ▼	*33.53*	*17.07*	*23.96*	*5.16*
	Solid Box ▼				
	Solid Box ▼				
	Solid Box ▼				
	Solid Box ▼				
	Solid Box ▼				
	Solid Box ▼				

OUTPUT

Hull resistance:	0.2	[mT]
Wave resistance:	20.9	[mT]
Wind resistance:	11.5	[mT]
Towline pull requirement	32.6	[mT]
Tug efficiency	53	[%]
Required bollard pull	**61.1**	**[mT]**

Bollard Pull Tool version 2.1

Project	PROJECT		
Subject	SUBJECT		
Job / Bid no.	JOBNO		
Date	25-Apr-07	Sheet	4.III

BOLLARD PULL FOR SEAGOING BARGES
DETAILED INPUT AND OUTPUT

Hull Resistance Calculation

ρ_w	1.025	[mT/m^3]
S	558	[m^2]
ν	1.0E-06	[m^2/s]
R_n	5.7E+07	[-]
A_{TR}	0	[m^2]
$C_{D\text{-}TR}$	0.213	[-]
F_{nB}	0.029	[-]
A_m	74	[m2]
L_{ENTR}	2.18	[m]
∇	8307	[m3]
C_P	0.981	[-]
Q	7.84	
C_{PST}	0.500	[-]
H_{VA}/T_A	1	[-]
P	0.011	

R_F	0.16	[kN]
R_{TR}	0.00	[kN]
R_W	0.00	[kN]
R_{VP}	0.20	[kN]
R_{APP}	*0.00*	[kN]
R_{ALL}	1.18	[kN]
R_{hull}	**1.55**	**[kN]**

Wave Drift Forces

C_1	0.025035166
C_2	0.100671828
C_3	0.825553069

F_{WAVE}	**205.3**	**[kN]**

Wind resistance

Description	**Area [m2]**	**C_{shape} [-]**	**C_{truss} [-]**	**$C_{shielding}$ [-]**	**F_{wind} [kN]**
Barge	213	0.7	1	*1*	27.6
LQ	409	0.75	1	*1*	85.5
				Total	**113.1**

5.0 APPENDICES

REV 0	ISSUED FOR CONSTRUCTION	4/13/07	

WEIGHT / CENTER OF GRAVITY DATA SHEET

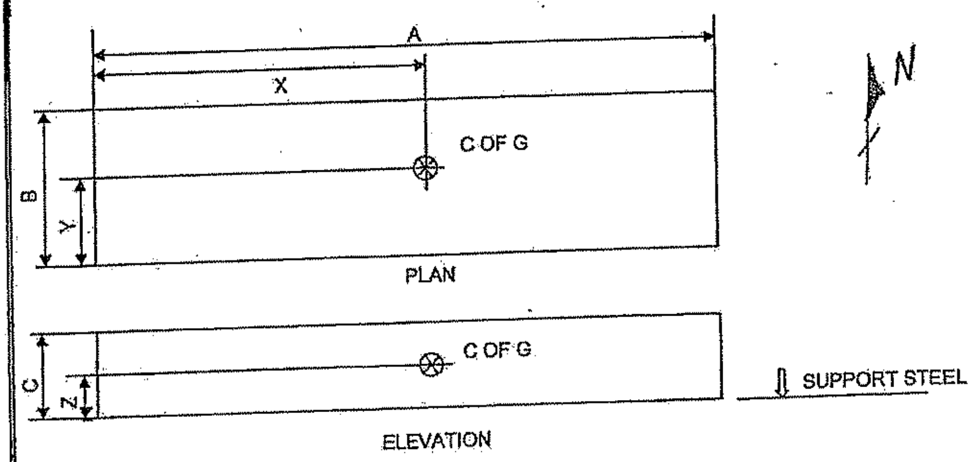
Project No.	6305		
Item No.	ALL		
Revision	B	Date:	11/29/2005
By	JS	Appr'd:	PVO
Unit	Tombua-Landana Development Project		
P.O. No.			
Inquiry No.			
Sheet	1	of	1
Doc No.			

Client:	Chevron (CABGOC)	Plant:	TL Drilling and Production Platform
Service:	ALL	Site:	Offshore Angola, Block 14

Number of Units:		Mfr. Model No.:	
Service:	ALL	Manufacturer:	

WEIGHT DATA (LB)

	TYPE	ESTIMATED WEIGHT	% CONTINGENCY ALLOWANCE	REMARKS	WEIGHT STATUS
WEIGHT DATA (LB)	DRY				○ [✓ ESTIMATE]
	LIFT	3,650,320	5		● VENDOR INFO.
	OPERATING	3,770,450	5		○ CERTIFIED
	TEST				○ WEIGHED INFO.



A=	110'	0"
B=	56'	0"
C=	78'	7½"
X=	56'	7 13/16"
Y=	25'	6 1/4"
Z=	30'	1 5/16"

NOTE:
1.) ALL DIMENSIONS IN FEET, INCHES.
2.) SKETCH IN SOME IDENTIFYING ITEMS ABOVE TO HELP ORIENT THE X & Y DIMENSIONS

WEIGHT CHECK LIST

ITEM	APPLICABLE		INCLUDED IN WEIGHT DATA		IF NOT INCLUDED AND APPLICABLE - ESTIMATED WEIGHT
FACTORY SKID/ STEEL WORK	☑ YES	☐ NO	☑ YES	☐ NO	
FIRE PROOFING	☑ YES	☐ NO	☑ YES	☐ NO	
THERMAL INSULATION	☑ YES	☐ NO	☑ YES	☐ NO	
FACTORY/ SKID INSTRUMENTS	☑ YES	☐ NO	☑ YES	☐ NO	
FACTORY / SKID ELECTRICS	☑ YES	☐ NO	☑ YES	☐ NO	
FACTORY / SKID PIPEWORK	☑ YES	☐ NO	☑ YES	☐ NO	
PLATFORMS / LADDERS	☑ YES	☐ NO	☑ YES	☐ NO	

FINAL WEIGHT DATA

ITEM	METHOD		WEIGHT		COMMENTS
CALCULATED	☐ YES	☐ NO		LBS	
CRANE LOAD INDICATOR	☐ YES	☐ NO		LBS	
CERTIFIED TRUCK SCALE	☐ YES	☐ NO		LBS	
LOAD CELLS	☐ YES	☐ NO		LBS	

No.	Date	Revision	By	App.
A	3/2/05	Issued for EDC and Client Approval	RS	
B	11/29/05	Issued for Design	JS	PVO

JOB NO. : I/0310

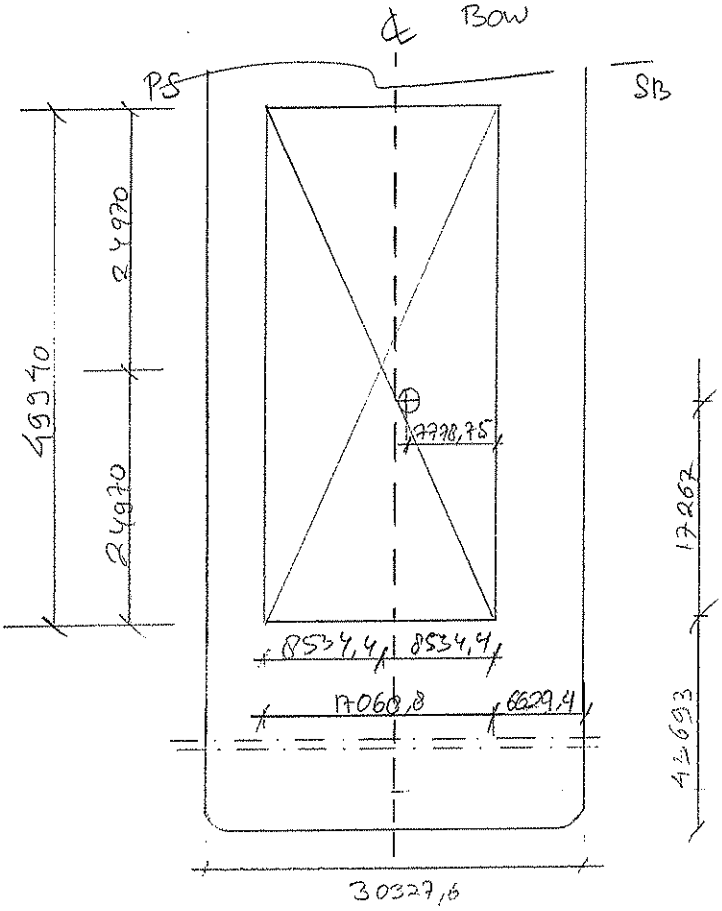
COMP'D BY : Andrew. H

CALC. NO. : QT400-RP01

DATE : 23rd April '07

SHEET NO.: 52

Transportation Forces



Module lift weight = 3650320 lb
= 1655,76 ton
= 16242,98 kN

X

X_1 = 56 ft + 7,8125 in = 56,651 ft = 17,27 m
X_2 = 143 ft + 4,19 in = 143,349 ft = 43,69 m
X_3 = $X_1 + X_2$ = 200 ft = 60,96 m
Δx = 55 ft − X_1 = −1,651 ft = −503,24 mm

Y

Y_1 = 25 ft + 6,25 in = 25,52 ft = 7,78 m
(COG (module − SB)) Y_2 = 6629,4 mm + Y_1 = 47,27 ft = 14,41 m
Y COG (from CL − barge) Y_3 = 15163,2 mm − Y_2 = 2,48 ft = 0,756 m

Δy = 28 ft − Y_1 = 2,48 ft = 755,62 mm

JOB NO. : I/0310

COMP'D BY : Andrew. H.

CALC. NO. : QT400 - RP01

DATE : 23rd April '07

SHEET NO.: 53.

Z

Relative to Z.O.S $Z_1 = 30 ft + 1,313 in$ $= 9177,34$ mm

$\Delta_z = Z_1 + H_{grill} + H_{barge}$

$= 9177,34 + 1524 + 6096$ $= 16797,34$ mm

Module Global Dimensions

$L = 110 ft + 16 ft + 14 in$ $= 30,76$ m

$B = 56 ft + 22 ft$ $= 23,77$ m

$H = 78 ft + 7,5 in$ $= 23,96$ m

Moment of Inertia

Safety factor = 1,3

$$MoI_x = \frac{1}{12} \cdot Weight \cdot SF \cdot (B^2 + H^2)$$

$$= \frac{1}{12} \cdot 1655,76 \cdot 1,3 \cdot (23,77^2 + 23,96^2)$$

$$= 204402,82 \text{ Tm}^2$$

$$MoI_y = \frac{1}{12} \cdot Weight \cdot SF \cdot (L^2 + H^2)$$

$$= \frac{1}{12} \cdot 1655,76 \cdot 1,3 \cdot (30,76^2 + 23,96^2)$$

$$= 372502,72 \text{ Tm}^2$$

Project	Tombua Landana		
Subject	Living Quarters		
Job / Bid no.	I/0310		
Date	30-May-07	Sheet	1

TRANSPORTATION FORCES

Transportation Criteria

Roll:	*20*	[deg]	(single amplitude)	
	10	[s]	(full cycle period)	
Pitch:	*12.5*	[deg]	(single amplitude)	*These criteria are according to Noble Denton, for large barges.*
	10	[s]	(full cycle period)	
Heave:	*5*	[m]	(single amplitude)	
	10	[s]	(full cycle period)	

Cargo specification: ***CARGO***

Weight:	*16242.98*	[kN]
Mass moment of inertia about roll axis, MoIx:	*204403*	[T·m²]
Mass moment of inertia about pitch axis, MoIy:	*372503*	[T·m²]
X coord (from stern):	*60.96*	[m]
Y coord (from centerline) :	*0.756*	[m]
Z coord (from bottom barge):	*16.797*	[m]

Barge/Ship information: ***BARGE***

X - coordinate of the center of rotation:	*60.96*	[m]
Mean draft of barge:	*2.44*	[m]

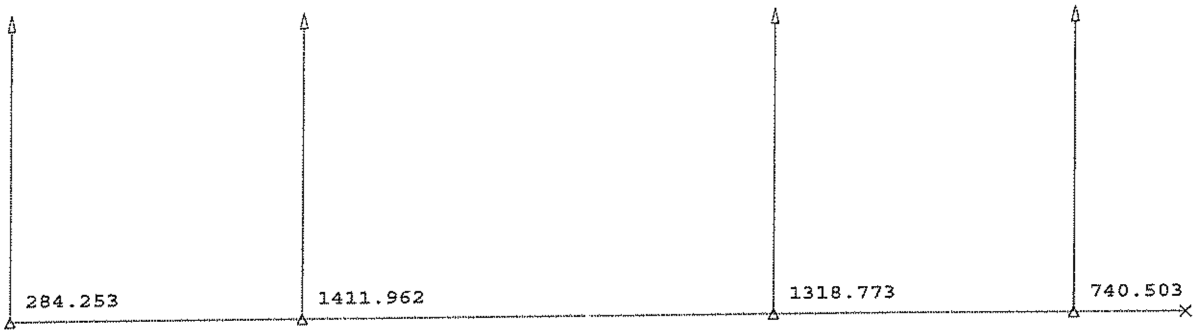
Forces and Accelerations (Static + Dynamic) exerted by module on barge:

Roll to SB	Fv:	-15091	[kN]	-0.93	g
	Fh:	-8831	[kN]	-0.54	g
	Moment:	28168	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g
Roll to PS	Fv:	-15436	[kN]	-0.95	g
	Fh:	8831	[kN]	0.54	g
	Moment:	-28168	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g
Pitch to stern	Fv:	-15858	[kN]	-0.98	g
	Fh:	-5563	[kN]	-0.34	g
	Moment:	-32083	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g
Pitch to bow	Fv:	-15858	[kN]	-0.98	g
	Fh:	5563	[kN]	0.34	g
	Moment:	32083	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g

Coordinates, and forces are according to the Bartran axis system. Moments according to Right Hand Rule.

sheet 5.5.

ISOMETRIC



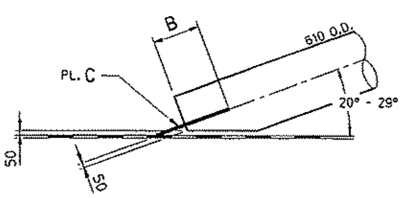
REACTION FZ

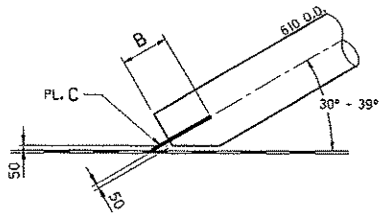
LC LIST

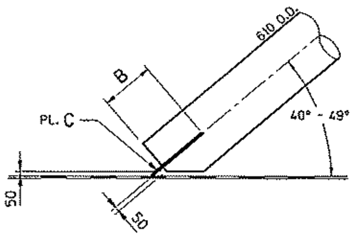
GENERAL NOTES

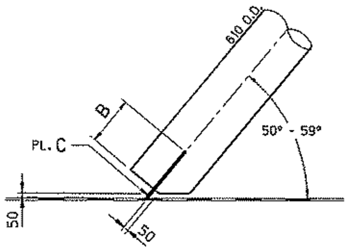
1. ✱= PLATE-LENGTH DETERMINED BY DRAWING OFFICE.
2. 610 O.D. AS DRAWN.

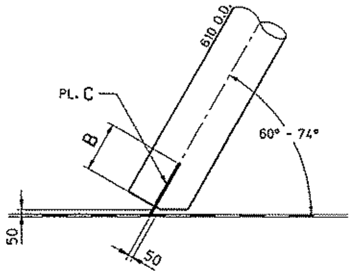
ENGINEER PROVIDED INFO	
A	MINIMUM WELD-LENGTH
B	MINIMUM WELD-LENGTH
C	PLATE-THICKNESS
D	WELDSIZE
E	WELDSIZE

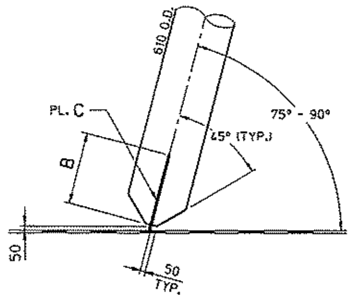












GRAPHIC SCALE 1 : 25 0 50 100 150 200 250 300 CM

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING		APP'D OPS.
B	15-6-99		NOTE REMOVED			MR
A	26-2-99		FOR INFORMATION			MR

PROJECT

IPE ENGINEERING - STANDARDS

SUBJECT

SEAFASTENING DETAILS
168 O.D. - 610 O.D.

Heerema Marine Contractors Nederland B.V.

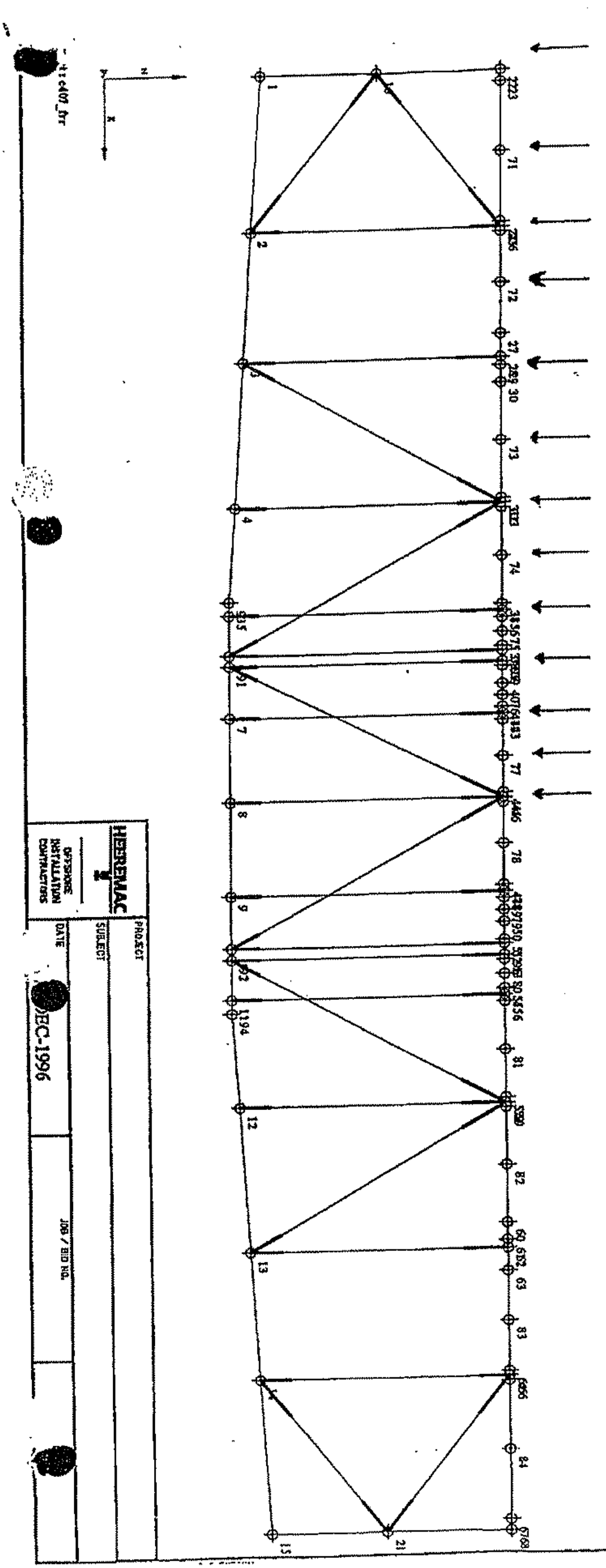
CLIENT'S DRAWING NO.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO.	REVISION
1 : 25	150.231.A2000	HI - 123 - 01 - 1	B

06-Nov-02 11:19:20 AM ...\hi12301l.dgn

Sheet 56.

CROWLEY 407



Max U.C.	SACS Output	LAPIPE Output
0,66	1515	2561
1,44 ~~1,63~~	694	
1,08	926	
1,05	952	
0,35	2857	3567
0,84	1190	
0,94	1064	
1,17	855	
1,24	806	
1,08	926	
0,90	1111	
0,63	1587	
0,24	1500	

DUE TO PLATE BUCKLING ONLY ~50% OF THE COLUMN CAPACITY IS AVAILABLE

↳ UNITY CHECK BASED ON 1000 kN UNIT LOAD.

ALL OUTPUT IN KN.

THE MAXIMUM LOAD IN THE MIDDLE IS 1500 kN BECAUSE THE LONGITUDINAL TRUSS FRAME IS GOVERNING.

APPENDIX B

TRANSPORTATION FORCES CALCULATION

JOB NO. : I/0310

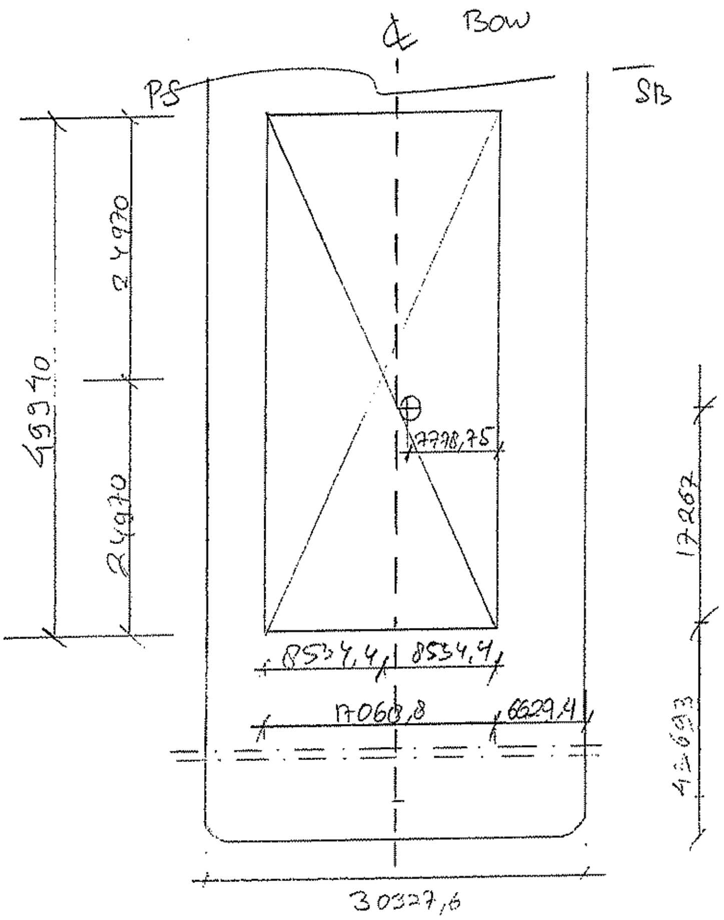
COMP'D BY : Andrew . H

CALC. NO. : QT400-RP01

DATE : 23rd April '07

SHEET NO.:

Transportation Forces



Module lift weight = 3650320 lb
= 1655,76 ton
= 16242,98 kN

X

X_1 = 56 ft + 7,825 in = 56,651 ft = 17,27 m
X_2 = 143 ft + 4,19 in = 143,349 ft = 43,69 m
X_2 = $X_1 + X_2$ = 200 ft = 60,96 m
Δ_x = 55 ft − X_1 = −1,651 ft = −503,24 mm

Y

Y_1 = 25 ft 6,25 in = 25,52 ft = 7,78 m
(COG (module - SB) Y_2 = 6629,4 mm + Y_1 = 47,27 ft = 14,41 m
y COG (from CL - barge) Y_3 = 15163,2 mm − Y_2 = 2,48 ft = 0,756 m

Δ_Y = 28 ft − Y_1 = 2.48 ft = 755,62 mm

JOB NO. : I/0310

COMP'D BY : Andrew. H.

CALC. NO. : QT-400-EP01

DATE : 23rd April '07

Z

Relative to B.O.S $Z_1 = 30ft + 1,313\ in$ $= 9177,34\ mm$

$\Delta_Z = Z_1 + H_{grill} + H_{barge}$

$= 9177,24 + 1524 + 6096$ $= 16797,34\ mm$

Module Global Dimensions

$L = 110\ ft + 16\ ft + 14\ in$ $= 38,76\ m$

$B = 56\ ft + 22\ ft$ $= 23,77\ m$

$H = 78\ ft + 7,5\ in$ $= 23,96\ m$

Moment of Inertia

Safety factor = 1,3

$$MoI_x = \frac{1}{12} \cdot Weight \cdot SF \cdot (B^2 + H^2)$$

$$= \frac{1}{12} \cdot 1655,76 \cdot 1,3 \cdot (23,77^2 + 23,96^2)$$

$$= 204\,402,82\ Tm^2$$

$$MoI_y = \frac{1}{12} \cdot Weight \cdot SF \cdot (L^2 + H^2)$$

$$= \frac{1}{12} \cdot 1655,76 \cdot 1,3 \cdot (38,76^2 + 23,96^2)$$

$$= 372\,502,72\ Tm^2$$

JOB NO. : I/0310

SHEET NO.: 3

COMP'D BY : Andreas H.

CALC. NO. : QT400-RP01

DATE : 23rd April'07

Heave

$$a_h : \left(\frac{2\pi}{T_{heave}}\right)^2 H$$

$$= \left(\frac{2\pi}{10}\right)^2 * 5$$

$$= 1,97 \ m/s^2$$

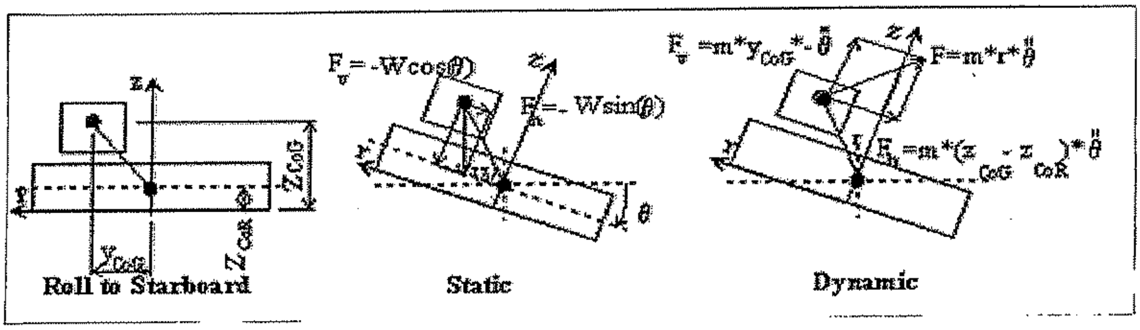
$$F_{heave} = M * a_h$$

$$= 1655,76 \quad * 1.97$$

$$= 3260,33 \ kN$$

Roll

(to starboard)



z CoG : 16,80 m

z CoR : 2,44 m

JOB NO. : I/0310

COMP'D BY : Andreas.H

CALC. NO. : QT400-RP07

DATE : 23rd April '02

SHEET NO.: 4

F_v

a. static

$F_{v\,sta} : -W \cdot \cos\theta_{roll}$

$: -16242,98 \cdot 0,94$

$= -15263,41$ kN

b. dynamic

$F_{dyn} = \frac{W}{9,81} \cdot Y_{cog} \cdot \left(\theta_{roll} \left(\frac{2\pi}{T_{roll}} \right)^2 \right)$

$= \frac{16242,08}{9,01} \cdot 0,756 \cdot \left(0,35 \left(\frac{2\pi}{10} \right)^2 \right)$

$= 172,96$ kN

$F_{v\,tot} : F_{v\,sta} + F_{v\,dyn}$

$: -15263,41 + 172,96$

$: -15090,45$ kN

F_h

a. static

$F_{h\,sta} : -W \cdot \sin\theta_{roll}$

$= -16242,98 \cdot 0,34$

$= -5555,43$ kN

b dynamic

$F_{h\,dyn} = \frac{W}{9,81} \cdot (z_{cog} - z_{cor}) \left(-\theta_{roll} \left(\frac{2\pi}{T_{roll}} \right)^2 \right)$

$= \frac{16242,98}{9,81} \cdot (16,80 - 2,44) \cdot \left(-0,35 \left(\frac{2\pi}{10} \right)^2 \right)$

$= -3276,32$ kN

$F_{h\ tot} : F_{h\ sta} + F_{h\ dyn}$

$: -5555,43 + (-3276,32)$

$= -8831,74$ kN

Moment

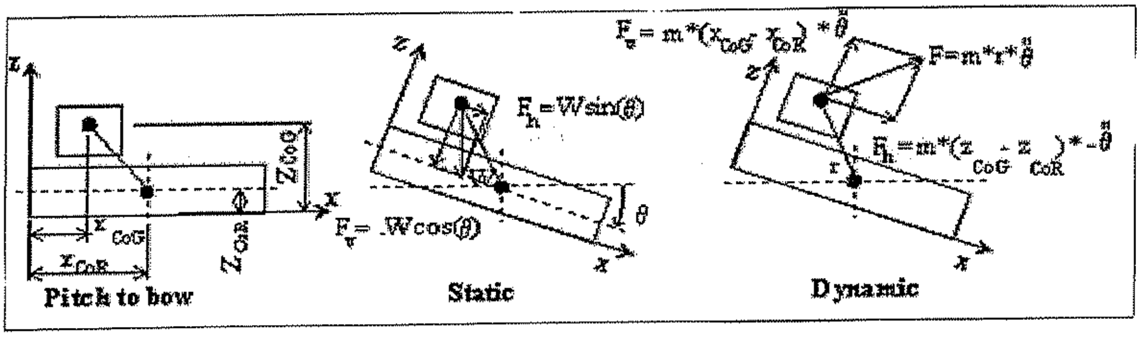
$$M = M_o I_x \left(\theta_{roll} \left(\frac{2\pi}{T_{roll}} \right)^2 \right)$$

$$= 204402,02 \cdot \left| 0,35 \left(\frac{2\pi}{10} \right)^2 \right|$$

$$= 28167,87 \text{ kNm}$$

Roll to port side forces are calculated with the same formula, but all of θ should be multiplied by (- 1)
The end result are showed in forces resume.

Pitch



X CoG : 30,08 m
X COR : 60,96 m

JOB NO. : I/0310

COMP'D BY : Andrew H.

CALC. NO. : QT100-RP01

DATE : 23rd April '07

SHEET NO.: 6

F_v

a. Static

$F_{v\,sta}$: $-W \cdot \cos\theta_{pitch}$

: $-16242{,}98 \cdot 0{,}98$

: $-15857{,}96$ kN

b. dynamic

$F_{v\,dyn}$: $\frac{W}{9{,}81} \cdot (X_{cog} - X_{cor}) \cdot \left(-\theta_{pitch} \cdot \left(\frac{2\pi}{T_{pitch}}\right)^2\right)$

: $\frac{16242{,}98}{9{,}81} \cdot (60{,}96 - 60{,}96)\left(-0{,}22\left(\frac{2\pi}{12{,}5}\right)^2\right)$

= 0 kN

$F_{v\,tot}$ = $F_{v\,sta} + F_{v\,dyn}$

= $-15857{,}96 + 0$

: $-15857{,}96$ kN

F_h

a. static

$F_{h\,sta}$: $W \cdot \sin\theta_{pitch}$

: $16242{,}98 \cdot 0{,}22$

: $3515{,}62$ kN

b. dynamic

$F_{h\,dyn}$: $\frac{W}{9{,}81} \cdot (z_{cog} - z_{cor}) \cdot \left(\theta_{pitch}\left(\frac{2\pi}{T_{pitch}}\right)^2\right)$

= $\frac{16242{,}98}{9{,}81}(16{,}80 - 2{,}44) \cdot \left(0{,}22\left(\frac{2\pi}{T_{pitch}}\right)^2\right)$

= $2047{,}70$ kN

JOB NO. : I/0310

COMP'D BY : Andrew.H.

CALC. NO. : OT400-RP01

DATE : 23rd April '02

SHEET NO.: 2

$$F_{h\,tot} : F_{h\,sta} + F_{h\,dyn}$$

$$= 3515,62 + 2047,70$$

$$= 5563,32 \text{ kN}$$

Moment

$$M : M_o I_y \left(\theta_{pitch} \left(\frac{2\pi}{T_{pitch}} \right)^2 \right)$$

$$= 372502,72 \cdot \left(0,22 \left(\frac{2\pi}{12,5} \right)^2 \right)$$

$$= 32083,12 \text{ kNm}$$

sheet 8

Project	Tombua Landana
Subject	Living Quarters
Job / Bid no.	I/0310
Date	30-May-07
Sheet	1

TRANSPORTATION FORCES

Transportation Criteria

Roll:	*20* [deg]	(single amplitude)	
	10 [s]	(full cycle period)	
Pitch:	*12.5* [deg]	(single amplitude)	
	10 [s]	(full cycle period)	
Heave:	*5* [m]	(single amplitude)	
	10 [s]	(full cycle period)	

These criteria are according to Noble Denton, for large barges.

Cargo specification: *CARGO*

Weight:	*16242.98*	[kN]
Mass moment of inertia about roll axis, MoIx:	*204403*	[T·m²]
Mass moment of inertia about pitch axis, MoIy:	*372503*	[T·m²]
X coord (from stern):	*60.96*	[m]
Y coord (from centerline) :	*0.756*	[m]
Z coord (from bottom barge):	*16.797*	[m]

Barge/Ship information: *BARGE*

X - coordinate of the center of rotation:	*60.96*	[m]
Mean draft of barge:	*2.44*	[m]

Forces and Accelerations (Static + Dynamic) exerted by module on barge:

Roll to SB	Fv:	-15091	[kN]	-0.93	g
	Fh:	-8831	[kN]	-0.54	g
	Moment:	28168	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g
Roll to PS	Fv:	-15436	[kN]	-0.95	g
	Fh:	8831	[kN]	0.54	g
	Moment:	-28168	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g
Pitch to stern	Fv:	-15858	[kN]	-0.98	g
	Fh:	-5563	[kN]	-0.34	g
	Moment:	-32083	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g
Pitch to bow	Fv:	-15858	[kN]	-0.98	g
	Fh:	5563	[kN]	0.34	g
	Moment:	32083	[kN·m]		
	Heave: (±)	3268	[kN]	0.20	g

Coordinates, and forces are according to the Bartran axis system. Moments according to Right Hand Rule.

Last Revision: May 98

APPENDIX C

LOAD-OUT PHASES

LOAD DESCRIPTION: Living Quarters
VEHICLE DESCRIPTION: 88-Lines SPMT's

UNITS:	METRIC	ENGLISH
TOTAL WEIGHT:	2,021.76 Te	4,457,212 lbs
LOAD/LINE	22.97 Te	50,650 lbs
LOAD/ AXLE	11.49 Te	25,325 lbs
LOAD/TIRE	5.74 Te	12,663 lbs
LOAD/LAT. INCH	0.41 Te	904 lbs
GROUNDPRESSURE:	6.75 Te/m^2	1,383 psf

Step 1

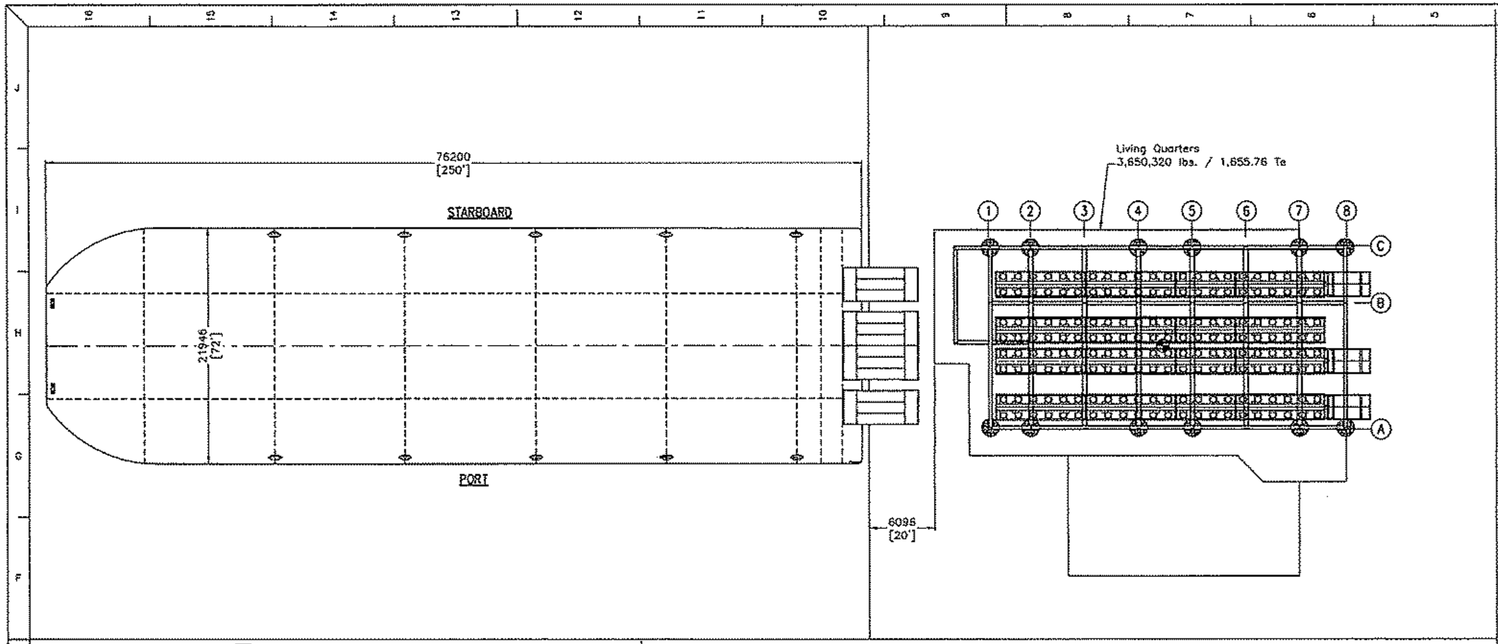
- The Living Quarter is built on supports with a clearance of 5'-0".
- The Trailers are driven in under the Living Quarter.
- Using the trailer hydraulics the Living Quarter is lifted clear of the supports.
- Wedges and Ramps are set up from the Quay to the 250'x72'x16' Deck Barge.

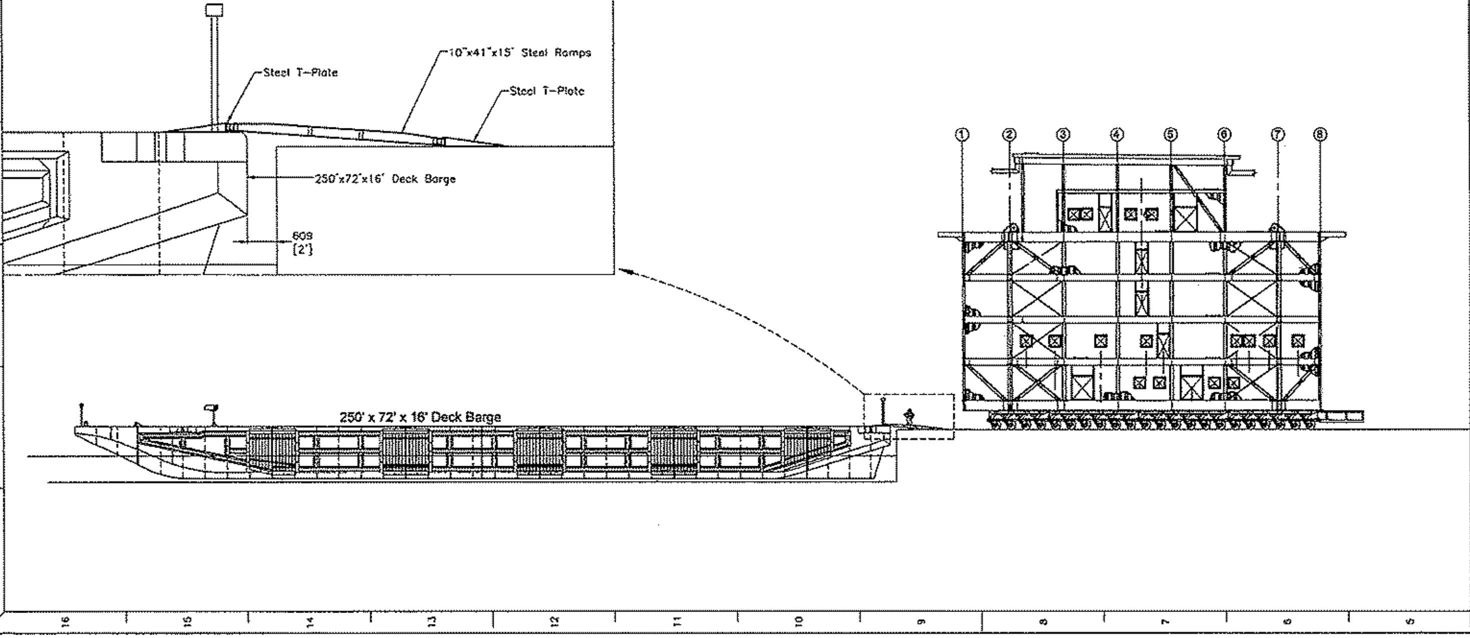
Notes:

- See Sheet 5 of 5 for end view of Living Quarters on 250' x 72' x 16' Deck Barge.
- See Sheet 5 of 5 for end view of Living Quarters on 400' x 99'-6" x 20' Deck Barge.

Reference Drawings:

- D-B14-TOL-DPP-40-1200 Rev. 0
- D-B14-TOL-DPP-40-1214 Rev. 0
- D-B14-TOL-DPP-40-1216 Rev. 0
- D-B14-TOL-DPP-40-1251 Rev. B





Preliminary

REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	APPROVED:
03	Fixed orientation of Quarters on barge	04/30/07	KAD KAD	JT	RR
02	Rotated Quarters 180 degrees	04/27/07	KAD	JT	RR
01	Rev'd. proced. for loading Quarters on barge	04/24/07	KAD	JT	RR
00	First Issue	04/24/07	KAD	JT	RR

CLIENT: DELTA ENGINEERING

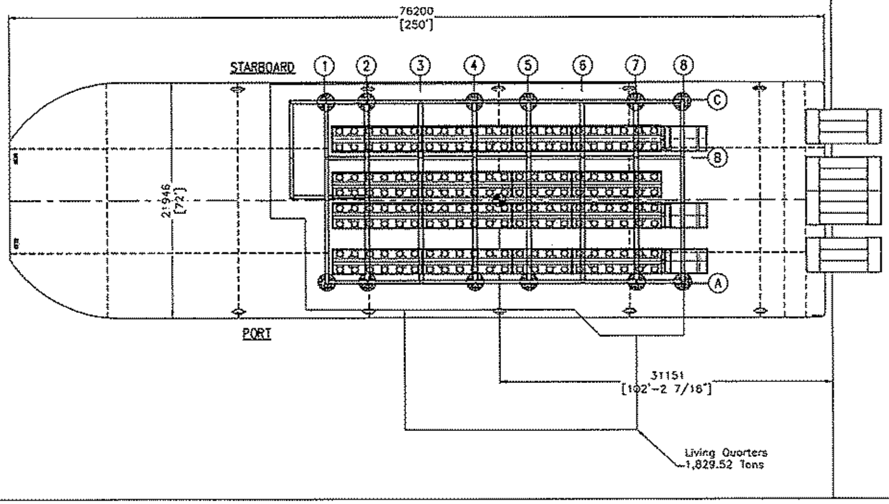
PROJECT: HOUSTON, TEXAS LIVING QUARTERS

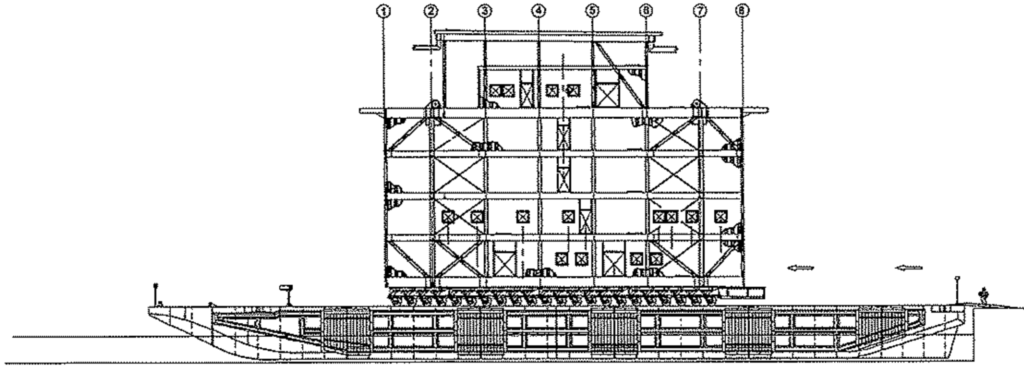
TITLE: MOVING LIVING QUARTER ONTO
AND SETTING ON SUPPORTS

MAMMOET
MAMMOET USA
20525 FM 521, Rosharon, TX 77583
Tel. +1 (281) 369-2200 / Fax. +1 (281) 369-2178
www.mammoet.com

SCALE: N.T.S. SIZE: B

SAP No:	DRAWING NUMBER					
	PROJECT No:	SUB:	DOC:	PART:	SHT.	REV.
7000024259	0010025925	P030	D	W01	1/5	03





Step 2

- The Living Quarter is driven from the Assembly Point to the 250'x72'x16' Deck Barge as shown.
- Once the Trailers, with the Living Quarter, are in the right location on the Deck Barge, tie-downs are attached for the trip to the 400' Deck Barge.
- The 250' Deck Barge is towed to the 400' Deck Barge and they are tied together as shown on Sheet 3 of 4.

Preliminary

REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	APPROVED:
03	Fixed Orient. of Quarters on barge	04/30/07	KAD	JT	RR
02	Rotated Quarters 180 degrees	04/27/07	KAD	JT	RR
01	Rev'd. proced. for loading Quarters on barge	04/24/07	KAD	JT	RR
00	First Issue	04/24/07	KAD	JT	RR

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DRAWING NUMBER

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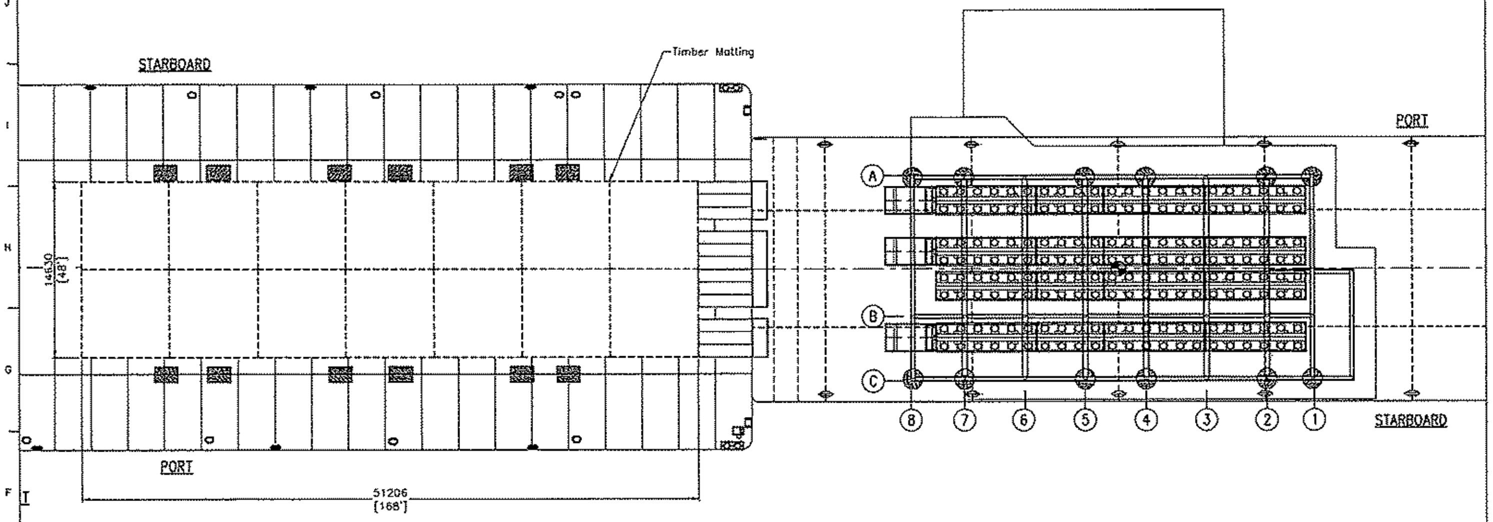
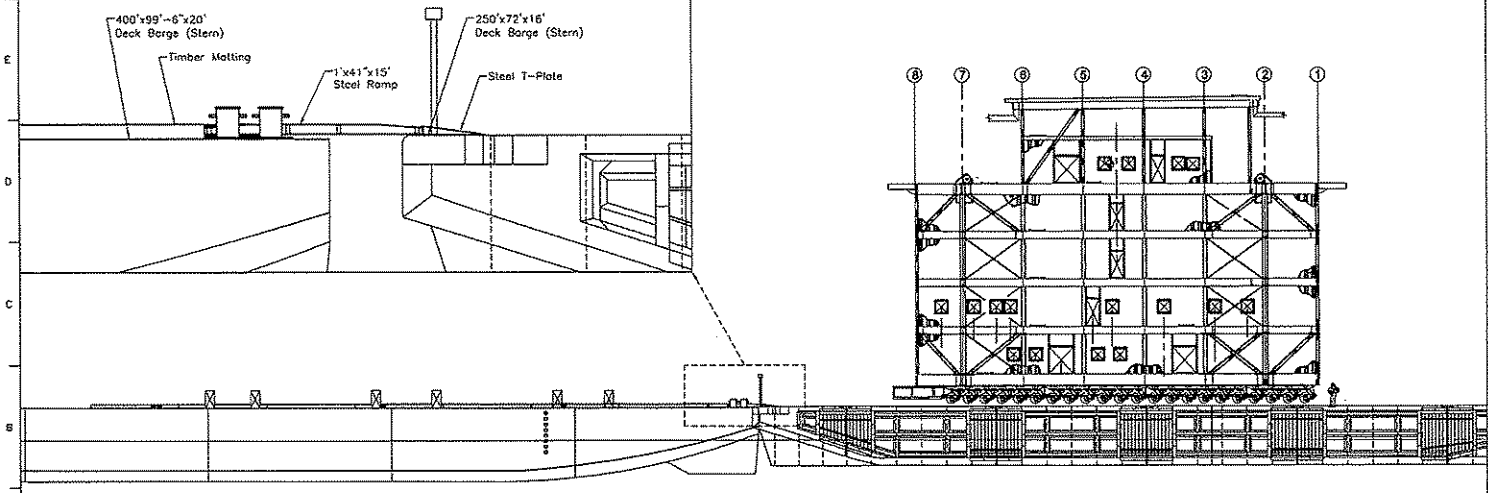


Step 3

- The 250'x72'x16' Deck Barge with the Trailers and Living Quarter is moved to a position adjacent to the 400'x99'-6"x20 Deck Barge, stem to stem and tied off.
- Steel Wedges and Ramps and placed from the 250' barge to the 400' barge.
- The Living Quarter is moved from the 250' barge to the 400 ' barge as shown on Sheet 4 of 4.



Preliminary

REV.	DESCRIPTION:	DATE:	DRAWN:		CHECKED:		APPROVED:
03	Fixed orient. of Quarters on Barge	04/30/07	KAD		JT		RR
02	Rotated Quarters 180 degrees	04/27/07	KAD		JT		RR
01	Rev'd. proced. for loading Quarters on barge	04/24/07	KAD		JT		RR
00	First Issue	04/24/07	KAD		JT		RR

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PROJECT: HOUSTON, TEXAS LIVING QUARTERS

TITLE: MOVING LIVING QUARTER ONTO
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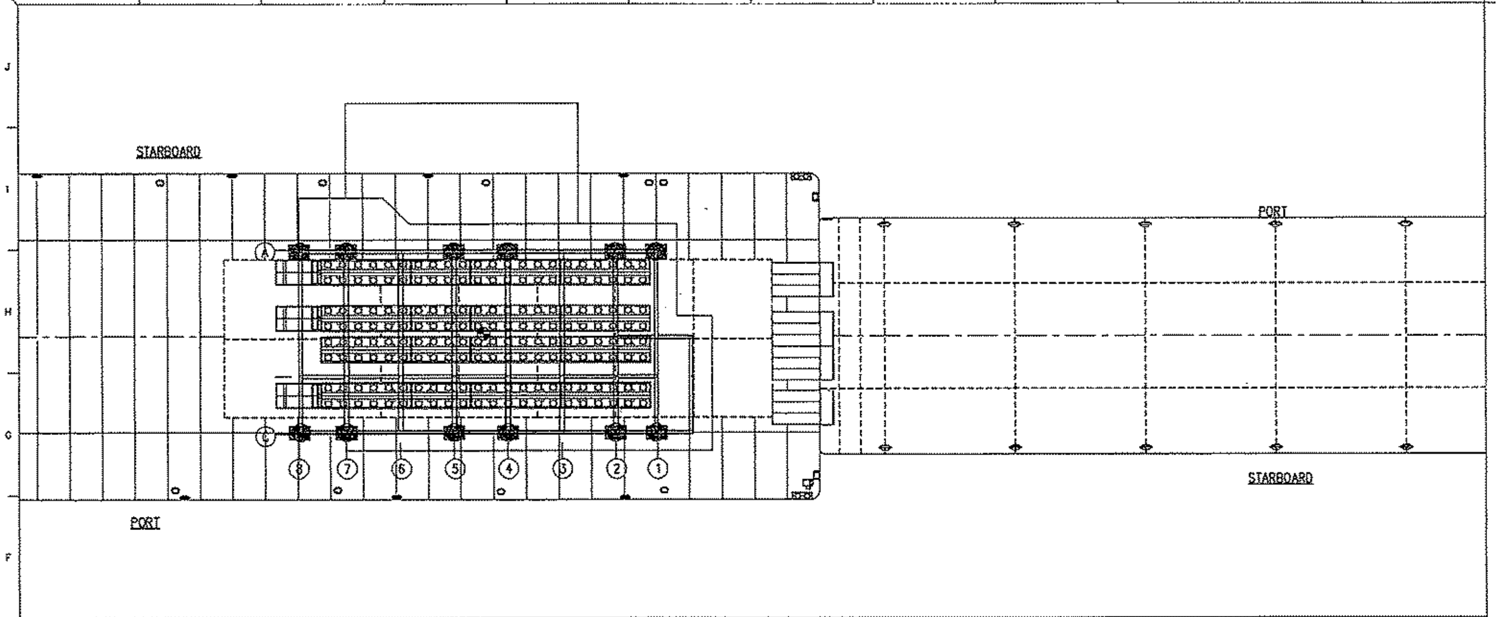
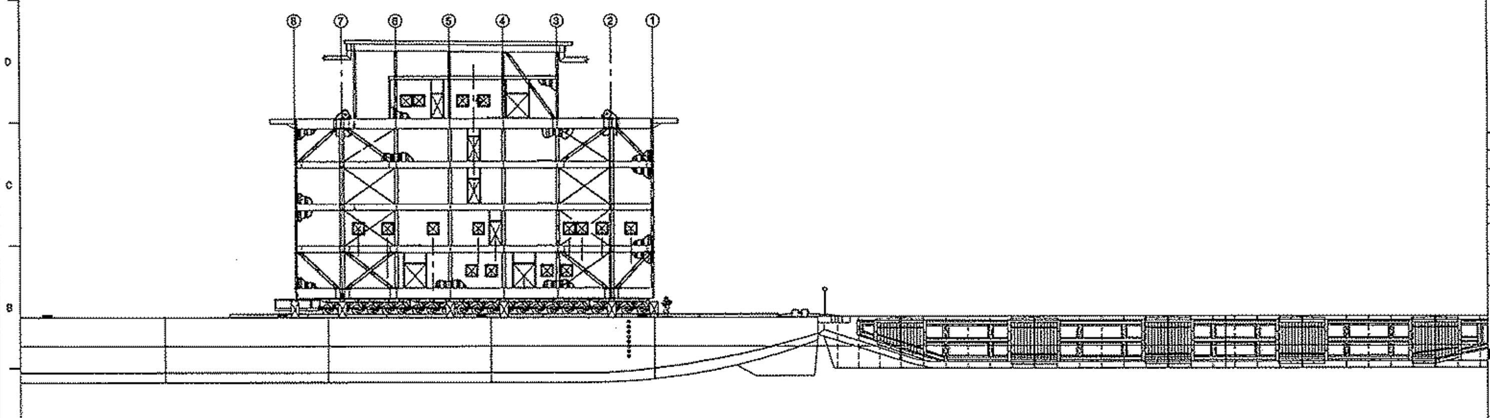
DRAWING NUMBER
SAP No: 7000024259
PROJECT No: | SUB: | DOC: | PART: | SHT. | REV.
0010025925 - P030 - D - W01 - 3/5 - 03





Step 4

- The Living Quarter is moved from the 250' barge to the 400' barge.
- When the Living Quarter is in the proper location it is set down onto the supports that have been supplied by the Client.
- The trailers are removed.
- Tie-downs are place on the Living Quarter to secured it for transit.

Preliminary

REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	APPROVED:
03	Fixed orient. of Quarters on barge	04/30/07	KAD	JT	RR
02	Rotated Quarters 180 degrees	04/27/07	KAD	JT	RR
01	Rev'd. proced. for loading Quarters on barge	04/24/07	KAD	JT	RR
00	First Issue	04/24/07	KAD	JT	RR

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DRAWING NUMBER

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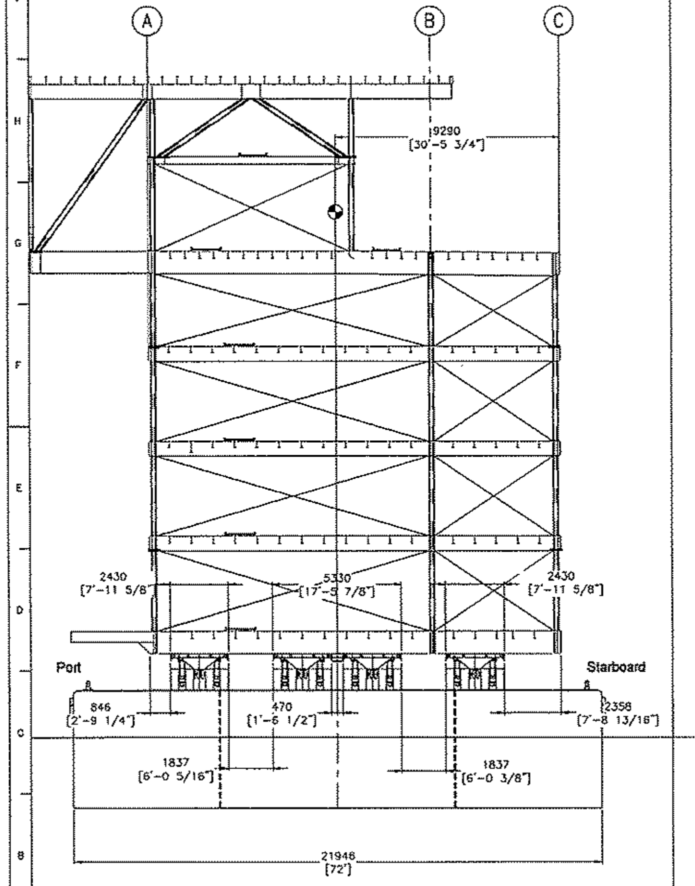
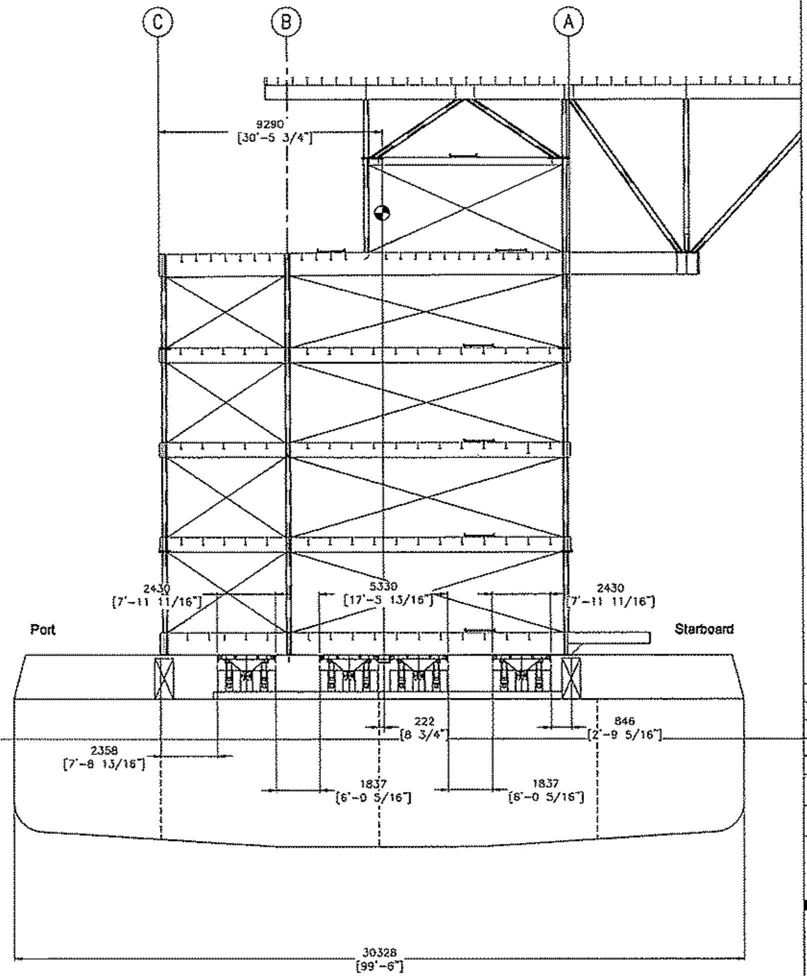
7000024259	0010025925	P030	D	W01	4/5	03



Quarters on 250' x 72' x 16'
Deck Barge



Quarters on 400' x 99'-6" x 20'
Deck Barge

Preliminary

REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	APPROVED:
03	Fixed orient. of Quarters on barge	04/30/07	KAD	JT	RR
02	Rotated Quarters 180 degrees	04/27/07	KAD	JT	RR
01	Rev'd. proced. for loading Quarters on barge	04/24/07	KAD	JT	RR
00	First issue	04/24/07	KAD	JT	RR

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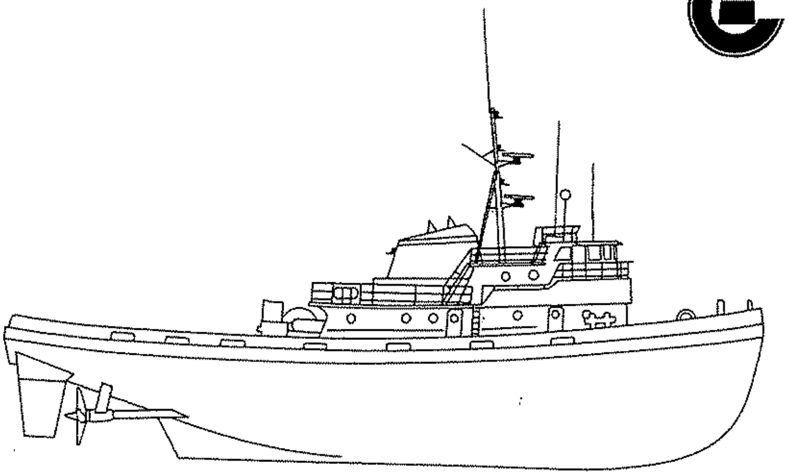
SCALE: N.T.S.	SIZE: B	DRAWING NUMBER					
SAP No:		PROJECT No:	SUB:	DOC:	PART:	SHT.	REV.
7000024259		0010025925 -	P030 -	D -	W01 -	5/5	- 03

APPENDIX D

INVADER TUG

INVADER - CLASS TUGS

Tug	Built	Official No.	Call Sign
INVADER	1974	559404	WBO 3337
CRUSADER	1974	560235	WYP 4482
EXPLORER	1975	563687	WBN 7618
GLADIATOR	1975	566429	WBN 5982
MONITOR	1975	567988	WBN 5981
NAVIGATOR	1975	562688	WBO 3345
PIONEER	1975	566933	WBN 5040
WARRIOR	1975	565291	WBN 4383
ADVENTURER	1976	577697	WBN 3015
BULWARK	1976	577084	WBN 4113
CAVALIER	1976	570693	WBN 5983
CENTURION	1976	574171	WBN 3022
COMMANDER	1976	571180	WBN 5980
DEFENDER	1976	576314	WBN 3016
GAUNTLET	1976	575769	WBN 6511
GUARDSMAN	1976	572647	WBN 5978
PATRIARCH	1976	578312	WBN 3014
RANGER	1976	571909	WBN 5979
SENTINEL	1976	573426	WBN 6510
STALWART	1976	575052	WBN 6512
ENSIGN	1977	581177	WBN 3012
HUNTER	1977	578655	WBN 3744
MARINER	1977	582112	WBN 5096
PILOT	1977	580326	WBN 3011
SENTRY	1977	579188	WBN 3013



INVADER - CLASS SPECIFICATIONS:

FLAG
United States

PORT OF REGISTRY
San Francisco, CA

BUILDER
J.R. McDermott & Co.
Morgan City, LA

OVERALL DIMENSIONS

Length:	136' 2 1/2"
Breadth:	36' 6"
Depth:	19' 2"

TONNAGE

199	tons gross
135	tons net

CONSTRUCTION
Steel

LIGHT DRAFT
17'

LOADED DRAFT
20'

FUEL CAPACITY
155,000 gallons

POTABLE WATER
15,000 Gallons

LUBE OIL
3,300 Gallons

MAIN ENGINES
2 EMD 20-645-E5

AUXILIARY ENGINES
2 Caterpillar D 3304

PROPULSION
Twin-screw
5-bladed stainless steel

HORSEPOWER
7,200 maximum
continuous BHP

REDUCTION GEAR
2 Falk, ratio 4.345:1

TOWING WINCH
Markey TDSDW 36C,
double-drum

TOWING WIRE
Maximum 2 @ 3,000' of
2 1/4" wire rope

EMERGENCY TOW GEAR
450' x 7.5" Spectra Line (SK-75)
Orville Hook
and appropriate
connecting gear
Line throwing gun.

BOLLARD PULL
150,000 lbs. ahead
120,000 lbs. astern
(Bollard pull will vary slightly
by vessel)

NAVIGATION / COMMUNICATIONS EQUIPMENT
Radar 1: Gyro Azimuth Stabilized Furuno FR1510 mk2 or mk3 with ARP-15 Target Plotter and GPS and Depth data interface.
Radar 2: Gyro Azimuth Stabilized Furuno **FR8111** or FR8100D with GPS data interface.
GPS: Trimble **NT300D**, NT XL or Navtrac.
LORAN C: Furuno **LC90mk2**
Depth: 200kHz Furuno **LS-6000**
Inmarsat Mini-M Satellite Phone (if fitted): **Worldphone Marine**
HF SSB #1: Stephens **SEA330**
HF SSB #2: Stephens SEA225 or **SEA235**
VHFs 3ea: Stephens **SEA156**, SEA157, or Icom **M127.**
Sperry Mk37 gyrocompass with Universal Gyropilot.
EPIRB: **ACR 2754** or **ACR 2774** 406MHz Satellite EPIRB.

CROWLEY

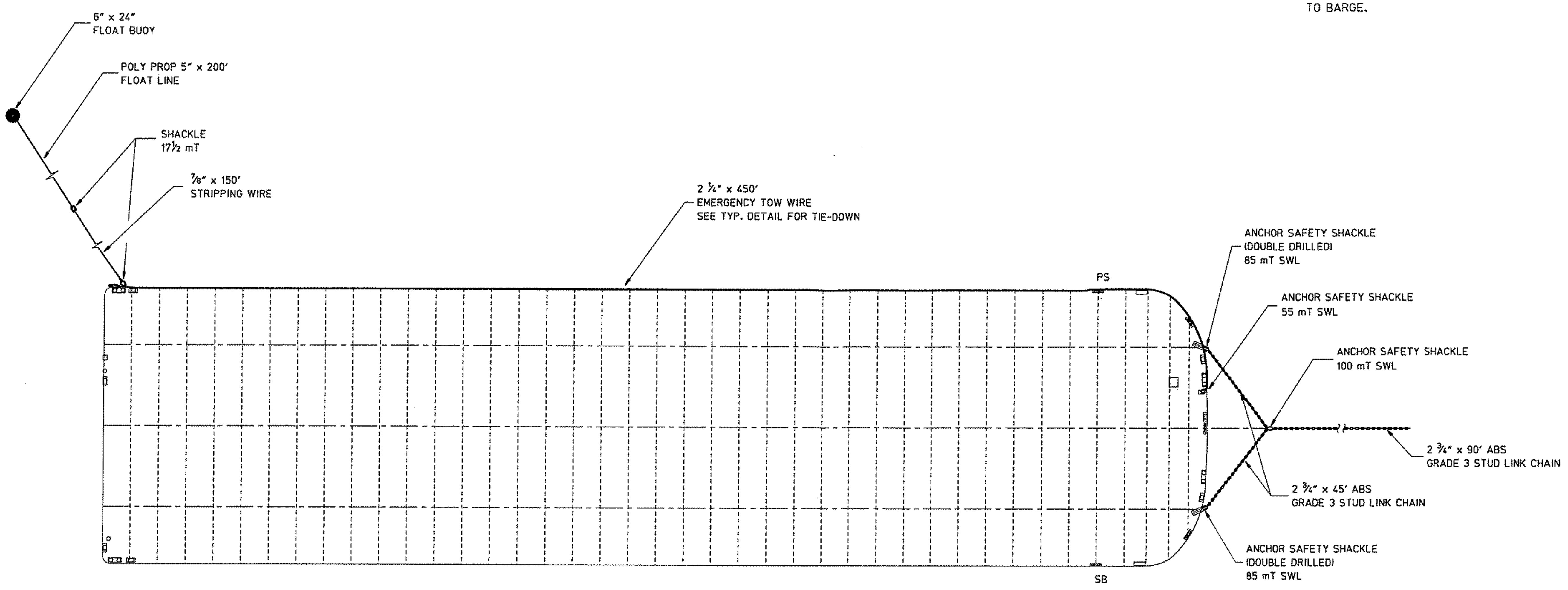
2 Northpoint Drive, Suite 900
Houston, Texas 77060
Telephone: (281) 260-4410 Facsimile: (281) 260-4597
http://www.crowley.com

APPENDIX E

EMERGENCY TOWING GEAR

GENERAL NOTES

1. mT = METRIC TONNES.
2. EMERGENCY TOW WIRE ARRANGEMENT WILL BE PROPERLY SECURED TO BARGE.



PLAN
1 : 250

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING	APP'D OPS.
A	28 OCT 2005	AdH	FOR INFORMATION (IN HOUSE ONLY)		

PROJECT
BARGES CONTRACTORS

SUBJECT
CROWLEY 406 TOWING ARRANGEMENT

MARINE CONTRACTORS
Heerema Marine Contractors Nederland B.V.

CLIENT'S DRAWING NO.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO. DISCIPLINE - IDENT. NO. - SUBJECT NO. - SHEET NO.	REVISION
1 : 250	150450.27000	CB - 161 - 01 - 3	A

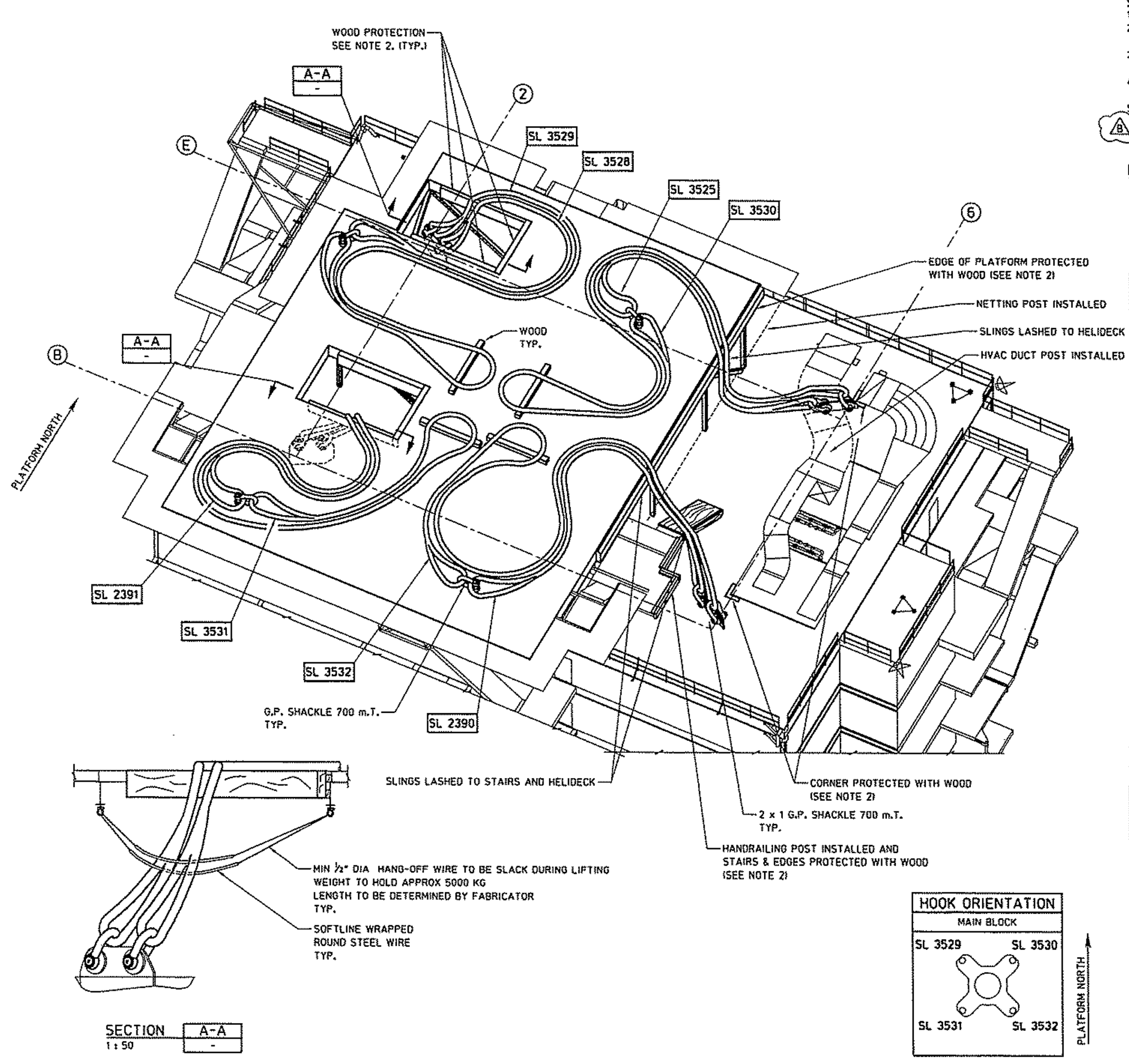
PREPARED USING [illegible] CAD/CAE SYSTEM

02-May-07 3:35:47 PM ...\aadp\dms00387\CB-161-01-3.dgn

APPENDIX F

INSTALLATION PHASES

Sheet 1



GENERAL NOTES

1 FOR GENERAL NOTES SEE DWG. HI-124-01-1
2. WOOD PROTECTION BY FABRICATOR.
DETAILS ACCORDING REF. MEMO M-HMC-DSME-0404.
3. ALL SHARP EDGES IN VICINITY OF SLINGS TO BE COVERED OR REMOVED (HMC TO APPROVE).
4. RIGGING ARRANGEMENT BASED ON LIVING QUARTER WEIGHT REPORT REV E.
5. m.T. = METRIC TONNES.

B

REFERENCE DRAWINGS

HI-124-01-1 TYPICAL SLING AND GROMMET LASHING DETAILS

LIFT POINT	SLING No.	LENGTH		S.W.L.	DIA		SHACKLES
		mm	INCHES	m.T.	mm	INCHES	m.T.
B2	SL 3531	54420	~178'	700	224	(8")	1 x 700 G.P.
	SL 2391	24370	~79'	700	229	(9")	2 x 700 G.P.
B6	SL 3532	54440	~178'	700	224	(8")	1 x 700 G.P.
	SL 2390	24260	~80'	700	229	(9")	2 x 700 G.P.
E2	SL 3529	53770	~176'	700	224	(8")	1 x 700 G.P.
	SL 3528	24670	~80'	600	210	(8")	2 x 700 G.P.
E6	SL 3530	53640	~175'	700	224	(8")	1 x 700 G.P.
	SL 3525	24770	~81''	600	210	(8")	2 x 700 G.P.
TOTAL RIGGING WEIGHT = ~79.7 mT.							

B

FOR INSTALLATION
DATE: 27 SEP 2004 REV. B

GRAPHIC SCALE 1 : 50 0 1 2 3 4 5 6 M
GRAPHIC SCALE 1 : 100 0 2 4 6 8 10 12 M

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING			APPD OPS.
B	27 SEP 2004	JvS	FOR INSTALLATION / REV. AS INDICATED				
A	07 MAY 2004	NdV	FOR INFORMATION				

PROJECT
CABGOC BENGUELA/BELIZE

SUBJECT
LIVING QUARTERS RIGGING ARRANGEMENT
LAY-OUT

Heerema Marine Contractors Nederland B.V.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO.	REVISION
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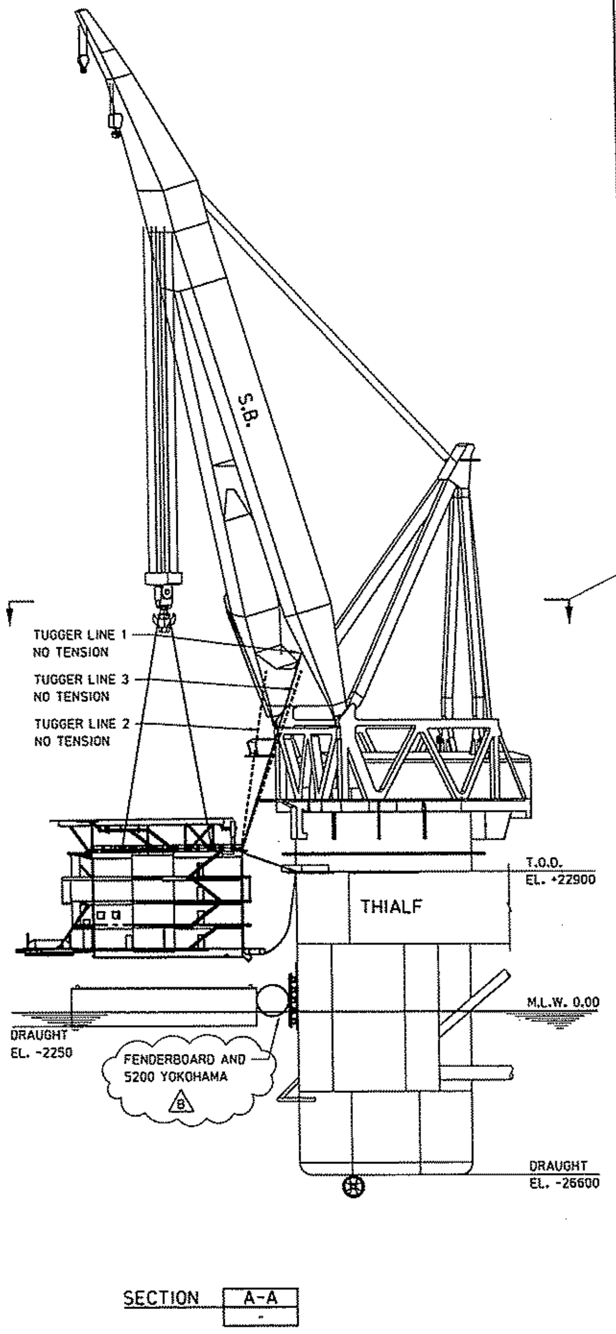
CLIENTS DRAWING NO.

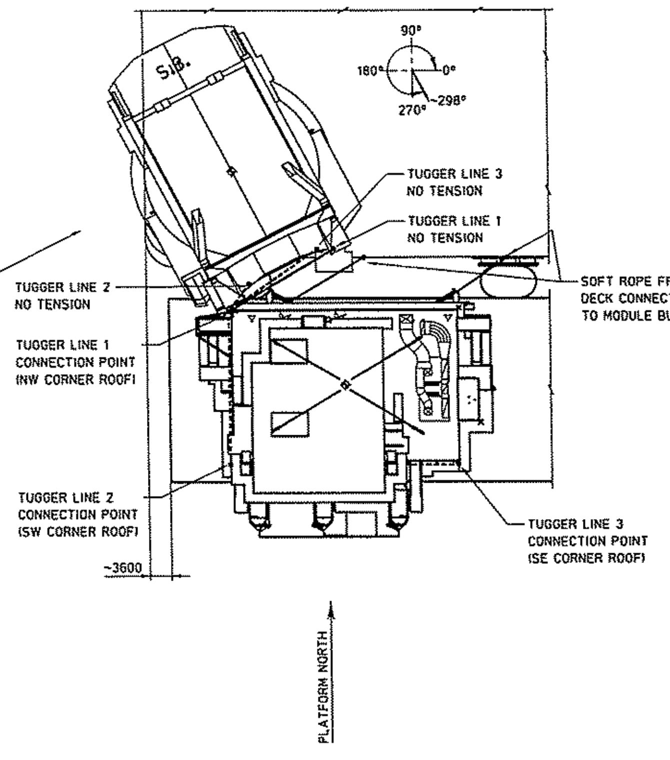


GENERAL NOTES

1. m.T. = METRIC TONNES.
2. WEIGHT IS BASED ON DELTA SUPPLIED REV. 0 WEIGHT REPORT DATED 18 NOV 2004. △B
3. HOOKLOAD INDICATES 10 % INACCURACIES AND RIGGING WEIGHT.

CRANE	S.B.
RADIUS	39341
HOOKLOAD	2410 m.T.
CAP.	6536 m.T.
HOOK EL.	64130

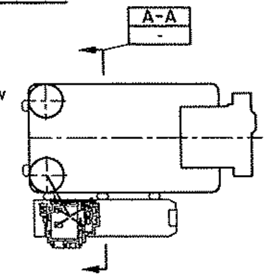
△B



REFERENCE DRAWINGS

HI-153-20-1	D.S.M.-2 AND LIVING QUARTERS ON BARGE AMT CARRIER LAY-OUT
HI-186-01-2	LIVING QUARTERS LIFT-OFF AND ROTATION WITH THIALF SB CRANE - STEP 2 & 3
HI-186-01-3	LIVING QUARTERS LIFT-OFF AND ROTATION WITH THIALF SB CRANE - STEP 4 TO 6
HI-186-01-4	LIVING QUARTERS LIFT-OFF AND ROTATION WITH THIALF SB CRANE - STEP 7 & 8
HI-186-02-1	LIVING QUARTERS INSTALLATION WITH THIALF SB CRANE FROM SOUTH SIDE
D-CAB-BEB-DPP-40-964A/966A/957	LIVING QUARTERS BUILING ROTATION (CLIENT DRAWING)

SITUATION



FOR INSTALLATION

APPROVED FOR INSTALLATION BY CLIENT

STEP 1

- MOOR BARGE ALONGSIDE SSCV.
- BRING TUGGER LINES OVER TO LQ AND CONNECT TO PRE-INSTALLED SECTIONS ON LQ. △B
- HOOK ON RIGGING, CUT SEAFASTENING AND LIFT-OFF LQ.

GRAPHIC SCALE 1 : 400 0 8 16 24 32 40 48 M

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING			APP'D OPS.
B	24 JAN 2004	NdV	FOR INSTALLATION / REV. AS INDICATED				
A	27 AUG 2004	NdV	FOR INFORMATION				PA

PROJECT
CABGOC BENGUELA/BELIZE

SUBJECT
LIVING QUARTERS
LIFT-OFF AND ROTATION WITH THIALF S.B. CRANE
STEP 1

Heerema Marine Contractors Nederland B.V.

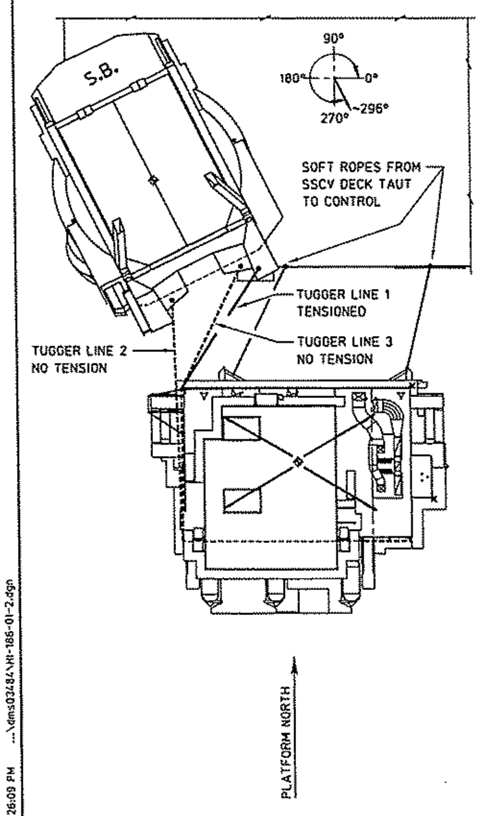
SCALE (A1 FORMAT)	JOB NO.	DRAWING NO.	REVISION
1 : 400	10246.00000	HI - 186 - 01 - 1	B

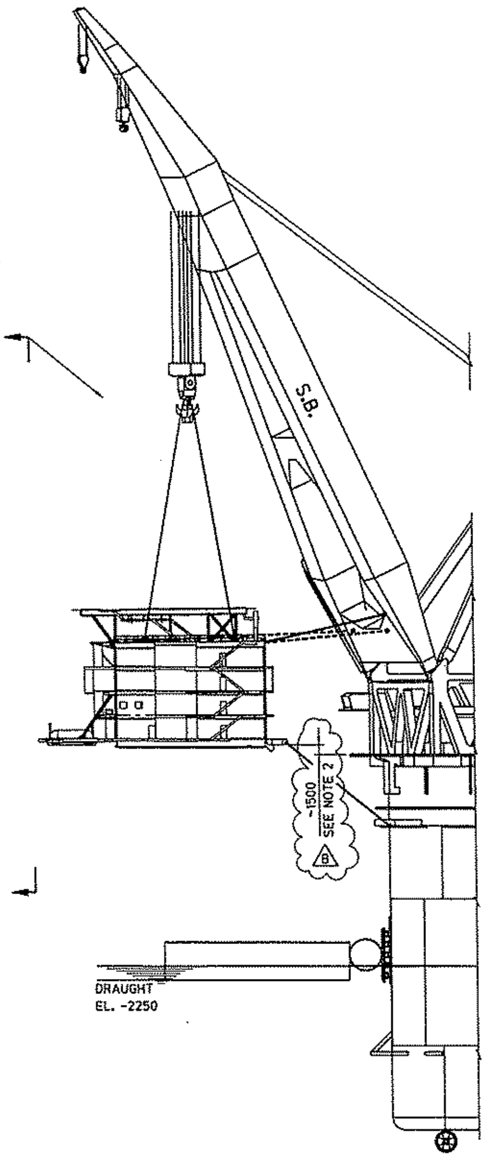
CLIENT'S DRAWING NO.

Sheet 2

CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000

B





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STEP 2

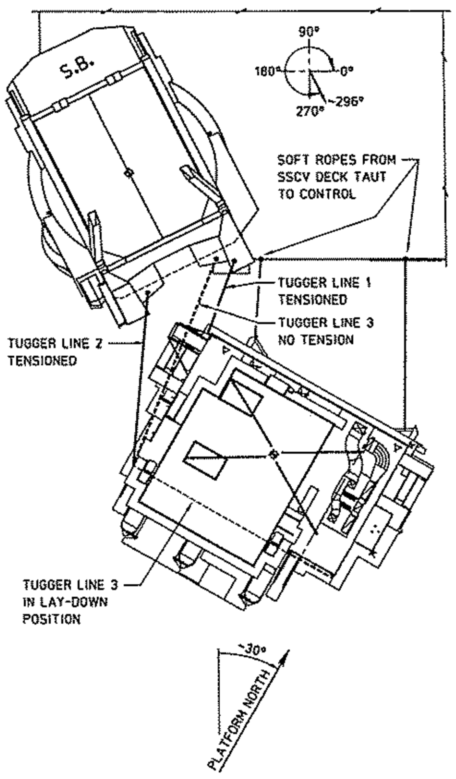
- BOOM OFF AND HOIST BLOCK TO OBTAIN SUFFICIENT CLEARANCE WITH LQ. (SEE NOTE 2) B
- TENSION LINE 1 TO START ROTATION.

GENERAL NOTES

1. FOR GENERAL NOTES AND REFERENCE DRAWINGS SEE HI-186-01-1.
2. CRANE BOOM TUGGER LINES TO PULL APPROX. HORIZONTAL TO AVOID LINES SLIDING FROM GUIDANCE. B

CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000

B



STEP 3

- CONTINUE TENSIONING TUGGER LINE 1
  INVOLVE TUGGER LINE 2 TO ROTATE LQ
- KEEP CONTROL ON ROTATION USING SOFT ROPES.
- KEEP NO TENSION ON TUGGER LINE 3 AND KEEP FREE FROM LQ STRUCTURE / IN LAY-DOWN POSITION.

FOR INSTALLATION
APPROVED FOR INSTALLATION BY CLIENT

GRAPHIC SCALE 1 : 400
0 8 16 24 32 40 48 M

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING			APPD OPS.
B	24 JAN 2005	NdV	FOR INSTALLATION / REV. AS INDICATED				
A	27 AUG 2004	NdV	FOR INFORMATION				

PROJECT
CABGOC BENGUELA/BELIZE

SUBJECT
LIVING QUARTERS
LIFT-OFF AND ROTATION WITH THIALF S.B. CRANE
STEP 2 & 3

MARINE CONTRACTORS
Heerema Marine Contractors Nederland B.V.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO.	REVISION
1 : 400	10246.00000	HI - 186 - 01 - 2	B

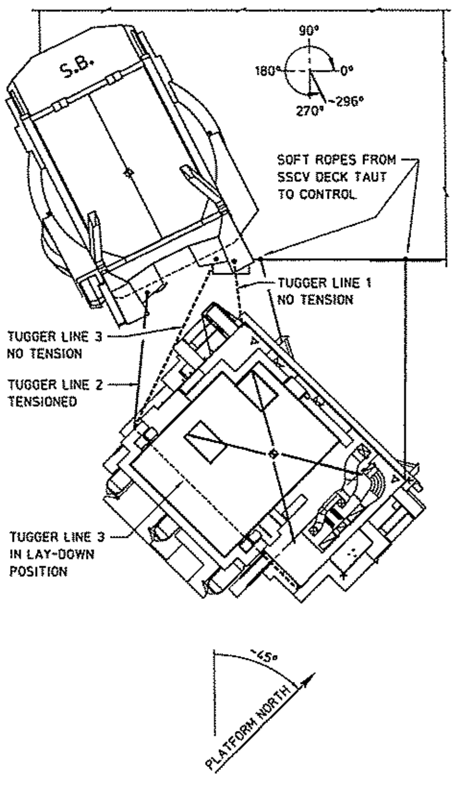
CLIENT'S DRAWING NO.

Sheet 3

GENERAL NOTES

1. FOR GENERAL NOTES AND REFERENCE DRAWINGS SEE HI-186-01-1.

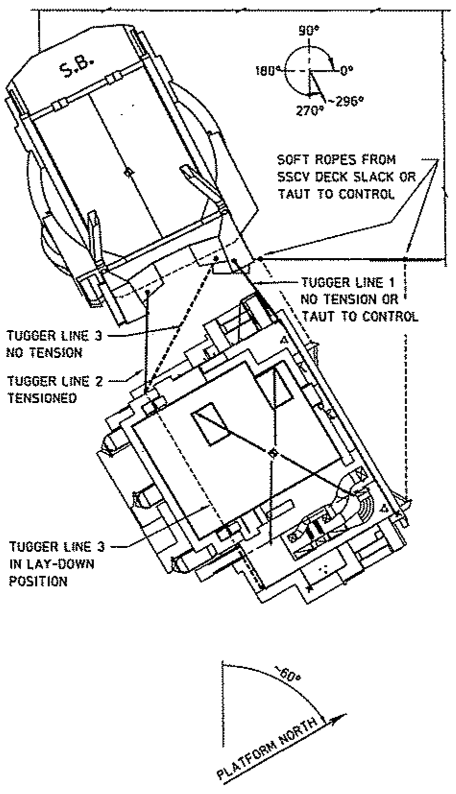
CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000



STEP 4

- CONTINUE TENSIONING TUGGER LINE 2 TO ROTATE LQ AND RELEASE TENSION ON TUGGER LINE 1.
- KEEP CONTROL ON ROTATION USING SOFT ROPES.
- KEEP NO TENSION ON TUGGER LINE 3 AND KEEP FREE FROM LQ STRUCTURE / IN LAY-DOWN POSITION.

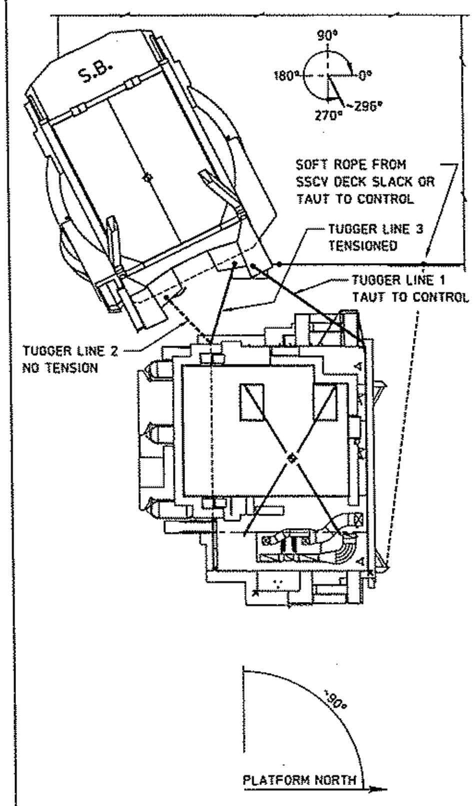
CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000



STEP 5

- CONTINUE TENSIONING TUGGER LINE 2 TO ROTATE LQ.
- KEEP CONTROL ON ROTATION USING SOFT ROPES OR TUGGER LINE 1.
- KEEP TUGGER LINE 3 AT LOW TENSION AND KEEP FREE FROM LQ STRUCTURE / IN LAY-DOWN POSITION.

CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000



STEP 6

- RELEASE SOFT ROPE AT NORTH-WEST SIDE.
- INVOLVE TUGGER LINE 3 TO ROTATE LQ AND RELEASE TENSION ON TUGGER LINE 2.
- KEEP TUGGER LINE 1 TAUT TO CONTROL ROTATION.
- KEEP NO TENSION ON TUGGER LINE 2 AND FREE FROM LQ STRUCTURE IN LAY DOWN POSITION.
- KEEP CONTROL ON ROTATION USING SOFT ROPE OR SLACKEN.

FOR INSTALLATION
APPROVED FOR INSTALLATION BY CLIENT

GRAPHIC SCALE 1 : 400 0 8 16 24 32 40 48 M

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING			APP'D OPS.
B	24 JAN 2005	NdV	FOR INSTALLATION / REV. AS INDICATED				
A	27 AUG 2004	NdV	FOR INFORMATION				

PROJECT
CABGOC BENGUELA/BELIZE

SUBJECT
LIVING QUARTERS
LIFT-OFF AND ROTATION WITH THIALF S.B. CRANE
STEP 4 TO 6

Heerema Marine Contractors Nederland B.V.

CLIENT'S DRAWING NO.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO.	REVISION
1 : 400	10246.00000	HI - 186 - 01 - 3	B

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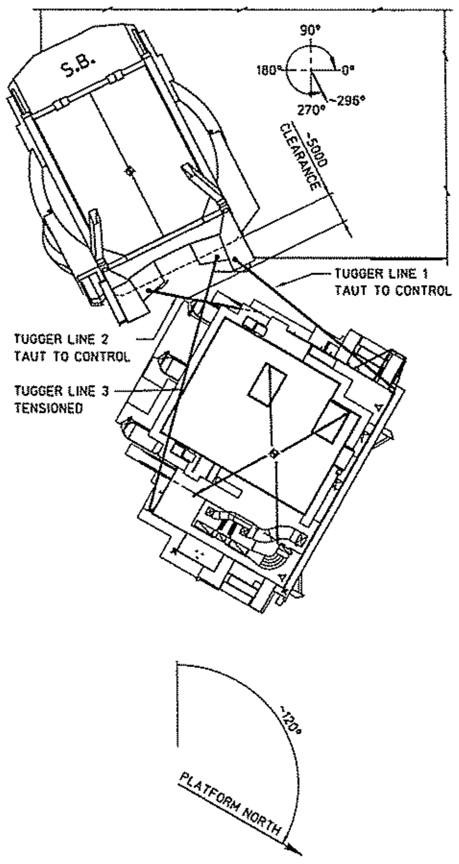
Sheet 4

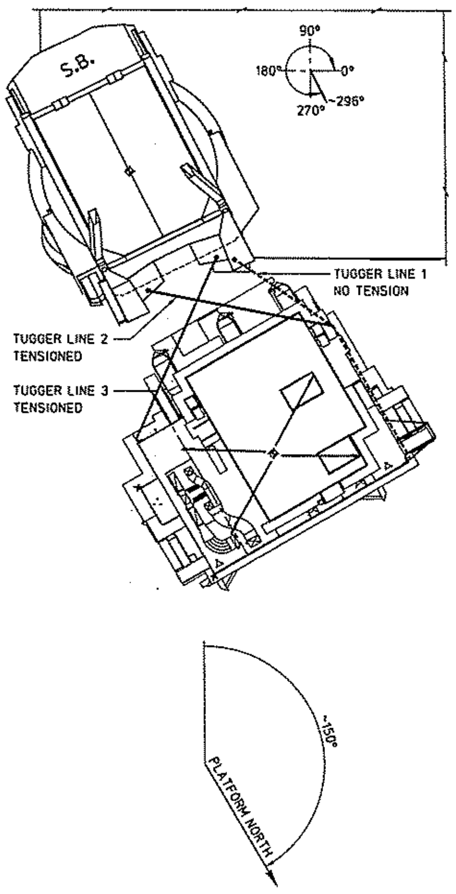
CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000



STEP 7

- RELEASE SOFT ROPE AT NORTH-EAST SIDE.
- KEEP TENSION ON TUGGER LINE 3 TO ROTATE LQ.
- INVOLVE TUGGER LINE 2 TO CONTROL ROTATION.
- KEEP TUGGER LINE 1 TAUT TO CONTROL ROTATION. WHEN TUGGER LINE 1 ALONG MODULE WEST ELEVATION RELEASE TENSION AT 130°.

CRANE	S.B.
RADIUS	51432
HOOKLOAD	2410 m.T.
CAP.	4472 m.T.
HOOK EL.	91000



STEP 8

- KEEP TENSION ON TUGGER LINE 3 TO CONTROL LQ.
- NO TENSION ON TUGGER LINE 1.
- KEEP TUGGER LINE 2 TAUT TO CONTROL ROTATION.
- BRING LQ IN INSTALLATION POSITION REF. HI-186-02-1

GENERAL NOTES

1. FOR GENERAL NOTES AND REFERENCE DRAWINGS SEE HI-186-01-1.

FOR INSTALLATION

APPROVED FOR INSTALLATION BY CLIENT

GRAPHIC SCALE 1 : 400 0 8 16 24 32 40 48 M

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING			APP'D OPS.
B	24 JAN 2005	NdV	FOR INSTALLATION / REV. AS INDICATED				
A	27 AUG 2004	NdV	FOR INFORMATION				

PROJECT
CABGOC BENGUELA/BELIZE

SUBJECT
LIVING QUARTERS
LIFT-OFF AND ROTATION WITH THIALF S.B. CRANE
STEP 7 & 8

Heerema Marine Contractors Nederland B.V.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO.	REVISION
1 : 400	10246.00000	HI - 186 - 01 - 4	B

CLIENT'S DRAWING NO.

Sheet 5

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Sheet 6

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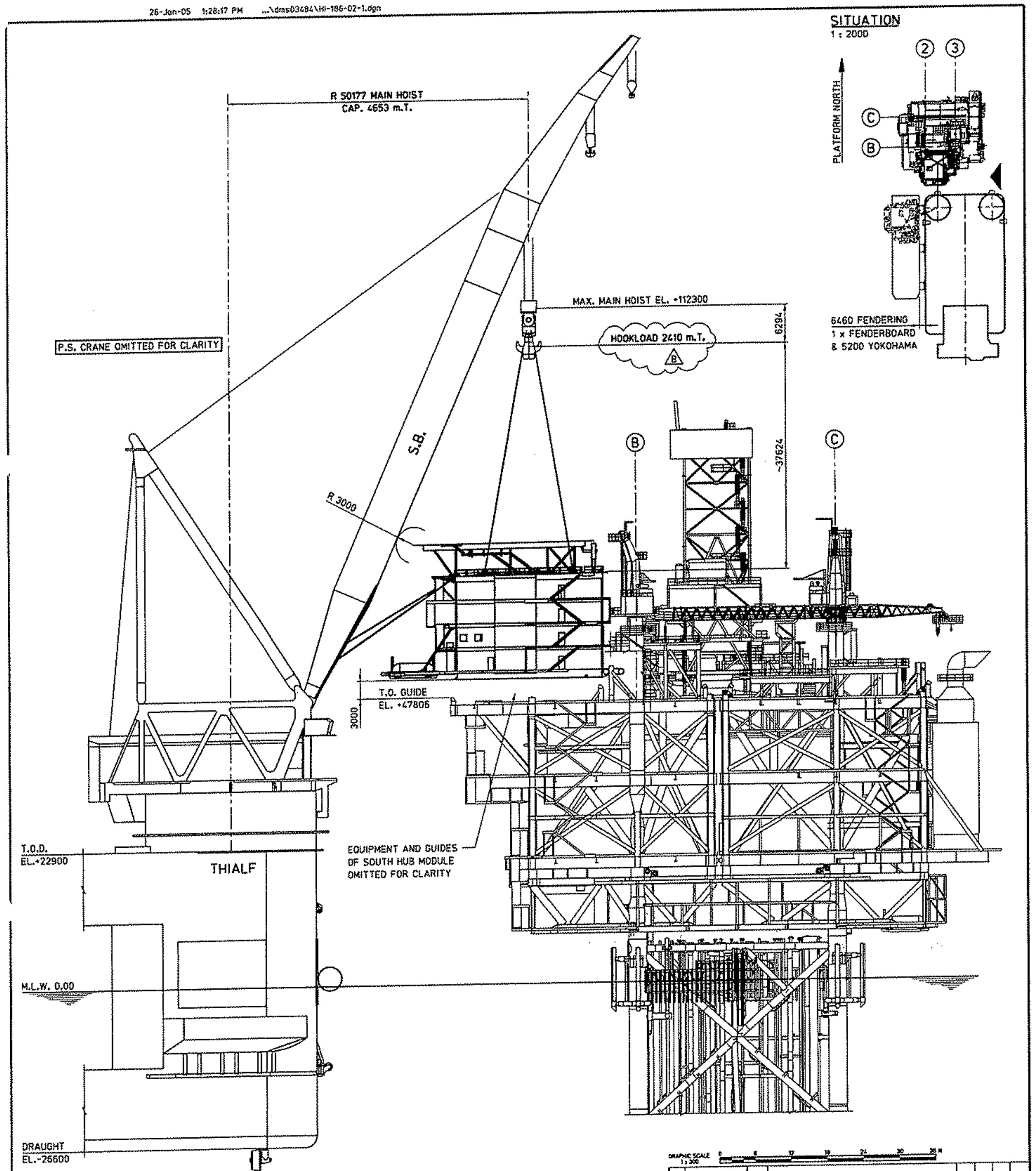

GRAPHIC SCALE 1 : 300 0 6 12 18 24 30 36 M

REV.	DATE	DRAWN	DESCRIPTION	APPROVED ENGINEERING			APP'D OPS.
B	24 JAN 2005	NdV	FOR INSTALLATION / REV. AS INDICATED				
A	25 OCT 2004	NdV	FOR INFORMATION				

FOR INSTALLATION

APPROVED FOR INSTALLATION BY CLIENT

PROJECT

CABGOC BENGUELA/BELIZE

SUBJECT

LIVING QUARTERS INSTALLATION WITH
THIALF S.B. CRANE FROM SOUTH SIDE

GENERAL NOTES:

1. m.T. = METRIC TONNES.
2. WEIGHT AND C.O.G. INFORMATION IS BASED ON DELTA SUPPLIED REV. 0 WEIGHT REPORT DATED 18 NOV 2004. B
3. HOOKLOAD INCLUDES 10% INACCURARIES AND RIGGING WEIGHT.

REFERENCE DRAWINGS:

HI-186-01-1 LIVING QUARTERS LIFT-OFF AND ROTATION WITH THIALF S.B. CRANE

Heerema Marine Contractors Nederland B.V.

MARINE CONTRACTORS

CLIENT'S DRAWING NO.

SCALE (A1 FORMAT)	JOB NO.	DRAWING NO. DISCIPLINE / IDENT. NO. / SUBJECT NO. / SHEET NO.	REVISION
1 : 300	10246.00000	HI - 186 - 02 - 1	B

PREPARED USING HEEREMA'S CAD/CAE SYSTEM