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THE HEAVY LIFT ENGINEER

...managing & delivering heavy lift projects

FEATURING

HOW INTEGRATED IS YOUR PROJECT MANAGEMENT

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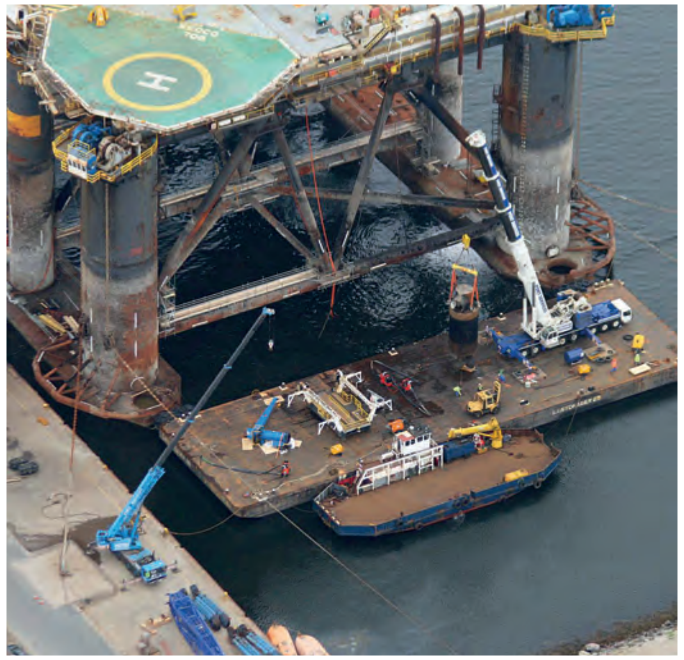
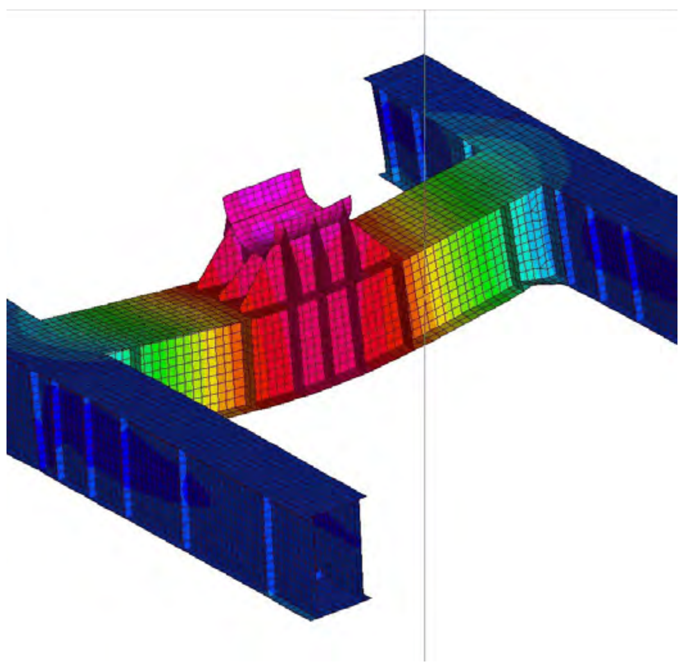
CHALLENGES OF A LARGE TURNKEY TRANSPORT PROJECT PART 2

A Malin Group PUBLICATION





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EDITORIAL

JOHN MACSWEEN

MANAGING DIRECTOR, MALIN GROUP

Welcome to our second edition of the Heavylift Engineer. If you missed the first one, it can be found online here (www.heavyliftengineer.com/magazine).

It has been great to hear all of your responses and feedback to date and I look forward to your views on our latest edition.

As I mentioned previously, heavy lift engineering may mean a myriad of different things to different people and this variety is reflected in our latest edition where we have a broad range of topics covered. We discuss integrated project management, investigating the processes and personnel required to ensure your project, no matter the scope or size, is successful. This is teamed with a piece demystifying what exactly Finite Element Analysis is and how it can be applied practically to heavy lift projects. Not to mention our investigation of the challenges involved in a large turnkey transport project, with a particular focus on how both locks and direct entrances work.

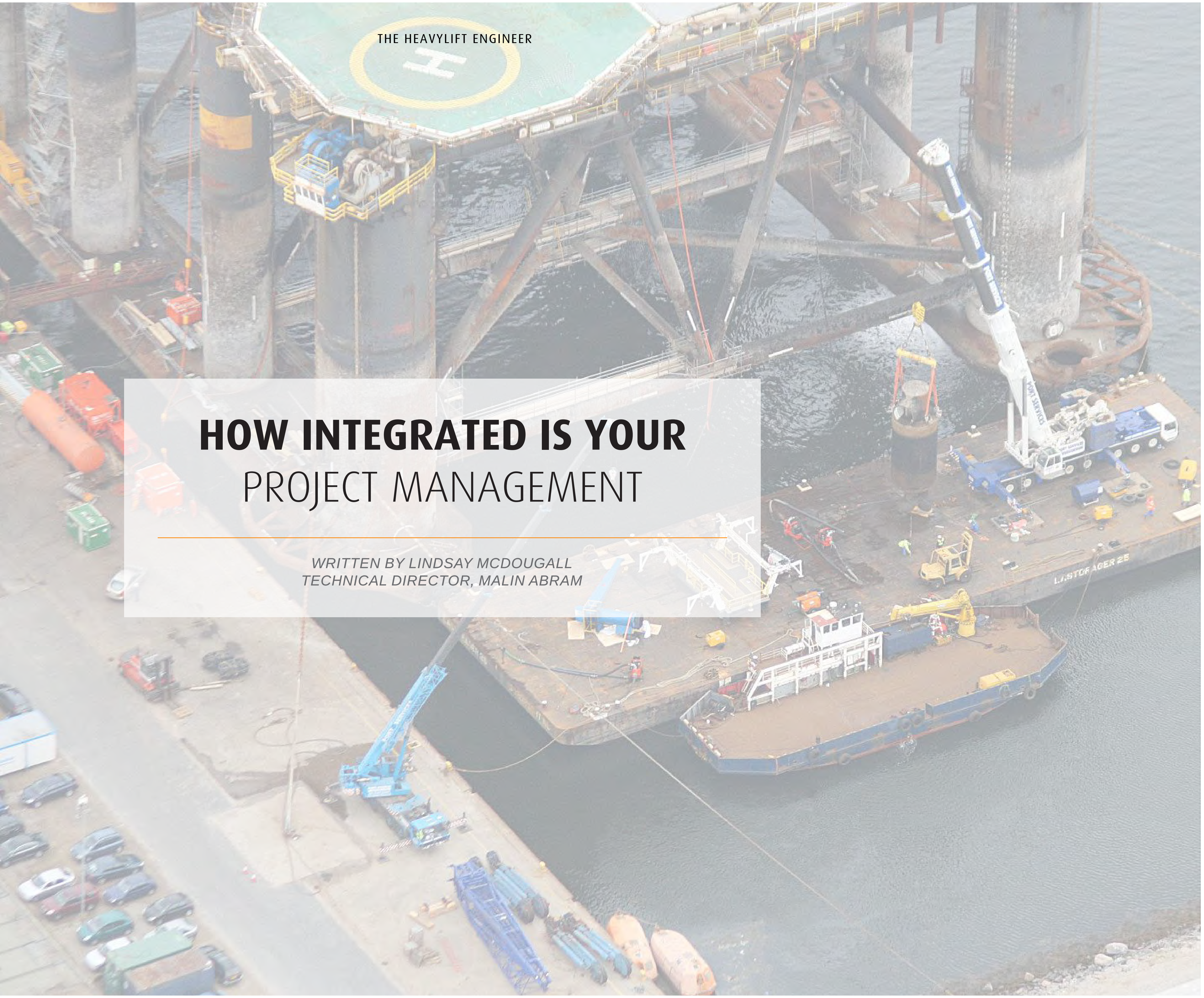
We also have a great article by Andrew Atkinson from DMC Training on contract risk, providing an insightful overview of the implications of a letter of intent (LOI).

We have a selection of our helpful heavy lift tips, covering everything from uplift on hatch covers, to hydraulic trailer circuits and pivot points – and of course our book reviews, to offer some helpful recommendations for your next read.
Whether you are in shipbuilding, heavy fabrication, power generation or mining, the heavy lift engineer's skill set is critical. No other engineering discipline, if you decide to dive deep enough, offers such a range of technical challenges. We hope that this edition reflects that variety, offering something of interest to you, regardless of your background.

Please do get in touch if you have a topic you would like to see covered or would like to guest feature for a future edition – and I hope you enjoy this new edition!

We would love to hear from you!
Please send any questions to: **heavyliftengineer@malingroup.com.**

Please also sign up for exciting future editions at: **www.heavyliftengineer.com/magazine**



HOW INTEGRATED IS YOUR PROJECT MANAGEMENT

WRITTEN BY LINDSAY MCDOUGALL
TECHNICAL DIRECTOR, MALIN ABRAM

fig. 01/ A birds-eye view of a mobile crane deployed on a barge

- Integrated (with various parts or aspects linked or coordinated)
- Project (an individual or collaborative enterprise that is carefully planned to achieve a particular aim)
- Management (the process of dealing with or controlling things or people)

The above are the Oxford dictionary definitions of the words Integrated Project Management. Individually they are a bit gauche, but together they represent something that is greater than the sum of its parts, and that is the goal behind having a properly integrated project management system.

Integrative (Project) Management (the application of management processes that integrate some or all fundamental components of scope, schedule, cost, risk, quality and resources.) – from the APM Body of Knowledge

On successful projects, especially on complex challenges such as turnkey heavy lift operations, developing an integrated approach is essential. It is not enough to be able to manage one of these components individually, they need to be managed holistically.

A common change in heavy lift projects is a material change to the cargo. Often the subtlety of seemingly small changes can be overlooked across the projects supply chain and a controlling hand is needed to make sure that holistic planning and adjustments are made accordingly. For example, what would the impact be if the centre of gravity shifted between design stage to when the "as weighed" condition post fabrication? Is the lift arrangement still adequate? Does the sea fastening, grillage and deck support arrangement still work? These are some of the things the integrated project manager will consider as they have a view of the bigger picture.

Ensuring that this happens is not straight forward. It requires robust processes and personnel; without these, you will have no control of your project, and processes will be mere sheets of paper (or electronic equivalents), without the staff to understand and implement them.

Inevitably, as a project progresses, there will be changes. Client requirements will develop, information will mature, and schedules will change. The corner stone to an integrated project management system is a good change management process. It is the key to ensuring that changes to one component of the project is examined for impact across others.

For example, what impact does a scope change have on the baseline schedule, and what onward impact does that have on the resource requirements and cost? Or similarly, if resource availability changes, how does that impact the schedule and the quality of the product? In heavylift projects programme changes can have significant impacts on resource availability, with many projects relying on temporary hire of specific, and often highly utilised, assets at tightly defined points in a programme.

An effective change management process allows a Project Manager to review the changes across the board and make informed decisions on the best course of action or enables them to escalate knowledgably.

Most heavy lift projects are run on tight budgets. Making use of integrated project management can present opportunities to save money at various stages. With many sub-contractors involved, the Project Manager will have a deep knowledge of the agreements in place with each. With the client's interests in mind the project manager can identify any risks or opportunities to arise from changes.

The Project Manager (PM) is the key person within the system, and they need to have a combination of soft and hard skills in order to run an integrated system correctly. On one hand the PM will need to communicate with the stakeholders and lead a project team, but on the other be technically capable of analysing data and carrying out impact assessments. These are just a handful of examples to illustrate the point but Project Manager's duties extend to a lot more.

So, process and personnel go hand in hand when running an integrated project management system...

And a fully integrated system does not just stop at project level; it should encompass the whole organisation as requirements for one project may impact on another. No one project in an organisation exists in a bubble, but rather each are part of a larger whole. Sucking in extra resource due to overruns has a very real, and mainly detrimental impact on other projects waiting on that resource to be made available. This is particularly true of smaller organisations who may run matrix structures where resource is shared throughout projects.

Project management websites and textbooks are replete with example documents that need to accompany an integrated project. Whilst these are definitely 'cogs in the machine' they are not a panacea. Completion of these is the start, not the end of the process. Often projects will be too small to justify the overhead of this level of paperwork and having strong fundamentals in the project team is what will keep the principles of integrated project management alive as opposed to a set of documents.

How is this level of integration achieved? As would be suggested by the word 'integration,' there is more than one facet to achieving this. Change and documentation control along with effective communication, as mentioned above are others. Only by having effective communication is it possible to determine the impacts that will ripple throughout an organisation. Speaking to varied personnel is the best way to get a broad knowledge of how an organisation works and understand the various drivers at play.

It can be summarised that integrated project management is the collection of processes that ensure various elements of projects are properly coordinated. It establishes and manages the involvement of all relevant stakeholders and resources, according to defined processes devised from your organisation's set of standard processes. Finally, it involves making trade-offs among competing objectives and alternatives to meet or exceed needs and expectations.

Integrated project management is an aid to eliminating haphazard management techniques and instinctive managerial actions. By understanding, sharing and collating processes and knowledge across the entire organisation, integrated project management brings a much needed robustness to project management approach.

With an integrated approach to project management, it is possible to build a project charter, sketch out the project scope and map the project plan. Projects are closely monitored, and performance is measured against an established baseline. There is also a fixed process for dealing with stakeholders and their requests.

Implementing integrated project management gives a broad understanding of each project and its requirements, helping the project team to share knowledge and processes across projects, making for a healthier organisation.

fig. 02/ a mobile crane bieng used to install a linkspan

HEAVY LIFT TIP
CARGO LASHING

Anyone that has ever secured a load to a road trailer – be it project cargo or a new sofa – will be inherently familiar with the importance of a suitably tensioned lashing arrangement. For road moves where over-the-top type lashings are typically used, the pre-tension applied will dictate the level of friction generated. In other words, the more pre-tension there is, the more downward force, more friction and less lashings it requires. It is crucial that any tensioning equipment constructed to European Standards (EN 12195 Series) is marked with the "Standard Tensioning Force" (STF) which it can create.

However, if we consider the marine environment, does the same idea still apply?

- The International Maritime Organisation Code of Safe Practice for Cargo Securing prohibits excessive use of types of friction lashing.
- Direct lashing between cargo and strong points is, therefore, more typical and friction is less useful.
- The transportation loads that a cargo item will experience at sea are likely to be the highest and most varied it will ever be subjected to. Adverse weather conditions can often lead to multiple lashings being required in every direction.

Simply put, stand-alone use of over-the-top pre-tensioned lashings should be avoided when lashing cargo aboard a ship. Instead, lashings in all the primary directions of motion are required.

As well as making sure that there are sufficient lashings in all directions, consideration also needs to be given to how they are tensioned as well. In the road example, high pre-tension is desirable, whereas for lashing at sea the considerations are more complex. For example, a line with a capacity of 10Te, which is pre-tensioned to 2Te, will only have 8Te of capacity left for restraining sea-going forces. In addition any variation in pre-tension between lines acting in the same direction will result in the tighter line taking more load, reducing the effectiveness of the other lashings. It is also important to note that equipment will not always be constructed to European Standards, therefore the STF force can vary significantly.

While a minimum tension should always be maintained to ensure the cargo does not shift (and lashings regularly checked), it is clear that more tension can mean less capacity. Not only is the proper stowage and securing of cargoes necessary for the safety of the cargo itself, but it is also of the utmost importance for the safety of the vessel and crew. Improper securing of cargo units can result in serious injuries and damage to the vessel. To ensure that all potential cargo lashing hazards are dealt with correctly, it is essential to gain specialist advice from a professional who can plan and uphold safe carriage of the cargo, regardless of the behaviours of the sea.

fig. 03/ lashing chains at various angles required to restrain heavy cargo

CHALLENGES OF A LARGE TURNKEY TRANSPORT PROJECT

PART 2

WRITTEN BY LINDSAY MCDOUGALL
TECHNICAL DIRECTOR, MALIN ABRAM

In a previous article, we examined the technical challenges facing a heavy lift engineer on large turnkey projects. However, they do not end there, and once the dust has settled on the engineering, attention turns to the operations themselves.

Regardless of the extent of engineering and planning that is carried out, site work retains the capacity to raise additional potential issues for the heavy lift engineer. The source of these are numerous: environmental, third parties, suppliers, local authorities, not to mention the presence of chance or luck.

Turnkey heavy lift operations are multi-faceted with many interfaces, such that a small issue can often escalate into a serious one. For example, a vessel can quickly slip into demurrage rates awaiting a critical task ashore such as site moves or cargo inspection. With so many dependencies to manage, site work on heavy lift projects is always challenging and plans need to be regularly updated to account for what happens during operations.

Where port operations are involved, sea and land-based personnel and equipment are required to work together, posing their own set of challenges.

If we define a port as both the operating berth and the wider jurisdiction which the port has control over then operations can be split into two broad categories.
1. Getting the vessel in and out to the berth
2. Cargo operations at the berth

There are a multitude of questions the heavy lift engineer needs to ask when planning arrival/departure operations in a port.
• Where is the berth within the port?
• Is the berth tidal? (i.e. can it be used at any state of tide)
• Is access to the berth tidal? (i.e. can transit occur at any state of tide)
• Is the berth in a basin, and is there a lock or direct entrance to navigate?
• How long are passage times? (Often ports may have speed limits and long approaches so you cannot assume a particular cruising speed when assessing arrival/departure timings)
• Availability and requirements for support tugs and pilots
• Any simultaneous ops going on? (ferry/cruise ship arrivals, major construction projects etc etc)
• Draught and Air Draught restrictions?

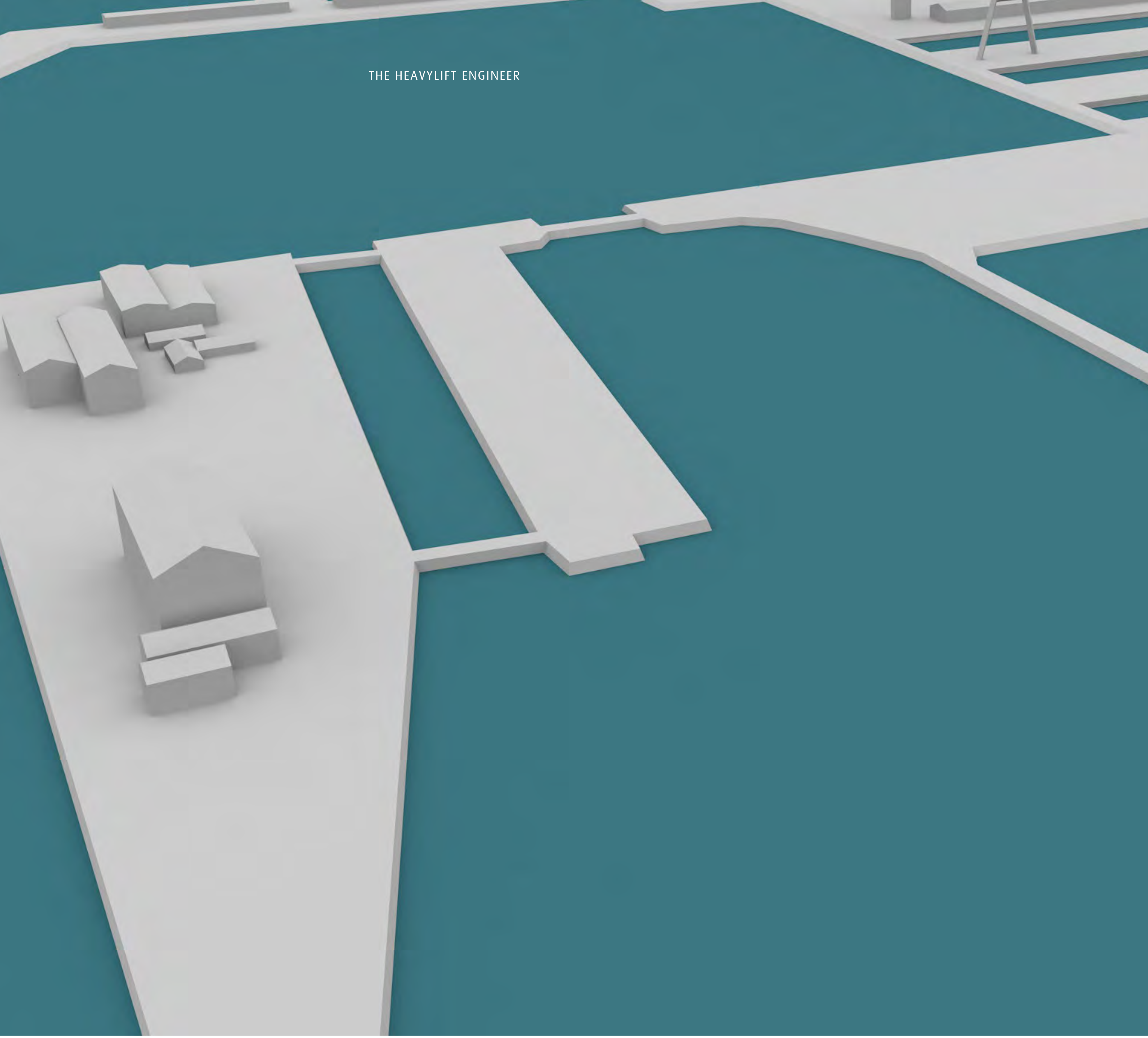
While not exhaustive, the list above does capture the main operational considerations. By way of example, carrying out shipments in the South West of England, you will need to be aware of large tidal ranges in the region and how that impacts accessibility to berths further up the estuary system. Appledore in Devon, for example, has a spring tide range of 7.2m and berths will 'dry-up' at certain times of the day.

Operations at this port need to be carefully planned as there are several factors to consider. For example, a certain tide level will be required to enter the estuary, coupled with tide levels required for entering the dock. Due to the distances involved it is usually not possible for docking operations to happen on the same tide, therefore a lay-by berth and mooring arrangement would be required to allow the vessel to lay-up in preparation for the next tide. Any vessel that is required to stay in the estuary will need to be cleared by both owners and class to be able to sit on the mud when the berth dries out. This is also known as 'taking the bottom'.

Ports like this may have periods of the month where it is not possible for certain vessels to enter or exit due to tide requirements. Therefore, part of the planning process is to consider loading and securing time and allow for delays if possible, to ensure that there is still a window for the loaded vessel to depart.

Berths inside basins also have a similar restriction. Often locks cannot open until certain stages of the tide due to the requirement to equalise the water levels inside and out. Therefore, arrival timings need to be considered to ensure that access is available on arrival. In many cases, the required tide will occur during the hours of darkness which will require an additional set of mitigations put in place to cover the risk associated with working in low light.

fig. 04/ harbour tug shown 'dried out' at low tide



HOW DO
LOCKS AND DIRECT ENTRANCES WORK?

It is important to understand how different entrance systems into basins work in order to be able to determine working windows.

These are two of the most typical entrance types. Actual operation of the gates etc may differ but the principles remain the same.

Locks

Locks have a minimum of 2 gates, one that is sea facing and one that is internal. Locks work by equalising the water inside the lock to either the sea or the basin water level. Locks allow a greater range of access tides as they allow a discrepancy between the internal level and the sea level. They will still need a certain level of water to operate to allow the vessel to clear the sill and reduce pressure on the internal gate, but the operating range will typically be higher than a direct entrance.

Operating steps
Stage 01
Water outside of lock equalised with water level inside (can be achieved by pumping in/out of lock but normally achieved by sluice gates)
Stage 02
With water levels equalised external gate can be opened and vessel enters the lock
Stage 03
Outer gate is closed
Stage 04
Water level inside lock is equalised with the level inside the basin usually by means of pumping
Stage 05
With water levels equalised internal gate can be opened and vessel enters the basin

Direct entrances

As the name would suggest, direct entrances connect the basin directly with the sea. Their operating principles are the same as the locks, water levels need to be equalised before opening. The key difference is that the operating range is typically a lot less because tides that match the basin level directly will occur less often. This includes both lower tides and higher tides. Increasing the basin level beyond standard levels can be just as damaging as reducing it.
This also means direct entrance transit operations need to be timed very carefully as the direct entrance can only be opened/closed for short windows of time.

Direct entrances maybe wider than locks, meaning they are the only option for vessels of a certain size. Using a direct entrance does carry more inherent risk.

Operating steps
Stage 01
Vessel awaits water outside of direct entrance to be equalised with water level inside. This is normally based on the external tide level. Pumping to change levels in basins is possible but can be time consuming and expensive
Stage 02
Water levels are equalised. This is typically in and around high water (slack tide)
Stage 03
With water levels equalised the entrance can be opened, and vessel enters the basin directly
Stage 04
With water levels remaining fairly consistent the vessel enters the basin and entrance is closed

Whilst inside a port jurisdiction, currents are often stronger and sea-room limited, therefore the vessels' crew is reliant on the local knowledge of the pilots and help from support tugs. It is important to know beforehand what the port's requirements are for pilotage, tugs and chart provision as some ports will have mandatory stipulations, but others may have exemptions. Failure to pre-book services could lead to vessels not being allowed into the Port and resultant delays and impact to operations.

On longer projects keeping consistent port personnel can be a challenge, as often ports rely on 'rack pilots' who may not be available to attend planning meetings and would have to get into the job 'cold' on the morning of the operation. That pilot may or may not have had any specific experience with the type of work required on the project. Some Port authorities can accommodate project pilots, which assists greatly in the planning and executing of more complex marine operations. By engaging with the port early and ensuring they understand the project requirements it will increase the possibility of these types of arrangements being put in place.

The services of tugs are often at a premium in ports as they try to handle large volumes of traffic with a finite resource. Managing the schedule between competing requirements is a massive challenge and one that must be managed by early booking of tugs, regular dialogue with the port and being aware of alternatives in the local vicinity.

Finally, will the vessel (and cargo) fit? Bridges and power lines can restrict the overall height and sandbanks and dock sills can restrict the floating draught. Canal systems can be particularly challenging as the draught and height restrictions have very little tolerance as the vessels try to avoid grounding but still be able to fit under low bridges.

Some berths will be dedicated to cargo handling with the infrastructure in place for heavy lift operations. But where this is not the case either through age, design or differing primary purpose then the use of heavy lift equipment needs to be carefully planned.

Historic berths can offer a lot of challenges. Ground bearing loads may be limited, resulting in additional equipment or inventive load-spreading solutions.

In addition, bollards may be unrated or just unsuitable. This can be solved by carrying out proof load tests in line with expected loading during operations. Industry standard guidelines also recommend that bollards are tested in the direction they will be loaded in practice, so testing can often involve both marine craft and shore-based solutions, therefore any testing needs to be identified early and plant hired accordingly. Unfavourable results could mean further engineering is required so early identification of issues is essential.

Newer berths, even those that have been designed for handling heavy lift cargoes, can still offer challenges due to the large variety of cargoes that qualify as "heavy lift". Quay edge details, bollard positions, lighting tower locations, service ducts and others can all create their own set of issues.

Site inspections are essential when dealing with an unfamiliar quay. Being forewarned is key to ensuring there are no delays. This allows the heavy lift engineer to source any additional equipment or services that maybe required to deal with the issue. For example, additional load spreading material might be needed to go over drainage channels or quayside furniture may need to be temporarily removed.

In conclusion, the heavy lift engineer faces many operational challenges to ensure a project is delivered successfully and whilst this article concentrates on the issues working in around ports and port infrastructure, there are also the issues around cargo handling, loading operations and securing operations to be considered as well.

fig. 05/ a layered load spreading arrangement underneath crane outriggers, required to meet allowable ground loading at the port.

fig. 06/ sand used to level the ground due to presence of drainage channel

HEAVY LIFT TIP
BARGE SEA FASTENING

In a previous heavy lift tip, we considered the problems that can arise when using lashings aboard an un-manned barge. A solution to those problems is to use welded sea fastenings instead. However care must still be taken when using this sea fastening method.

While an engineered solution may be shown to have sufficient capacity to restrain the cargo, it is only of use if it is installed correctly. It may seem an extremely obvious point to raise but experience within the industry has shown that without close supervision by a suitably informed professional who understands the requirements of the job and has the authority to correct any problems, critical issues can occur.

Typical issues that need to be considered in the planning or site supervision stage include:

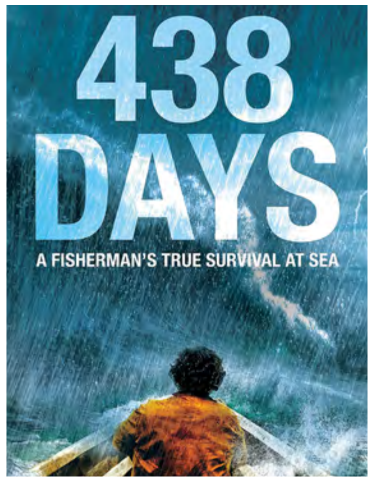
- Weld seams on the cargo, not considered in the design, in contact with stoppers increasing the resulting moment past the allowable limit
- Heavy stoppers being pushed close to the cargo without actually coming into contact (or only making contact on one corner)
- Stoppers being applied to crated cargo
- Repositioning sea fastenings to a part of the deck
- Older drawing revisions being supplied to the installation team on site
- Calculated weld size of braces and blockers differing from that actually installed. A weld gauge should be on hand at all times and periodic checks made to ensure corners for the sake of speed are not cut
- Good alignment of sea fastenings with under deck structure

It is imperative to understand that any of the above issues could cause failure in the sea fastenings during transportation and potentially result in cargo loss. To ensure a successful transportation aboard a barge, we always recommend that a qualified engineer who understands the sea fastening design attends on site throughout the sea fastening installation activities. This way they can continuously inspect the ongoing works and identify any issues before time and effort is wasted in remedial work, ensuring barge departs at the planned sailing time.

fig. 07/ braces and gusseted deck grillages

BOOK RECOMMENDATIONS...

438 DAYS
BY JONATHAN FRANKLIN



On the 17th November 2012, José Salvador Alvarenga and Ezequiel Cordoba set sail in a 7m open top fibreglass skiff from the coast of Mexico for 30 hours of fishing. With the exception of a terse radio message he was not heard from again until the 30th January 2014.

During that time he had drifted an estimated 6,000 miles over a period of 438 days and made landfall in the Marshall Islands.

The book tells his story, surviving, thanks in no small part to floating debris. Discarded water bottles were one of many things that helped save his life, rigged into sea anchors as well as allowing him to store water when it rained.

It is sobering to think that irrespective of the size of the pacific ocean, one man floating alone bears witness to an endless choice of detritus ranging from trainers to styrofoam blocks drifting by.

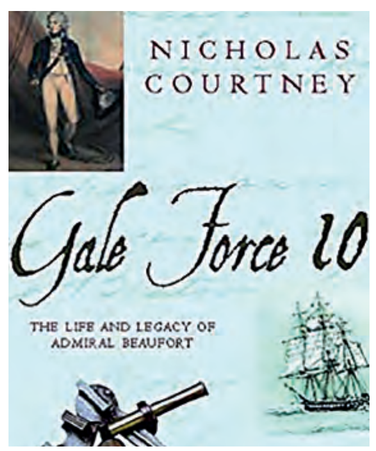
Despite some controversy surrounding the writing of the book, it tells a magnificent tale of survival and what we are capable of under extreme duress.

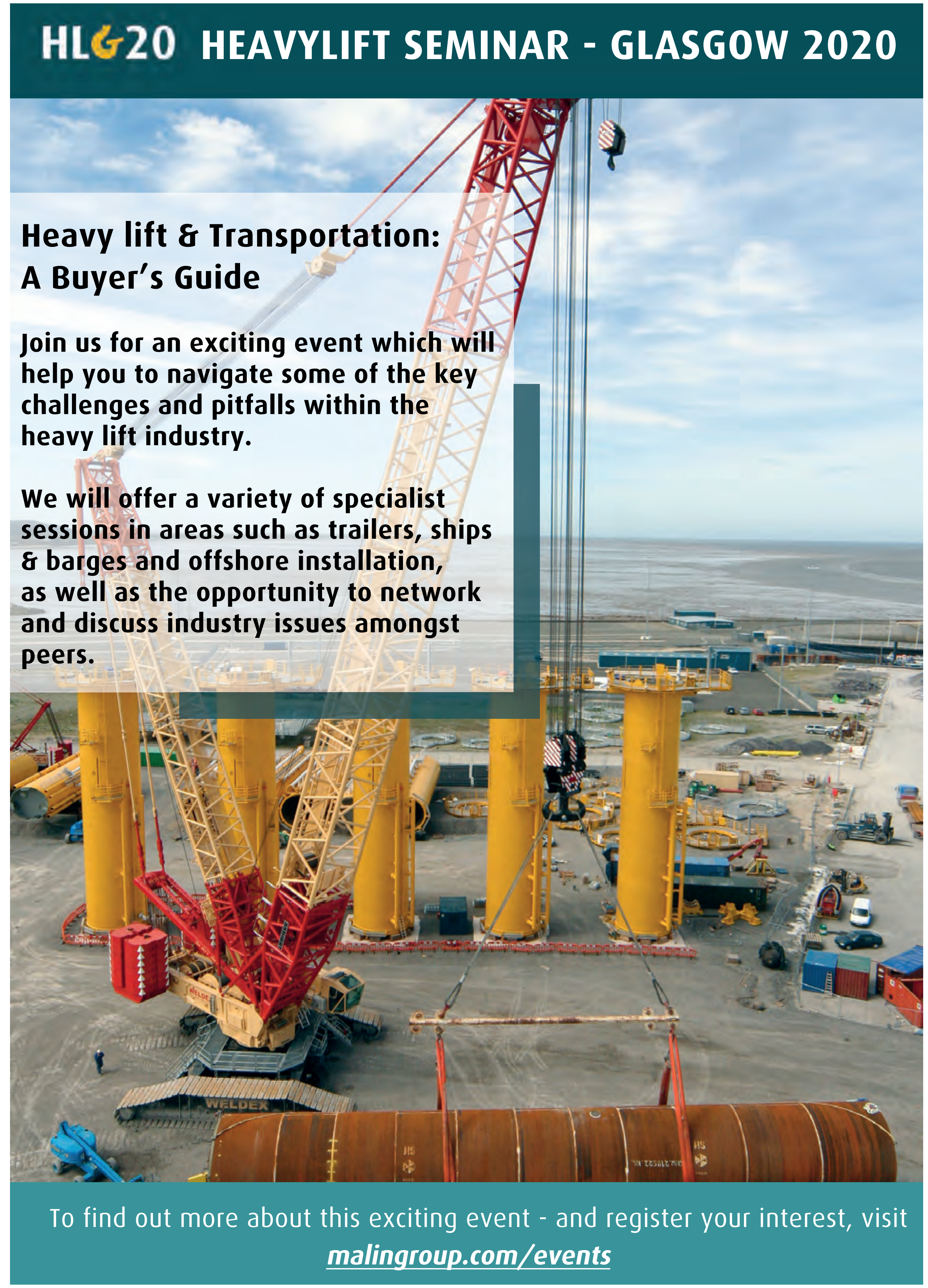
GALE FORCE 10 - THE LIFE AND LEGACY OF ADMIRAL BEAUFORT
BY NICHOLAS COURTNEY

I suspect everyone in the UK reading this magazine will have listened to the Shipping Forecast at some point. But Sir Francis Beaufort did so much more than contribute his surname to the famous wind speed chart for seafarers.

Not only did he have a distinguished Naval career, but at the age of 55 he was appointed British Admiralty Hydrographer of the Navy. For the next 25 years he oversaw the development of the collection of sea charts that seeded the british admiralty chart collection used by over 90 percent of ships trading internationally.

The book is a treasure trove of anecdotes and hidden surprises - from the revelation that he was Robert Fitzroy's mentor, to the fact the he was instrumental in securing Charles Darwin a place on the Beagle.
If you enjoy this book then it will set you on a path of Patrick O' Brian, C. S. Forester and the fantastic, little known gem by Harry Thomson "This Thing of Darkness". The latter book is a semi fictional account of HMS Beagle's trip exploring Tierra del Fuego and the complicated and tragic relationship between Charles Darwin and the Beagle's temporary Captain, Robert Fitzroy.





HEAVY LIFT TIP
POACHER TURNED GAMEKEEPER

Choosing a third-party surveyor to ensure that your project cargo is transported safely from point of loading to point of delivery can be a tricky job in itself. It is important to note that, whether you go with a Marine Warranty Surveyor (MWS) or a third-party consultant, all surveyors have their own specific skills and specialist knowledge.

While it is safe to say that a number of MWS's are ex-Master Mariners, from time to time you can also come across a surveyor with an engineering background, such as naval architecture or marine engineering.

A valuable third-party surveyor or MWS not only understands the ins and outs of successfully conducting a full examination of the vessel, but also recognises and reacts to any issues as they occur, before they have a chance to grow.

Selecting the right marine surveyor should go beyond nominating a third party to witness and photograph what happens onsite. They should also be able to complement and add to your own in-house expertise. For example, a Master Mariner will be highly skilled in ship procedures and operations and in some cases, have an understanding of cargo securing and lashing standards (you can read about this on page 11).

However is such a surveyor right for consulting your team on barge roll-on operations or complex structural design of grillage and sea fastening? Also, a naval architect can give excellent advice on marine structural design and ship motions but may not be as knowledgeable on towage operations as a Tug Master.
Perhaps your transportation project covers a number of complex operations and transport engineering elements, in which case it is best to find an experienced heavy transport partner who has the required expertise to ensure your cargo is delivered in a safe and efficient manner.

Ultimately, you need to find someone who has the skills, competency and ability to carry out the type of inspection that you require. Choosing a marine surveyor is a crucial part of determining whether your vessel is seaworthy, so take the time to consider what you are looking for and the kind of person needed to help you get from the planning stages through to the physical cargo transportation.

fig. 08/ roll braces connected directly to the barge deck in way of longitudinal steelwork

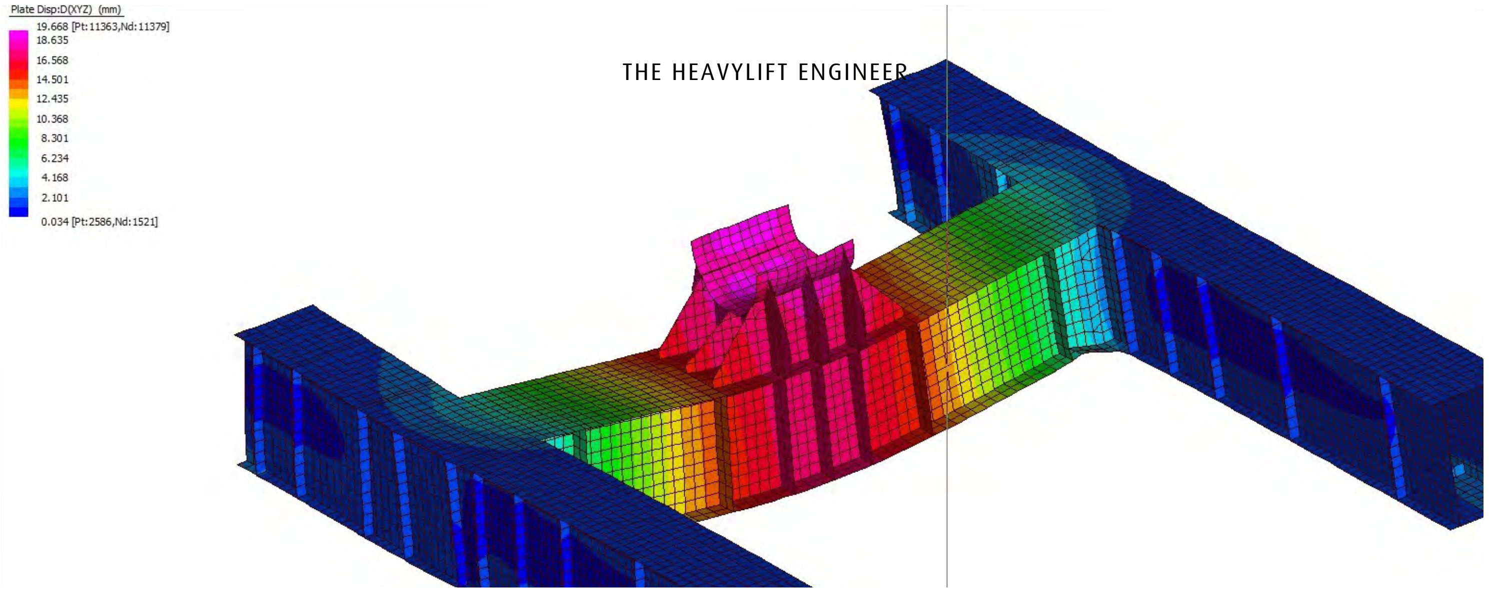


fig. 09/ transport frame showing exaggerated displacement

FINITE ELEMENT ANALYSIS (FEA):
AN INFINITELY BETTER APPROACH TO LOAD ANALYSIS?

WRITTEN BY JOHN ANGUS MACSWEEN
MANAGING DIRECTOR, MALIN GROUP

Finite Element Analysis (FEA) is a powerful tool that enables engineers to gain a deep understanding of how any given structure responds to external loads, combined with an appreciation of how these loads flow through a structure. This understanding helps them to then identify areas of local, high stress.

Despite this value, outside structural engineering circles, it is also one of the least understood areas of engineering analysis. This misunderstanding is two fold:
• how does FEA do what it does?; and
• how can it add value to a project?

Addressing the first question, FEA works by building a representative numerical model of a structure. In every case, this model is an approximation of the real thing, often thought of in terms of how it is portrayed on screen.

It is important to realise that this is just a visualisation of the underlying numerical model made up, in the simplest sense, of four main sections, namely:

1. Element list
2. Nodal co-ordinates list
3. Connectivity section
4. Load cases section

The element list consists of a library of standard elements (nodes, beams, plates, 3D brick elements etc). These standard elements are typically referred to repeatedly and are stored in a "lookup table" of one form or another. This lookup table, in its simplest form, assigns each element a unique number, alongside various properties such as thickness, section properties, material assignment etc.

The nodal co-ordinates list details all the points in space that represent a position where one element connects to another or to a point that represents the model boundary (foundation, anchor point on a ship, interface with a large structure etc).

The connectivity section assigns how nodes are connected to each other and which element is to be assigned to that connection, for example node 1 is connected to node 3 via a beam 2 from the element list. It also allows the restraints on nodes to be specified, for example node 2 is rigidly connected to a foundation and so cannot translate in x, y or z directions and is also not free to rotate about any of these same 3 axis.

The final section, load cases, specifies how the loads are to be applied and where. So, for example, load case 1 has a force of 10kN applied in y direction to node 4 and load case 2 has a force of 10kN applied in the z direction to node 5 etc.

The number of elements used to describe any one given structure is driven by the mesh size which drives cost of building the model (modelling) and analysing the output (post processing) measured in man hours. Once all this has been specified either in a text file (if you are old enough to remember doing it this way) or via a more modern graphical user interface, the connections and element properties are arranged into a stiffness matrix. The power (or magic) of matrix algebra is then harnessed to solve thousands and thousands of simultaneous equations to ultimately tell us how the structure reacts to the applied load. It is a common misconception that the key output is structural stress. It is in fact structural deflection, and this is then turned into a stress plot and visualised on the screen. See fig. 10.

By understanding the key fact that the analysis is centred on stiffness rather than stress, the power of FEA becomes apparent, suggesting, as it does, how it may be practically used in a heavy lift project where timeliness and applicability of any engineering is key.

We can first set aside the obvious questions such as whether or not a deck structure can accept a particular load or if a lifting beam is overloaded or not - answers which 9 times out of 10 can be gained using quicker, traditional hand calculations. Instead, we may consider more complex, interesting questions, for example, where should sea-fastenings be placed on a structure, or what is the expected load path for a given layout of weightors under a structure. It is from questions such as these that we can see how the FEA approach, focused as it is on how the structure deflects, displays its real potential.

By addressing these questions, you are afforded the opportunity to make real savings. The approach is however also of great practical use in the execution of a heavy lift project by
the structure deflects, displays its real potential.

By addressing these questions, you are afforded the opportunity to make real savings. The approach is however also of great practical use in the execution of a heavy lift project by dramatically reducing not only the amount of steel for sea fastenings, but also the cost of installing, removing and making good deck and cargo after. In the weighing case, the position of weighing points can be ruthlessly economised allowing a more efficient weighing pattern, reducing cost to the end client both financially and in terms of down time and site disruption around the installation and removal of equipment.

It is also worth considering what the model is to be used for, to ensure that the mesh size is appropriate. FEA is often dismissed as a potential tool as the perception is that it will take too long and be too expensive to build a representative model. But if we bear in mind that all models no matter their complexity, are approximations of the real thing, then the question reduces to one of

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ensuring that the detail used is appropriate to the task in hand.

When I was a student, our professor who took the structures lab was an incredibly well-respected offshore engineer, who literally wrote "the" book on offshore structural analysis. He was a major advocate of the use of FEA, albeit sparingly, to the extent required by the situation in question. Simple models that were representative of what was going on to feed and inform early stage design decisions were an invaluable tool. A well thought out model consisting of only 20 or 30 elements rather than one containing 2-3 million, of an offshore jacket and its foundation piles could give quick useful answers that led the early stage FEED in a well-informed manner.

This same approach can be applied to heavy lift projects. An understanding of load paths through hatch covers and decks to inform cargo stowage options can be invaluable during tendering and early stage design phases - even for warranty approval.

Similarly, when looking at the distribution of loads through a complex structural cargo, such as in the case of dry transportation of a ship hull, both fully meshed and simpler part models have a place.

The former, as in figure 12 overleaf, is a major undertaking but can be used to understand the complex interaction between transport vessel and cargo, as well as being used for the verification of internal structure around hull and bulkhead openings.

For "simpler" ships, the cross section at paired frames in way of transport cradles can be represented by beams only, with stiffeners and associated plates simplified to the point that modelling becomes easier but also allows for an accurate understanding of how loads are transferred and shared among decks and pillars.

Lastly, there is the situation where the whole ship, or cargo, can be modelled as a single series of beams with each being the full section modulas of the ship at a particular location along its length. These models are simple to generate but like those mentioned earlier, are good for understanding the interaction between cargo and vessel under global load cases and can be used to guide early operational decisions prior to detailed design taking place.

So when faced with a challenge, tools like FEA should not be dismissed as a hammer too big for the nut in question. Like all engineering tools, their usefulness can be tailored to the job at hand and simple models built in a day or two can deliver insights that otherwise would be difficult or impossible to glean by hand.

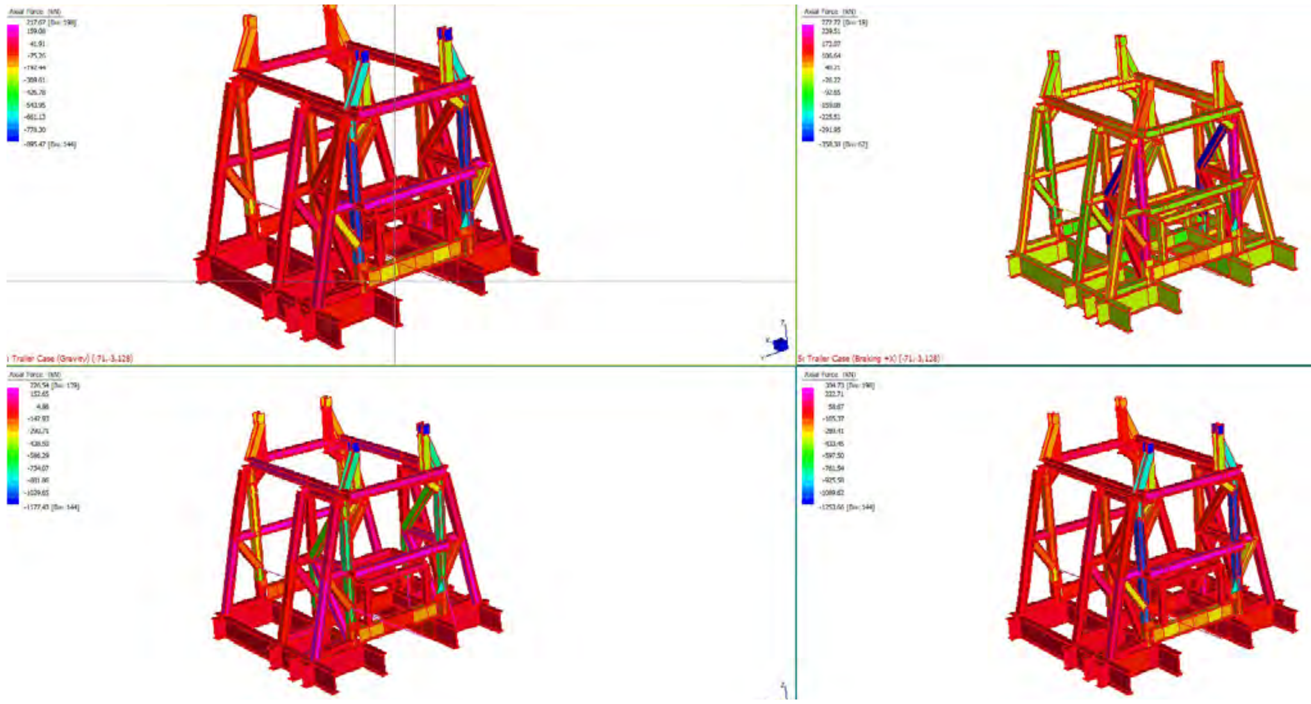

fig. 10/ multi view of transport jig model showing different load cases

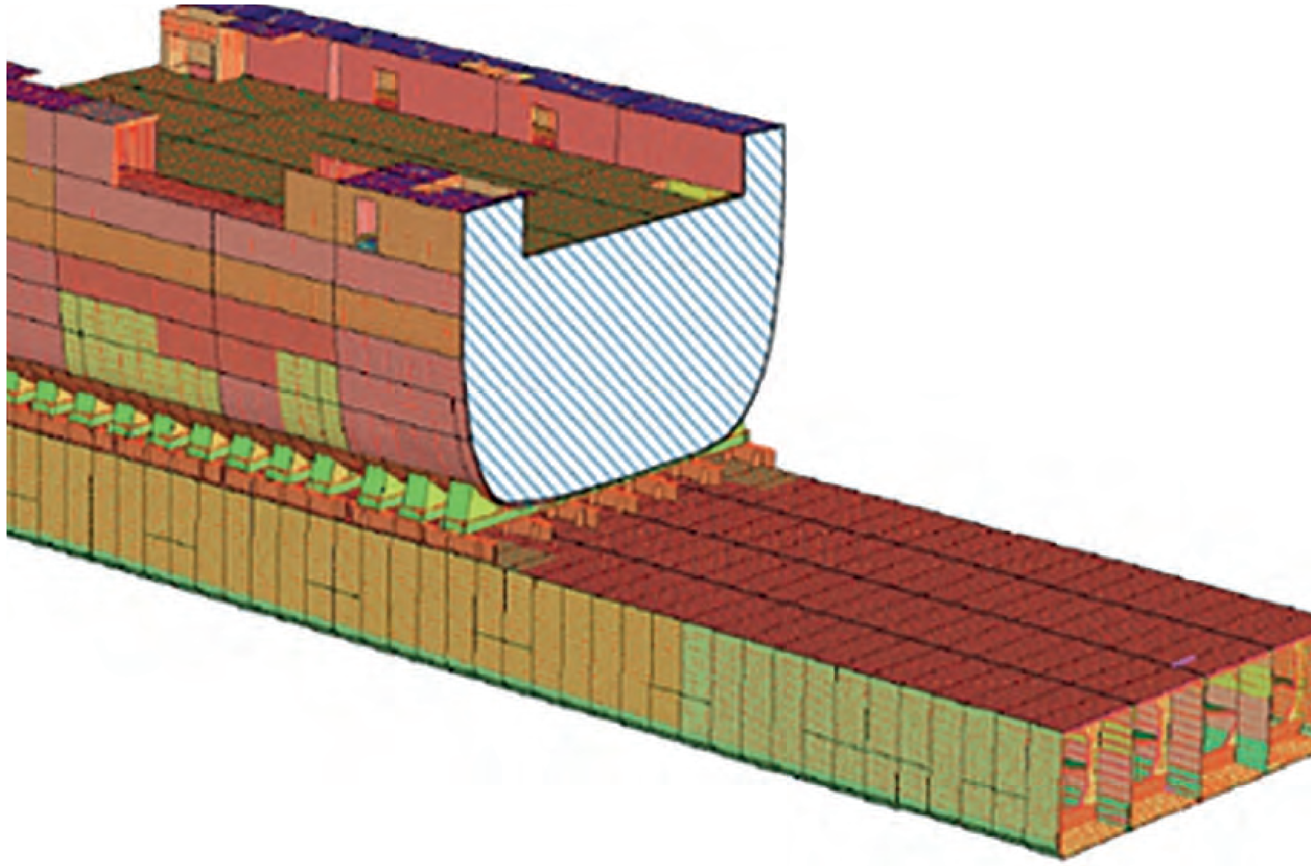

fig. 11/ FEA model of cargo, barge and connecting steelwork

HEAVY LIFT TIP
UPLIFT ON HATCHES

In today's competitive market, ship owners and brokers are always looking to make sure their ships are fully booked before transporting cargo. With respect to project cargo, this can mean shipping cargo up on the weather deck or hatch covers, especially when the cargo is too large to fit below deck in the hold.

Failure to recognise any structural defects in the hatch covers can ultimately endanger the cargo, the ship and its personnel. If hatch covers are not maintained properly, the strength of the hatch will be reduced and, furthermore, leaks can occur which can lead to underdeck cargo being exposed to sea-water and in the long term, corrosion of the ships own internal structure. It is vital to carry out regular examinations of hatch covers to identify any corrosion, and subsequently rectify any faults or damaged parts prior to cargo transportation.

The primary concern with shipping large cargoes on the hatch covers is the strength of the hatches under heavy loading. Cargoes stowed on the weather deck are subject to higher forces than those under deck, therefore more likely to experience 'uplift' where the cargo is physically tipping due to centripetal and transverse forces acting on the cargo. After the uplift connection to the hatch cover itself is checked and adequately designed, consideration should be given to the adequacy then of the hatch cover's connection to the vessel coaming.

The problem arises when the tipping moment (including cargo inertia) is significant but only restrained on one or two hatch covers. In such circumstances, there can be an over reliance on the assumption that the combined weight of the cargo and hatch covers suitably lowers the combined centre of gravity and this, coupled with the support span between coamings, removes the uplift load on the hatch connections. In cases where this has not been checked and there is still an uplift load, typically the only thing restraining the hatch cover from lifting off the hatch coamings are the securing cleats. It is more than likely that there will only be two cleats per hatch cover – port and starboard – and these are normally not more than a threaded bolt and nut. Should these fail due to insufficient strength, the result could be catastrophic.

In the past, some of the possible solutions or mitigations that we have found practical include:

- Bypassing the hatch covers with respect to uplift lashing by lashing the cargo to the upper deck structure
- Adding welded sea-fastening between ship's hatch covers and hatch coaming structure
- Increasing the quantity of uplift lashing to improve the distribution of the lashing over multiple hatch covers

In conclusion, uplift load paths on cargoes should be followed right into the principle structure of the ship itself, ensuring that there are no unanalysed failure modes.

fig. 12/ typical hatch cleat

SIGN ON THE DOTTED LINE

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Every time an organisation enters into a contract it is inevitably facing commercial risks. Consequently, risk – which can be defined as "the effect of uncertainty on objectives" 1 - is at the heart of commerce. Part of the management team's responsibility, on behalf of the corporation, is to mitigate this risk. Commercial risk can be managed in many ways including the establishment of policies & procedure, management of change, peer review, planning, insurance and the contractual transfer of risk.

Unexpected and unwelcome events do occur, but these are the exception and, when they do occur, a corporation may need to rely on the safety net provided by the legal liability framework. The most successful approach to contracting is to draft the contract in such a way as to be clear in terms of what has to be done and then do what the contracts says should be done.

One of the most-likely-worst-case-scenarios is that a company will go to work without a clear written contract. One situation which will result in this is that a contractor makes an offer to a potential client and, subsequent to the offer, there is a flurry of communication (some written, some not), and the client gives an instruction to start the job before the contract is reduced to a single document and executed (signed). This is often predicated on the issuing of a Letter of Intent (LOI)

It has become common in the international offshore oil and gas industry to start work before a contract is formed on the basis of an LOI. An LOI is a pre-contractual written document that details a preliminary understanding between the parties involved. As such, an LOI allows a contractor to start work and, if necessary, to order long-lead items and/or commence engineering and fabrication before a final contract has been agreed. Furthermore, as they are designed to expedite work, LOIs typically refer to and incorporate previous communications between the parties. They may also incorporate provisions from previous agreements as an interim arrangement until a final contract is agreed. However, despite all the above, an LOI does not necessarily mean that the final contract has been secured. As such, it is vital to understand whether an LOI is simply one more item of communication or the final step in the conclusion of a contract.

The fact that an LOI is not, in itself, the same as a contract was clarified in ERDC Group v Brunel University [2006], 2 where the court commented that LOIs come in many forms: some are simple expressions of intent; some make it clear that they do not create any legal obligations between the parties involved; and some are close to full-blown contracts. Consequently, the term 'letter of intent' does not offer any legal clarity. Nevertheless, although the term has no legal significance, courts often treat LOIs as legally binding. 3 As such, the wording of an LOI should be considered. Additionally, as well as the wording of an LOI, courts will look at the facts surrounding its writing to establish whether there is a contract between two parties. 4

To see how important, it is to understand when an LOI counts as a contract, we can first look to British Steel v Cleveland Bridge [1984]. 5 In this case, Cleveland Bridge, the client, issued an LOI to British Steel, the contractor, before the terms of a full contract were agreed. As part of this, Cleveland Bridge requested that British Steel expedite the work. British Steel then went on to fabricate nodes for Cleveland Bridge, as per the LOI. After the receipt of the LOI, while the work was being carried out, the parties continued to negotiate over the terms of the final contract. British Steel never agreed to certain terms proposed by Cleveland Bridge but, nonetheless, completed the work and delivered the nodes. After delivery, Cleveland Bridge refused to pay the full amount because of the timing of the delivery and the order in which the nodes were delivered. This led to a conflict in which British Steel raised an action against Cleveland Bridge to recover the shortfall and additional monies for storage. The court, however, held that no contract existed, despite British Steel beginning the work as requested, because the parties were still negotiating material terms at that time.

In the judgment, the court commented that both parties were confident a formal contract would be agreed when Cleveland Bridge asked British Steel to commence the work. The court added that if a contract had been agreed, the parties would have been bound by its terms. However, no contract was agreed, so there were no terms to refer to. In this situation, the law provided that Cleveland Bridge pay British Steel a reasonable sum for the work and, because the parties had not concluded their negotiations, it was not possible to establish the extent of their respective liabilities. This shows that working on an LOI alone, without clearly setting out whether this will count as a contract in the event of a dispute, can give rise to harmful uncertainty.

We can see another case of uncertainty caused by relying upon an LOI in RTS Flexible Systems Limited v Molkerei Alois Muller [2010]. 6 In this case, three courts - the court of first instance, the appeal court and the Supreme Court - reached three different conclusions after reviewing the same facts. To summarise, RTS, the contractor,

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1 ISO 31000
2 ERDC Group Ltd v Brunel University [2006] BLR 255 at 256
3 In Turrif Construction Ltd v Regalia Knitting Mills Ltd. [1971] 9 BLR 20, contractural obligations were held to exist

4 AC Controls v British Broadcasting Corporation [2002] 89 Con LR 52
5 British Steel Corporation v Cleveland Bridge and Engineering Co ltd [1984] 62 BLR 107

was asked to provide an automated system for packing yoghurt pots by Muller, the client. During negotiations, RTS provided several different offers, the last of which included a fixed price of £1,682,000 and a description of the work. The work was to be completed by September 2005. To meet this deadline, in February 2005, RTS agreed to commence work based on an LOI in which Muller expressed their wish to proceed with the project as set out in the last offer, with a final contract set to be agreed and signed within four weeks. The LOI went on to state that the contract would be based on a model form contract provided by the Institute of Electrical Engineers. The model form, meanwhile, provided that the contract would not take effect until it was executed. This LOI was enough for RTS to commence the work. But when the LOI expired in May 2005 without a final contract being signed, RTS continued to work on the project and delivered the machines in September the same year.

This proved problematic when a dispute developed regarding whether the machines RTS delivered met Muller's performance requirements. By this point the parties had agreed on the majority of the model contract, but it was never formalised. Muller then only paid RTS 70% of the contract price, so RTS raised an action to recover the full amount.

The judge in the court of first instance held that RTS and Mueller had concluded a contract for RTS to carry out the work set out in the LOI, but not under the terms of the draft contract. This judgment relied on Percey Trentham v Archital Luxfer [1993], 7 which held that it was unrealistic to suppose that the parties did not intend to create legal relations when substantial performance had already occurred. The court of appeal, however, came to a different view, holding that there was no contract at all between the parties and citing British Steel v Cleveland Bridge [1984] as authority for this. The Supreme Court reached yet another opinion, stating that the parties had entered into a contract on the terms of the draft contract and, by their conduct, had waived the provision that the terms of the contract would not take effect until signed. This judgment reiterated that the existence of a binding contract depends on whether, 'objectively' (i.e. by the standards of a reasonable person as opposed to what the parties thought), the parties had agreed to create legal relations and whether they had agreed on the major terms of the contract. Overall, however, this case shows that different courts may interpret the same facts in different ways, partly because there is a vast amount of case law to draw upon as a precedent. Since it is virtually impossible to predict a judgement, the key to success is ensuring clarity.

More generally, the cases above show how, while working on the basis of an LOI is common, uncertainty can arise when it is not clear whether or when a contract has been agreed. The only way to avoid this uncertainty – and the associated risk – is to have a clearly drafted contract before starting work. Or, as Lord Clarke noted in RTS v Muller, the moral of such cases for contracting parties is always 'to agree first and to start work later'.

Of course, commercial pressures will sometimes result in contractors commencing the work on the basis of an LOI. But when this does happen, the contractor should always ensure that the wording and obligations of the LOI, if any, are clearly understood by both parties. The contractual allocation of risk is a skill that should be practiced by every management team. Good contracting starts with taking an interest in the contract and ensuring that the contract is clear and unambiguous Finally, and, arguably, most importantly, the management team should also endeavour to have the LOI reduced to a comprehensive contract as soon as possible; preferably, before the work starts in earnest.

6 RTS Flexible Systems Limited v Molkerei Alois Muller Gmbh [2010] UKSC 14
7 Percey Trentham v Archital Luxfer [1993] 1 Lloyds LR 25

HEAVY LIFT TIP
GROUND BEARING PRESSURE UNDER CRANE MATS

A question that appears time and again in the heavy lift industry is how to calculate the ground's allowable bearing pressure to determine its ability to withstand the force exerted under crane mats or outriggers. It has been estimated that around 40 per cent of crane accidents occur due to under-estimated outrigger loads, or the ground failing due to the load imposed upon it. Therefore is it essential that the outrigger load is determined accurately, the acceptable ground bearing pressure is known, and using those values, that the load is then adequately spread into the ground.

While this issue can be complex, one of the main factors to ensure a safe lift is to establish the maximum load:

- For a mobile crane, the maximum load occurs when the loaded jib is aligned over one of the outriggers (assuming they are all equidistant from the centre of rotation)
- For a crawler crane, there is a different distribution based upon a trapezoidal distribution:
- This distribution is affected by the size and radius of load, but not in the obvious way. The position and size of the load affects the load distribution (as opposed to the load intensity)
- This distribution is further altered by use of a super-lift

Effective management is crucial for the safety of any lifting operation and will only succeed if all parties are aware of their individual roles and responsibilities on the job. On the basis of a contract lift, the crane hire companies will supply the maximum outrigger load for any given crane and load configuration. It is then the responsibility of the site owner to inform the crane supplier of the acceptable ground bearing capacity that it can withstand. Once these two values are determined, it is a fairly straightforward calculation to determine the size of the outrigger pad to ensure the ground is not unduly loaded.

Inexperienced people commonly assume that if there is, for example, a requirement for 1m2 loadspreading under an outrigger, then the 1m diameter mat that comes with the crane will be big enough. This is simply not the case. Accurate calculations are crucial for a successful lifting operation and should be properly prepared and executed by a professional.

Improper crane set-up and lack of expertise increases the chance of lifting accidents, so ensure you have a highly-skilled team who can assess the ground's capability to withstand the load in question.

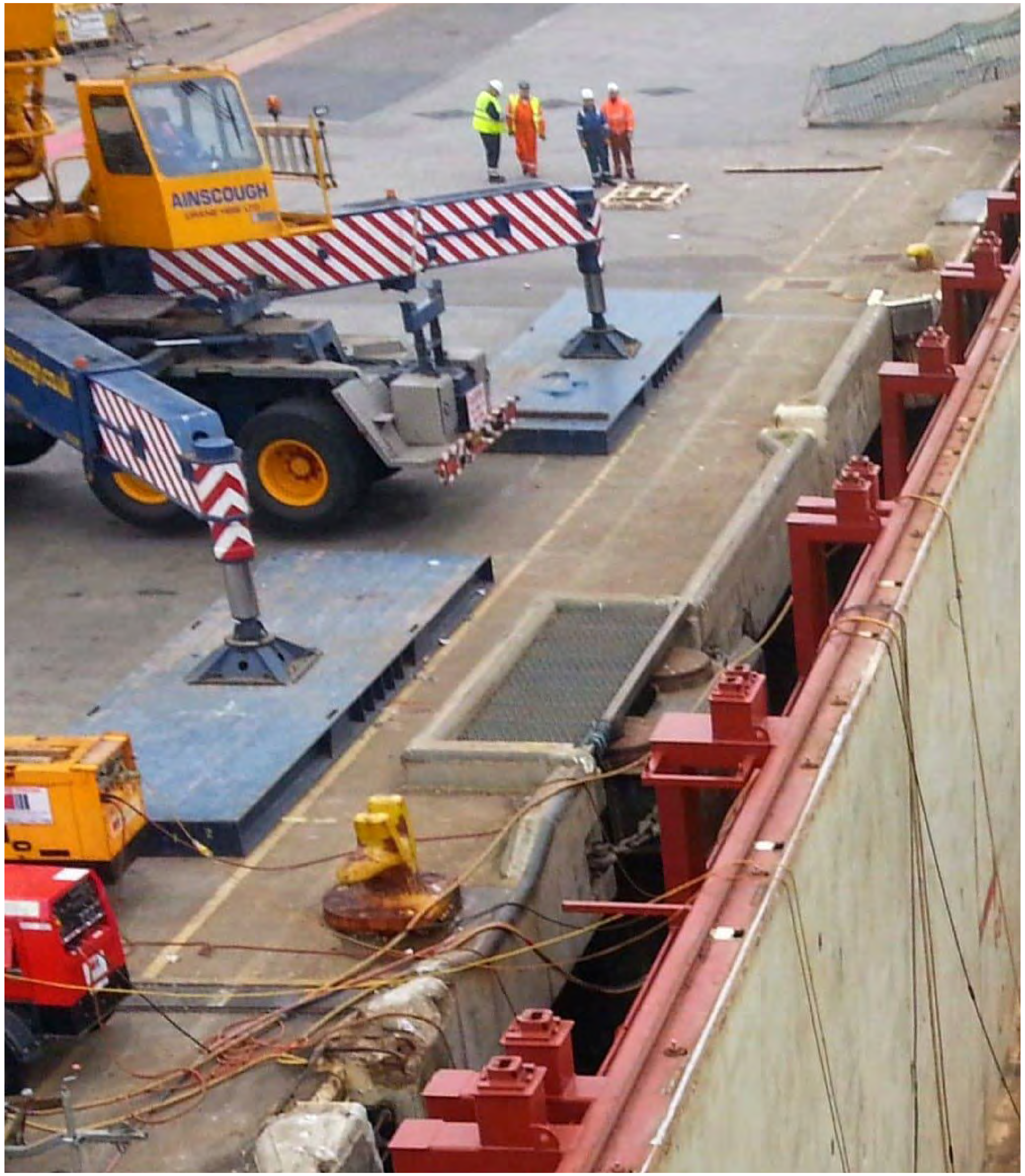

fig. 13/ crane setup to lift reels on quayside

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