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UPGRADING OFFSHORE MARINE FACILITIES FOR LARGER VESSELS

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Abstract: The purpose of this paper is to describe the issues faced when considering design upgrades of offshore marine facilities, and particularly the challenges that arise when considering changes in the design vessel. This is achieved through a comparison of some of the original shipping and design criteria assumptions at a range of offshore marine facilities, as well as consideration of the types of design issues that have arisen for existing facilities as part of upgrade projects.

Connell Wagner's involvement in the design and upgrading/extension of many of the near shore and offshore terminals in Queensland, as well as many other parts of the country, is drawn on for comparisons and anecdotal evidence of shipping trends, as well as the ongoing development of design innovation. The key points addressed by the paper are:

- Shipping Trends – what general changes have occurred over the historical design life of existing facilities, and how has this impacted on design. Consideration is given to the offshore berths, but also to facilities closer to shore.
- Design Issues – The types of issues and challenges faced by the designer, and some practical design considerations to minimise their impact.

While there has undoubtedly been movement in ship sizes and vessel design criteria, this paper notes where this has had an impact for some facilities. From the point of view of the designer, this paper highlights a number of important considerations in not only upgrades, but also for the design of extensions and new facilities.

Keywords: Wharf, Dolphin, Offshore, Shipping, Design, Upgrade, Extension

INTRODUCTION

When considering the design of any marine facilities, setting the basic design criteria is the natural and obvious first step. If the facilities are new, the challenge lies in agreeing the practical minimum and maximum limits (in order to minimise capital expenditure, yet serve the basic functions) to suit the design life of the facility. If the facilities are existing, the challenge lies in whether to adopt or modify what has been set before to suit the current and future needs, while determining the capital cost impact on the existing facilities.

Many of the current harbour and near-shore wharves for bulk products in Queensland (Bundaberg, Mackay, Townsville, Mourilyan, and Cairns), were developed and implemented in the 1950's and 60's (and earlier in some cases). The design criteria were set with the practicalities of the then current barge and vessel sizes in mind, to suit predominantly coastal trading routes.

As interest and growth in international trade developed, so did the offshore jetties and wharves in the 1970's and 1980's (Dalrymple Bay and Hay Point Coal Terminals, Abbot Point Coal Terminal, Lucinda Sugar Terminal, RG Tanna Coal Terminal, Cape Flattery Silica Mines Wharf etc). Each of these facilities being located in offshore or deeper water settings to take advantage of the larger bulk carrier vessels.

Through the 1990's and to today, as the life of these facilities requires extension over an above original expectation, there has been a need to upgrade and extend them. As part of this process, the designer has been required to take into consideration the following basic principles:

- Reconsideration of the design parameters, and how to modify them to meet the new and extended design life and purpose;
- Design of the upgrade or extension to suit any constraints inherent within the existing facilities; and
- Design of the upgrade or extension to suit the current needs, yet also with an eye to future expansions.

SHIPPING TRENDS

A general (historical) definition of vessel sizes and typical characteristics is provided in the table below:

Vessel Sizes and Typical Characteristics

Vessel Class	DWT (t)	Length Overall (m)	Beam (m)	Fully Laden Draft (m)	Hatch Length (m)
Handy	20,000 to 25,000	170	25	10.0	120
Handimax	40,000 to 50,000	210	30	11.5	155
Panamax	60,000 to 80,000	240	32	13.5	170
Small Cape	110,000 to 130,000	270	42	16.0	200
Medium Cape	140,000 to 160,000	295	45	17.5	215
Large Cape	170,000 to 250,000	325	52	20.5	240

Bulk carriers of up to 300,000 dwt (LOA 340 m, Beam 55 m, Draft 23 m) exist in trades such as iron ore, however the occurrence of these vessels is not currently dominant. More prevalent in shipping today is a growth in vessels with characteristics between Panamax and Small Cape Class vessels. These are called "Large Panamax" for the purpose of this paper, with the basic definition being a vessel that has its dead weight tonnage maximised, while still exhibiting dimensions that allow it to pass through the Panama Canal.

In terms of harbour and near-shore wharves, when some of the original wharves were developed for industries such as sugar in the 1960's, the design vessel was 10,000 to 15,000 dwt (Mourilyan and Bundaberg). Through the 1970's and 1980's, fender systems and wharf capacities were assessed for Handy Class vessels, and then Handimax Class vessels into the 1990's.

The design life of these original wharves was not envisaged as greater than 50 years, however as these wharves reach their half century, they are being considered for and have had implemented re-designed fender systems and, where appropriate, strengthening to accommodate Handimax Class vessels for another 50 years. It is noted that given their location and near-shore constraints, particularly in terms of vessel access, the cost effectiveness of considering upgrades past Handimax Class does not reasonably exist. If and/or where pressure (current or future) forces consideration of Panamax and larger vessels, the possibilities and cost competitiveness of offshore wharves begins to favour the offshore construction.

Ports such as Mackay and Townsville (and in general terms, many regional ports around Australia) were located and designed with some flexibility in mind. While the original cargoes suited the small 10,000 dwt vessels, there was rapid growth in early years to Handy Class vessels. Through the early 1990's, port plans identified the movement in vessels from Handy to Handimax Class, and further to Panamax Class for certain cargoes. Most of these types of regional ports are either currently upgrading, or have already upgraded to Panamax vessel capabilities.

In terms of offshore jetties and wharves, the following table demonstrates the original and developed design criteria of a number of offshore facilities:

Original and Developed Vessel Size

Facility	Original Construction	Original (dwt)	Second Stage/ Current Capacity (dwt)	Third Stage (dwt)
Hay Point Services Coal Terminal	1971	100,000	200,000	-
Cape Lambert Iron Ore Export Wharf	1972	100 to 150,000	230,000	230,000
RG Tanna Coal Terminal	1978	120,000	220,000	220,000
Dalrymple Bay Coal Terminal	1980	200,000	200,000	200,000
Abbot Point Coal Terminal	1981	165,000	-	-
Lucinda Sugar Wharf	1976	40,000	70,000	-
Cape Flattery Silica Mines Export Wharf	1986	60,000	80,000	-

This demonstrates that when the original designs of these facilities was undertaken, vessel sizes for the large bulk product facilities were typically in the range of Medium Cape Class – up to 165,000 dwt. However, as use of larger vessels increased through the late 1970's and 1980's, any upgrades of such facilities resulted in the adoption of larger design vessels.

A classic example of this is demonstrated in vessel statistics from the Cape Lambert Iron Ore Export Facility over its first 25 years. Figure 1 below shows how vessel sizes steadily increased from below 100,000 dwt in the early 1970's, to 230,000 dwt by the mid 1980's, and then remaining relatively stable.

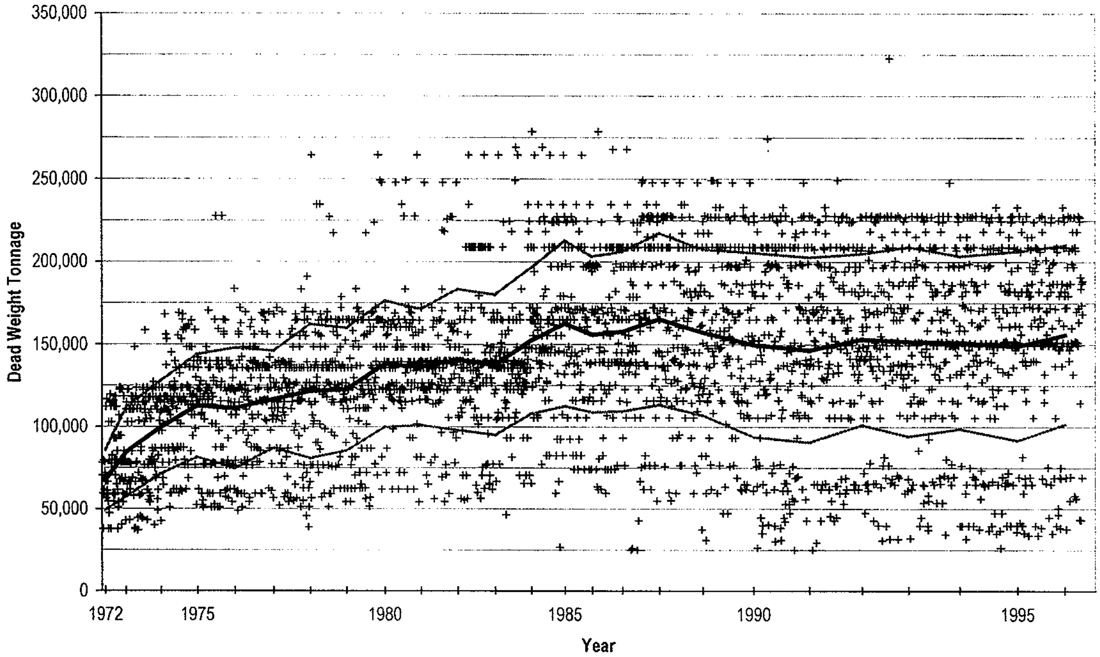

Figure 1: Cape Lambert Vessel Sizes

A recent study into shipping trends for bulk coal exports identified that there has been no significant movement in the maximum vessel size of bulk coal carrier from Australian ports (such as Dalrymple Bay Coal Terminal and Hay Point Services Coal Terminal), however there has been some movement in Panamax size coal vessels. Figure 2 below demonstrates the higher proportion of Panamax vessels that are now toward the 80,000 dwt end of the Panamax range, as well as vessels of 90,000 dwt capacity.

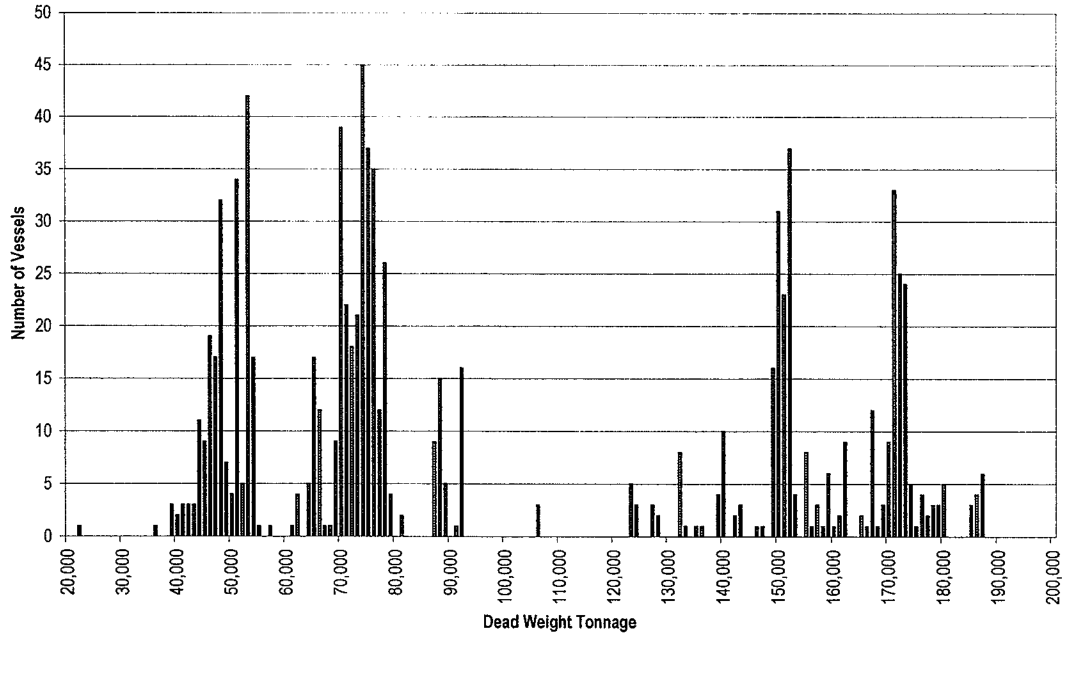

Figure 2: Port of Hay Point Vessel Sizes (February 2003 – January 2004)

In summary, a study of the design criteria and shipping trends for offshore bulk products exports indicates that while there was consistent and significant increases in design vessel size throughout the 1970's and 1980's, the maximum vessel size appears to have stablised over the recent 15 to 20 years. However if one considers the possible future lifespan of these facilities, further upward trends in vessel size cannot be discounted.

Harbour and near-shore facilities, as well as container terminals, are however facing increasing pressure. Through the 1970's and 1980's, wharves were typically upgraded to minimum Handy class. Through the 1990's wharves were upgraded to minimum Handimax, and where practical Panamax Class. Present shipping trends indicate that Panamax facilities are facing pressure to accommodate Large Panamax vessels, signaling that design of upgrades, or new wharves, for Panamax class must seriously consider allowance for future expansion.

DESIGN CONSIDERATIONS

Whether the upgrade of a facility is for a near-shore wharf, or for an offshore terminal, many of the principles and design considerations are similar. It is interesting to note that many of the bulk export terminals were conceived and implemented in the 1970's and 1980's. These facilities were designed with 25 or 30 year design lives as a primary consideration, possibly with some recognition that some extension may be required. This was however, not necessarily the highest priority in thinking.

While vessel sizes steadily increased and then stabilised, the offshore facilities coped without significant upgrade work, essentially drawing on latent inbuilt capacity to the point of saturation, or arguably in some cases, exceedance. During the 1990's, major upgrades and extensions of many facilities were embarked upon, and it was at this time that some of the design decisions made during implementation of the original terminals were highlighted as requiring some innovative design for expansion. Examples of this are:

- Berthing Dolphins – at some facilities (eg Cape Lambert and Cape Flattery), the berthing dolphin structures were designed to suit the original design vessel. However, subsequent developments identified the need to increase the capacity of these structures, principally due to increase in vessel size. While not impossible (since it was achieved), the ability to design and install new piling under or adjacent to existing facilities required significant design effort.

- Mooring Dolphins – common amongst the original wharves was the decision to orient the mooring dolphin structures in the line of the mooring load, or to rake piles in directions that suited the most efficient structural design (maybe at 20 or 45 degrees to the main axis of the structure). This produced relatively efficient dolphin structures. However, as a new wharf is built over the top of the mooring dolphins, two issues arose:
  - a) The potential for clashes between the existing mooring dolphin piles and the new wharf piles above; and
  - b) The need to convert the mooring dolphin structure into a berthing dolphin, where the structure is oriented with its strongest axis in a direction other than that of the berthing load.

- Deck Space – minimising the amount of decking on the offshore structure reduced overall design load, and ensured efficient design of the substructure. However, with space at a premium for operations and maintenance activities, operators found the cost of access for day to day operations relatively high. Also, when the time came for expanding the offshore facilities, the conflicting needs and demands of access for operations and new construction placed a premium on the capital cost.

- Deck Capacity – mobile cranes have increased in size and capacity since the original design. It is often a matter of convenience to use such larger cranes for operational and maintenance purposes today.

The above issues should not be considered errors of the original designers. As is the case today, the original designers were driven by the practicalities of design techniques and the usual pressure to minimise capital investment. As computer methods have allowed more complex analysis in much shorter timeframes, designers are able to more fully investigate the effects of layouts and geometries that are more amenable to future upgrade, expansion and extension.

The design hours invested into upgrading existing offshore facilities has also identified the following key areas that are worthy of lingering consideration by the designer – even if at the time it appears certain that no further expansion is likely to occur at the facility:

- Dredging – Where practical, berth pockets and approach/departure channels should be located away from rock that is within a few metres of the design depth (requiring sensible investigative techniques and extent during preliminary development). The future cost of significant rock dredging may far exceed the cost of site investigations and a bit of additional channel length. There are also ramifications for pile and/or wharf structure design, should the design of piles closest to the berth pocket be ill considered for future increases in berth pocket depth – even if the piles are already founded on near surface rock.

- Berthing Criteria – Berthing velocity sizes the fender, which in turn determines the capacity for the dolphin structure. If it is not cost prohibitive, some additional structural capacity should be considered, or at the very least, the design of a layout that can be readily added to without being limited in the future by oddly angled or raked piles. Typically, this may mean consideration of what initially appears to be slightly inefficient pile layouts or rakes, but ultimately a design that can be more readily supplemented with additional piling in the future. Where fenders are mounted directly on the wharf structure, some time invested in consideration of the impacts of next generation or larger vessels will most likely be time well spent.

- Shiploaders/Unloaders – The ability to accommodate more shiploaders/unloaders on the wharf structure, including the ability to accommodate additional conveyor streams, needs to minimise or eliminate the need for installation of additional substructures to support increased loads. It is always infinitely more difficult to strengthen existing structures on a wharf that is being utilised at or near its full capacity.

- Shutdowns – Layout and design of drive towers and/or transfer towers to incorporate future conveyors with little or no shutdown requirements. It is the ultimate irony of upgrades/expansions that in order to increase the throughput of a facility that is working at its limits, a complete shutdown of operations for a period of time is required. Obviously, the less the period of the shutdown, the less the overall impact on the business of the client when the throughput is needed most.

- Access – Where capital cost constraints dictate that (for example) a roadway cannot be incorporated in the initial facility, design of the substructure with capacity for a future roadway is often prudent. It has often been the case that further investment of capital for operational reasons (such as improving access) has occurred sooner than originally anticipated. The cost of driving a third pile, compared to a small provision in terms of pile diameter for two piles, may be seen in hindsight as an unnecessary expense.

- Detailing – Some of the small practicalities, such as extending the main rail girders a metre or more past the end of the wharf, or rear ends of headstocks of the wharf or dolphins an extra half metre, are worthwhile allowances. This will permit future splicing with reasonable tolerance and clearance from the existing structure – improving the cost of the upgrade work.

- The Environment – Most facilities today require strict control of potential contaminants, or if not required for the present purpose, consideration needs to be given to possible future uses of the facility and the need for retrofitting spillage trays, pipeline and slurry return systems, sumps or other collection and control devices. A practical suggestion is uniform sloping of a roadway or decked area in one direction (rather than in two directions from a central crown). This will mean that future installation of drainage collection systems is only necessary along one side of the roadway/decking. If not required initially, provision for incorporating future belt turn-overs or washing systems may also be worthwhile.

- Drive and Equipment Sizing – Some practical (yet not excessive) spare capacity or conservative sizing of drives may be relatively inexpensive if it can accommodate a future conveyor extension without upgrading. Alternatively, if the lower cost of installing the smaller drive initially is attractive, ensuring that adequate space for a future larger drive will be prudent.

WHERE THE FUTURE LIES

While original facilities have been designed with 25, 30 or even 50 year "project lives", which is not dissimilar to the new facilities or extensions to existing facilities today, it is recognised that bulk products such as coal and iron ore will have a finite life. In order to save the capital dollar, it may therefore be tempting to consider the current round of expansions as the "ultimate" or "final" round for these facilities – believing that their next stage of life will be their decommissioning and/or removal.

However, serious consideration of such action is another project life from coming to fruition. We do not really know what changes will occur to the coal export terminal of today, by 2060. It may be that in 5 or 10 years time, an urgent and unforeseen immediate capacity upgrade is required due to changes in the global markets.

While vessel sizes have remained relatively stable since the mid 1980's, this is no guarantee of continued stability. It may be that changes to the shipping market and/or bulk product handling capabilities in the destination markets (for example) over the next 15 to 20 years sees another step up in typical vessel size.

For the simple reason of the unknown, it is unwise and ultimately unhelpful to the client, to ignore the possibilities of incorporating minimal or low cost practical design and detailing that permits future expansion. It is the view of the Authors that it is always prudent to allow for possible future upgrading or expansion of offshore berths. This can be achieved with thoughtful and practical design, almost always without significant additional capital cost, or at a cost that is readily justifiable in terms of future benefit.