Goliath Cranes

Major tool of the shipbuilding & offshore industries

Trends for 2nd Generation

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1. To begin with - a bit of history

Date of birth of heavy gantry cranes - later called "Goliath" because of their size - is situated just before 1960.
At that time the shipbuilding industry of Europe underwent major technological change aiming at more rational and faster construction process.
The basic idea was to fabricate large sections outside the dock in a streamlined, sheltered production zone. Then these sections were to be moved by /on multi-wheel transporters, specially developed for this task, to storage zone next to the dock; there to be picked up by a crane to be positioned inside the dock next to other sections of the hull under construction; finally to be joined by welding.
This method had many advantages - the best proof being that it is still used today - its analysis, however, exceeding the scope of this paper.

Return to the crane ...
Parameters such as width of the dock, requirement to pick up the load (section) from all four sides of the dock and to place it anywhere inside it, anticipated height of ships to be constructed, estimated mass and size of sections to be lifted etc., finally resulted in choice of a large gantry type of crane - to replace jib and hammerhead cranes until then dominant in naval construction.

This principal decision taken, a plethora of designs of this 1st generation by numerous suppliers appeared on the market, in the first instance in Europe.
Of these designs only two survived (refer Annex. 1 & 2) in the long run; of the original suppliers none. Either they went out of business, have been taken over by others or abandoned the market.
The two design concepts later propagated to Asia, the KRUPP concept to Japan, the other to Korea; finally both to China as of present days.

What Europe supplies today are the KRUPP design in the hands of one supplier and the Jucho/PHB design in the hands of another, who skillfully modified the original concept by moving hoisting systems directly onto the trolleys.
The author's knowledge of present Asian suppliers is limited but numerous exist in Japan, Korea and China.

Turning to dimensions and capacity of these designs they were
in span: starting at 40-60m, later to 80-140m, as of today even beyond 200m
in lifting height : at the start up to 60m, later up to 80m, today even beyond 100m
in capacity: at first around 150-300T, later up to 900-1000T, today up to 2000T

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(Note: As a point of interest it is to be mentioned that a dimensionally futuristic crane was built by PHB in 1974 having a span of 176m, lifting height of 114m and lifting capacity of 1500T. It serves - after transfer from Europe to Asia - until today and dimensionally fully complies with today's requirements.)

Two points of importance are to be mentioned:

(i) In the early days a concept of coupling 2 cranes to achieve doubling of lifting capacity appeared on the market. Its success was short-lived because
- its runway, even if constructed with one foundation beam on each side, required altogether 4 rails (consequence: higher cost of installation plus maintenance cost of the runway multiplied by two).
- it is difficult to see why two cranes of capacity X should be cheaper than one crane of capacity 2X (apart from doubling of maintenance and of operator cost)

On the other hand, some advantages could be found in lesser energy consumption in long-travel and in the possibility (in twin configuration) of partly rotating the load in its horizontal plane.
It is believed that some of these systems are still operational in Asia where their lower mass could be of advantage in earthquake locations.

(ii) the second point of prime interest concerns capacity of the long-travel track. With the first installation of a Goliath crane in a given yard its wheel loads, indicated by the designer, provided loading parameters for the runway to be built accordingly. In another words, it was the crane design that dominated design of the runway.
Later we shall see that for cranes of 2^{nd} generation in many instances precisely the opposite will be the case and we shall examine how this situation affects the crane design.

2. History (regrettably) continued

In the previous chapter we dealt with the first construction wave of these cranes that lasted roughly between 1960 and 1980.
After a gap of about 20 years, the second wave came at the end of the 90ties and lasted until eruption of the world financial crisis in 2008. It was based on
- updating of equipment required by increase in size of ships to be built (lifting height) and further rationalization of construction calling for still larger building blocks (lifting capacity)
- emergence of new yards (China, Brazil) and calls for construction capacity increase (Korea)
- limited modernization of yards (Germany, Japan)

Where did these cranes come from?
Firstly, the second-hand crane market in European yards- many of them closed - was swept clean by transfers to Asia.
As far as new cranes are concerned these were built, based on the two surviving concepts, by European and Asians suppliers; many in cooperation between the two groups.

What is important and surprising at the same time is that - the electrical equipment apart - there was hardly any innovation to speak of, despite roughly 30 years between the two

construction waves. And that despite doubling of lifting height and lifting capacity as against the first wave, described in Chapter 1.
Evidently, a regrettable loss of opportunity in these new installations, explained by

- enormous, irreplaceable loss of experienced staff due to disappearance of many suppliers and non-replacement of personnel over the 20 years of production gap.
- satisfaction of remaining suppliers derived from disappearance of much of competition - hence complacency in further development.
- increase in Asian suppliers, but with little contribution in development
- many yards where these new cranes were installed were either new or without such cranes in previous operations. Hence, the all important factor of load capacity of (existing) runways rarely emerged, thus delaying the inevitable process of recognition of its influence on future designs.

In conclusion, a regrettable continuation of the same, 30 and more years later.

3. The road map for 2nd generation

Earlier we stated that there was hardly any development to speak of in this group of cranes since their conception. By that we aimed at principal development e.g. of concept and, in consequence, of the structure.
On the other hand, developments of the electrical system have been significant, but as they are common to other cranes as well, they will be dealt with separately.
Even in mechanical equipment there were developments, but these were limited to components (brakes, ropes etc.) As such, they are only marginally represented in the overall context and for that reason shall not be subject of this paper. (Nevertheless, ideas exist but due to their potential patentability cannot be disclosed at present.)

Let us therefore commence with future concepts and their expression in the **structural part**.
The two existing concepts mentioned previously and described in Annex.1 have been around for at least half a century. Is this a reason to subject them to doubt or to dismiss them completely?
Definitely not, because

- they are creation of great minds and great experience
- they have been tested for decades and competed successfully with all other concepts on the market coming out on top
- to an unequal degree their potential for further development is not exhausted.

Is there a need to compare them against each other before we move ahead?
No, because KRUPP did so already (ref. 1) decades ago. While their evaluation is not entirely faultless, it is grosso modo correct and fair.

What then to say about the two concepts today?
Firstly, that likelihood of emergence of a new concept, radically different from these two, is small; moreover, what was invented cannot be reinvented.
Second, that in their own ways they both have a future role to play, as we shall demonstrate later.
What then are the requirements for future development steps from today's perspective?
The following points have to be taken into account:

1. the 50 years gap when technology and requirements moved ahead
2. cost of operations
3. cost of maintenance

4. more stringent environmental standards
5. safety aspects
6. global climate change
7. consequences of inadequate (existing) runway capacity, if and when applicable.

Let us now examine the individual points closer:

re 1. While many consequences of this gap are covered by points 2-6, the basic problem is first-class equipment, but 50 years of age.
Under normal circumstances this situation would be unacceptable; why it is still surviving was explained in Chapter 2.
Changes could come from

- new materials: stronger, lighter, corrosion-resistant
- new design approaches and simulation tools, for example in aerodynamic performance ; wind loads, in majority of cases, being responsible for fatal accidents of these cranes. Moreover, better aerodynamic performance means less corrosion (every decrease in turbulence means increase in durability of the paint) in the long run and operational cost economies.
- growth in size of section may call a.o. for increased distance between hooks (of the same trolley), especially if soft panels are involved
- heavier sections requiring heavier cranes have in consequence more impact during long- travel, thus increased loading of the crane travel system and of the track; hence manifest interest to reduce these forces.

re 2. The following suggestions are being made:

- lower mass of the crane plus lower aerodynamic resistance during long-travel result in savings in energy
- majority of loads during ship construction are between 5 and 40T. Consider alternatives to using returning trolley for these lifts and displacements with savings in energy and wear in consequence
- lighter lifting accessories resulting in increase in useful load capacity
- manpower: is the crane driver indispensable?

re 3. Corrosion alone represents 60% of maintenance effort. Therefore it has to be reduced to a minimum, first of all by corrosion-avoiding design. Of equal importance are corrosion resistant materials, maintenance remaining as the third line of defense.

- cranes should be supplied with light-weight, corrosion resistant scaffolding, for maintenance of the main beam. Design of scaffolding in combination with hoisting mechanisms of the crane should be such as to permit installation, movements and dismounting of the scaffolding by the crane itself (mobile cranes are expensive!)
- service crane, if any, should be well protected against corrosion and enjoy maximum flexibility of movement and application
- access conditions should be optimized (lift well starting as low as possible), without being excessively generous
- number of long-travel wheels should remain limited by mass reducing design and optimal aerodynamic performance.

re 4.

- long-life, eco-friendly painting system
- integrated, self-sufficient, easily accessible and serviceable sanitary system
- suitable design arrangements for easy collection of excess oil and grease
- reduction in energy consumption (see also item 2)

re 5. crane:

- optimum securing of crane and trolleys under storm-wind conditions
- efficient load monitoring system (magnitude and positioning)
- avoidance of excessive application of overload tests; if unavoidable, their strict management
- regular inspections with disciplined follow-up

personnel:

- easy evacuation arrangements in case of fire
- optimum fire control and fire suppression arrangements
- corrosion control of access structures or application of corrosion resistant materials
- solid and regular maintenance of all means of vertical transport, as well as all other mechanisms influencing safety of personnel

re 6. Increased frequency and violence of storms
improved aerodynamic performance of the structure

- stronger storm – anchoring system
- improved corrosion resistance (see also re 3)

re 7. Although listed last, this item deserves much attention.
It is framed by the following scenario:
As the ships grow larger and higher, requirement is increase in lifting height. Equally, as productivity drives workshops to come up with ever larger sections (with corresponding reduction in their number per ship), their consequence is requirement of increase in lifting capacity. As ever larger sections have to be lifted, there may be requirement of increase in distance between hooks of the (same) trolley.
To summarize, all three requirements point towards new crane with corresponding increase in mass and in wheel loads.
How to counter that if you have an existing runway originally designed for a smaller –even much smaller- crane of the 1st generation?
First, let us state a fact that to increase capacity of the runway by reinforcing it is out of question. This is not only a problem of cost that, most probably, would be in excess of the cost of a new crane; it is also a matter of disruption to the production.
To build another runway next to the existing one? If there is space available there is actually little difference to what was stated previously.
So the first obvious – most primitive - solution is to increase the number of wheels of the long-travel system. Simple as it appears, it has three principal disadvantages:

- the higher the number of wheels per corner, the longer, higher and heavier will be the "pyramid" of the equalizers to support them; in a way a self-defeating effort.
- as a consequence, the longer the long-travel system, the bigger will be corresponding loss of serviceable space at each end of the runway; or in-between two cranes installed on the same runway. In addition, this situation will increase wear of wheel flanges as sensitivity of the whole system to crabbing and lateral runway imperfections will be magnified.
- finally, the higher number of wheels, the higher the cost of maintaining them. What then is the alternative?

First, to fight **in a substantial way** the increase in mass. That is a question of design and of materials, but above all that of design.
The second approach is improved aerodynamic performance (each decrease in aerodynamic resistance resulting in decrease in the overturning moment) of the crane with resulting reduction in wheel loads.
Admittedly, neither is an easy task given the scenario described previously, but not only it can be done, it is equally the only **rational** solution.

4. From trends to design

Chapter 3 summarized author's views on future needs.
Their practical expression can be found in concepts SP2000/SP2000A (ref. 2); their international patent proceedings being currently in progress.
To examine these concepts in detail is beyond scope of this paper; that would require a detailed presentation with a discussion during and after such event.

Nevertheless, let us state clearly that some principal features of currently marketed 1st generation cranes have been sensibly retained.
Thus, the SP2000 concept is based on a twin-beam design, the SP2000A on a monobeam design; the difference in approach justified by somewhat different mission of each variant. On the other hand, concept of all members below the beam bottom line is identical for both variants.
Further, the author does not wish to hide his opposition to concepts with more than two trolleys on the crane, finding this expensive in procurement, operation and maintenance when compared with additional benefits such solution may offer.

It appears desirable, however, to make specific observations regarding these concepts that go beyond their description in the patent documentation:

4.1. <u>In case of SP2000 crane</u> (intended lifting capacity 600 – 2000T, concept aimed at large, sophisticated yards for a key role there)

The service crane to be mobile and fully sheltered (if out of operations).
There are several reasons for this approach.
Firstly, current fixed service cranes have very limited application and as such represent costly investment; hence the idea of making the crane an active piece of equipment.
Moreover, installed in a position permanently exposed to inclement weather they require - to assure their all-round readiness-continuous attention by maintenance.
Further, mobile service crane of adequate capacity

- offers optimum flexibility for maintenance tasks
- eliminates need of large capacity hired telescopic cranes required – even for small loads – due to considerable height of the SP2000 crane. Needless to say, such cranes are expensive to hire and uneasy to get in emergency situations.
- is available at all times to operations for lifting construction loads up to its capacity and placing them where required. Thus, it complements the basic lifting system of the two trolleys at no extra charge.
- assists in lifting scaffolding for beams together with principal lifting equipment of the crane.

4. 2. <u>In case of SP2000A crane</u> (intended capacity 200 – 500T; principally aimed at small yards having a dual role there. Equally suitable for a secondary role in large shipyards or for tasks completely outside the shipbuilding sector.)

To dispense with the service crane altogether.
Three reasons for that

- as the SP2000A crane is generally much lower than its big brother, it is convenient to use hired telescopic cranes for maintenance. Due to lower height of the serviced crane and lower mass of loads to be expected, capacity of the telescopic crane can be lower too ; hence less cost and easier availability for hire.
- no scaffolding for maintenance of (most of) the beam and trolleys is required, as all work can be performed from the returning trolley
- low capacity of the returning trolley makes it highly flexible and cheaper to employ for smaller construction loads.

4. 3. Finally, the much debated topic of the usefulness of 4 points load suspension.
While this is not the place to reopen this debate, it should be of interest to those favouring this way of suspension to learn that the SP2000A crane provides this possibility.
What is unusual about the arrangement is that it is based on two trolleys **including** the returning mode of trolley operation.
For those interested in it there is no need for any confusion stemming from the announced lower capacity and lifting height of the SP2000A crane. Cranes of the same capacity and lifting height as SP2000 can be built along the concept lines of SP2000A ; but they will not enjoy many of the advantages of the SP2000 concept. Whether the four points suspension that SP2000A provides is worth of so many sacrifices is up to the relevant client to decide.

5. Conclusions

Only development and construction of the SP2000 and SP2000A cranes shall fully demonstrate their multiple superiority over the 1st generation systems; their design based on experience described in ref. 3.
Inevitably, during and after that time innovation and further refinements shall continue in a never-ending process of evolution.
That, under all circumstances, shall be the duty and durable commitment of those participating in this project.

References:

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2. PCT publication n° WO 2009 / 125127A1
3. V. Nevsimal – Weidenhoffer / N. Tsouvalis / V. I. Papazoglou: Goliath Gantry Cranes
   Their Steel Structure – A Neglected Element.
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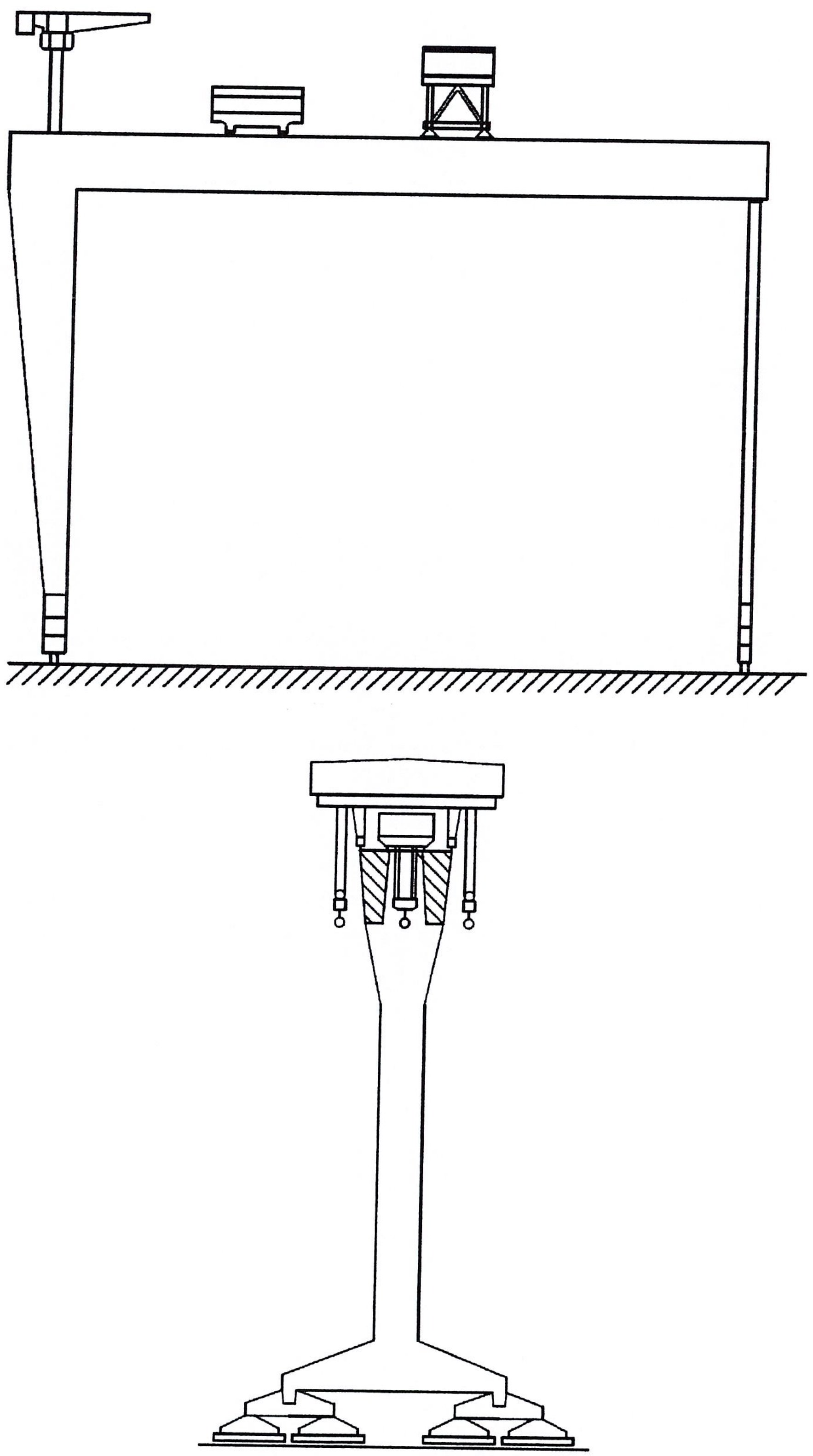
5. Annexures 1 & 2

APPENDIX 1



APPENDIX 2