Goliath Gantry Cranes

Their Steel Structure – A Neglected Element

Experiences in Surveillance and Reconditioning of the Last Two Decades

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1. INTRODUCTION

Goliath gantry cranes have been increasingly used in the shipbuilding industry for up to five decades, their size and lifting capacity becoming larger as the size of ships and their building blocks increased. Existing designs of these very large metallic structures currently offered by the crane manufacturers can have a lifting capacity of up to 1500 tons, lifting height between 50 and 115 m and a rail span of up to 210 m. Many of these cranes have been built during the 60's and 70's and they are approaching the end of their nominal design life. The aim of this paper is to demonstrate that while steel structures of Goliath cranes may over their lifetime carry a somewhat divergent kind of risks, these risks, by their nature, may be quite significant with potential consequences far larger than those applicable to other cranes. The authors, having an extensive experience in the investigation, repair, refurbishment and development of Goliath cranes (see Appendices 1 and 2), are aware that the general topic applies to all cranes; however, to illustrate the problem, this type of crane was chosen because:

- the ratio of the structural component to other components of the crane is the highest in these cranes,
- general opinion of the corresponding industry (assisted, no doubt, by difficult and often dangerous access conditions), rates steel structure of these cranes as least susceptible to potential problems.

Three types of service are usually applied on a Goliath crane structure during its lifetime, in periods superimposed on each other. These are:

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(i) Maintenance
(ii) Reconditioning or refurbishment
(iii) Enhancement of technical/operational life

The first type of service, which lasts over the entire life of the structure, is not subject of this paper. The second, commencing at about 20-25 years of age (depending on the rate of utilization as well as on quality of maintenance) is applicable for approximately 15 years, superimposed on the first. Structural refurbishment is usually being performed in conjunction with renewal of electrical (technology progress or lack of spare parts) and mechanical (renewal of gears, brakes, bearings, etc.) equipment of the crane. Timing of structural refurbishment is no hazard; it is at this time that first defects start showing through the paint (more about the origin of these defects in section 4). It takes all this time (20-25 years of operation) for the various defects of the steel structure (i.e. cracks) to grow enough to work themselves through the current elastic protective coating systems.

Normally structural refurbishment should conveniently coincide with renewal of the protective coating, but there are other dominant constraints such as loss of production and cost, that influence such decision. Most certainly, it would be a logical step to include renewal of protective coating into this period and, additionally, let the inspection benefit from the exposed blank metal of the structure after the necessary blasting. Regrettably, such an approach is not usually followed by the yards, who normally do not subordinate the time requirements of painting to the legitimate and important needs of parallel structural inspection, irrespective of how sensible such a course of action may be.

The third service type during the lifetime of a crane structure involves interventions that, while in progress over several years, are still in an exploration and experience-collecting stage. To the best of the authors' knowledge, in this category of cranes only one project of this kind has been attempted and, while in its final stages, it is still in progress. However, technical feasibility and cost attractiveness of this project have already been proven beyond doubt. Current knowledge on the subject is described in section 6.

2. INSPECTION

Before dealing with the inspection procedure, requirements to carry it out should first be examined. To commence with, the most important part is the inspector. He must possess engineering qualifications (preferably in several fields) as well as experience, the latter being of primary importance. Physical fitness, tolerance of dirt, bruises, inclement weather and, above all, easy adaptation to work in height and in confined spaces, are equally a must. Briefly, inspection is work for professionals and that for professionals of a "trench type".

Another primary requirement is good and safe access. This is not a small problem, given the fact that the structures are very large along all three dimensions and that many areas of interest are in locations with difficult access conditions. Mobile or fixed scaffolding, hydraulic platforms or platforms suspended from nearby jib cranes or even from hired telescopic cranes are most often used. However, it should be emphasized that not all of these practices can at all circumstances comply with the most stringent rules of safety codes. There is always an inevitable factor of risk in every inspection and it is the duty of the inspecting team to minimize this risk as much as possible.

Regarding the inspection and its objectives, what an inspector should primarily look for are the consequences of:

- Material defects
- Design errors or omissions
- Fabrication defects
- Erection defects
- Corrosion
- Operational damage
- Unauthorized interventions, and
- “Ghost” items

The unusual last term is used to represent situations impossible to be anticipated, even to be imagined. For better understanding, relevant examples will be discussed in section 4.

Having established what an inspector should look for, let us turn to how to localize these items or, in broader terms, which are the areas of interest through the crane structure. However, prior emphasis should be given to the obvious and self-evident principle that for all practical purposes it is impossible to locate and identify all defects on a structure. On the other hand, the duty of the inspector is to localize and identify ideally all defects of importance, in particular those that could present a threat to structural integrity.

A good starting point is review of structural drawings and calculations, if available. Although of limited help, such a review is always useful even if drawings alone cannot reveal complete picture of potential problem areas; moreover, availability of “as-built” drawings is rare in most instances.

Turning from general points to visual inspection, a skilled engineer is able to anticipate potential problem areas, but after that it is experience that takes over. However, experience alone is equally insufficient, since it will always be limited by the past, e.g. it is only what you experienced in the past you can anticipate in future. The inspector should always keep in mind that protective coating is providing the best “cover-up” and defects are not always evident. Generally speaking, a proper visual inspection should always, right from the start, include a sound and well planned approach concept, a good eye, attention to detail and intuition. In addition, understanding and correct interpretation of some “signs” of damage, in conjunction with an inductive reasoning regarding the way the structure is operating, can lead the inspector to localization of further areas of interest.

Non-destructive investigation techniques are normally incorporated in these inspection procedures, but being intimately and widely known, in this paragraph emphasis is given only to their limitations. First of all, the cost of these techniques and the required time to be spent on the structure are two major factors that have to be considered. In addition, cost of access required must be taken into account, not forgetting that many of these techniques require special conditions (e.g. absence of paint, optimum weather, etc.) that further limit their use. All of these factors together speak by themselves against massive application of non-destructive investigation techniques (the only exception perhaps being the Alternating Current Field Measurements – ACFM). Due to the above reasons, the role of these techniques is normally restricted, mostly towards verification of areas of interest defined previously by visual inspection. In these cases they can be very useful, even indispensable. Under such conditions, even a multi-layered NDT approach can be required and applied to the best effect. In conclusion, in an inspection non-destructive investigation techniques will always remain a useful support tool of an overall effort carried out by other means.

In summary it can be stated that inspection is the most important element in condition monitoring, refurbishment and life-enhancement service periods, providing an information basis for any one of these service types. Its quality is of paramount importance for success of these services, whereas its grading, accuracy and assessments based on it largely depending on the individual in charge.

3. REFURBISHMENT

Based on results of preceding in-depth inspection, refurbishment represents the first stage in reconditioning of a structure during its lifetime. In the true sense of the word, its objective is to improve overall condition of the structure bringing it as close to its original status as possible. As previously indicated, it can be (and often is) combined with other major interventions, such as:

- modification of the crane (e.g. geometry, capacity, performance)
- modernization (e.g. electrical equipment)
- transfer of the crane to other location

While the above interventions are of equal interest with the refurbishment works, dealing with all their aspects, requirements and special conditions is clearly beyond the scope of the present paper; hence, we concentrate further on refurbishment of the structure.

Based on results of inspection, priorities of work are established and, unless immediate interventions are required before crane operations can be resumed, the schedule of works is fixed, always **depending on crane availability**. This is the first and crucial parameter that will rule execution of works. Its importance is witnessed by the fact that the way of execution of a given corrective measure is often dictated by requirements of the production department of the yard and consequent availability of the crane.

The second and equally crucial parameter is **weather conditions** (temperature, wind, rain) permitting satisfactory and safe execution of works. Moreover, final two major parameters to consider are the **conditions of access** and, last but not least, the **cost**.

Taking into account all the above parameters, refurbishment works can be split-up into the following categories:

a) *Works where prior engineering is not required, with easy conditions of access*:

In such case everything is a matter of labour. Experience has shown that best results have always been achieved by using workforce of the yard. There are many advantages in this approach; the people are motivated by working on their own equipment and are much more efficient instantaneously knowing the whereabouts of any services, tools or other support. An additional benefit to the yard and to each one of the staff involved is that by working with the inspecting team they acquire some experience in detecting, analyzing and repairing structural defects on their own. Thus the yard is acquiring a measure of know-how and that free-of-charge! Of course, reasons for using the workforce of the yard are equally valid in the case of the next two categories of refurbishment works.

b) *Works where prior engineering is required:*

Engineering solutions are generally provided by the inspecting team and the yard may wish to participate in this procedure. In all cases, design of these solutions should respect crane availability and lifting requirements. The inspecting team also carries out various special investigations and tests (i.e. advanced structural analysis, laboratory material examination tests, etc.), if and when required and to the extent the team is in possession of means for doing so. Otherwise, such services are subcontracted, the inspecting team having the supervision. The same applies to supply of any hardware required by the engineering solution.

c) *Works requiring special access arrangements and/or heavy lift operations:*

Although actual refurbishment works remain the sole responsibility of the inspecting team, tasks like creation of the necessary infrastructure for carrying out this type of works (i.e. scaffolding, erection, bringing down for dismantling, review and refurbishment) are generally subcontracted, but their planning would always remain subject to approval of the inspecting team.

Regarding defects that can be encountered during an inspection, some characteristic examples are presented and analyzed in the next section 4. As far as their origins are concerned, an indicative list was given in section 2, but their split-up is impossible to quantify; there is no general rule.

Corrosion is, of course, of frequent appearance on these structures and its origins are not to be sought primarily in poor design; negligence in conservation is mostly the cause. Corrosion is capable of creating dangerous situations on its own, particularly if of the hidden type.

Renewal of protective coating in parallel to refurbishment works has already been mentioned in section 1. However it should be emphasized once more that, apart from its protective role, protective coating can equally cover up a number of actual or potential problems.

Last, but not least, the issue of damage. It is quite natural that in real life every crane is virtually bound to suffer some damage from operations. As such damage may have serious consequences, it is imperative that it does not go unreported. Staff that directly witnesses such accidental damage is, in the majority of cases, not qualified to assess its importance. Moreover, human nature tends to hush up such incidents and leave the situation as it is. It is therefore warmly recommended to encourage staff to report **every** accidental damage and leave the decision on its importance to those with relevant qualifications. Crane drivers in particular should be encouraged in this direction as, under circumstances, their lives may depend on it.

Finally, equal emphasis should be given to the issue of damage caused by unauthorized and/or inappropriate interventions. Welding, drilling, oxy-cutting etc. without previous proper consideration and supervision can result in considerable damage, which is often uneasy, if not impossible, to repair. Approval, insistence on discipline and proper supervision in all interventions is therefore a clear must.

4. DEFECTS

Regarding defects that can exist on the steel structure of a Goliath crane, the most common categorization is linking the defects to their origin. Thus, as mentioned in section 2, defects can be subdivided into several major categories, such as material defects, i.e. defects having their origin in production of steel and of steel products; design errors or omissions having their origin either in oversight during design or in lack of sophisticated design tools, like modern finite element software codes; fabrication and erection defects created during these two stages of the crane construction, having their origin in poor workmanship or insufficient supervision; corrosion problems caused by either poor design or improper maintenance; operational damage, most often caused by collisions with surrounding structures or equipment; unauthorized interventions in the structure by inexperienced personnel; and finally "ghost' or "phantom" items, a general category including all cases hard to imagine, usually as a result of a combination of all the above parameters and beyond. Typical examples of those defects encountered by the authors are shown below:

4.1 Material defects – Case 1

This case refers to a defect discovered in the lower part of web of the main beam of a large gantry crane, near the joint with the bottom flange (see Figure 1). It existed at mid-span, extending for a length of approx. 600 mm and a height of 50 mm above the bottom flange. It was discovered by the Alternating Current Field Measurement (ACFM) method. First it had appearance of a crack, but after careful examination and grinding it was established that it was a "lap" in the plate, present since the origin that after the years became loose. Careful grinding of the area was carried out until the defect was eliminated. No re-welding was envisaged due to tensile stress permanently present in this area from the main beam own weight, reaching approximately 100 MPa.

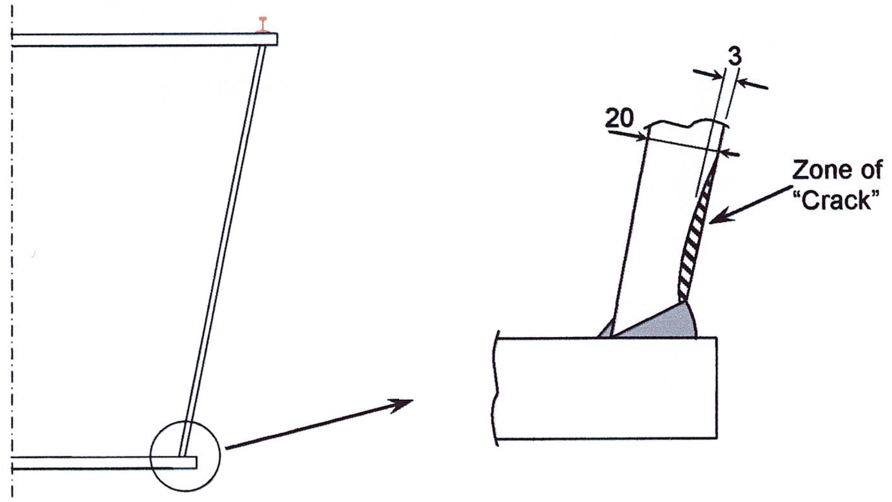
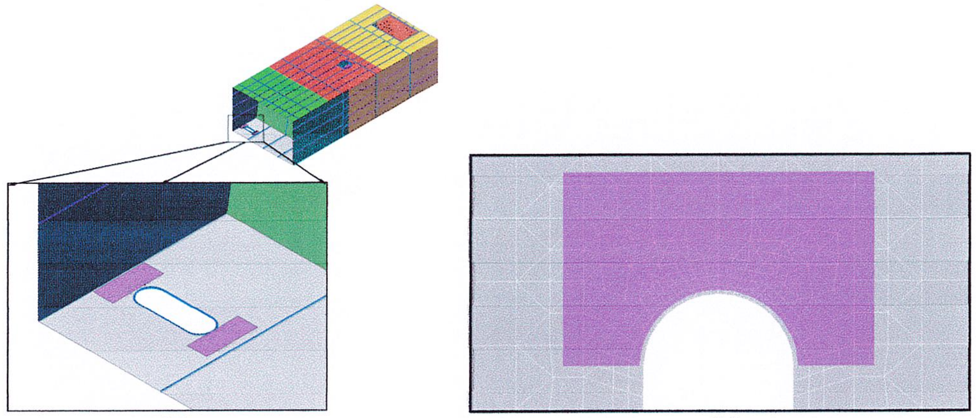


Figure 1: Material defects – Case 1.

4.2 Design errors – Case 1

The design problem in this case was a cable hole in the bottom flange of a cross beam of the crane, being oriented with its largest dimension perpendicular to the direction of principal tensile stresses developed in the plate (see Figure 2a, where half of the cross beam is shown for better illustration). This configuration resulted in a large stress concentration at the edges of the hole, which in time could have jeopardized structural integrity of the cross beam. The area was reinforced by putting friction-bolted doubler plates near the edges of the cable hole. Various shapes were investigated by using finite elements, with the one shown in Figure 2b found to be the optimum one.

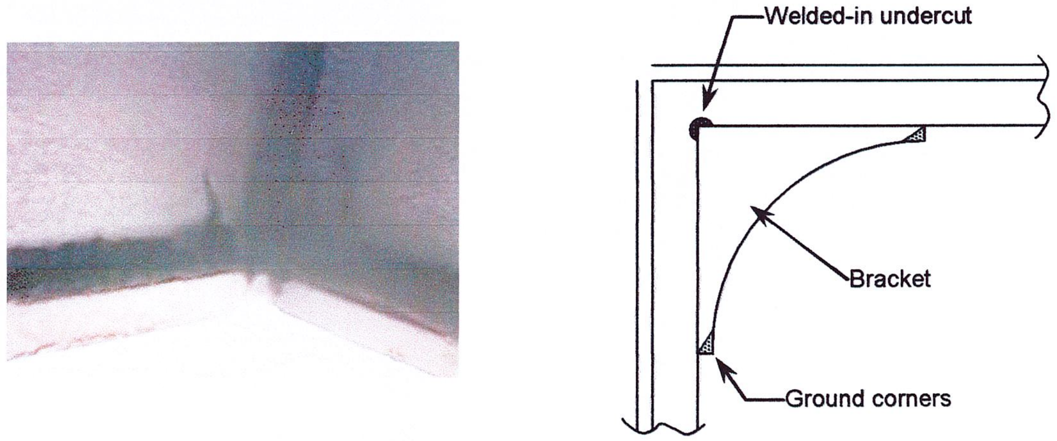


(a) (b)

Figure 2: Design errors – Case 1.

4.3 Design errors – Case 2

The problem was the existence of an undercut in a junction of bottom flanges of two beams of a trolley (Figure 3a), both these flanges being loaded in tension. Repair works included filling of the undercut with weld and welding of an additional curved bracket, as shown in Figure 3b). The initial right-angle corners of the bracket were, after welding of bracket to the beams, ground smooth for optimum geometry.



(a) (b)

Figure 3: Design errors – Case 2.

4.4 Fabrication defects – Case 1

In this case, the problem concerned improper execution of throat weld between the top flange and the web of main beam of the crane, just below the trolley rail (Figure 4). Insufficient penetration of this welding resulted in development of a longitudinal crack in the weld extending for about 200 mm, discovered by the ACFM method. The crack was repaired by careful removal and rewelding limited to the area where the crack was found. Although the problematic throat weld was extending along the whole length of the section involved (16 m), for practical reasons it was not possible to repair the whole weld. The yard was informed to pay specific attention to this area during future surveys.

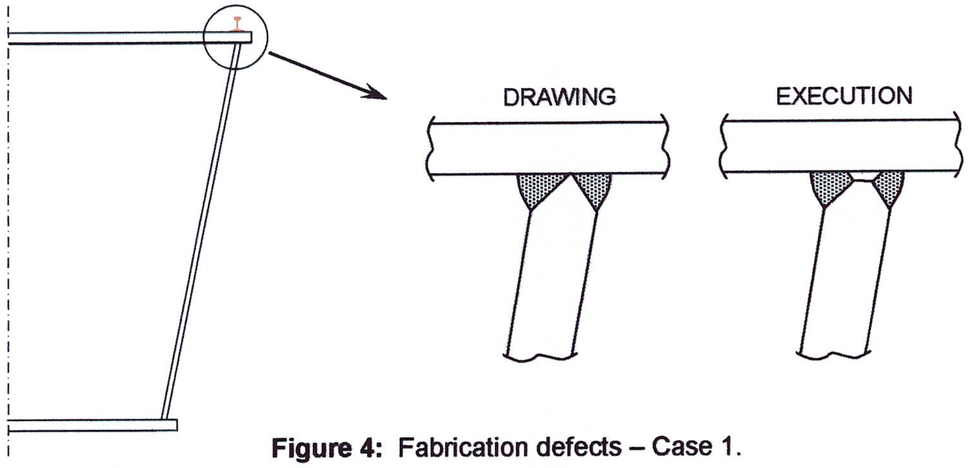


Figure 4: Fabrication defects – Case 1.

4.5 Fabrication defects – Case 2

In many cases, remnants of gussets and brackets used for fabrication and/or erection purposes were found like those shown in Figure 5 below. These remnants were traces of weld metal due to improper removal of these structural appendices leading to cracks in some cases. The cracks were discovered by grinding out these remnants and investigating the area with NDT techniques. Repair was limited to grinding out the cracks, since they were not deep.

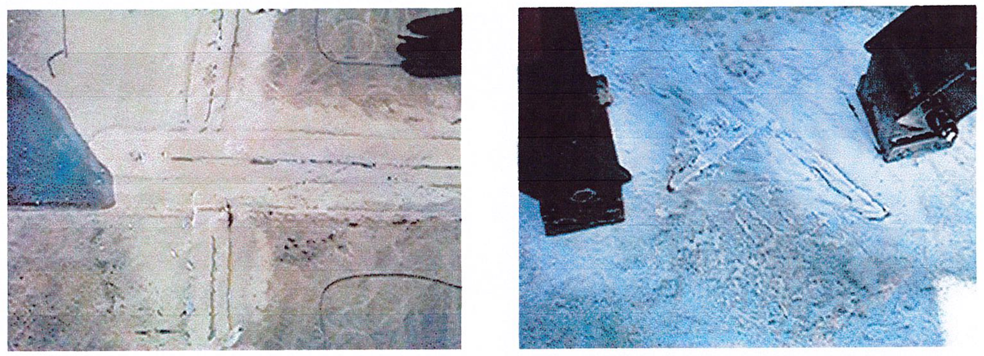


Figure 5: Fabrication defects – Case 2, two different examples.

4.6 Fabrication defects – Case 3

A common fabrication defect is poor quality of edge cutting of various free edge plates, like the one shown in Figure 6 of the cross beam web plating. These saw-tooth shaped edges are a perfect example of potential crack initiation points, when they are parallel to main tensile stresses of the structure. The problem was resolved by grinding the edges smooth and checking with magnetic particles to verify that no micro-cracks remained behind.

Figure 6: Fabrication defects – Case 3.

4.7 Erection defects – Case 1

This case is about a situation on the main beam of a Goliath crane equipped with a bracket. In the area of maximum tensile stress of the beam top flange, lifting plates for erection purposes were introduced passing through the tension flange in a direction perpendicular to the principal stress (Figure 7). After erection these plates were cut off flush with the top surface of the flange. The erector, being aware of having done something incorrect, drilled a hole on each side of the slotted plate, introducing a bolt in each, spot-welded to the flange. In addition, a reinforcing plate was designed and welded to the flange on each side of the detail (Figure 7). The result was creation of cracks in the bolt holes, with much worse potential damage to be expected from such arrangement. Repair included removal of existing reinforcing plates and designing and installing friction-grip bolted doubler plates on both sides of the flange, around the critical area.

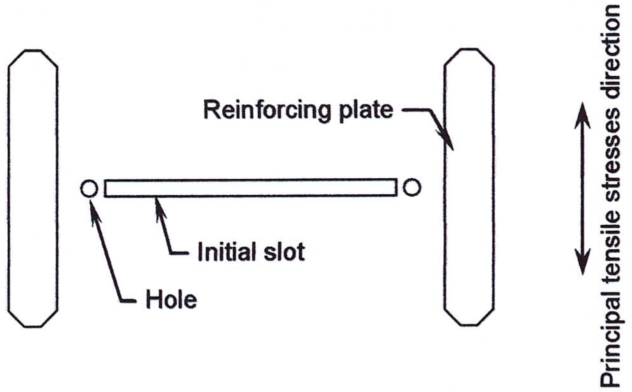


Figure 7: Erection defects – Case 1.

4.8 Erection defects – Case 2

This example concerns bolt holes drilled initially to accommodate bolting of connection plates in order to join by welding sections of the crane beam. After assembly, these holes were normally filled in by welding. In several cases, this welding was done improperly resulting in formation of defects like those shown in Figure 8, leading to severe stress concentrations. These defects were visually discovered after removal of paint. Initial attempt to re-weld the holes with preheat led to formation of cracks. This fact indicated that the parent material was very brittle, indicating execution of the initial fill-in welds at a low temperature and without preheat. Final solution was to re-drill the holes, preheat and re-weld.

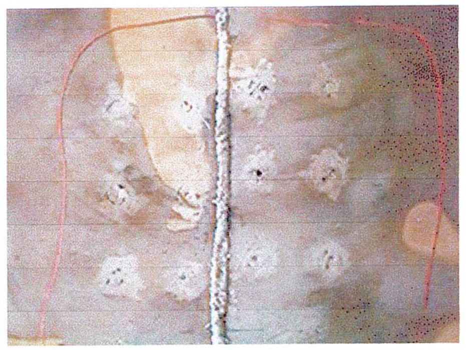


Figure 8: Erection defects – Case 2.

4.9 Erection defects – Case 3

This case refers to the damage done to the service crane rails in order to fit the power tool socket on the bolt head to torque up the bolts. The bottom of the rail head was oxy-cut to make more space for the socket, as can be seen in Figure 9. No corrective measures were taken in this case, as the damage was characterized as irreparable. It has to be noted that these rails, friction-grip bolted to the main beam (hence part of the cross-section) are located in a zone of maximum tensile stress of the top flange, due to bracket action mentioned in paragraph 4.7.

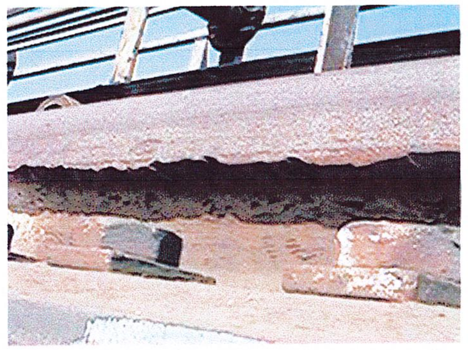


Figure 9: Erection defects – Case 3.

4.10 Corrosion – Case 1

As shown in Figure 10, extensive corrosion was discovered at a friction-grip bolted joint of the main beam, due to insufficient attention paid to the water tightness of this joint. Corrective measures consisted of removal of rust as much as possible and sealing the joint.

Figure 10: Corrosion – Case 1.

4.11 Operational damage – Case 1

This example involves damage to one of the main beam webs near the counterweight area, due to collision with another crane (Figure 11). Compressive strength of the web plating has been substantially reduced by this damage. Repair was done by reinforcing local stability of the structure by installing additional stiffeners inside.

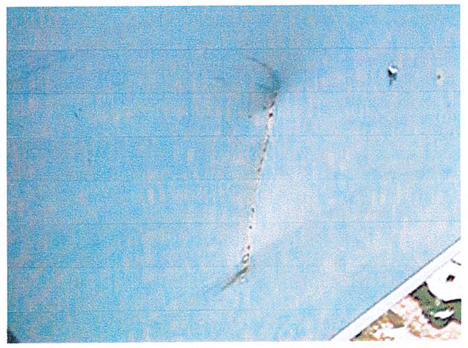


Figure 11: Operational damage – Case 1.

4.12 Unauthorized interventions – Case 1

A perfect example of this category of defects is the case of an equalizer, where a bracket was initially welded to its bottom flange (probably as a temporary measure to support it) and then cut-off. As a result, remnants of the weld including undercuts were left in the flange. These remnants were ground out and consequent NDT check showed no cracks. However, grinding resulted in a significant local reduction of the flange thickness. Since the equalizer flange was subject to considerable tensile stress, a weld repair procedure was proposed to the owner, who declined execution.

4.13 "Ghost" items – Case 1

This case involves holes which were initially drilled to accommodate fitted bolts of a joint. Since installation of these was found expensive by the erection company, the fitted bolts were replaced by HSFG bolts (having diameter smaller by 1.2 mm) and these were torqued up. Problem: the erection company "forgot" to properly prepare friction surfaces by blasting, leaving these surfaces with a coat of primer, as initially prepared for the fitted bolt connection.

4.14 "Ghost" items – Case 2

The next case involves again a bolted connection equipped with fitted bolts. Several years after the erection of the crane an inspection company of some renown "found" that these bolts were not torqued up, believing wrongly that they had in front of them a friction-grip connection. So they torqued up the bolts that, although of 8.8 grade, did not have the geometry to withstand these stresses undamaged. Result: all of these bolts when removed showed cracks in the thread-shank intersection.

4.15 "Ghost" items – Case 3

This example refers to the lower horizontal box girder of a triangular shear leg of a crane (Figure 12). The box girder had an approximate width of 800 mm and a height of 600 mm and was of the fully seal-welded type, e.g. there was no access into the interior. A cable tray was running on top of this box girder, sitting on "buckles" welded to the top flange. These buckles were so low (30 mm) that it was impossible to look properly under the tray.

The first indication was that the zone under the cable tray was heavily corroded. After removal of the cable tray and cleaning of the rust underneath, five small holes were discovered with a diameter of approx. 6 to 8 mm in the zone under the tray, in a rather concentrated area. A wire test established that they were going through the thickness of the flange. These holes must have been drilled before installation of the tray, which, evidently, was never removed before.

Result of these holes was water penetration inside the box beam, a fact that remained unknown for 30 years. The beam had no protective coating on the inside and, in consequence, heavy corrosion has formed. The box beam was opened on the side and about 50 buckets of rust mud were removed. The thickness reduction of the plates was about 50% in the bottom flange, 30% in the webs and 20% in the top flange. The only favorable issue was that the holes were very small, their diameter further reduced by rust. As a result, water and oxygen penetration remained restricted.

In order to fix the problem of the box beam under permanent tension, it was recommended to use reinforcing strips in the areas affected.

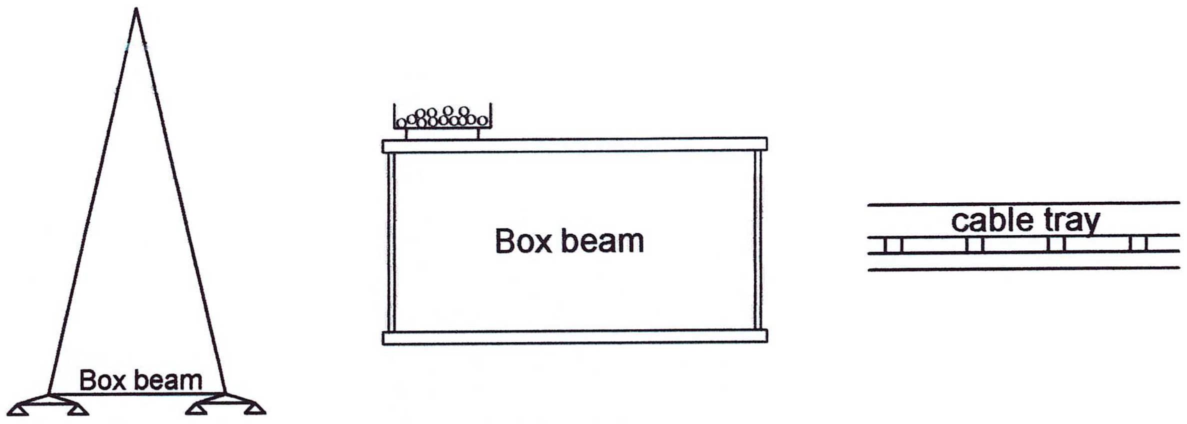


Figure 12: "Ghost" items – Case 3.

5. REGULAR INSPECTIONS AND THEIR IMPORTANCE

It is evident that at all times the structure must remain under surveillance, especially after refurbishment. This, not only to safeguard its safety and integrity and verify correctness and adequacy of the measures taken, but equally as a wise cost-cutting measure.

Current codes[1,2] are relatively vague on the subject of intervals between these inspections and, in view of the authors, this is because there are many factors influencing a decision like this, such as:

- initial condition of the crane on delivery (design, fabrication, erection)
- quality and frequency of maintenance works
- rate of exploitation
- climatic conditions (corrosion rate)
- damages etc.
- and, inevitably, the cost factor

In this context, a question may be raised whether it is better to have these inspections carried out by different inspectors, or whether it is of advantage to keep them in the same hands. While the first approach may bring the benefit of difference in view-points and experiences, it is the latter option that is favored and recommended. The first reason for this recommendation is that knowledge of case histories of individual defects by a single inspector is of considerable advantage, an advantage that must not be lost. The second

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[1] ISO 9927-1, Cranes – Inspections – Part 1: General, 2009.

[2] ISO 12482-1, Cranes – Condition monitoring – Part 1: General, 1995.

reason is that, only that way, a long-term "relationship" with a structure can develop and result in a "feel" for it.

Under such conditions a decision on frequency, even extent of inspections, is easy and optimized. In any circumstances, a decision on these issues should be left in the hands of an expert, rather than to rely on some inflexible rules that may (and in many cases do) either underrate or overrate the issue, resulting in losses either in safety or in cost.

6. ENHANCEMENT OF OPERATIONAL LIFE

Aging is a natural process of all things, bringing their life to end at some stage. However, within this fact it is necessary to distinguish between "life" and "useful life", the end of which may come much earlier. Leaving for the moment all technical aspects aside, the extent of useful or operational life of a Goliath crane depends on:

- adequate compatibility with operational requirements at a given time, and
- cost of operations

If the first point can be anticipated satisfied over an extended period of time, then it is of interest to examine the option of enhancement of operational life of a given crane structure. The first condition to be satisfied is the economy of such action, i.e. the ratio between the cost involved and the additional number of years in operation so gained. A further condition is reasonable (restricted) maintenance cost during the time so gained.

Nowadays the prevailing view of the industry is that the currently operating generation of Goliath gantry cranes (built in the 60's and afterwards) has a very long life. This belief is essentially correct, although it is still not exactly known how long is "long". There is indeed a large variety of software available for residual life calculations that can be used in an estimate of the life of the structure. The question is, of course, how reliable results of these calculations are, the problem not being associated with the validity of the software codes themselves, but mostly with the way these codes are implemented in a structure as large and complicated as a Goliath gantry crane. Such calculations will readily show how long a theoretical model of the structure can last until the limit number of cycles of a critical member is reached. However, this result will be on the basis of an ideal configuration, where very few of the problems inflicted on the real structure during and after its conception can be modeled. Hence, whatever may be established on the basis of a theoretical calculation, it will be nothing more and nothing less than an upper boundary of the residual life of the crane.

Moreover, a definition has to be given to what residual life really means. The answer to this can only be the useful (operational) life of the structure, within the above mentioned maintenance cost limitations, since any other definition has no practical value. As far as "life" is concerned, the current status is that inspectors are still in the process of gathering experience and for this reason the answer to the all important question "how long?" remains inconclusive for the time being.

Having established what "life" of a structure means, here we arrive at the fundamental difference between refurbishment and enhancement of operational life, be it in the technical measures to implement or in their costing.

In the first case (refurbishment), after a thorough inspection the inspector knows virtually all and it only remains to add it up. In the second case the issue is practically the same, but this is only the starting point. Major part of "enhancement of operational life" works consists, firstly of **correctly** anticipating one or more sequences of local deteriorations that could potentially lead to local failures, and thereafter, of developing and implementing measures how to counter these in time. This involves a combination of surveillance with preventive engineering measures, ranging from improvements over to modifications and even complete replacement of components; all these, of course, under constant review of cost to keep this important factor in check.

All in all, "enhancement of operational life" is a task of constantly keeping ahead of problems before they develop or, at least, before they become unmanageable and this at cost levels that can be justified at all times. No doubt a daunting task, but it can be done successfully as the authors' engagement of the last six years demonstrates. Additional experience from current and future projects shall refine the tasks of this kind, improve their technical and financial success and, in consequence, add to their attractiveness to the industry.

7. OVERLOAD TESTS

Following reconditioning measures discussed in chapters 3 and 6 it is sometimes necessary to subject the crane, or part of it, to an overload test.

To evaluate its full effect on a structure is a complex issue transcending scope of this paper.

Nevertheless, the authors feel the need of proposing at least some principal guidelines for such tests:

1. During its lifetime the crane suffers unavoidable damage (accidents, unauthorized interventions, corrosion) and consequences of any weakness in design, fabrication and erection. In other words, as the years pass the structure accumulates problems which with each new test may grow, thus increasing potential risk.
2. These tests represent the most damaging condition for the structure and, as such, they should remain very limited in number during lifetime of the crane. They should not be carried out unless fully justified on technical grounds (crane age and problems known

taken into account) and, if so, should include good planning to limit potential risks and a good check-out on completion.

3. While overload tests constitute the only method of exhaustive evaluation of effective operational security, they do NOT represent a guarantee against failure on their own. Only in conjunction with close monitoring of the crane (ref. chapters 2 and 5) the desired levels of safety can be attained and maintained.

8. CONCLUSIONS

This paper presented fundamental steps in taking care of a steel structure of a Goliath gantry crane, including problems to be expected and principles of how to deal with them. By doing so, the aim was to dispel some widely established myths still pervading the industry, namely that:

- steel structures of Goliath gantry cranes require only a minimum amount of inspection because they are largely “inert” to risks, and
- steel structures of such cranes do not, in general, suffer from fatigue.

Regarding the first point, the previous sections of this paper demonstrated beyond doubt that the situation is different and that structural components of these cranes need at least as much attention as those of any other crane, in particular given the magnitude of potential risks involved. And here we are not talking only about magnitude and value of such crane, hence of potential cost of major technical problem. Far more important appear specific consequences of such problem for operations. For, contrary to other crane equipment, many of these cranes operate over a dock as a single unit offering little or no possibility of rapid substitution by another crane. In case of their immobilization, lost production not only means disruption and delays, but far too often painful financial losses for the construction process of the yard.

As far the second item is concerned, it should be clearly stated that this point of view is as much in error as the first one. The answer to the question “in what part of the crane, if any, fatigue damage can evolve”, the response is “in those areas where the number of cycles required for fatigue to develop can be collected”. In a frequently used crane, such areas should particularly be sought in the long-travel system exposed to imperfections of the track and inertial forces from travel.

The very essential at the end: All the works mentioned can only be carried out and completed successfully on condition of first-class cooperation between the parties; hence in full mutual confidence, trust and respect of each party responsibilities. Where these conditions do not prevail, works should be terminated at once as their continuation may result in unacceptable risk to this or that party, or both, and, most importantly, to the safety of the equipment and of those operating it.