

## FATIGUE DAMAGE AND NEW DESIGN OF GANTRY CRANE EQUALIZER BEAM

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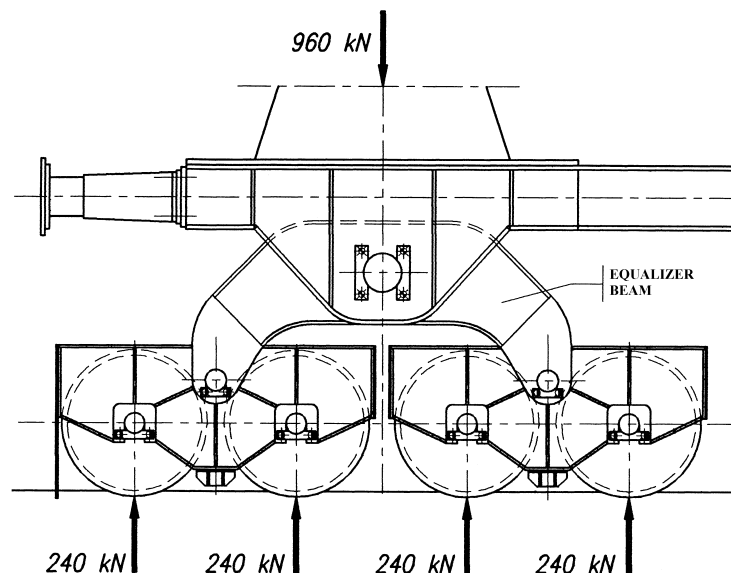
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### 1. Introduction

In the hydroelectric power plant engine room there are two gantry cranes high capacity and span (1,6 MN, 13,8 meters). Every crane has four equalizer beams-elements used to uniformly distribute the loads from platform to the wheels and rails. During regularly inspection of gantry cranes a numerous cracks, in region of vertical with upper, as well as lower, plates joints was observed. Repair, grinding and welding of cracks, was performed. Radiographic control of repaired weldments detected new cracks. Whereas equalizer beams play important role in the cranes reliability, decision for production of new designed equalizer beams was made. Therefore, on the basis of Finite Element Analysis of the new designed equalizer beam, technical documentations were made. Production, assembly and testing of equalizer beam under QA and QC have been done.

### 2. Finite Element Method analysis

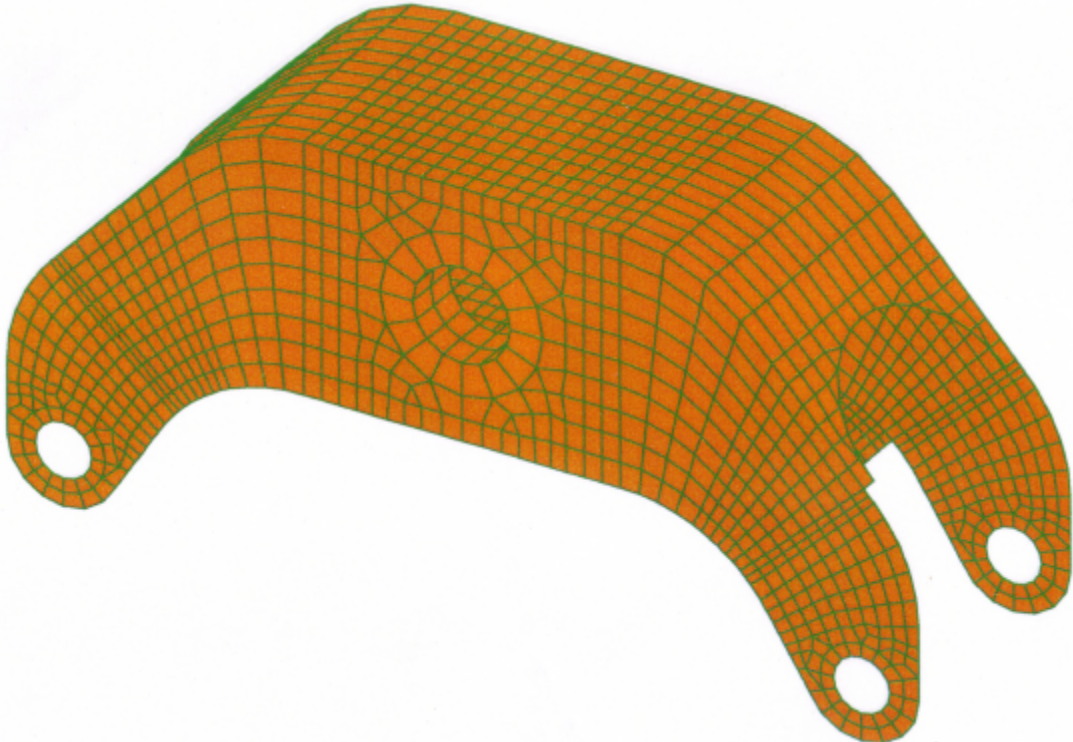
According to the geometry and load of equalizer beam (Fig. 1) FEM was performed.



**Figure 1. Equalizer beam**

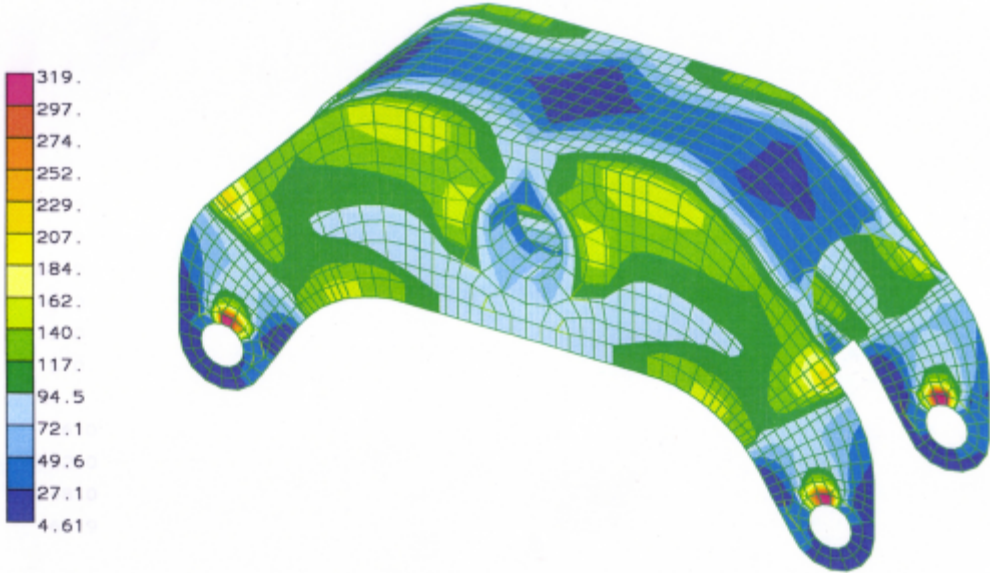
Finite Element Method analysis was used to determine the global stress distribution, and to find out weak points of equalizer beam that could cause stress concentration. Linear elastic model and thin shell elements with four and three nodes and six degrees of freedom were used.

The geometry of original equalizer beam (A) was defined by 2272 elements (Fig. 2).



**Figure 2. Equalizer beam A - FEM model**

FEM analysis has showed critical points of construction in regions of vertical plate with lower plates and with upper plates joints. In a region of lower joint equivalent stress is up to 162 N/mm<sup>2</sup>. In a region of upper joint equivalent stress has value up to 229 N/mm<sup>2</sup>. Stress distribution is shown in figure 3.

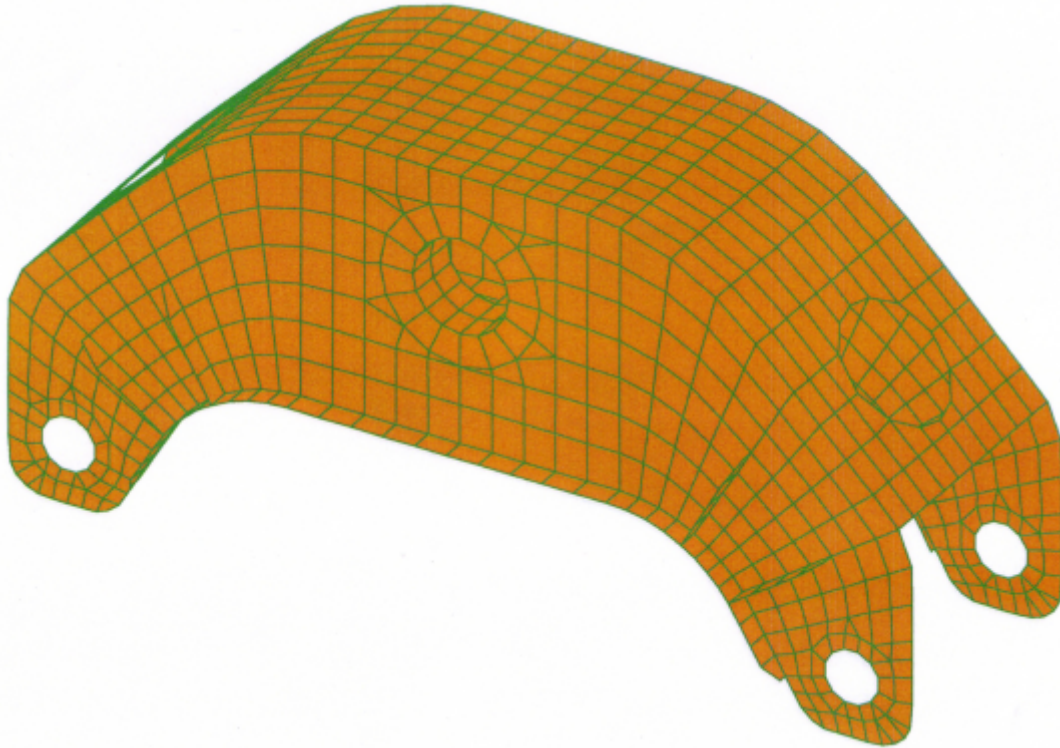


**Figure 3. Equalizer beam A - stress distribution**

This stress distribution and its values indicate the need for new designed equalizer beam. Main improvements of new designed equalizer beam (B) are:

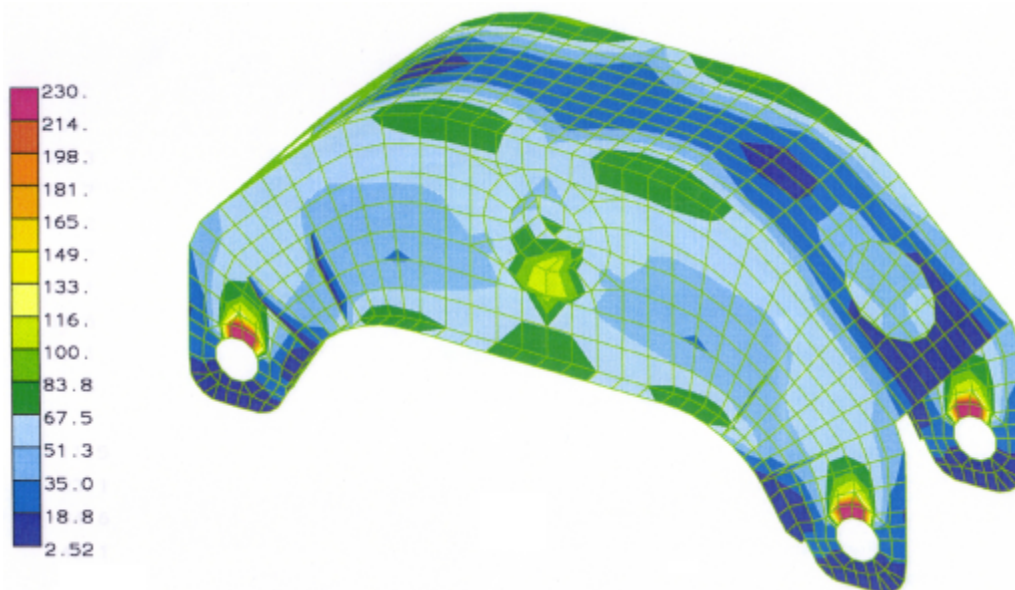
- vertical plates are made without changes in thickness and accordingly that no need for weldments,
- horizontal plates are modified,
- stiffeners are added in maximal stress regions.

Above mentioned modifications are integrated in FEM model shown in figure 4.



**Figure 4. Equalizer beam B - FEM model**

FEM analysis has showed stress distribution across the model B is almost uniform (fig. 5). In a region of vertical plate with lower plate and upper plate joint equivalent stress is up to  $83,8 \text{ N/mm}^2$ , that is significantly lower compared to stresses in model A.



**Figure 5. Equalizer beam B - stress distribution**

### 3. Production and Quality Assurance and Quality Control activities

Taking into account results of performed FEM analysis all necessary working drawings for production of equalizer beam are prepared. According to acceptable mechanical properties and weldability, St 52-3 (C.0562) was chosen as basic material. The plates, for production of equalizer beam, are sand blasted and coated with primer. Ultrasonic control of lamination was performed before plates cutting. After the cutting of plates was performed by NC plasma cutter, plates are manually arc welded. Heat treatment of fully formed equalizer beams was performed before bolt holes machining by horizontal milling machine.

Aware of the fact that adequately prepared and introduced QA system is vital for quality and operational availability of the mentioned crane parts, numerous activities were performed. Those activities can be grouped on the following manner:

<b>PRODUCTION</b>	Documentation inspection Verify certificates (materials, welder...) Attending during cutting, welding, heat treatment, machining Witnessing non-destructive tests Attending final dimension controls Control of corrosion protection procedures
<b>ASSEMBLING</b>	Assembly documentation review Control during erection Attending final test / takeover Review of QA/QC documentation and reports of testing
<b>FINAL REPORT</b>	Preparing final report about quality of realized works

### 4. Conclusion

The paper illustrates an example of inappropriate design. FEM analysis has showed that redesigned equalizer beam stress distribution is almost uniform and maximal equivalent stresses are approximately 36 percent of previous values. Special attention has been paid to the quality assurance which would provide for reliable and long equalizer beams life.

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### References

- Hobbacher, A., "Fatigue design of welded joints and components", IIV Doc XIII-1539-96/XV-845-96 Cambridge, Abington, 1996.
- Krstulovic, A., et al., "Završni izvještaj o kvaliteti balansera ", H-25-028, Ekonerg Holding Zagreb, 1999.
- Matic, T., "Dinamička izdržljivost zavarenih aluminijskih konstrukcija", Master thesis, Zagreb, 1995.
- Standards: DIN 8563, SVENSK STANDARD SIS 05 59 00, Pravilnik o tehničkim normativima za dizalice (Sl. list br. 65/91)

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