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REINFORCING SOLUTION ON EXISTING CRANE RUNWAY WITH CASTELLATED BEAMS-CASE STUDY

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Abstract: *The paper presents the reinforcing solutions applied to an existing crane runway in a warehouse located in Piatra Neamţ city, Neamţ County. The crane beams are steel castellated type. The owner of the studied warehouse wanted to replace the existing 3.2 tons crane with one of 5 tons capacity. Due to regulations and norms changing over the years the existing crane runway beams need some reinforcement measures in order to fulfil the owner necessities. In the end of the paper are presented some solutions that can be adopted in order to achieve increased load bearing capacity.*

Key words: *existing crane runway, castellated beams, reinforcing solutions.*

1. Introduction

The studied warehouse is located in Piatra Neamţ city, Neamţ County on the industrial platform of S.C. SIRCA S.A., a local producer of agricultural and industrial bearings, steel wheels, components for industrial and agricultural trailers, etc. The warehouse did no suffered major injuries or degradations that could jeopardize the proper performance of the specific technological activities, during its existence. On the existing warehouse operates a 3.2 tons crane. The owner wanted to replace the existing crane with one of 5 tons capacity [6].

2. The Existing Situation

The existing building (see Figure 1 and 2), with ground floor height has the resistance structure composed of: isolated foundations under the columns, vertical structure made with precast reinforced concrete columns with cantilevers and steel trusses, steel purlins, wind and roof bracings and steel castellated crane runway beams. The investigated crane runway has an 18.00 opening in transversal direction and twelve 6.00 m openings in longitudinal one (see Figure 3).

Fig. 1. *Inside of existing warehouse*

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Fig. 2. *Inside of existing warehouse*

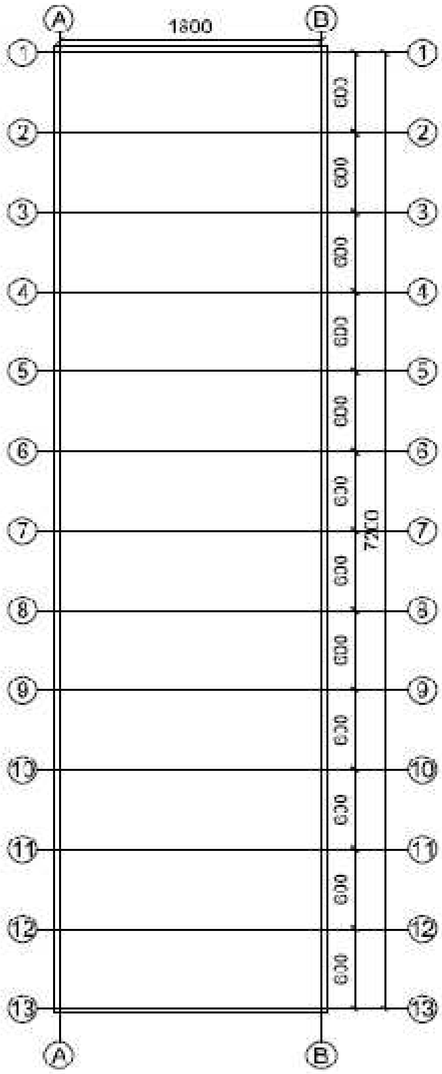

Fig. 3. *Warehouse axis*

The owner wanted to replace the existing 3.2 tons crane with one of 5 tons capacity.

After investigations and observations on site, were not found significant degradations of the structural elements of the warehouse.

3. Technical Evaluation of the Building

3.1. Structure Analysis

The structure analysis was performed in both situations: existing and proposed, based on current rules and regulations [3], [4], [5], [6]. All analysis was performed with Axis VM 12 finite element program. The loads for the new 5 tons cranes were provided by the producer and the ones for the existing 3.2 tons were taken from old norms [7]. The loads of the new crane were approximately 14% higher than the ones from existing crane.

After current verifications on all structural elements, made by current standards, the following were found: the foundations, precast concrete columns, cantilevers and bracing system have sufficient capacity to function in both situations. The most sensitive structural elements were the castellated beams (see Figure 4) [1], [2]. The cross section for all castellated beams is presented in Figure 5. The beam section is made from welded steel plates.

Fig. 4. *Castellated beams*

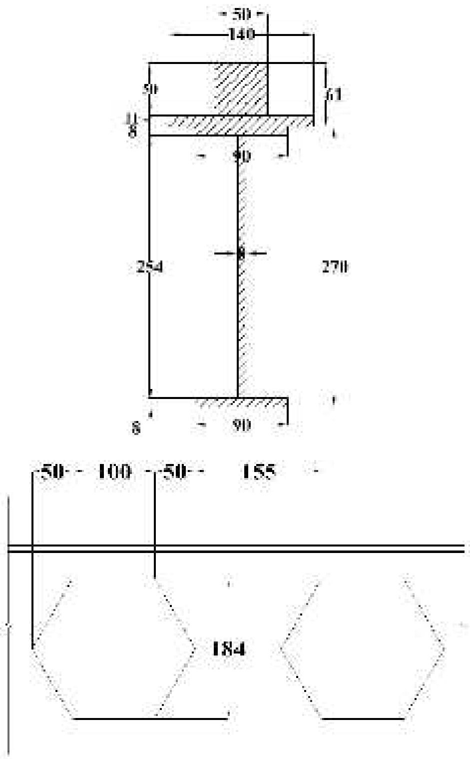

Fig. 5. *Cross section and lateral view of castellated beams*

All envelope diagrams obtained on the crane runway beams are presented in Figure 6 (bending moment), Figure 7 (shear force), Figure 8 (axial force) and Figure 9 (deflection).

In Table 1 are presented the maximum values obtained for the bending moment (on support M_{smax} and field M_{fmax}), shear force (V_{max}) and deflection (f_{max}) on both situations: existing (for 3.2 tons crane loading) and proposed (5 tons crane loading).

The difference between existing and proposed values in terms of efforts and deflections are of approximately 18% for bending moment, 12% for shear force and 22% for maximum deflection. The values for axial force were not presented because they are not significant for design purposes.

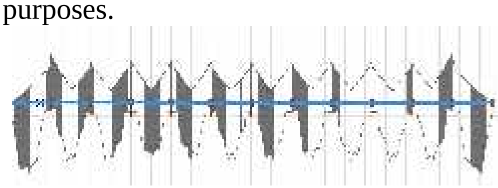

Fig. 6. *Bending moment diagram*

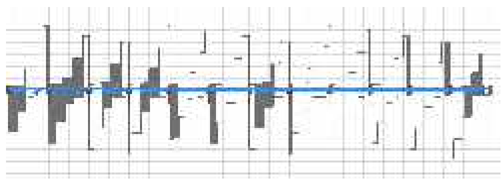

Fig. 7. *Shear force diagram*

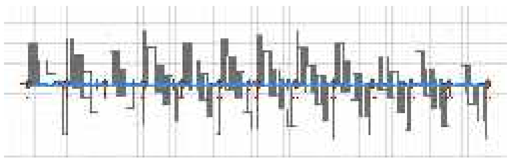

Fig. 8. *Axial force diagram*

Fig. 9. *Deflection diagram*

Values of maximum efforts and deflections on castellated beams for both situations: existing and proposed Table 1

Maximum efforts/deflections	3.2 tons crane loading	5 tons crane loading
M_{smax} [kNm]	52.32	61.68
M_{fmax} [kNm]	72.38	86.32
V_{max} [kN]	86.95	97.23
f_{max} [mm]	8.8	10.8

The verifications performed under 3.2 tons crane loading led to the following results [8]:

- At support where the holes are filled the beams check for bending moment, shear force or the two combined and also stability. The existing beams have no lateral restraint system, so the critical length used for all stability verification was 6.00 m.
- The beams do not check for bending moment, stability and combined shear force and bending moment in any point in the hole zones. The maximum shear force in the hole zones (74.30 kN) represents approximately 98% of design shear resistance. The load bearing capacity in this zone is exceeded with approximately 40%.
- The beams check in terms of deflections, with an L/480 maximum deflection in comparison with the admissible of L/600.
- The beams check in terms of fatigue. Group functioning crane was II (medium).

The verifications performed under 5 tons crane loading led to the following results:

- At support where the holes are filled the beams check for bending moment, shear force or the two combined and also stability.
- The beams do not check for bending moment, stability and combined shear force and bending moment in any point in the hole zones. The maximum shear force in the hole zones (91.05 kN) exceeds the design shear resistance with approximately 20%. The load bearing capacity in this zone is exceeded with approximately 67%.
- The beams do not check in terms of deflections, the maximum deflection exceeding the admissible one with about 8%.
- The beams check in terms of fatigue.

3.2. Reinforcing Solutions

Given the analysis performed and the obtained results, the safely functioning of the structure involves taking some reinforcing measures on the existing crane runway castellated beams, in both situations taken into account (current or proposed).

The easiest solution in terms of execution would be complete replacement of existing crane runway castellated beams with I type beams, having the same height as the existing ones (see Figure 10).

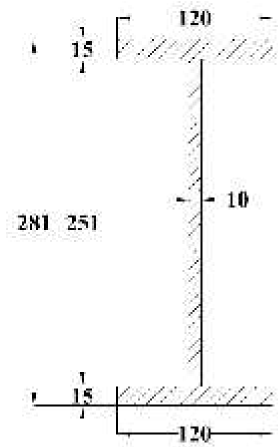

Fig. 10. *Cross section of new beams*

To increase the load bearing capacity of the existing beams one of the following solutions can be adopted:

- Filling all exiting web holes and taking some lateral restraint measures for upper flange, by providing two additional bracings.
- Filling the first 4-5 web holes near the supports and providing a similar extra flange to the existing one on the upper flange to the bottom one (see Figure 11 and 12).

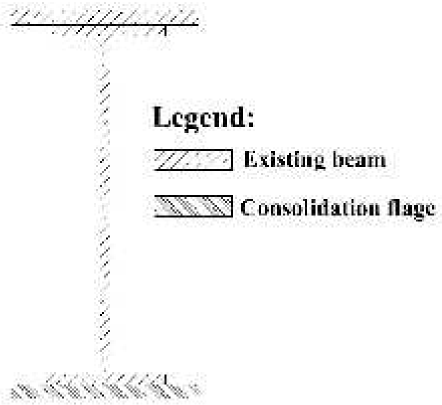

Fig. 11. *Cross section of reinforced beams*

All materials used for reinforcing will be made of S235 steel class.

The first solution of total replacement of castellated beams is easier to apply, because all new beams will be made in workshops and not on site, so the owner must stop its current production only where the new beams arrive on site, in order to replace de existing ones with the new ones.

The second solutions, which involves the reinforcing of existing beams is more difficult to apply because the owner must stop the production for more longer time and also all reinforcing welding are performed at height on existing elements.

The owner of the warehouse will choose the most advantageous solution applied for his case.

After all reinforcing solutions are applied on site will be completed a time tracking of the whole building for several years to come, so we can closely monitor the behaviour of all structural elements.

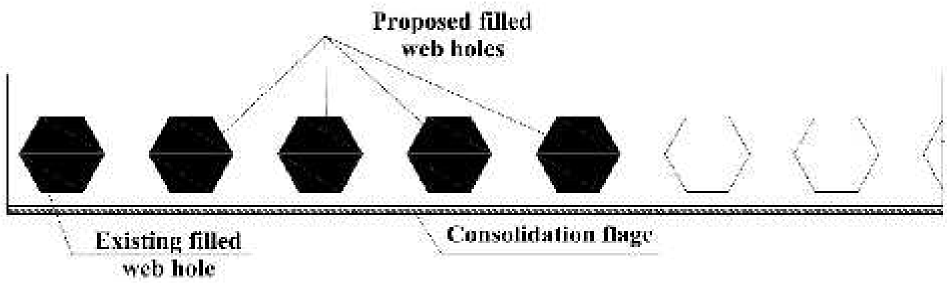

Fig. 12. *Lateral view of reinforced beams*

4. Conclusions

Even that in some periods of time steel castellated profiles were used for crane runway beams, they do not offer o very advantageous solution, for this types of elements, because due to large concentrated loads, they are subjected to important bending moment and shear force efforts across all length.

After performing a complete verification of this type of elements, on the case study chosen, the safely functioning of existing warehouse involves taking some reinforcing solutions on the existing crane castellated beams, in both situations taken into account: existing one or proposed.

Due to involving costs of changing all crane runway beams the owner of the studied warehouse choose the second reinforcing solution, of filling first 4-5 web holes near the supports and providing a similar extra flange to the existing one on upper flange to the bottom one.

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