Factsheet no. 7: Agrocolumna warehouse, Copăceni, Romania

Project summary

Client:	S.C. AGROCOLUMNA S.R.L.
Architect:	S.C. Tectonics Art S.R.L.
Structural engineers:	S.C. BON STEEL S.R.L.

Description of the existing building

The building was initially located in Craiova. It was built in 2004, consisting of a two storey office area and a warehouse. The main structure is made of cold-formed steel profiles in the case of the office building and welded steel profiles in the case of the warehouse building. The office building has a span of 7.5 m, 2 bays of 6 m (12 m in length) and the height of 6.4 m at the eaves, with the angle of the roof of 6°. The industrial building has a span of 12 m, 3 bays of 6 m (18 m in length) and the height of 4 m at the eaves, with the angle of the roof of 8°. The secondary structure consists of cold-formed steel purlins and side rails. The 3D view of the structural model is presented in Figure 1.

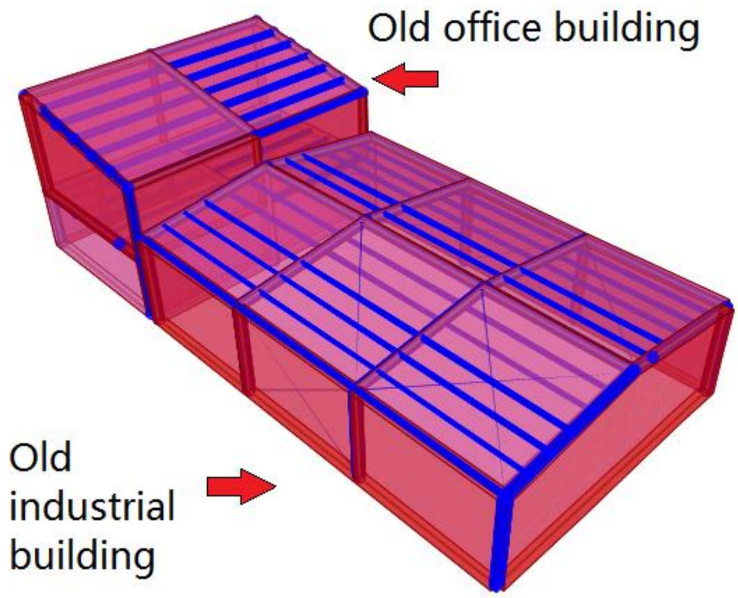

Fig. 1. 3D view of the initial structure (structural model)

The steel structure of the warehouse is composed of transversal frames; the columns have pinned column-base connections, while the transversal beams are rigidly connected to the columns. In the longitudinal direction, the transversal frames are connected by purlins at the roof level and side rails and longitudinal braces in the walls. No bracings were considered in the roof counting for the diaphragm effect of the roof sheeting.

The beam-to-column connections at the eaves and beam-to-beam connection at the ridge are made with bolted end plates. The columns and beams have a constant cross-section. Details of the structure are presented in Figures 2 and 3.

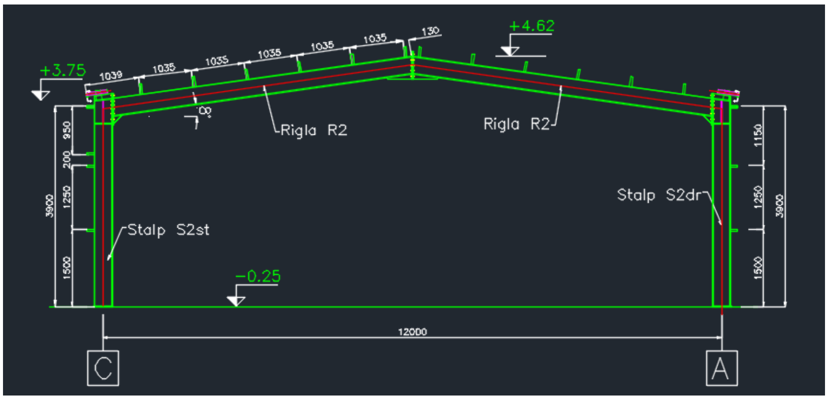

Fig. 2. Current transversal frame

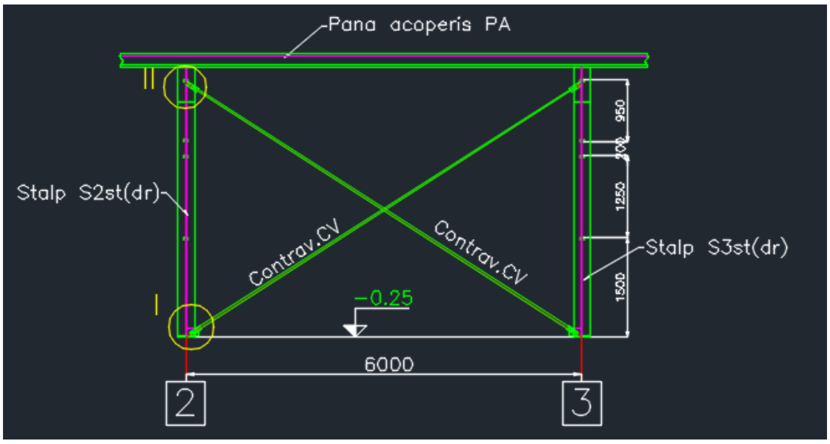

Fig. 3. Part of the longitudinal frame

The structure of the office building is made of back-to-back thin-walled cold-formed steel lipped channel members (2C350/3), as presented in Figures 4, 5 and 6.

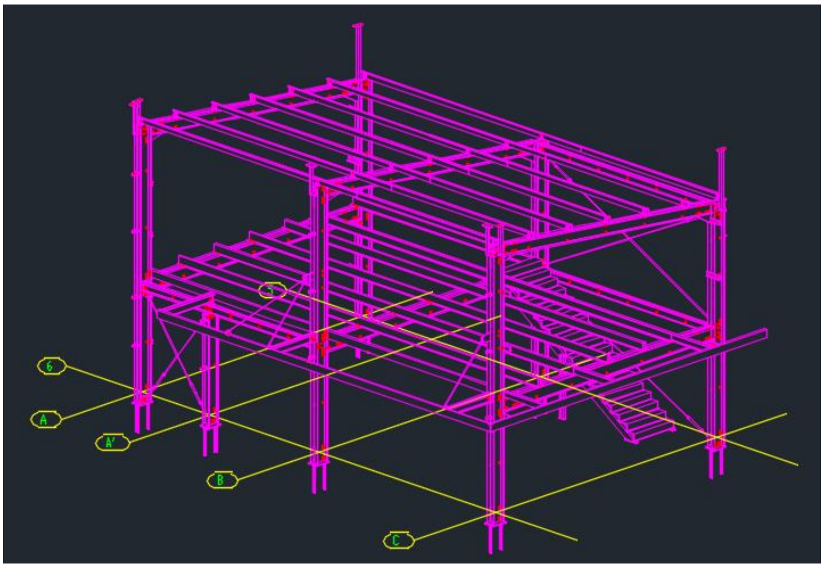

Fig. 4. 3D view of the office building

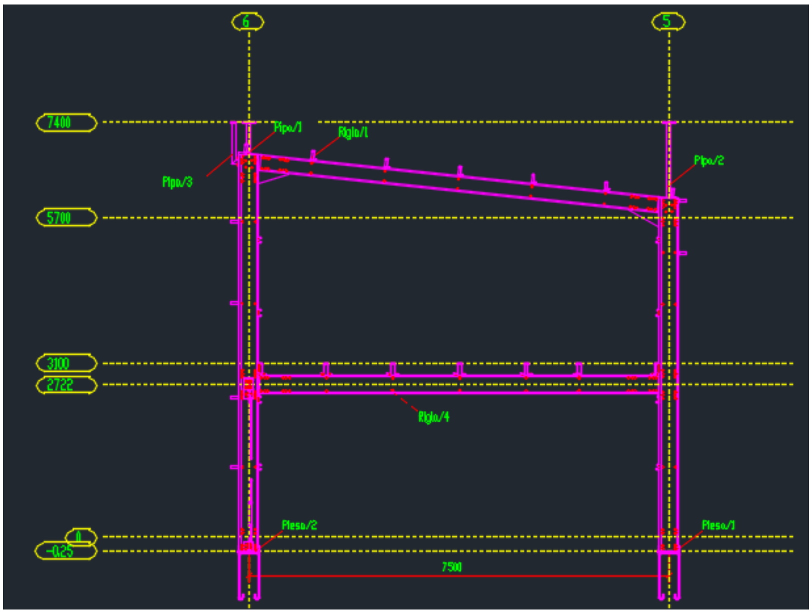

Fig. 5. Transversal frame of the office building

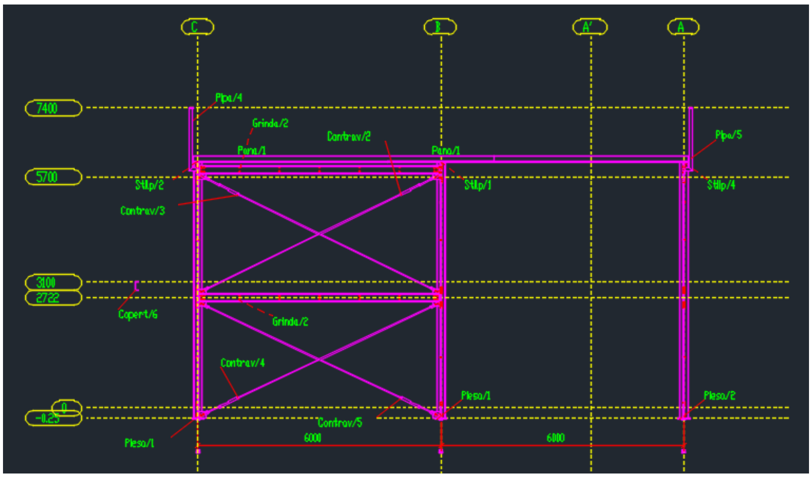

Fig. 6. Longitudinal frame of the office building

The cross-sections of the elements of the building are presented in Table 1.

Table 1. Cross-sections of the elements of the building

<table>
<tr><th colspan="3">ELEMENTS
(INDUSTRIAL BUILDING)</th><th rowspan="7"></th><th colspan="3">ELEMENTS
(OFFICE BUILDING)</th></tr>
<tr><td>Columns</td><td rowspan="3">S355</td><td rowspan="2">Welded profiles</td><td>Columns</td><td rowspan="4">S350GD+Z</td><td rowspan="4">C350/3
C300/3
Z200/2
C200/2</td></tr>
<tr><td>Beams</td><td>Beams</td></tr>
<tr><td>Bracings (walls only)</td><td>ϕ27</td><td>Joists</td></tr>
<tr><td>Roof purlins</td><td>S350GD+Z</td><td>Z200/2.5
Z200/2.0</td><td>Roof members</td></tr>
<tr><td>Roof sheet</td><td rowspan="2">S250GD+Z</td><td>LTP45/0.5</td><td>Roof/Floor decking</td><td>S250GD+Z</td><td>LTP45/0.6
LTP45/0.5</td></tr>
<tr><td>Wall</td><td>LLP20 0.6/0.5</td><td>Bracing (wall)</td><td>S355</td><td>Φ24</td></tr>
</table>

In 2012, the owner decided to build a new structure and to sell the existing one. The new beneficiary reused the building by moving it to Copăceni, near Bucharest, 227 km east of Craiova. The new building retains the same layout but one more bay was added to the warehouse. As the structure was designed in 2004, it was needed to be evaluated and strengthened due to the fact that the design codes in 2012 operated with higher values for snow, wind and seismic loading than those at the time of design. Moreover, the loading conditions (snow, wind, seismic action) in Copăceni/Bucharest are different than once for Craiova.

The structure is reused by relocation, while keeping the same layout. The entire main and secondary structure is reused, with the addition of a new bay and new components (required for strengthening the initial structure).

Design process

It has to be mention that the original project (drawings and structural checks, including the certificates for steel products) was available in order to start the new design. Therefore, laboratory tests were not required in order to determine the steel grade of the structural elements. The global and members dimensions were confirmed by in-situ measurements.

The new building had to be redesigned with the idea of employing all the elements recovered from the old building. Following a technical examination, it has been determined what measures need to be taken in order to reuse the structure. The structural analysis was performed using 3D models for both the hall and the office building. The 3D view of the reused structure is presented in Figure 7.

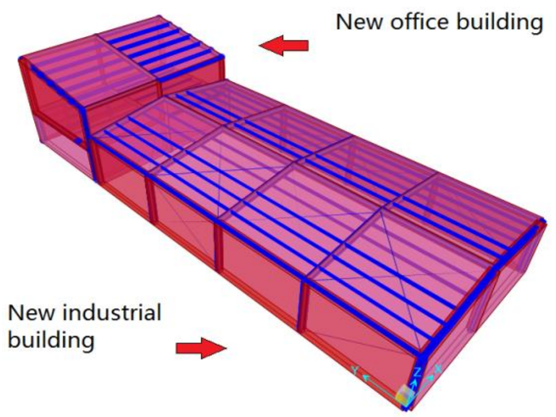

Fig. 7. 3D view of the new structure

In the case of the warehouse, as mentioned previously, a new bay was added (see the 3D view in Figure 8).

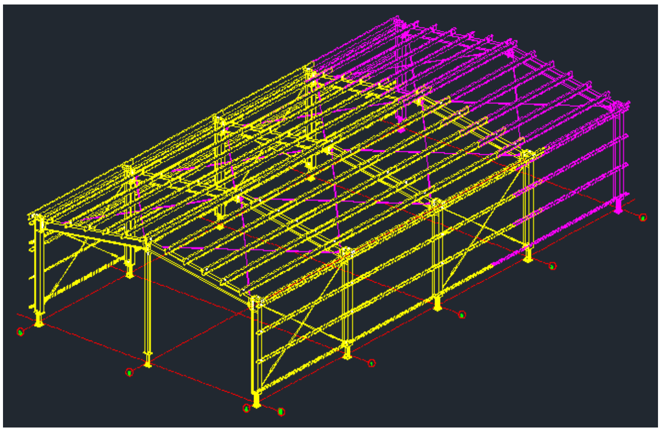

Fig. 8. 3D view of the modified warehouse

The changes regarding this part of the structure consists in the addition of the roof bracing system. In the initial project, in the roof it was counting for the diaphragm effect of the roof sheeting.

In the case of the office building, the transversal intermediate frame needs to be strengthened, as presented in Figure 9. The current frame had to be strengthened by strengthening the cross-section of the columns and beams as shown in Figure 10 (addition of two lipped channels C300/3).

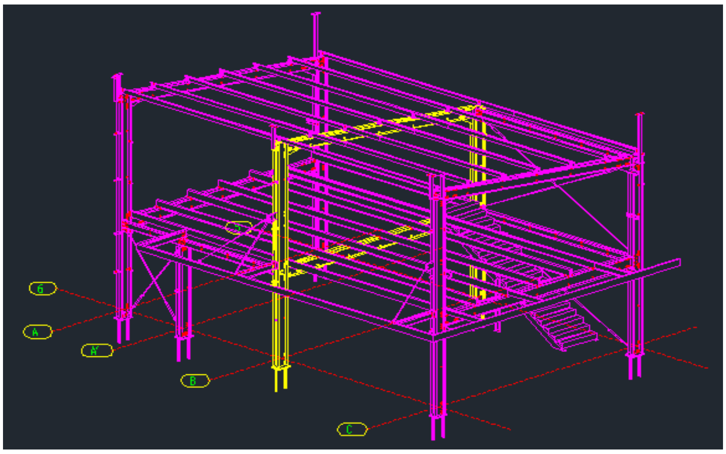

Fig. 9. 3D view of the office building with the required strengthening

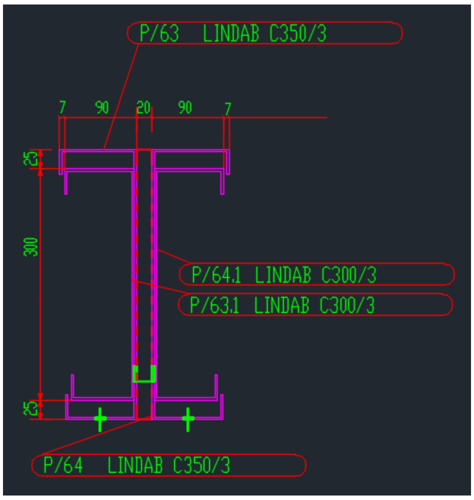

Fig. 10. Strengthening the cross-section of the columns and beams of the main frame

The cross-sections of the elements of the reused building are presented in Figure 13.

Table 2. Cross-sections of the elements of the reused building

<table>
<tr><th colspan="3">MATERIALS
(INDUSTRIAL BUILDING)</th><th rowspan="8"></th><th colspan="3">MATERIALS
(OFFICE BUILDING)</th></tr>
<tr><td>Columns</td><td rowspan="4">S355</td><td rowspan="2">Welded profiles</td><td>Columns</td><td rowspan="4">S350GD+Z</td><td rowspan="4">C350/3
C300/3
Z200/2
C200/2</td></tr>
<tr><td>Beams</td><td>Beams</td></tr>
<tr><td>Bracing (wall)</td><td>ϕ27</td><td>Joists</td></tr>
<tr><td>Bracing (roof)</td><td>ϕ20</td><td>Roof members</td></tr>
<tr><td rowspan="2">Roof purlins</td><td rowspan="2">S350GD+Z</td><td rowspan="2">Z200/2.5
Z200/2.0</td><td>Floor decking</td><td>S250GD+Z</td><td>LTP 45/0.6</td></tr>
<tr><td>Bracing (wall)</td><td>S355</td><td>Φ24</td></tr>
<tr><td>Roof/wall cladding</td><td colspan="2">Sandwich panels</td><td>Roof/wall cladding</td><td colspan="2">Sandwich panels</td></tr>
</table>

All the members from the old building have been reused in the new building, together with additional elements required in order to strengthen and to extend the structure. The beneficiary of the project decided to analyse if a standard design (the entire structure built from new elements) would be more advantageous than relocating the old structure and reusing it with the necessary strengthening. For this purpose another model was considered, i.e. Model B. The comparison of the materials consumptions between Model A (design involving reuse) and Model B (standard design) is presented in Table 3.

Table 3. Comparison of steel consumption between Model A and Model B

Item	Old building [kg]	Model A			Model B
		Design involving the reuse of old elements [kg]			Standard design [kg]
		Reused elements	New elements	Total consumption	Total consumption
Industrial	8800	8800	2762	11562	11562
Office	6436	6436	529	6966	6441
Total	15236	15236	3291	18527	18003

The main factors affecting the economic and environmental impact are: material production, erection and transportation. On the one hand, in the case of Model B, the steel making process is an important factor as all the elements are new, whereas in the case of Model A, the impact of steel making will be very small. On the other hand, transportation can have a big impact in the case of Model A (distance between old and new location is approximately 250 km) compared to Model B, for which the new elements were produced close to the new location and therefore transportation is not significant.

Processes related to demolition are not easy to evaluate because of the uncertainty of information. In this case study, the energy consumption related to the dismantling process has been ignored. Moreover, the impact of the foundations and anchor bolts was not considered as well. Table 4 presents the aspects considered for the economic and environmental impacts.

Table 4. Aspects considered for the economic and environmental impacts

ECONOMIC IMPACT				ENVIRONMENTAL IMPACT		
		Considered				Considered
Structure	Structural elements	✓		Structure	Structural elements	✓
	Foundation	✗			Foundation	✗
	Non-structural elements	✗			Non-structural elements	✗
Transportation		✓		Transportation		✓
Construction	Dismantling	✗		Construction	Dismantling	✗
	Installation	✗			Installation	✗
Others	Electricity	✗		Others	Electricity	✗
	Labour	✗			Labour	✗

The costs for Models A and B are presented in Figure 11. It can be observed that approximately 14000€ are saved in the case of Model A. Although the transportation distance is 250 km in the case of Model A (compared to 10 km in the case of Model B), the impact of steel production is much greater than the impact of transportation, hence the lower cost in the case of Model A.

Regarding the environmental impact, the following boundary conditions were considered:

1. All identical components and materials, including finishing, were left out of the comparison;
2. Transportation was taken into account;
3. The domestic use of the building (water/gas/electricity) was left out of the comparison;
4. The energy used for construction purposes (such as cranes and other machinery) was not included in the comparison.

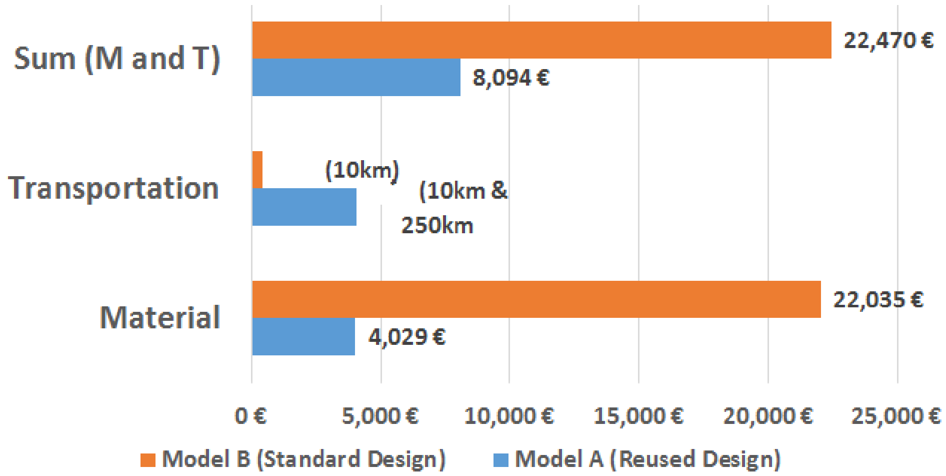

Fig. 11. Graphical representation of the costs for Models A and B

In order to simplify the Life Cycle Analysis, only the processes related to the material resources and transportation have been considered according to the boundary conditions presented above. The comparison of the environmental impact between Model A and Model B based on impact categories is presented in Figure 12. It can be observed that the environmental impact of Model B is greater than the environmental impact of Model A for almost every category. Although the transportation distance is 250 km in the case of Model A (compared to 10 km in the case of Model B), the impact of steel production is much greater than the impact of transportation, hence the lower environmental impact in the case of Model A. For both Models, the category of the greatest impact is Fossil Fuels.

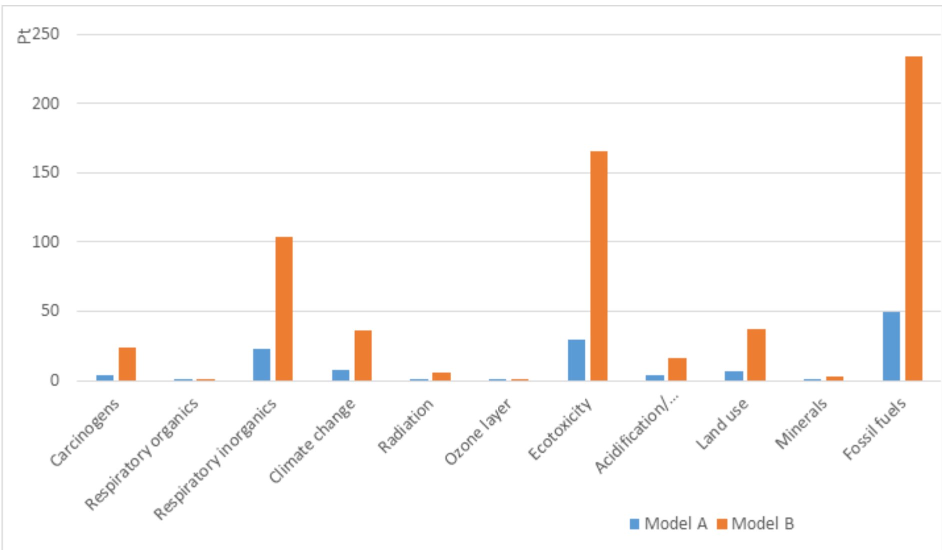

Fig. 12. Comparison of the environmental impact between Model A and Model B

Deconstruction and Construction processes

The project was divided into three contractual phases:

1. inspection of the existing structure and identification of available documentation, deconstruction process and inspection of the elements from the deconstruction of the existing building to assess their potential for reuse;
2. design of the new structure;
3. new construction (including groundworks)

Conclusions

The following conclusions can be drawn from this case study:

- The reuse benefited greatly from having the original project available due to the fact that laboratory tests were not required in order to determine the steel grade of structural elements, making the design process easier and faster;
- The dismantling process was relatively easy due to the reduced weight of the structure and due to the use of bolted connections;
- The cost and the environmental impact of the steel production are much larger than the cost and environmental impact of transportation. Therefore, the material savings are very important in the reuse design;
- The cost and the environmental impact of Model A (design involving reuse) are better than the cost and the environmental impact of Model B (standard design). Therefore, based on this case study, the reuse of the old steel structure is more feasible than building a new steel structure with the same dimensions and functionality.