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STUDY ON THE BEHAVIOR UNDER LOAD FOR RESISTANCE MECHANICAL STRUCTURES. ANALYSIS AND CASE STUDY-HALL FOR AGRICULTURAL MACHINERY AND STORAGE UNITS

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Abstract: This paper presents the study of behavior of steel structures resistance, welded solution executed on charges of operating action. Selected current topics of interest particularly so in the context of advantages for industrial use of structural steel and the opportunities offered by the use of this category of structure design of efficient computer programs automatically. The study undertaken aimed to undertake a static and strength analysis of the steel structure of industrial buildings' resistance, in order to estimate its operating behavior. Actual analysis, conducted through a case study of a warehouse for the storage of machinery and agricultural implements, was performed by the following steps: the determination of the structural geometry and its static scheme; determining actions and charges that confronts structure in accordance with current standards and related regulations, the set grouped as the Euro code; static calculation of the structure and calculation of resistance of structural elements, using two specialized computer programs automatically included in Advance BIM software package dedicated to structural design. The results of analysis were used to estimate the conditions of strength, stability and safety of the structure under study metal.

Keywords: steel structures, resistance, welded solution, static and strength analysis

1. INTRODUCTION

The **advantages** of using steel for strength structures of industrial buildings can be identified by the main features of metallic structures:

- ✓ increased safety in operation, due to homogeneity of both materials and its elastic-plastic properties;
- ✓ high mechanical resistance to all kinds of applications, including action from seismic, vibration, shock, or fatigue;
- ✓ low specific weight of the structure, thus resulting in smaller foundations;
- ✓ ability to achieve heights of structures and large openings, eliminating the need for introducing intermediate pillars;
- ✓ works for repairs, expansions and upgrades in less time and with constructive solutions simpler than the construction of concrete or masonry;
- ✓ ability to use a wide range of types of joints (welded, bolted, etc.)
- ✓ short design time and low execution time (with approx. 75% lower than the concrete or masonry construction) and feasibility in any season;
- ✓ greater accuracy in the execution of works and increased possibilities for further expansion, with the flexibility of building (halls can be dismantled and repositioned with minimal losses);
- ✓ shelf life up to 40-50 years after installation and the possibility of full recovery of material from the demolition of buildings.

The main **drawbacks** that limit the use of steel in construction are:

- ✓ reduced resistance to corrosive agents and requiring action to conduct periodic maintenance of protection;
- ✓ problematic behavior of the steel at high temperatures (e.g. 200°C is significantly alter the yield strength, at 500°C the bearing capacity of the structure is reduced by more than 50%, and at 600°C steel elements lose the ability to take efforts).

Among concerns and trends in the development of resistance metal building structure, significant to note are:

- ✓ Use protection methods based on metallization corrosion in polymers;
- ✓ Methods of achieving new low alloy steel grades with superior mechanical properties and resistance to corrosion;
- ✓ Methods for stating and sizing calculation that take into account the elastic-plastic behavior and ductility properties of steel, and collaboration features across spatial structure.

2. THE STUDY PROBLEM

The study of behavior under operating loads of steel structures resistance welded performed in solution was based on a case study by static analysis and structural strength of buildings for the storage of machinery and agricultural implements.

2.1. Technical characteristics

The industrial hall whose structure was analyzed, has the following characteristics:

- ✓ class IV significance - trivial; important category D - minor importance;
- ✓ Fit seismic ag = 0.15g, Tc = 0.7sec .;
- ✓ Sconstr building area. = 630.75 m2; Sutil = 613.20 m2 useful surface;
- ✓ Share the floor ± 0.00 to +0.15 above natural ground share, NGS;
- ✓ Foundation depth at 1.00m from NGS;
- ✓ Minimum eaves height of +5.37 m and +6.48 m ridge height of the quota ± 0.00

The resistance of the hall, carried in solution welded frame, is made of metal cross beams and rods with full heart: pillars have constant section and are made of rolled HEA220 and rulers, IPE360 profiles, as shown in Fig .1.

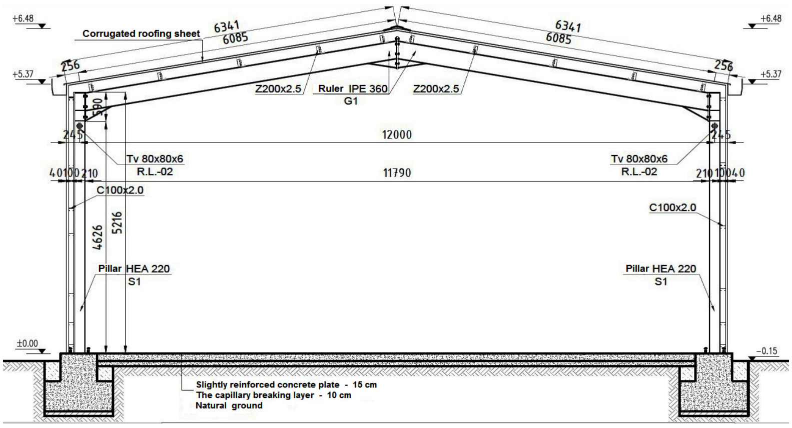


Fig.1. The metallic structure of the cross-current resistance

The hall has the opening of 12.00 m and joist of 5.00 m and the total length of the building is 50.50 meters. The structure of the building is braced both the pillars and the roof structure to ensure spatial collaboration resistance of structural components, Fig.2. The longitudinal bracing of the columns are made of square section steel tube of 80x80x6 mm, and the plane of the walls and the roof structure, the bracing is made of round sections having a diameter of 20 mm.

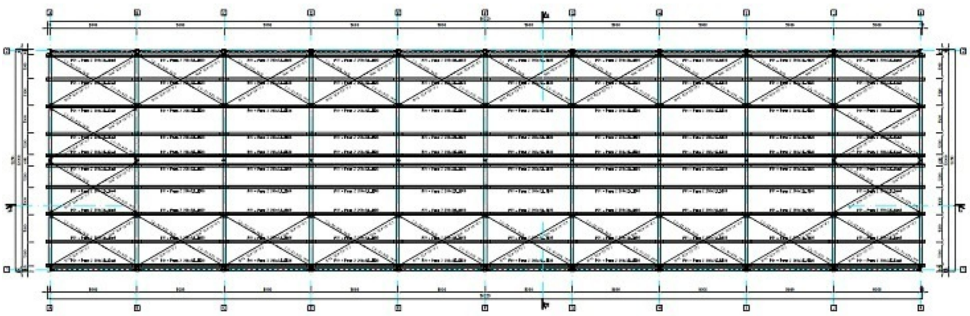


Fig.2. Structure consolidations and roof elements layout

Following geotechnical study, on the warehouse location a lithologic sequence was highlighted consisting mainly of sandy loam dust, gray yellowish ferruginous films, plastic consistent. According to the calculations and verifications made, the results were size insulated foundations reinforced soles: L2 = 1.30m; B2 = 1.30m and height respectively of the block Df = 1.00 m. Isolated foundations under pillars are connected by deep beams, Fig.3.

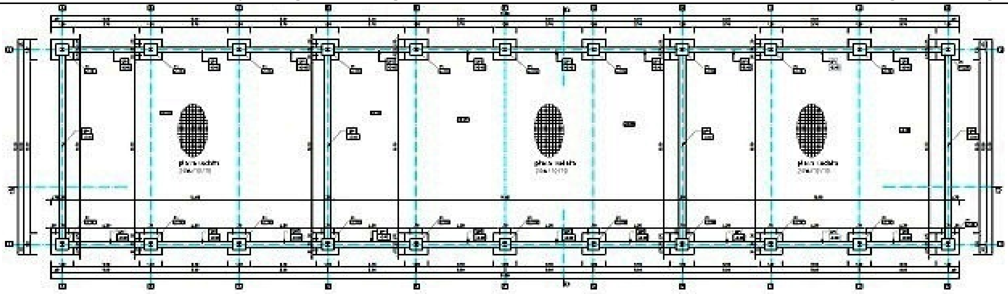


Fig.3. Foundation layout

The walls of the locking plate are made of folded C100x2.0 mounted on the panels which, in turn, are fastened to the posts by means of metallic elements made from profile UPN50. The cover is made of sheet metal panels that rest on the panels Z200x2.5 fixed by rulers cross frame elements made through all the profiles UPN50.

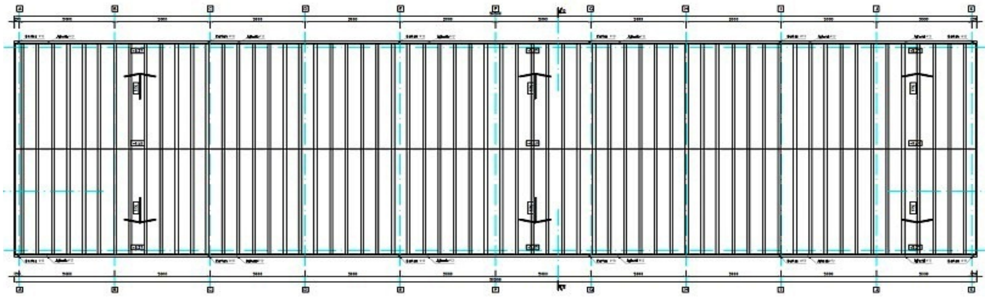


Fig.4. Covering layout

The finishes provided are closing walls cladding gray "RAL" COD 9002; trowel concrete floors; PVC white with windows; cladding, sandwich panels. Installation of water and sewer or electrical system, are expected to be connected to the road network and not part of the topic work.

2.2 Static analysis and structural strength

The analysis to estimate the behavior under load resistance of the steel structure was performed by the following steps:

- ✓ Establishing structural system, geometry and static scheme;
- ✓ Determine actions and charges that confronts structure in accordance with EN 1990 Eurocode 0: Basis of structural design; EN 1991 Eurocode 1: Actions on structures; EN1991-1-3 / CR 1-1-3 / 2012 (Action snow) and EN1991-1-4 / CR 1-1-4 / 2012 (wind action).
- ✓ Calculation of the static structure and calculation of structural resistance.

2.2.1 Automatic calculation programs used. Summary overview

Static and strength analysis was performed using computer programs automatically Advance Design and Advance Steel, specialized for the calculation and optimization of structures. These programs are part of the GRAITEC Advance BIM software, Fig.5 dedicated to structural design based on BIM, allowing import, export and synchronization patterns between the CAD and finite element analysis and multi technology -user, offering and accelerate the modeling process.

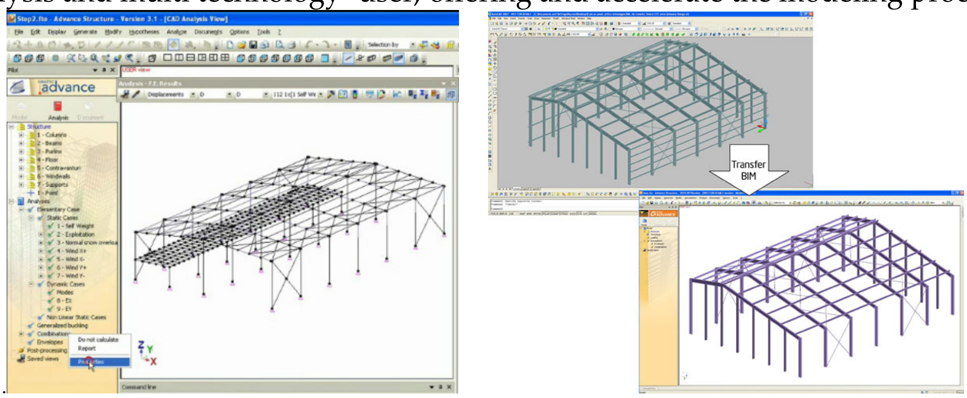


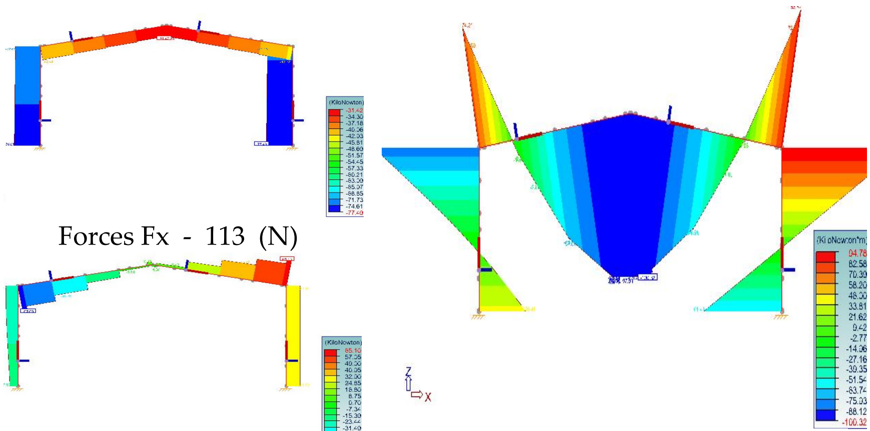
Fig.5. BIM GRAITEC Advance software package. Presentation.

The two computer programs, in summary, are as follows:

- ✓ **Advance Design** program contains its own CAD platform, tools that automatically generate climate loads, a calculation method for modal analysis, static, nonlinear, dynamic temporal and buckling as well as advanced features for checking elements of metal, concrete and wood. The program also includes interactive features of post-processing of results and the calculation notes are automatically generated. The user has at his disposal a complete library of structural elements (beams or flat, rigid supports or elastic, semi-rigid connections). Finite element analysis is conducted on the basis of algorithms for automatic mesh with the possibility of refining the mesh (Grid or Delaunay). The program performs the calculation and verification of metal, concrete and wood elements, in accordance with European standards and the national Annexes specific to each country, and calculation notes and graphics automatically update mines. In the checking items to: checking arrow buckling length determination, resistance checks and automatic optimization section, check connections and generating node details. Regarding control and exchange of information through BIM, Advance Design 2014 contains tools that can correct and adjust as geometric legally imported from Advance Steel models and other CAD programs.
- ✓ **Advance Steel** software contains modules for design, modeling and detailing of steel structures, automates the process of drawing (detailing the items, reports, installation plans, bill of materials / laminate) and also allows the generation of files for CNC machines. For 3D modeling provides full catalogs profiles, plates and screws, and a library of predefined connections; can also convert AutoCAD objects in Advance Steel objects and calculations are performed according to the set Euro codes EC3. Detailed plans are created automatically, achieving both automatic scaling of drawings and format page views and parts listing. Schedules are created directly from the 3D model and the overall vision and plans (2D and 3D views: elevations, top views, etc.) automatically updates the plates, with the so called "revision cloud". Advance Steel 2014 running multi-platform mode either AutoCAD or CAD platform integrated its own program.

2.2.2. Static calculation transverse frame

Assumptions that made metal components analysis of the structural frame components are sizing according to EC3 standard; calculation oblique plane bending; optimized profile such that the application of the elements to be less than 100%; maximum number of iterations in the optimization step after items, 8; profiles chip sorting criterion load level; buckling length calculated by the method η1-η2. For diagrams efforts, the results are illustrated in Fig. 6 and in Table 1 are listed the values of efforts axial, shear and bending.



Forces Fz – 113 (T)

Fig.6. Diagrams efforts. Illustration for the current transverse frame

Table 1. Load cases / combinations. Efforts beams. Measurement

a. Load case				
Checking type	Code	Check resistance coefficient	Check stability coefficient	List of cases / combinations
Checking profiles	ECELUSTR	1.000	1.000	101-139

Efforts in the appropriate load line (local landmark)								
Item number	Unit. Discr.	Node number	Fx(kN) (N)	Fy(kN)	Fz(kN) (T)	Mx (kN*m)	My(kN*m) (M)	Mz(kN*m)
24 Left pillar	SElt	START	-76.01	0.30	-17.95	0.02	36.41	0.47
		CENTER	-74.33	0.30	-24.45	0.02	-16.61	-0.28
		END	-72.66	0.30	-27.72	0.02	-83.18	-1.03
25 Right pillar	SElt	START	-77.49	0.30	31.50	-0.03	-61.41	0.42
		CENTER	-75.82	0.30	31.21	-0.03	16.98	-0.33
		END	-74.15	0.30	31.07	-0.03	94.78	-1.08
270 Left ruler	SElt	START	-42.44	-7.75	-63.69	0.38	74.31	-14.25
		CENTER	-38.23	-5.05	-37.61	-0.33	-67.60	0.55
		END	-31.42	1.01	6.47	-1.12	-98.58	10.78
271 Right ruler	SElt	START	-31.76	-0.93	-4.50	1.17	-98.64	10.79
		CENTER	-39.11	5.14	39.37	0.29	-61.36	0.28
		END	-43.32	8.33	65.10	-0.44	85.57	-16.25
Min (element, node)			-77.49 (25, 12)	-7.75 (270, 193)	-63.69 (270, 193)	-1.12 (270, 889)	-98.64 (271, 889)	-16.25 (271, 194)
Max (element, node)			-31.42 (270, 889)	8.33 (271, 194)	65.10 (271, 194)	1.17 (271, 889)	94.78 (25, 194)	10.79 (271, 889)

Beams measurement after section						
Section	Area (cm^2)	Perimeter (cm)	Lenght (m)	Volume (m^3)	Surface (m^2)	Weight (t)
(pillar)HEA220	64.34	128.60	10.00	0.06	12.86	0.51
(ruler) IPE360	72.73	138.40	12.19	0.09	16.86	0.70
		Total	22.19	0.15	29.72	1.20

Buckling length values are listed in Table 2, and Table 3 presents the optimization type of rolled structural execution.

Table 2. Buckling lenght

Buckling lenght and lateral buckling									
Item number	Lg (m)	Lfy (m)	Lfz (m)	Zvelteţe a Lfy	Zvelteţe a Lfz	Ldi (m)	Lds (m)	Zvelteţe a Ldi	Zvelteţe a Lds
25	5.00	8.21	5.93	64.64	148.94	5.00	5.00	90.71	90.71
270	6.09	4.26	4.26	28.51	112.62	6.09	6.09	160.88	160.88
271	6.09	4.26	4.26	28.51	112.62	6.09	6.09	160.88	160.88
24	5.00	8.21	5.93	64.64	149.03	5.00	5.00	90.71	90.71

Table 3. Optimizing structural profiles

Wrapped and optimization profiles: After element					
ID	Initial Start Section Proposed Start Section	Initial End Section Proposed End Section	Family	Report (%)	Case
25	HEA220	HEA220	HEA European Profiles	75.86 0.00	0
270	IPE360	IPE360	IPE European Profiles	77.32 0.00	0
271	IPE360	IPE360	IPE European Profiles	77.33 0.00	0
24	HEA220	HEA220	HEA European Profiles	75.86 0.00	0

2.2.3 Calculation of resistance transverse frame

Strength calculations for structural members analyzed the hall were made in accordance with the regulations set contained in Euro codes EN 1993 and Euro code 3: Design of steel structures, as follows:

- ✓ Calculation of resistance for the current cross was performed on the components, poles and respectively rulers, given the demands resulting from the static calculation: the pillars of the bolster, as required bar bending with axial force or bending compression with flat; rulers, as required bar bending with shear.
- ✓ Strength of structural elements was determined by calculation from the cross section of these elements, namely the calculation of the strength of the sections;
- ✓ The stability of the structural elements has been determined by calculating the resistance of the section, taking into account the effect of structural rigidity.

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Relationships used to check the resistance and the results of running the computer program are presented in Table 4 for the transverse current ruler frame and for pillar in Table 5.

Table 4. LEFT RULER - Beam number 270

Profile sheet - Beam number 270 Linear - LEFT RULER	
1) Section	
Profile	IPE360
Size(cm)	h = 36.00 b = 17.00 tw = 0.80 tf = 1.27 r = 1.80 r1 = 0.00
Sections(cm2)	Area = 72.73 Avy = 45.26 Avz = 35.14
Inertia	It = 37.32(cm4) Iy = 16270(cm4) Iz = 1043(cm4) Iw = 314510(cm6)
Modules(cm3)	Wply = 1019 Wplz = 191.1
Material	S235 E = 210000 MPa Nu = 0.3 G = 80800 MPa
Type	fy = 235.00 MPa fu = 360.00 MPa
2) Section classification	
Class	Lower wing. : Class 1, Heart : Class 1, Upper wing : Class 1, Section : Class 1
3) Sections resistance	
Stretching Compression (6.2.4)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit discr. nr. 270.1 Fx < Npl : 43.32 < 1709.16 kN (3 %)
Shear after y (6.2.6)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit discr. nr. 270.1 Fy < Vply : 8.34 < 614.08 kN (1 %)
Shear after z (6.2.6)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit discr. nr. 270.1 Fz < Vplz : 65.10 < 476.77 kN (14 %)
Bending /yy (6.2.5)	Case num. 113 : 1.35x[1 G]+1.05x[5 WX+D2]+1.5x[11 Snw], Unit discr. nr. 270.7 MyEd < MyRk : 100.32 < 239.46 kN*m (42 %)
Bending /zz (6.2.5)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit discr. nr. 270.1 MzEd < MzRk : 16.25 < 44.91 kN*m (36 %)
Oblique bending (6.2.9.1)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit discr. nr. 270.1 $\left(\frac{My}{Mny}\right)^{a} + \left(\frac{Mz}{Mnz}\right)^{b} < 1$ (6.41); $\left(\frac{85.57}{239.46}\right)^{2.00} + \left(\frac{16.25}{44.91}\right)^{1.00} =$ 0.48945 < 1 (49 %)
4) Elements stability	
Adverse event	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit discr. nr. 270.1 0/4
Buckling /yy (6.3.1)	Lfz = 4.26 m $\lambda_y = 0.304$ Curve a $\alpha_y = 0.21$ $\Phi_y = 0.56$ $\chi_y = 0.977$ Ncry = 18540.05 kN
Buckling /zz (6.3.1)	Lfy = 4.26 m $\lambda_z = 1.199$ Curve b $\alpha_z = 0.34$ $\Phi_z = 1.39$ $\chi_z = 0.479$ Ncrz = 1188.52 kN
Interaction coefficient (Anexa A)	kyy = 1.01 kyz = 1.00 kzy = 1.00 kzz = 1.00
Verification (6.61)	$\frac{N_{Ed}}{\chi_y \bullet \frac{N_{Rk}}{\gamma_{M1}}} + k_{yy} \bullet \frac{M_{y,Ed} + \Delta M_{y,Rd}}{\chi_{LT} \bullet \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \bullet \frac{M_{z,Ed} + \Delta M_{z,Rd}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1.00$ 0.03 + 0.36 + 0.36 = 0.75 < 1.00 (75%)
Verification (6.62)	$\frac{N_{Ed}}{\chi_z \bullet \frac{N_{Rk}}{\gamma_{M1}}} + k_{zy} \bullet \frac{M_{y,Ed} + \Delta M_{y,Rd}}{\chi_{LT} \bullet \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \bullet \frac{M_{z,Ed} + \Delta M_{z,Rd}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1.00$ 0.05 + 0.36 + 0.36 = 0.77 < 1.00 (77%)

Table 5. LEFT PILLAR - Beam number 24

Profile sheet - Beam number 24 Linear - LEFT PILLAR	
1) Section	
Profile	HEA220
Size(cm)	h = 21.00 b = 22.00 tw = 0.70 tf = 1.10 r = 1.80 r1 = 0.00
Sections(cm2)	Area = 64.34 Avy = 50.15 Avz = 20.67
Inertia	It = 28.46(cm4) Iy = 5410(cm4) Iz = 1955(cm4) Iw = 193550(cm6)
Modules(cm3)	Wply = 568.5 Wplz = 270.6
Material	S235 E = 210000 MPa Nu = 0.3 G = 80800 MPa
Type	fy = 235.00 MPa fu = 360.00 MPa
2) Section classification	
Class	Lower wing.: Class 1 Heart : Class 1 Upper wing : Class 1 Section : Class 1
3) Sections resistance	
Stretching Compression (6.2.4)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit. discr. nr. 24.1 Fx < Npl : 77.49 < 1511.99 kN (5 %)
Shear after y (6.2.6)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit. discr. nr. 24.5 Fy < Vply : 0.31 < 680.42 kN (0 %)
Shear after z (6.2.6)	Case num. 119 : 1.35x[1 G]+1.05x[7 WX-S2]+1.5x[11 Snw], Unit. discr. nr. 24.1 Fz < Vplz : 31.92 < 280.45 kN (11 %)
Bending /yy	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit. discr. nr. 24.5

Profile sheet - Beam number 24 Linear - LEFT PILLAR	
(6.2.5)	MyEd < MyRk : 94.78 < 133.60 kN*m (71 %)
Bending /zz (6.2.5)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit.discr. nr. 24.5 MzEd < MzRk : 1.09 < 63.59 kN*m (2 %)
Oblique bending (6.2.9.1)	Case num. 125 : 1.35x[1 G]+1.05x[9 WX-D2]+1.5x[11 Snw], Unit.discr. nr. 24.5 $\frac{M_{Ed}}{M_{c,Rd}} < 1$ (6.12) : 0.70942 < 1 (71 %)
4) Elements stability	
Adverse event	Case num. 119 : 1.35x[1 G]+1.05x[7 WX-S2]+1.5x[11 Snw], Unit. discr. nr. 24.5 4/4
Buckling /yy (6.3.1)	Lfz = 5.93 m λ_y = 0.688 Curve b α_y = 0.34 Φ_y = 0.82 χ_y = 0.790 Ncry = 3191.87 kN
Buckling /zz (6.3.1)	Lfy = 8.21 m λ_z = 1.587 Curve c α_z = 0.49 Φ_z = 2.10 χ_z = 0.288 Ncrz = 600.42 kN
Interaction coefficient (Anexa A)	kyy = 1.09 kyz = 0.61 kzy = 0.56 kzz = 0.69
Verification (6.61)	$\frac{N_{Ed}}{\chi_y \bullet \frac{N_{Rk}}{\gamma_{M1}}} + k_{yy} \bullet \frac{M_{y,Ed} + \Delta M_{y,Rd}}{\chi_{LT} \bullet \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \bullet \frac{M_{z,Ed} + \Delta M_{z,Rd}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1.00$ 0.06 + 0.69 + 0.01 = 0.76 < 1.00 (76%)
Verification (6.62)	$\frac{N_{Ed}}{\chi_z \bullet \frac{N_{Rk}}{\gamma_{M1}}} + k_{zy} \bullet \frac{M_{y,Ed} + \Delta M_{y,Rd}}{\chi_{LT} \bullet \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \bullet \frac{M_{z,Ed} + \Delta M_{z,Rd}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1.00$ 0.15 + 0.35 + 0.01 = 0.52 < 1.00 (52%)

Profile sheet - Beam number 25 Linear - RIGHT PILLAR (selective)	
1) Section	
Profile	HEA220
Size(cm)	h = 21.00 b = 22.00 tw = 0.70 tf = 1.10 r = 1.80 r1 = 0.00
Sections(cm2)	Area = 64.34 Avy = 50.15 Avz = 20.67
Inertia	It = 28.46(cm4) Iy = 5410(cm4) Iz = 1955(cm4) Iw = 193550(cm6)
Modules(cm3)	Wply = 568.5 Wplz = 270.6
Material	S235 E = 210000 MPa Nu = 0.3 G = 80800 MPa
Type	fy = 235.00 MPa fu = 360.00 MPa
2) Section classification	
Class	Lower wing : Class 1 Heart : Class 1 Upper wing: Class 1 Section : Class 1
3) Sections resistance	
Stretching Compression(6.2.4)	Case num. 113 : 1.35x[1 G]+1.05x[5 WX+D2]+1.5x[11 Snw], Unit discr. nr. 25.1 Fx < Npl : 77.49 < 1511.99 kN (5 %)
Shear after z (6.2.6)	Case num. 107 : 1.35x[1 G]+1.05x[3 WX+S2]+1.5x[11 Snw], Unit discr. nr. 25.1 Fz < Vplz : 31.93 < 280.45 kN (11 %)
Bending /yy (6.2.5)	Case num. 113 : 1.35x[1 G]+1.05x[5 WX+D2]+1.5x[11 Snw], Unit discr. nr. 25.5 MyEd < MyRk : 94.78 < 133.60 kN*m (71 %)
Bending /zz (6.2.5)	Case num. 113 : 1.35x[1 G]+1.05x[5 WX+D2]+1.5x[11 Snw], Unit discr. nr. 25.5 MzEd < MzRk : 1.08 < 63.59 kN*m (2 %)
Oblique bending (6.2.9.1)	Case num. 113 : 1.35x[1 G]+1.05x[5 WX+D2]+1.5x[11 Snw], Unit discr. nr. 25.5 $\frac{M_{Ed}}{M_{c,Rd}} < 1$ (6.12) : 0.70942 < 1 (71 %)
4) Elements stability	
Adverse event	Case num. 107 : 1.35x[1 G]+1.05x[3 WX+S2]+1.5x[11 Snw], Unit. discr. nr. 25.5
Buckling /yy (6.3.1)	Lfz = 5.93 m λ_y = 0.688 Curve b α_y = 0.34 Φ_y = 0.82 χ_y = 0.790 Ncry = 3191.87 kN
Buckling /zz (6.3.1)	Lfy = 8.21 m λ_z = 1.586 Curve c α_z = 0.49 Φ_z = 2.10 χ_z = 0.288 Ncrz = 601.14 kN
Lateral buckling (6.3.2.1)	Ldi = 5.00 m Lds = 5.00 m; C1 = 2.420 C2 = 0.032 zg = 0.00 m kz = 1.000 kw = 1.000 Mcr = 608.68 kN*m λ_{LT} = 0.468; Curve - α_{LT} = 1.00 Φ_{LT} = 1.00 χ_{LT} = 1.000
Verification (6.61)	$\frac{N_{Ed}}{\chi_y \bullet \frac{N_{Rk}}{\gamma_{M1}}} + k_{yy} \bullet \frac{M_{y,Ed} + \Delta M_{y,Rd}}{\chi_{LT} \bullet \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \bullet \frac{M_{z,Ed} + \Delta M_{z,Rd}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1.00$ 0.06 + 0.69 + 0.01 = 0.76 < 1.00 (76%)
Verification (6.62)	$\frac{N_{Ed}}{\chi_z \bullet \frac{N_{Rk}}{\gamma_{M1}}} + k_{zy} \bullet \frac{M_{y,Ed} + \Delta M_{y,Rd}}{\chi_{LT} \bullet \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \bullet \frac{M_{z,Ed} + \Delta M_{z,Rd}}{\frac{M_{z,Rk}}{\gamma_{M1}}} \le 1.00$ 0.15 + 0.35 + 0.01 = 0.52 < 1.00 (52%)

2.3 Analysis and interpretation of the results after running

Through the design and construction measures of resistance structures, during the construction operation the following basic requirements must be met:

- ✓ The condition of strength and stability of the construction under the forces during the operation;
- ✓ The safe operating condition;
- ✓ The fire safety condition;
- ✓ The condition of hygiene, health and environmental protection;
- ✓ The condition of protection against noise;
- ✓ The condition of energy economy and heat retention inside.

From the results obtained from analysis of the constructive system under study in this paper and the reports generated by automatic calculation programs Advance Design and Advance Steel (selectively included in this paper), one can notice comply with basic requirements, namely the compliance terms of strength, stability and safety of the structure strength.

3. CONCLUSIONS

The study of behavior under operating loads Structural steel resistance conducted in this paper based on a case study can be achieved by static analysis of the structure and strength, namely its structural components.

The use of performance automatic calculation program provides opportunities for import, export and synchronize models between CAD and finite element analysis applications and facilitates the accelerate multi-user modeling technology. This has both the advantage of significant efficiency of accuracy and of the time required for design calculations, as well as the possibility of optimizing the strength structures under study.

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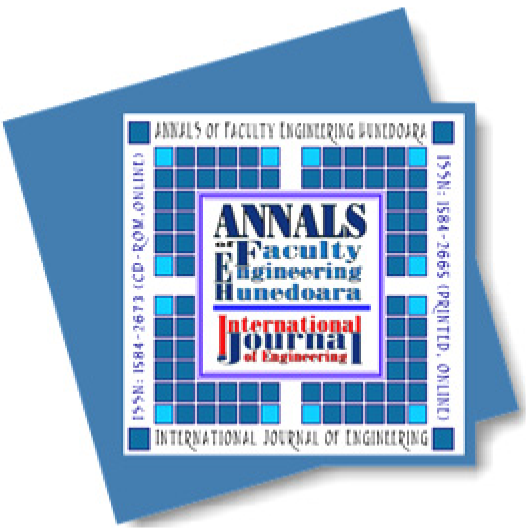

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