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Design Of A Metal Canopy With Hpl Panels

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Abstract

The article proposed a detailed methodology for the design of composite structure column and standing canopy covered with HPL panels, representing complete architectural solution for entrance of an office building Class A (-) prepared by Aruid - Panayotovi - sie SD Rousse. There have been strength calculations in endangered sections through a combination of classical computational methods and strength - deformation check on finite element method. For the design of the structure is used system Solid Works 2015, in combination with the module for FEM analysis SimulationXpress.

Keywords: Canopies, HPL Panels, FEM Analysis, Hot-rolled Profiles

1. Introduction

Canopies are architectural elements transmitting characteristic appearance of the buildings. Basic structure of their supports is made up of linked in a of connected in a particular spatial configuration steel profiles. According scheme of establishment are divided into: column, hanging, console, standing and others. Depending on the type of material for protector layer are: glass, metal, composite panels,HPL panels, reinforced, polycarbonate, etc. This papers proposed methodology for the design of composite structure column and standing canopy covered with HPL panels representing complete architectural solution entrance of an office building Class A (-). The canopy is made of steel hot rolled sections, covered by farms [1].

2. Methodology and consistency of design

The methodology for the design of structures of this type includes a set of design-computational work that are interrelated and are carried out in a certain sequence [1].

2.1 Introduction to architectural design

The methodology for the design of structures of this type includes a set of design-computational work that are interrelated and are carried out in a certain sequence [1].

In the first place stands the need for detailed research and analysis of source documents and in particular architectural concept (Aruid - Panayotovi - sie SD Rousse), which will be implemented with the designed structure. Particular attention in the analysis should be paid to the establishment of the scheme. If the result of the analysis constructor find a more rational decisions on the scheme of establishment or the construction of the facility, these decisions must be agreed with the architect and structural engineer, and then be reflected in project documents.

The constructor must also be familiar with the available support materials and reference books. Particular attention is given in this case of this study the technical documentation utilized in manufacturing facilities such as what must be designed.

2.2 Choice of establishment scheme

Based on facility-based on conducted analysis of technological output documentation proposed by the constructor accepts a construction engineer and architect basing scheme or select and coordinate them with other more rational.

Score status of basic surfaces intended establishment - under existing metal structures or predetermined slabs of the building to which can be welded rail fixing parts of the roof construction.

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2.3 Construction of the bearing elements of the structure

It is made up of separate hot rolled and welded profiles, welded construction. Maintained by column size Ø377x8 and mounting brackets. They are set by anchoring to the bearing elements of reinforced construction.

2.4. Design of elements from substructure of the shell of HPL panels and prepare the components for it.

It is planned to be executed as a set of cantilevered elements farms of varying length which is set by HPL cladding panels. Opportunities are provided for setting the height, rotation of the farms as well as the translation axis perpendicular to the direction of installation, by setting before welding.

The cladding is made of sheets HPL, mounted on profiles in the form of K40x20x2 as farms. They are welded directly to the bearing hot rolled profiles from the bearing metal construction

Elements of the enclosure cladding be established directly through profiles of the consoles from profile and L30x30x1 and self drilling screws DIN 7504P directly to them The individual plates are thick and 8mm and joints between the sheets 5 mm.

2.5. Choice of technology and design of the route for the installation of the facility.

The designed structure with composite cladding is prefabricated and transported on separate nodes.

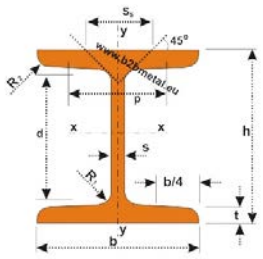
3. Design of the elements

3.1. Selection of materials for manufacturing of striation

Materials for manufacturing of individual elements of the canopy with cladding from HPL panels are selected depending on the functional purpose fig.1 and Table 1 [4,5]:

- for the basic elements of supporting steel construction using hot rolled sections:

- beams [24 and I24 - S235JRG2, according to EN 10025 (RSt37,2 according to DIN 17100),
- capitals [16- S235JRG2 according to EN 10025 (RSt37,2 according to DIN 17100),
- major Column Ø377x8



Identification	Nominal weight 1m	Nominal dimensions					Cross-section	Dimensions for detailing			Surface	
		b	h	s	t	R1 R2	A	d	Ø	pmin pmax	AL	AG
	kg/m	mm					cm2	mm	mm		m2/m	m2/m
IPN 160	17,9	74	160	6,3	9,5	6,3 3,8	22,8	125,8	-	- -	0,575	32,13
IPN 240	36,2	106	240	8,7	13,1	8,7 5,2	46,1	192,5	M10	54 60	0,844	23,32

Identification	Section properties, static data											
	strong axis x-x					weak axis y-y						
	Ix	Wel.x	Wpl.x	ix	Avy	Iy	Wel.y	Wpl.y	iy	Ss	It	Iw
	cm4	cm3	cm3	cm	cm2	cm4	cm3	cm3	cm	mm	cm4	cm
IPN 160	935	117	136	6,40	10,83	54,7	14,8	24,9	1,55	35,2	6,57	3,14
IPN 240	4250	354	412	9,59	22,33	221	41,7	70,0	2,20	48,9	25,0	28,7

Fig. 1 Hot rolled profiles [4.5]

Table 1 Mechanical properties and chemical composition of steel RSt 37,2 DIN 17100 [4,5]

Annealing hardness HBS	Cold pull hardness HBS	Preheating temperature °C	Quenching temperature °C: salt-bath furnace	Quenching temperature °C: controlled atmosphere furnace	Holding time min	Hardening medium	Temper temperature °C	After tempering hardness HRC
235	262	788	1191	1204	5 – 15	air cooling	522	60

Steel plate/Sheet thickness / mm	σb MPa	σs ≥MPa	δ Samples from the standard for 50 mm (2 in)	180 ° of cold bending test: longitudinal	180 ° of cold bending test: horizontal
Hot-rolled/Cold rolling 5 - 150	520	415	16 – 18	2a	3,5a

C ≤	Si ≤	Mn ≤	P ≤	S ≤	Cr	Ni
0,20		1,40	0,035	0,035		
Mo	Al	Cu	Nb	Ti	V	Ce
		≤ 0,55				
N	Co	Pb	B	Other		
≤ 0,012				how ≥ 40 laoyang N		

- for farms:

- rectangular aluminium profiles K40x20x2,
- profiles L40x40x3.

- for finishing elements – galvanized steel 1 mm

- for cladding from - HPL panels Prodema [6], 8 mm thick, ensuring corrosion and fireproofing material and reducing the tendency to form surface crazing fig.2.

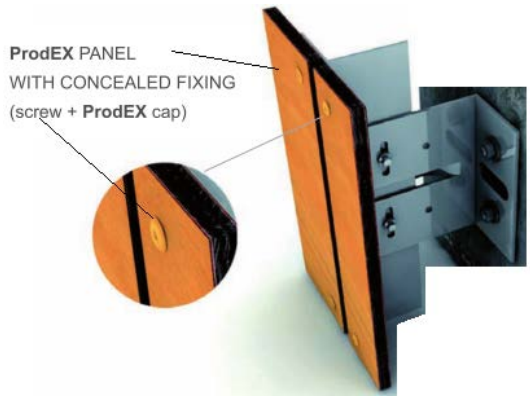


Fig. 2 PRODEMA - mounting elements [6]

- SSF that are used are from company Wurth[7]

- screws 7504P 3, 9x19
- anchors M16x160
- studs M20h260

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3.2 Strength checks

The machining engineers, although have the recommendations from the architects and structural engineers about what profiles to use need to undergo strength checks [3]. They are attached to the exposed sections. The main workloads faced bay metal structures are made of snow. For each geographical area there are recommended values of extreme loads, the area of the city for which it is intended to using a design they are within St=1,42kN/m^2.

3.2.1 Checking the bending of horizontal profiles capitals

With strength calculations of the profiles is an essential moment verification of account, that is, the determination of the required section modulus and comparing it with that of the selected profile W_x, from this geometrical characteristic is determined suitability profile fig. 3 [3]:

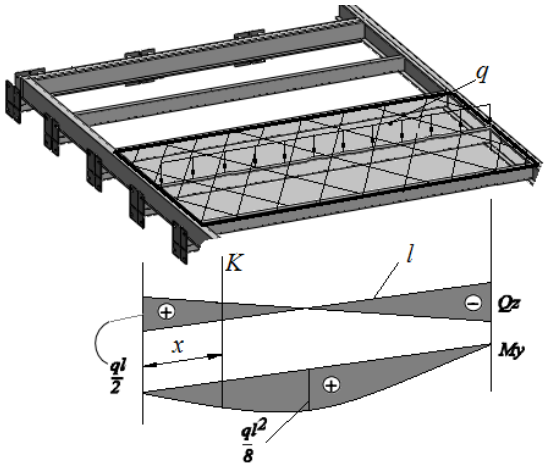

Fig. 3 Computational scheme of bending of horizontal profiles

$$W_x \geq \frac{|M_b|}{\sigma_b} = W_{x1} \quad (1)$$

where:

- $\sigma_{[b]}$ = 160 MPa –permissible bending stress,
- W_x – section modulus. For profile [16 - W_x=116.10^{-6} m^3,
- M_b – bending moment is defined in scheme of figure 3 and dependence 2.

$$M_b = \frac{q.l^2}{8} = \frac{1{,}57.4^2}{8} = 3{,}14kN.m \quad (2)$$

where:

- q [N/m] – distributed load – fig.4,

$$q = \frac{S_t.F}{l} = \frac{1{,}42.4{,}42}{4} = 1{,}57kN/m \quad (3)$$

l = 4000 mm - length of the capital.

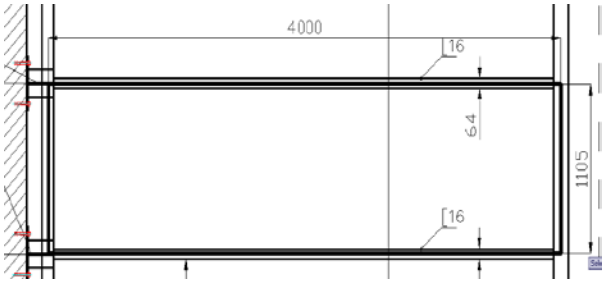

Fig. 4 Computational determination scheme by distributed load

After conversion dependence (1) have type:

$$W_{x1} = \frac{|M_{b.}|}{\sigma_b} = \frac{1{,}57.10^3}{160.10^6} = 98{,}1.10^{-6}m^3 \quad (4)$$

→ The selected profile [16 is appropriate, W_{x1}<W_x.

3.2.2 Strength - deformation check on FEM

The check is carried out under snow load and own weight profile I24 is depicted graphically in fig.5. It is carried out in dependence (5):

$$F_I = St.F + F_{c1} = 1{,}42.11{,}94 + 10{,}76 = 27{,}71kN \quad (5)$$

where:

- F_{c1} = 10,76kN – own weight of the structure,
- F = 11,94 m^2 – area of part of the structure to which it belongs profile I24.

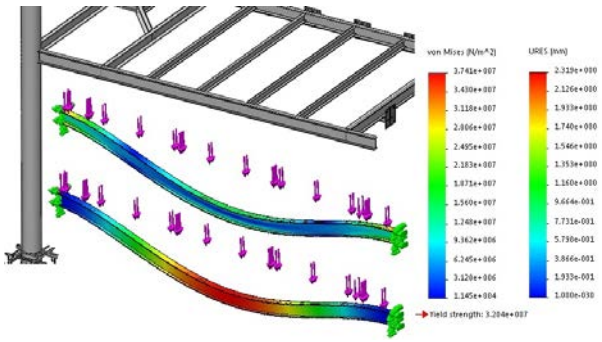

Fig. 5 Strength - deformation check – profile I24

From the results, it is apparent that profile I24 implements necessary preformed in choosing his

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expectations as deformation is 23,19mm, and tensions 3,74.10^{7}Pa, eligible under strain and tension limit 24,66mm and 3,204.10^{7}Pa.

3.2.3 Test resistance of the column

The task of resistance fig.6 is associated with the moment of inertia of the section J_y, from this geometric feature is determined suitability profile - Ø377x8 [3].

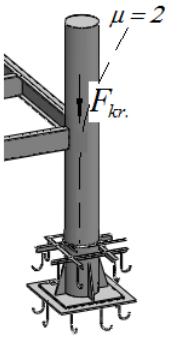

Fig. 6 Diagram of the stability of column

$$J_{\min} = \frac{F_{kr}.l_{02}.\nu}{\pi^2.E} = \frac{66{,}47.10^3.3{,}148.4}{\pi^2.2{,}1.10^{11}} = 4046.10^{-8}\,m^4 \quad (6)$$

where:

- $[J_{min}]$ $[m^4]$ = 15 792.10-8m4– allowable moment of inertia of the section,
- $F_{kr.}$ – is determined by the mass of the metal structure plus the area of the entire snow loading structure:

$$F_{kr.} = F_c + S_t.F = 14{,}82 + 36{,}37.1{,}42 = 66{,}47kN \quad (7)$$

- F_c = 14816 N = 14, 82kN – own weight of the structure
- $l_{02} = l.\mu = 1362{,}5.1 = 1362{,}5$ mm,
- $\mu = 2$ – dimensionless coefficient for free rod,
- $\nu = 4$ – safety factor,
- $E = 2{,}1.10^{11}$ – elastic modulus.

→ The selected profile Ø377x8 has a moment of inertia $[J_{min}] = 15\ 792.10^{-8}m^4$ he is bigger than $J_{min} = 4046.10^{-8}m^4$, i.e. the selected profile is suitable.

3.3 Montage of the elements

The structure is fully welded. It is established by means of weld to the waiting plates, placed in reinforced concrete. The individual beams are manufactured in workshops, through the method of metal inert gas welding of CO_2 with fusible electrode. When fitting out using arc welding by a fusing electrode. Mounting schemes of individual elements are shown on fig.7÷9. When mounting the individual elements using specific equipment installations [2]. The equipment is mainly used for mounting element facade systems.

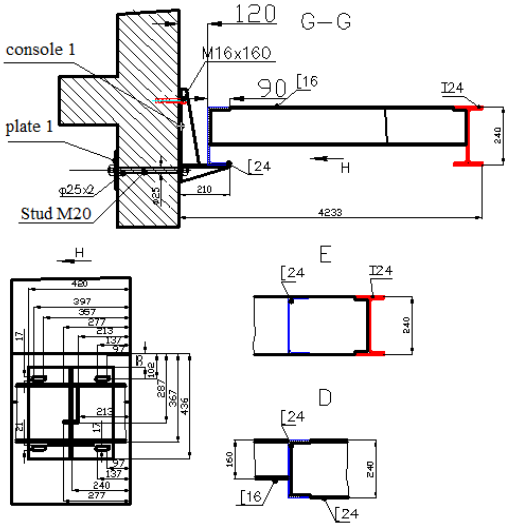

Fig. 7 Mounting plan - profiles

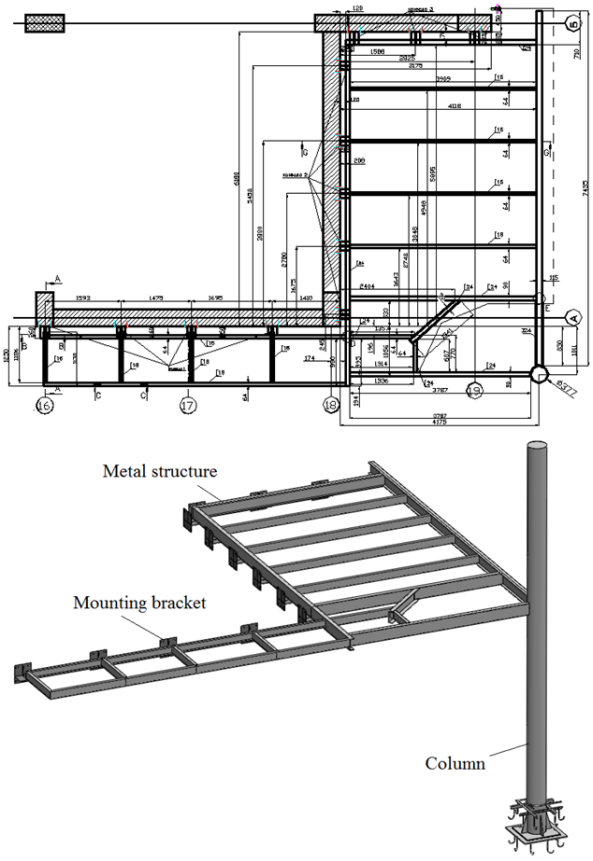

Fig. 8 Mounting plan - metal structure

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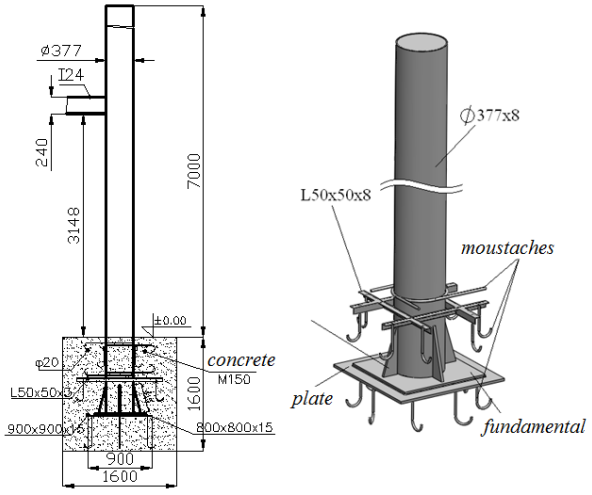

Fig. 9 Mounting plan - column

The cladding is mounted by drilling screws directly to metal profiles K40x20. Individual boxes plates are thick and 8mm and joints between the sheets 5 mm. General arrangement of the components of the enclosure are shown in fig. 10.

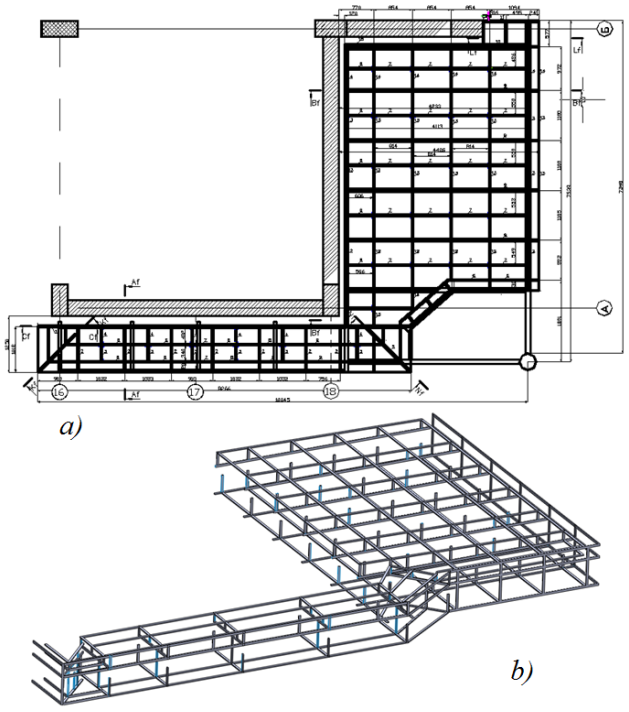

Fig. 10 Cladding structure:
a) farms, b) three-dimensional model

In finished form the canopy without and mounted on her cladding from HPL panels is shown in fig.11 and fig.12.

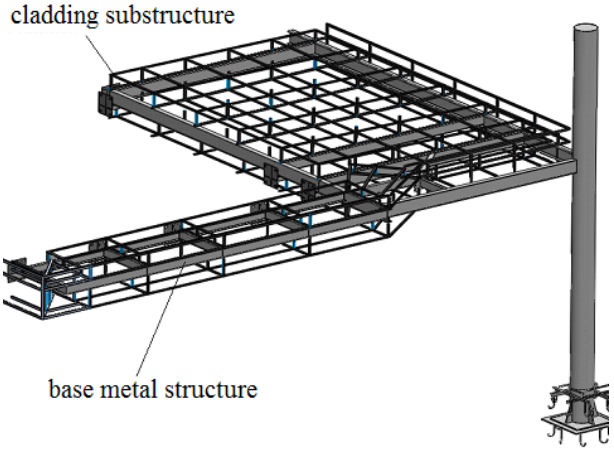

Fig. 11 Canopy without cladding

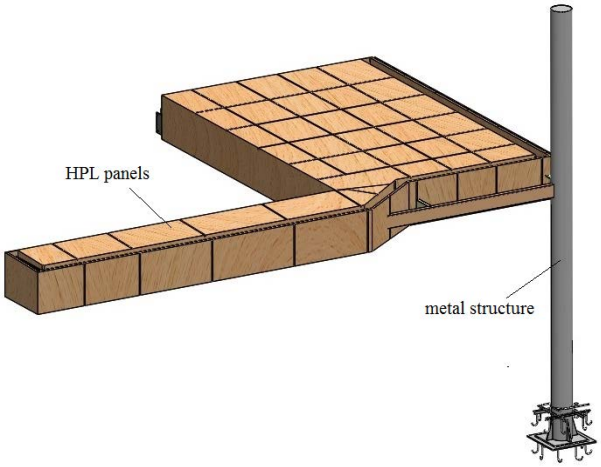

Fig. 12 Canopy with mounted cladding from HPL panels

4. Results

The proposed structure, the analyzes and the results allow to be made following conclusions:

- proposed and testing methodology for the design of composite structure column and standing canopy, covered with HPL panels, representing complete architectural solution entrance of an office building Class A (-),
- canopy gives the characteristic appearance of the building in accordance with the architectural project,
- canopy meets all applicable building regulations required for the facilities of a this type,
- analis conducted by finite element method, using Solid Works 2015 module SimulationXpress, proves the applicability of the preparation for the construction of metal profiles and load-bearing elements.

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5. Conclusions

The structure is designed, developed, tested and installed as part of the facade of the administrative building Class A (-) of the company Preciz Al Ltd, Bulgaria. Development and results are fully applied in nature. Putting architectural element of this type, although costs incurred increases the level of the site in accordance with the established categorization scale, gives a modern architectural appearance of the facade and the completion of the building exterior.

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