

MEASURING OF THE BUILDING STRUCTURES WITH SAP 2000

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Abstract: *New tendency of design of building structures is to use appropriate software. It facilitates design and changes in project, shorts terms and provides additional security.*

One of these programs for analysis of building structures is SAP2000. It is most popular design software in Bulgaria. It has built in module for check of design resistance of any element by many standards. The program checks the elements by equations and use coefficients for them that could be changed, according to real conditions of work of the structure.

It is recommended to check used by default in SAP 2000 coefficients to reduce design mistakes and improve necessary quantity of used materials.

Key words: *computer design, SAP 2000, Eurocode 3, design resistance, unbalanced length*

For good or for bad the computers and their software services are more and more used in the designer's practice. They use a programs for preparing of drawing (AutoCAD, Advance Steel, BoCAD, Nemetschek) as well as a programs for analysis and/or measuring of the different parts of the building structures (SAP 2000, ETABS, ROBOT, RISA). One of them is especially popular amongst the civil engineers in Bulgaria and it is SAP 2000. It is due to many reasons and no to a last point huge opportunities and facility in working with this program.

1. Introduction

The special software SAP 2000's option for automatic measuring of construction's members has been used very often. This software gives the opportunity to determine easily and quickly necessary sections of the elements according to the requirements of the AASHTO, AISC, ACI, EUROCODE 2 and 3, UNI. The requirements of different investors can be satisfied without problem in accordance with leading normative documents in the world. The measuring of building structures which uses the SAP 2000's settings by default is very convenient but not always correct. Considering this point the creators of the programs gave the option for individual changes in the coefficients.

2. Analyzed building structure

For the purpose of the current research it has been designed a steel silo with cylindrical shape for sand storage (fig. 1). Its diameter is $D = 3,0$ m and the length of its cylindrical part is $H = 7,0$ m. The thickness of the sheets in the cylindrical and cone parts is $t_s = 5$ mm. In the transitional area the thickness of the sheets is $t_s = 8$ mm. The supporting ring of the silo in the part in which it is put on the horizontal girders is situated on the level $+4^{500}$ m. The steel columns are 4 and between them have been developed supporting X - and K - braces. The connections have not been put in one of the directions in order to facilitate the unloading of the stored sand.

The steel of the main construction is BCт3nc.

The girders of the vertical connections are made by hot rolled sections and the 4 columns are built up welded members.

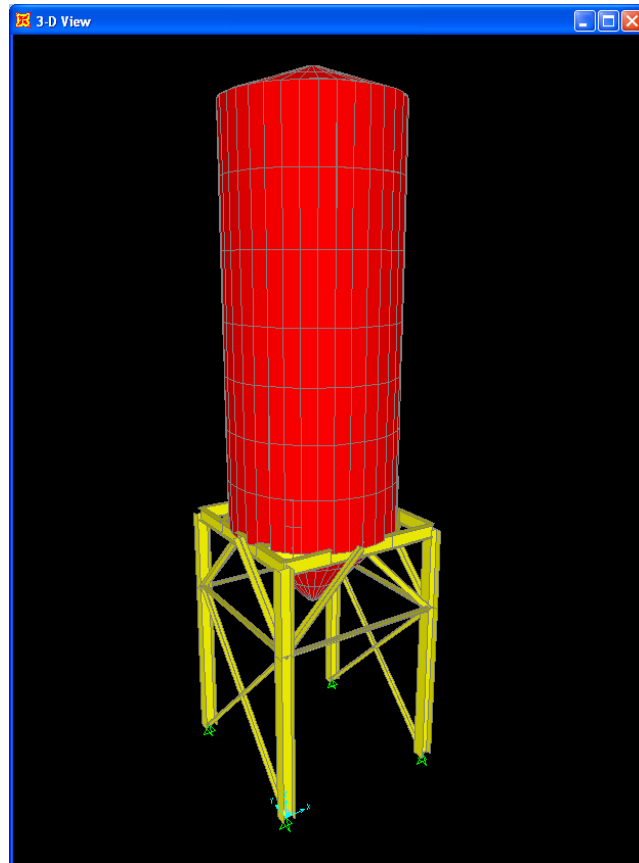


fig . 1 Cylindrical steel silo

It has been done a three dimensioned analysis of the facility considering the impact of the following loadings:

- the weight of the facility – g ;
- stored dry sand with density $\rho = 1,5 \text{ t/m}^3$ – Sa ;
- snow on silo's roof with intensity $s_n = 1,0 \text{ kN/m}^2$ – Sn ;
- wind with intensity $w_m = 0,43 \text{ kN/m}^2$ on the axis „x-x” – w_x ;
- wind with intensity $w_m = 0,43 \text{ kN/m}^2$ on the axis ‘y-y’ – w_y ;
- earthquake's impact with the seismic coefficient $k_c = 0,27$ – E [2] .

The combinations of the loading are 8 in accordance with [1].

3. Measuring of steel structure with SAP 2000

During the design of the facility for analysis and measurement of steel structure under cylindrical steel silo it have been used design module in SAP 2000. The authors have created three dimensioned computer model which has been calculated and measured according to the setting by default in the program (fig.2). After that the measuring of the construction under the silo has been done manually on paper.

The measuring in both cases is done according the requirements of Eurocode 3 [3].

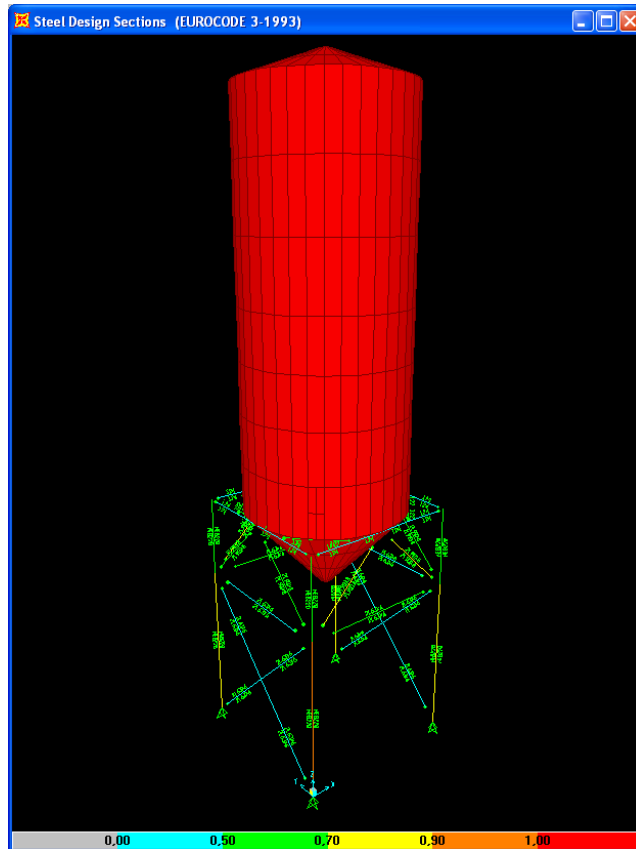


fig . 2 Measuring with SAP2000 according to Eurocode 3

In the table below the coefficients calculated by the two ways of measuring are compared.

TABLE 1 Measuring of compressed diagonals in braces

Element	Force kN	Length m	Coefficient / Result	Method of measurement		Difference %
				on paper	with SAP 2000	
2L90x8	-328,92	2,121	A, cm^2	27,8	27,52	1,017
			l_y	1	1	0
			l_z	1	1	0
			μ_y	1	1	0
			μ_z	1	1	0
			χ_y	0,6509	0,6501	0,123
			χ_z	0,8067	0,8073	0,074
			$N_{cy,Rd}$	386,57	382,22	1,138
			$N_{cz,Rd}$	479,1	474,61	0,946
2L63x6	-28,698	2,121	A, cm^2	14,56	15,082	3,585
			l_y	1	1	0
			l_z	2	2	0
			μ_y	1	1	0
			μ_z	1	1	0
			χ_y	0,44892	0,4453	0,813
			χ_z	0,2987	0,2981	0,201
			$N_{cy,Rd}$	139,63	143,488	2,763
			$N_{cz,Rd}$	92,91	96,05	3,38

TABLE 2 Measuring of the columns and main girders

Element	Length m	Koefficient / Result	Method of measurement		Difference %
			on paper	with SAP 2000	
built up welded column	3	A, cm^2	106	106	0
		l_y	1	1	0
		l_z	1	1	0
		μ_y	2	1	100
		μ_z	1	1	0
		χ_y	0,9365	1	6,781
		χ_z	0,8184	0,8165	0,233
		$N_{cy,Rd}$	2120,75	2264,54	6,78
		$N_{cz,Rd}$	1853,3	1848,89	0,239
		C_1	1,879	1,88	0,053
		k_{LT}	0,8895	1	12,423
main girder I24	0,88	A, cm^2	34,8	34,226	1,677
		l_y	1,705	1,705	0
		l_z	1	1	0
		μ_y	1	1	0
		μ_z	1	1	0
		C_1	1,879	1,88	0,053
				k_{LT}	0,987

In TABLES 1 and 2 following marks are used:

A is a cross section of the elements;

l_y, l_z – coefficients reporting the unsupported length on the relevant axis of the element;

μ_y, μ_z – coefficients reporting type of fixing and type of loading of the element on the relevant axis “y-y” or “z-z”;

χ_y – coefficient of loss of stability on axis “y-y” for compressed elements;

χ_z – coefficient of loss of stability on axis “z-z” for compressed elements;

$N_{cy,Rd} = \chi_y \cdot A \cdot f_y / \gamma_{MI}$ – design resistance on compressed elements on axis “y-y” ;

$N_{cz,Rd} = \chi_z \cdot A \cdot f_y / \gamma_{MI}$ – design resistance on compressed elements on axis “z-z” ;

$f_y = 235 \text{ MPa}$ – yield strength of used steel;

$\gamma_{MI} = 1,1$ – coefficient of safety of the material.

C_1 – coefficient reporting the form of the diagram on the bending moment longitudinally on the element ;

k_{LT} – coefficient of lateral torsional buckling.

4. Conclusions

Undoubtedly there is a difference between the results calculated with Eurocode 3 on paper manually and with SAP 2000. It is due to the following reasons:

- often the entered in SAP 2000 element's sections have geometrical characteristics which are so close but do not coincide completely with the characteristics of the real existing sections;

- the program does not consider every time in a correct manner buckling length of the elements. The value accepted by default in the program in 3D structures is $\mu_y = \mu_z = 1,0$;

- when the coefficient k_{LT} is determined it is very important whether steel element is built up welded or hot rolled.

Unfortunately the building structures measuring with the use of the settings by default of SAP 2000 is not always safety. The maximum difference of the element's bearing ability in this concrete example is 6,78 %, but in other cases it can be increased considerably. Due to this fact it is recommended to check the accepted by the program coefficients during process of analysis and design of the structure.

Literature

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