DYNAMIC ANALYSIS AND DESIGN OF STEEL COLUMN UNDER EXPLOSION

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Abstract.

Main contribution of this communication is a numerical analysis of steel column loaded by an shock wave which occur as a result of an explosion. Here both issues concerning the design and computations of steel column are included: (1) a computational scheme and column dimensioning according to standards, and (2) column modeling and numerical analysis in ABAQUS [1] (definition of a strain rate dependent material, selection of failure criterion, choice of mesh size, column elements modeling – solid C3D8R or shell S4R). Additionally the methods of automatic calculations using PYTHON [2] and SCILAB [3] and/or MATLAB [4] scripts are used and presented. The two types of explosions (air blast and surface blast) are compared here. Then the influence of charge localization on column blast resistance is tested.

Moreover, for chosen computational model, methods of increasing I-beam column blast resistance are suggested and analyzed. Among them are: section class change, use of bearing capacity decrease, thicken of section parts, reinforcement techniques, replacement section with rectangular tube. In the last part all strengthening methods are compared in order to choose the most effective among them and to propose the design recommendations of steel structures exposed to explosions.

Analysis results. For construction loaded by an explosion of a charge localized in a specified place, there can be found find maximum size of charge that will not have an effect on column damage. In reality, damage criterion could be based on visual assessment of construction after explosion. In numerical analysis there are few damage criteria, but measurable values that best illustrate damage of a construction are:

- Displacements of column points,
- Damage dissipation energy,
- Kinetic energy.

Few methods of strengthening were analyzed. Among them are:

- cross-section class change,
- use of bearing capacity decrease,
- thickening of section parts,
- use of strengthening ribs,
- replacement section with rectangular tube.

When we compare only the increase of the charge mass, we do not include significant increase of the column mass. Therefore, a ratio that combines these two aspects and compares all the methods to dimensioning using the third class I-beam section was used.

$$R_{eff,i} = \frac{\frac{m_{TNT,1,i}}{m_{TNT,1,1}} + \frac{m_{TNT,4,i}}{m_{TNT,4,1}} + \frac{m_{TNT,7,i}}{m_{TNT,7,1}}}{3\frac{m_{C,i}}{m_{C,1}}}$$

- $R_{eff,i}$ – strengthen efficiency ratio for *i* analysis,
- $m_{TNT,d,i}$ – mass of destructive charge for *i* analysis form the distance of d meters,
- $m_{C,i}$ – mass of steel column for *i* analysis.

After analyzing this comparison criterion it should be noted that the most effective methods of strengthening the column are replacing the section with rectangular tube or thickening web and flanges. Important is that these analyses are related to the column with specified dimensions and loadings. However, it can be expected, that the change of designing parameters will cause only the disturbance of the obtained results.

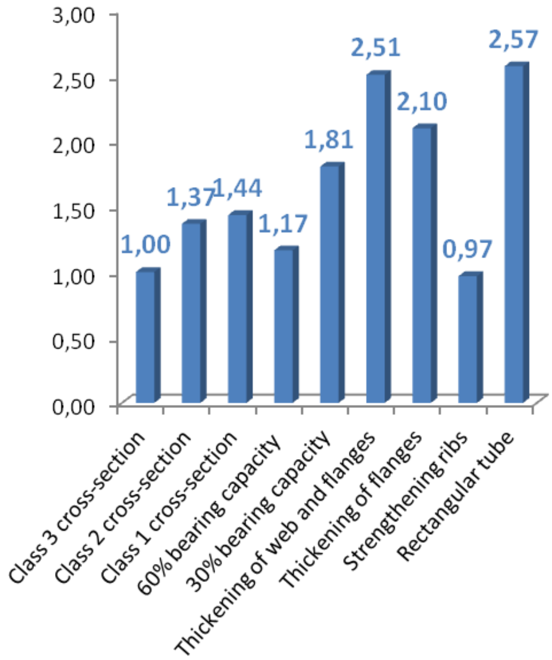

Figure 1. Strengthen efficiency ratio

References:

[1] Abaqus Analysis User's Manual, ver. 6-11, Dassault Systèmes, 2011
[2] Python Programming Language, ver 2.7; http://www.python.org/
[3] Scilab ver. 5-3; http://www.scilab.org/
[4] Matlab, R2011, MathWorks, 2011

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