EVALUATION OF GAS EXPLOSION ON METHANE TANKS ELEMENTS

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- This paper deals with the behaviour of structural elements of a methane tank from Wastewater Treatment Plants Oradea, subjected to blast pressure.
- The first part of the paper is devoted to general aspects of the effects of explosion on structures and also to the characteristics of blast pressure

  - Any explosion in a gaseous medium gives rise to a sudden pressure P_{so}.
  - Blast pressure is characterized by the explosive weight Q expressed as the equivalent weight of TNT, and the radial distance R between explosion centre and target.

- it is used a global parameter, the scaled range Z, in order to characterize the blast pressure:

$$Z = \frac{R}{Q^{1/3}}$$

- the blast pressure P_{so} acts on structural elements as is shown in Fig. 1:

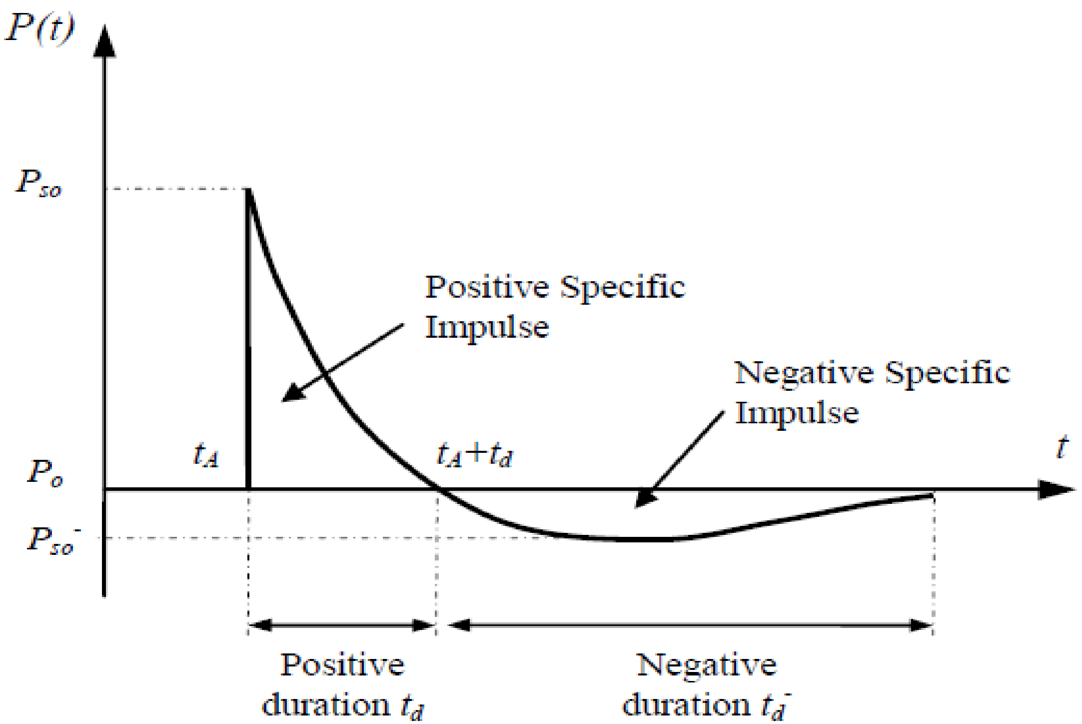


Fig. 1. Blast wave pressure – time history

- The parameters of the blast pressure can be appreciated from the static and dynamic values of the concrete members.
- The main parameters for dynamic analysis are:

  - **ductility factor** ρ which represents the ratio between total deformation and elastic deformation of concrete

  - **dynamic coefficient μ** which represents the ratio between blast pressure P_{so} and maximum static load P_{st}

  - **natural period T:** $T \cong 0.2 \cdot \sqrt{a_{st}}$

  - critical time t_{cr} :

$$t_{cr} = 0.25 \cdot T \cdot \sqrt{\frac{R}{P_{so}}}$$

  - pulse time t_d :

$$t_d = 10 \cdot \frac{R}{Z}$$

STRUCTURAL ANALYSIS OF A TANK

- The structural elements subjected to blast pressure that were analyzed are the cylinder wall and the dome roof of a methane tank.

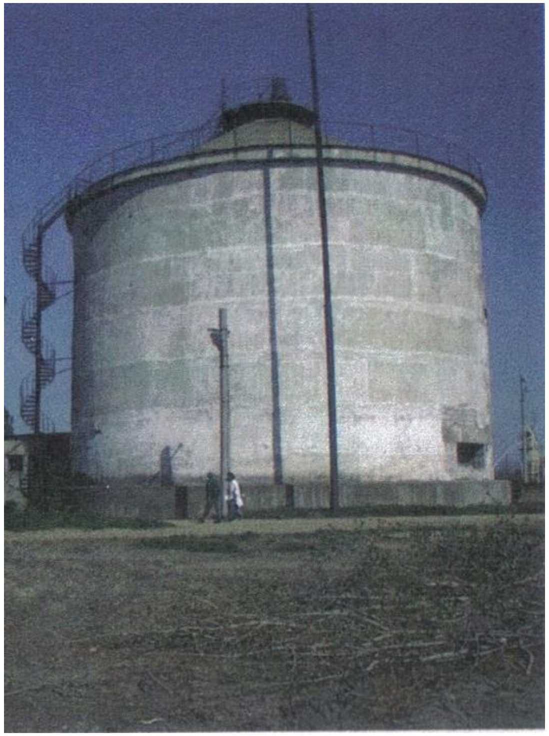


Fig. 2. Methane tank from Wastewater Treatment Plants Oradea

The dimensions are:

- diameter: D = 19 m
- height : H= 10.75 m
- wall thickness : t = 35 cm

- The results for the relevant parameters of the structural members are presented in Table 1:

Relevant values of structural members subjected to blast pressure Table 1

Parameter	Wall of the tank	Dome roof
Cracking bending moment m_{cr} (kN·m)	45.26	19.8
Maximum bending moment m_{max}(kN·m)	173.18	96.9
Maximum static load P_{st} (kN/m^2)	60.17	35.3
Static deflection a_{st} (mm)	0.596	0.351
Natural period T (ms)	48.82	37.5
Ratio pulse time on natural period t_d/T	0.85	1.1
Ductility factor ρ	4.67	4.67
Peak load P_{so} (kN/m^2)	146.2	74.5
Dynamic coefficient $\mu = P_{so}/P_{max}$	2.43	2.11

- The value of bending moment was calculated according to eq.:

$$m_{cr} = \frac{f_{ctm} \cdot I_1}{y_t}$$

- The static deflections for the cylinder wall and dome roof were calculated according to the following equations:

$$a_{st} = \frac{P_{st} \cdot r^2}{E \cdot \delta}$$

$$a_{st} = \frac{z}{E \cdot \delta}\left(N_\Phi - \mu \cdot N_x\right) \cdot ctg\alpha$$

- Maximum static load P_{st} was determined based on load capacity

- The peak load P_{so} was obtained from the correlation ratio of the equivalent static load to peak load with ductility ratio and pulse time to natural period ratio (Kinney GF).

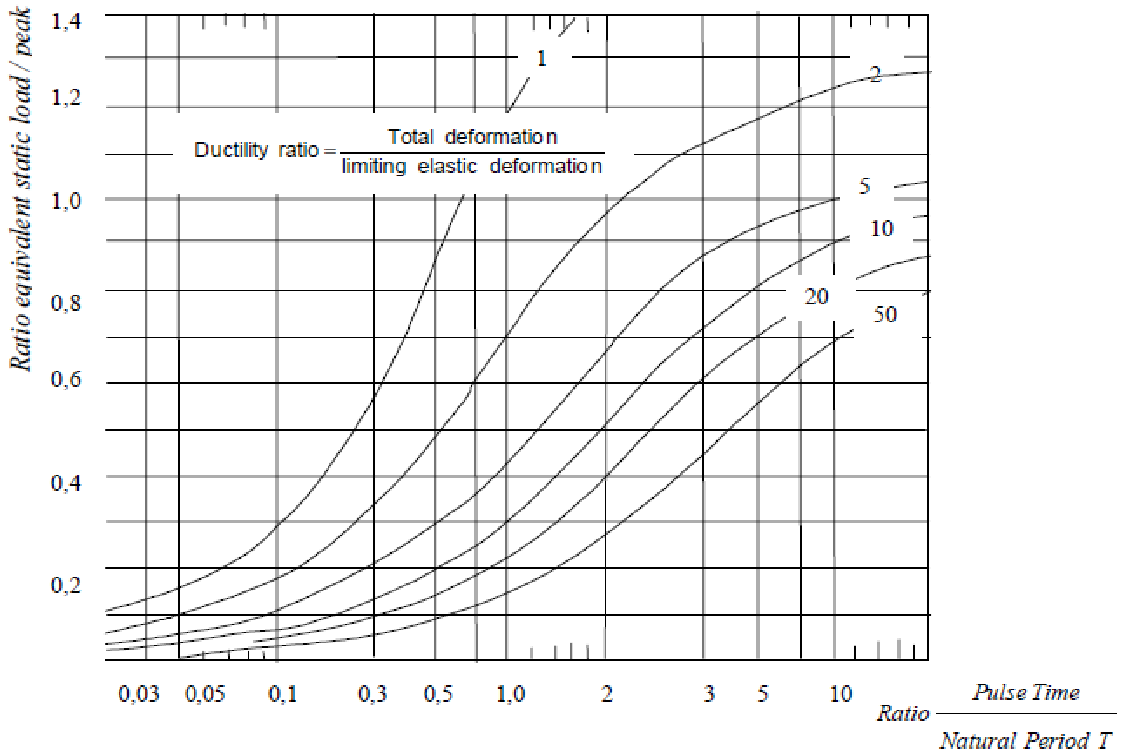


Fig. 3. Ratio of the equivalent static load function on ductility ratio, pulse time and natural period

- Based on the relevant parameters values in table 1, it was obtained the structure elements response:

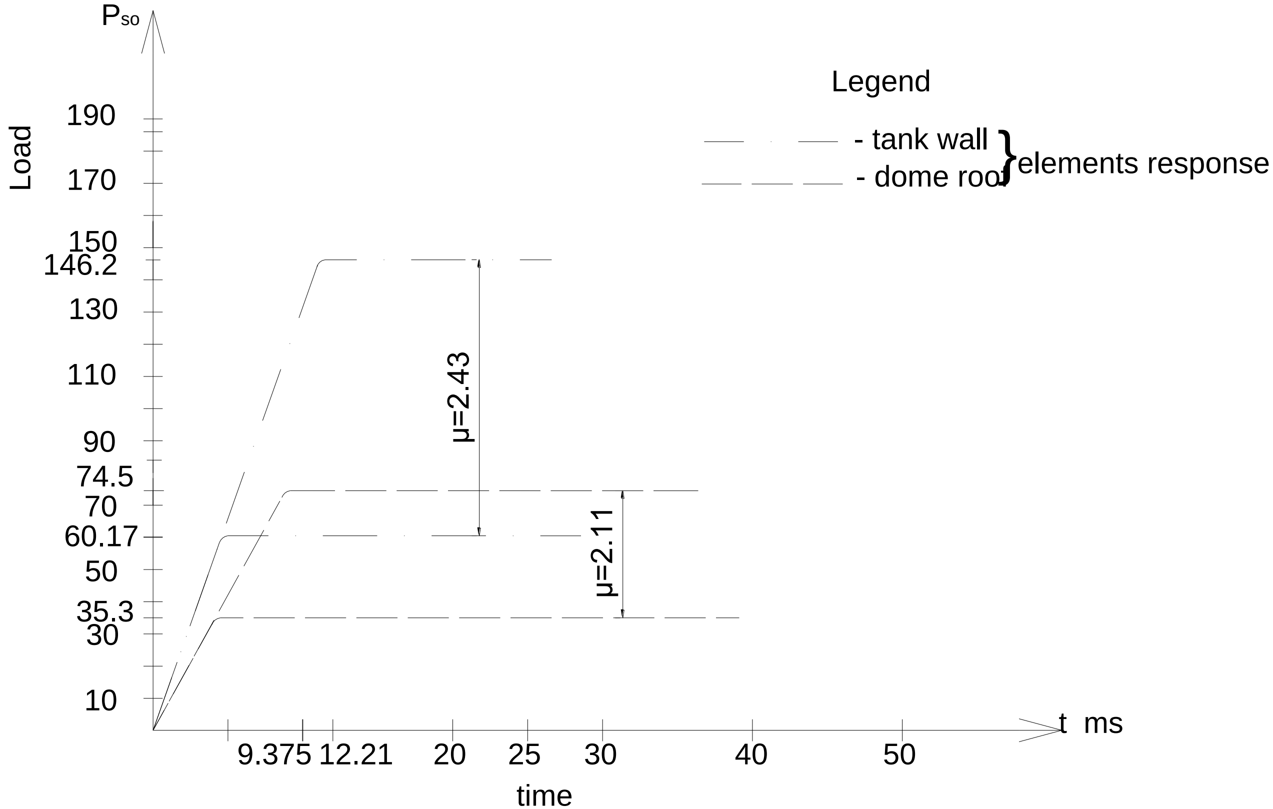
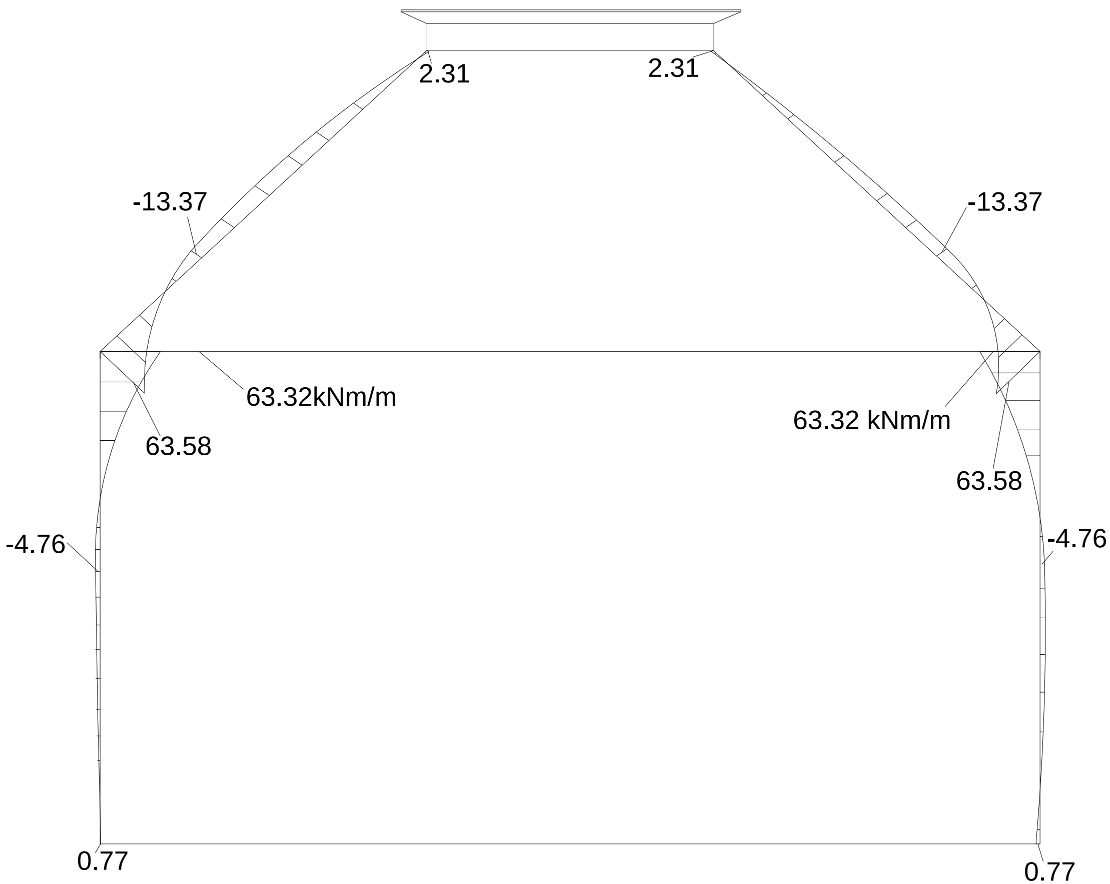


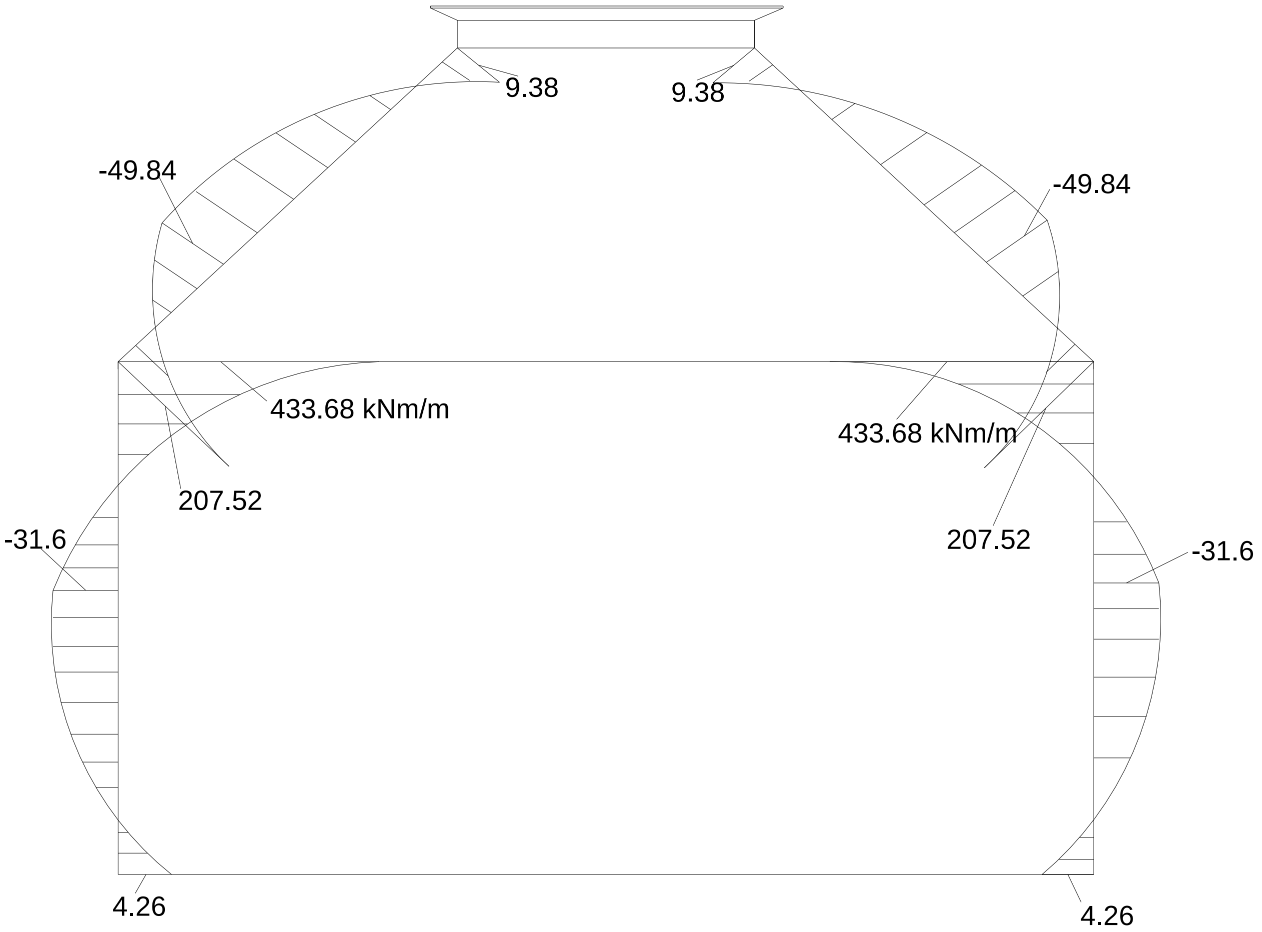
Fig. 4. Model of elements response

Analysis of the state stresses

- **bending moments diagram M_y (kNm/m) taking into account the load assumptions that are used in current design**



- **bending moments diagram M_y (kNm/m) taking into account the blast pressure too**



- Comparing these diagrams it can be seen that the bending moments are bigger in the second case than in the first one which means that the state stresses is affected by explosion.

Conclusions:

- The effects of explosion on methane tanks are functions of peak incident pressure.
- The blast pressure is function of the following parameters: dynamic coefficient μ, ductility factor ρ, maximum static load P_{st} , pulse time t_d and natural period T.
- The response of structural elements subjected to direct blast pressure presents an important tool in judging the parameters of the explosion.
- The state stresses is affected by explosion, so it is proposed to take into account the blast pressure in design calculations.

Thank you for your attention!