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FINITE ELEMENT STRESS ANALYSIS VS CALCULATION METHOD FOR THE CONSTRUCTION OF A METALLIC TANK USED FOR DANGEROUS GOODS TRANSPORTATION

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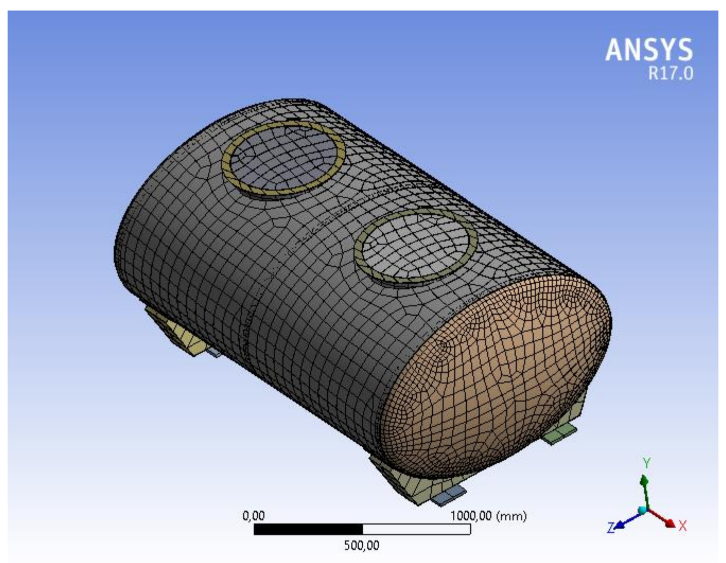
Abstract Metallic tanks are widely used for the transportation of dangerous goods. Their design and construction fall into the European standard EN13094:2015. In the present paper the design of a tank is verified with the two computational methods proposed in the standard i.e. the finite element stress analysis and the calculation method. For the implementation of the calculation method an application has been set up in the Graphical User Interface Development Environment of MATLAB® 2016a in order to automate the procedure, while for the implementation of the finite element stress analysis ANSYS ® Workbench v.17.0 has been used.

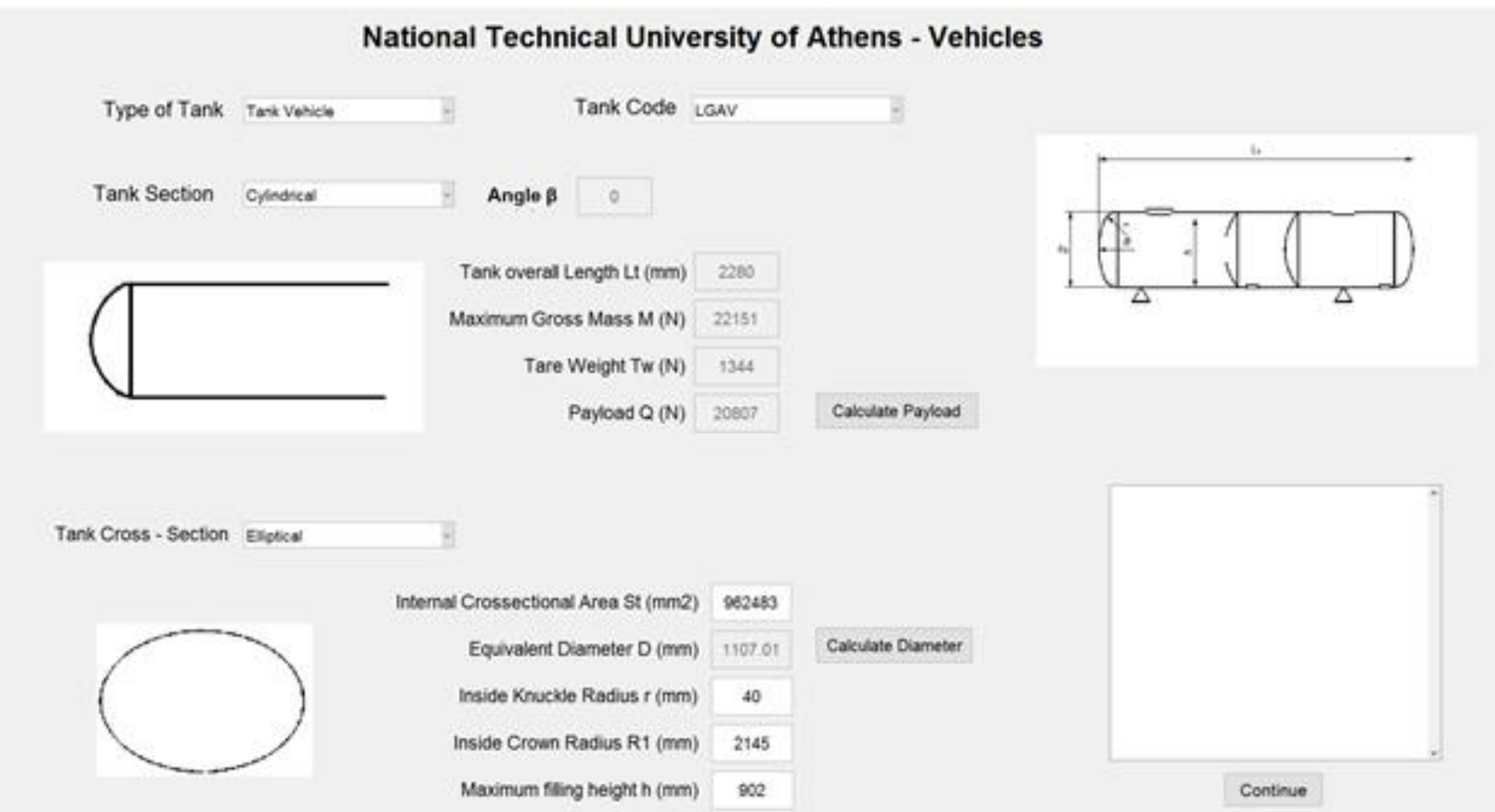
Introduction

The ground transport of dangerous goods in European Union (EU) consists of road and rail transport. The fact that more than half of the transported by road dangerous goods are flammable liquids points out the importance of the proper design of the ADR tank vehicles constructed to transport them. If the tank is metallic and its working pressure is not exceeding 0.5 bar its design and construction is additionally related to the European Standard EN 13094 [1]. In Annex A of the aforementioned standard it is stated that there are four different methods for the verification of the design of such a tank, namely, (a) dynamic testing, (b) finite element stress analysis, (c) reference design, (d) calculation method or a combination of them. In order for (a) or (c) to be performed the construction of the tank is a prerequisite, while both (b) and (d) can be performed right after the preliminary design of the tank, prior to its construction, leaving space for the construction of an optimized design.

Materials & Methods

Finite element (FE) stress analysis was performed with ANSYS v.17, whereas for the application of the calculation method (CM) a computational procedure, described, in Annex A of the standard EN13094:2015 has been set up in the Graphical User Interface Development Environment (GUIDE) of MATLAB® in order to automate the procedure (TanCalc).

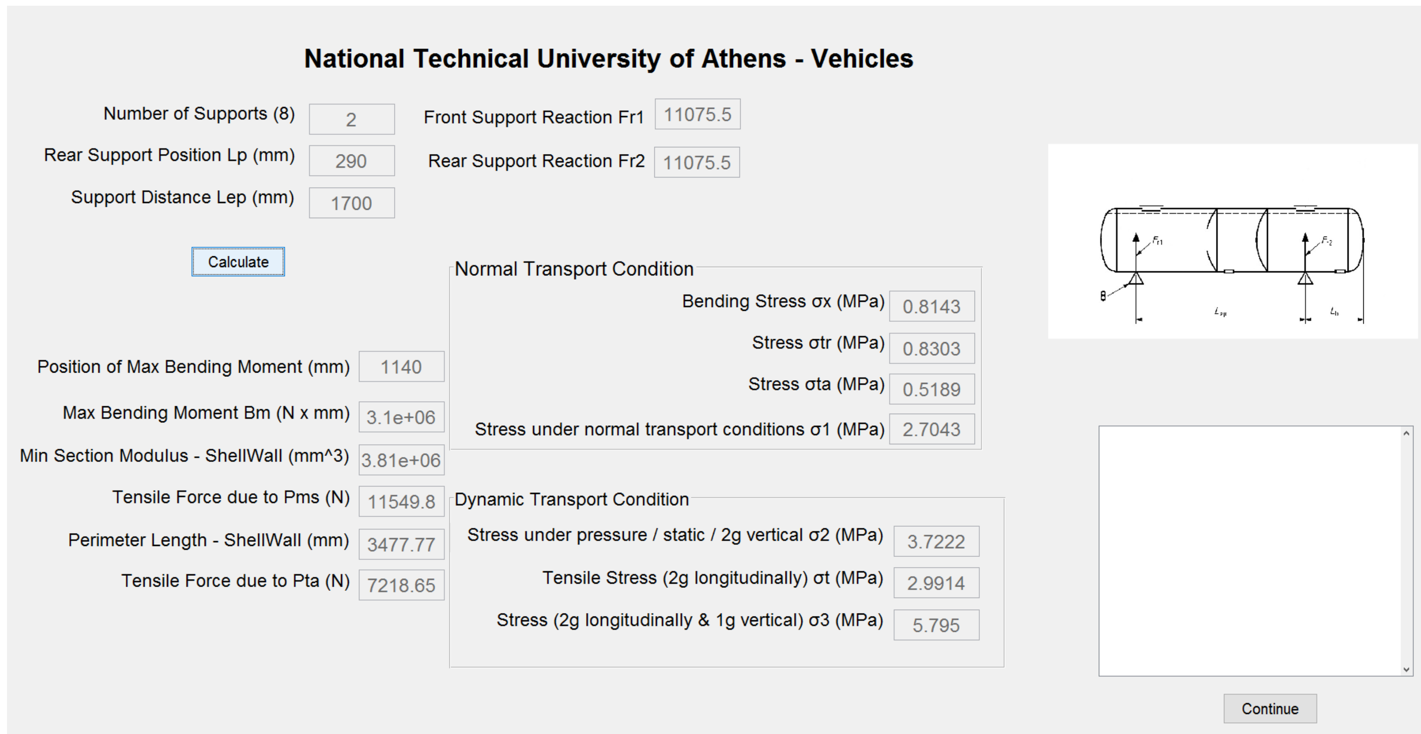




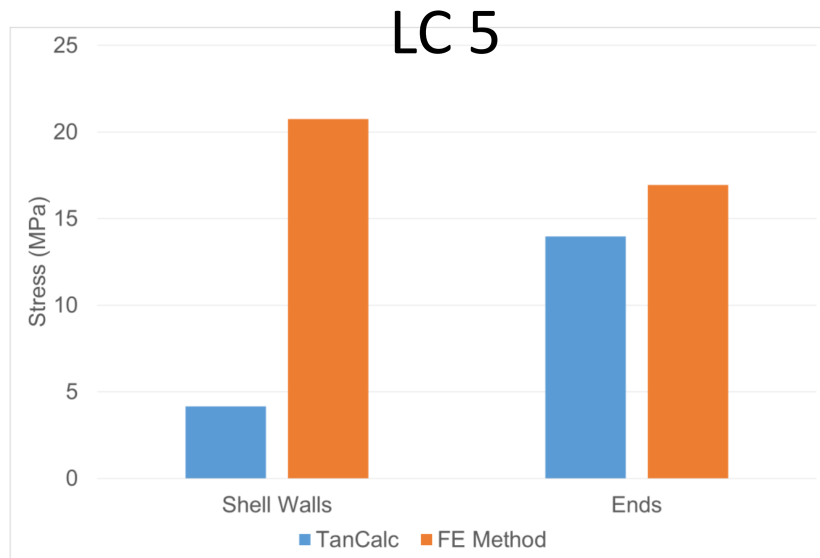
Results & Discussion

Both methods are considered EQUIVALENT for the verification of the design of a tank (EN13094:2015)

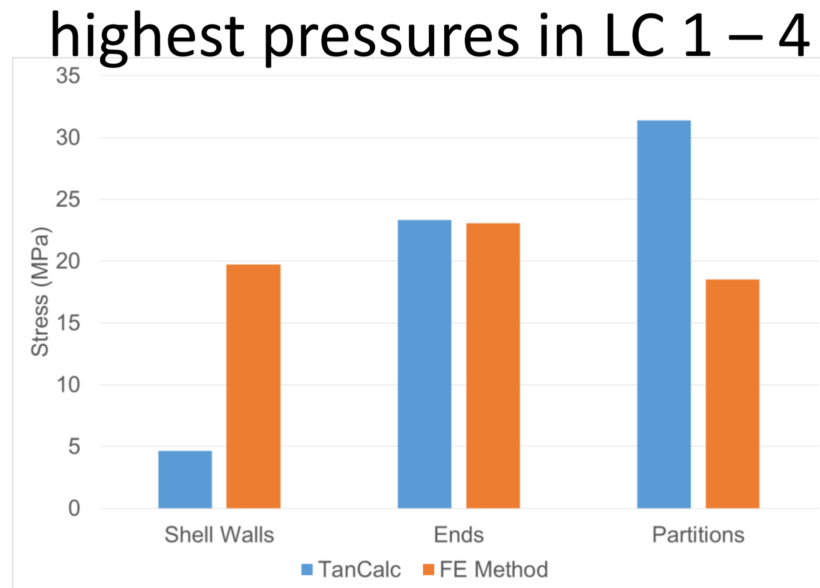
The FE method: results in 7 loading Cases while TanCalc results in 3 sets of conditions (test, service and transport)



Test conditions
LC 5



Service Conditions
highest pressures in LC 1 – 4



Conclusions

FE method provides Information on (a) the distribution of equivalent Von Mises stress (b) the weldments, the supports and the mounting on the vehicle and (c) Possibilities of optimization of the overall design
BUT requires expert knowledge and computational cost

TanCalc provides (a) Low computational cost (b) A good overview on the performed calculations (c) Repetitiveness with slight changes in the design parameters and variables
BUT Geometric irregularities are not fully considered (elliptical or box cross-sections, knuckle radius, etc) and the supports are not included

References *[1] ROAD FREIGHT TRANSPORT BY TYPE OF GOODS. EC, EUROSTAT STATISTICS EXPLAINED, HTTP://EC.EUROPA.EU/EUROSTAT/WEB/PRODUCTS-DATASETS/-/ROAD_GO_TA_DG, 13 FEBRUARY 2017 [2] ADR, (2015), "EUROPEAN AGREEMENT CONCERNING THE INTERNATIONAL CARRIAGE OF DANGEROUS GOODS BY ROAD". [3] EN 13094 (2015), "TANKS FOR THE TRANSPORT OF DANGEROUS GOODS – METALLIC TANKS WITH A WORKING PRESSURE NOT EXCEEDING 0.5 BAR – DESIGN AND CONSTRUCTION". [4] MATHWORKS, INC. NATICK, MA, MATLAB R2016A ®; 2016. [5] VICTORIA, M., QUERIN, O. M., DÍAZ, C., & MARTÍ, P. (2016). LITEITD A MATLAB GRAPHICAL USER INTERFACE (GUI) PROGRAM FOR TOPOLOGY DESIGN OF CONTINUUM STRUCTURES. ADVANCES IN ENGINEERING SOFTWARE, 100, 126-147. [6] ANSYS®ACADEMIC RESEARCH, RELEASE 17. 2016. [7] DAS, S., SUNDARESAN M.K., HAMEED, A.S. (2015), "FEA OF CYLINDRICAL PRESSURE VESSELS WITH DIFFERENT RADIUS OF OPENINGS", INT. J. FOR RESEARCH IN APPLIED SCIENCE & ENGINEERING, 3 (IX), PP. 406-414.*