SPIF - 2020 International Blind Prediction Contest

Seismic Performance of multi-component systems in special risk Industrial Facilities

SERA (**S**eismology and **E**arthquake Engineering **R**esearch Infrastructure **A**lliance for Europe) Framework

02.04.2020

Shake table

EUCENTRE – Shake table - Italy	

Project partner

RWTH Aachen University - Germany Center for Wind and Earthquake Engineering	
University of Trento - Italy Depart. of Civil, Env. & Mechanical Engineering	
National Technical University of Athens (NTUA)	
Maurer Engineering GmbH - Germany	
University of Belgrade - Serbia Faculty of Civil Engineering	
Roma Tre University - Italy Department of Engineering	
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INAIL, DIPARTIMENTO INNOVAZIONI TECNOLOGICHE - Italy	

Content

1. Introduction

We are pleased to announce the SPIF–2020 International Benchmark of a model of the three–storey steel moment frame building with vertical and horizontal vessels, arranged on the three levels with some of them connected to each other by pipes. It is a part of the SERA (Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe) framework.

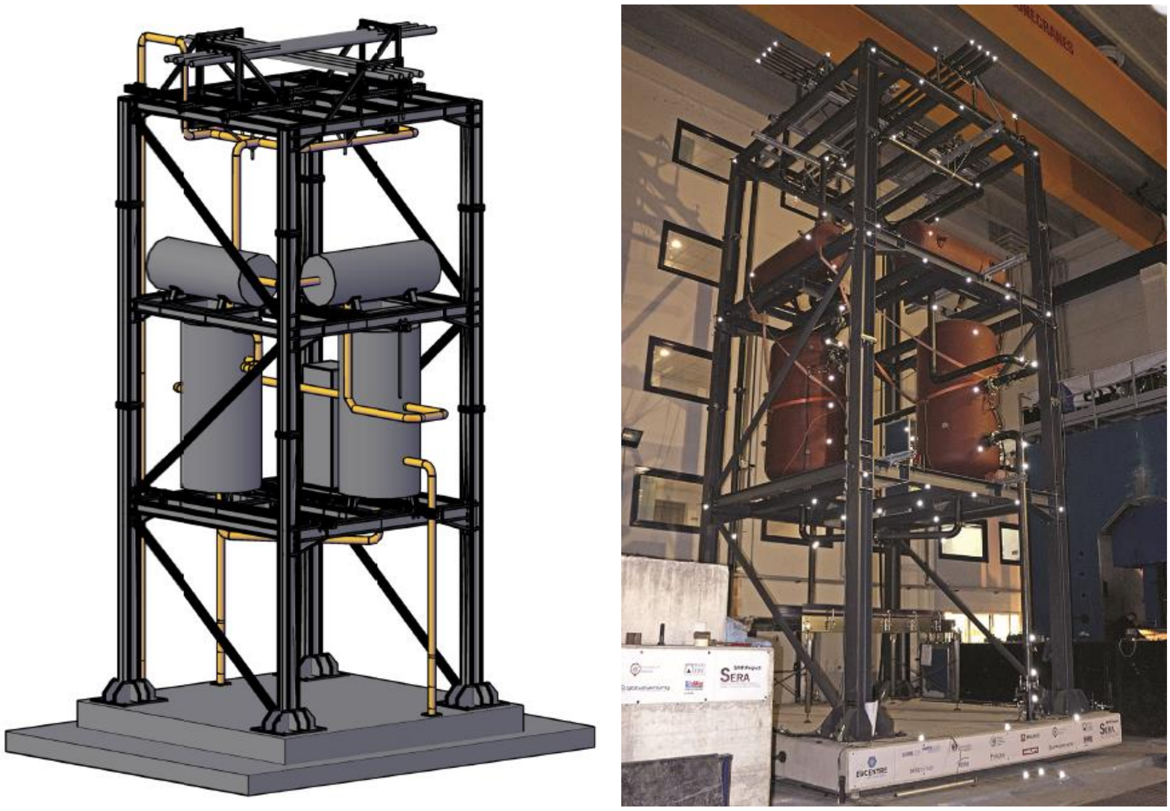
The objective of the project is the holistic investigation of the seismic behaviour of industrial plants equipped with complex process technology by means of shaking table tests. The necessity exists, since past earthquakes have shown that critical interactions can occur in these plants between the supporting structure and plant components, but also between the individual plant components. The structural or process-related interactions can lead to serious secondary damages which, in addition to loss of production, also pose a danger to humans and the environment if hazardous substances are released due to leakages. The main objective of the test is to investigate the interactions between the primary structure and components as well as between the components among themselves, with the use of a shaking table test. The proposed structure is a three-storey steel frame having the height of 9.3 m and the base of 3.7 m x 3.7 m, with the non-structural components. The full scale three–storey steel moment frame building (Figure 1) will be tested under seismic loading conditions at different intensities at the shaking table in the laboratory of the EUCENTRE in Pavia - Italy. The tests are carried out with fixed base of the industrial structure.

Before initiation of the experimental research an International Blind Prediction of the test outcomes is announced to the research community. It is anticipated that these competitions, popular in engineering community will result in innovation and creativity.

The participants of the SPIF–2020 blind test contest have to submit two reports containing their results. The first report includes the static analysis and system identification of the structure based on the provided information.

The second report includes the simulation results of the shake table tests. The reports to be submitted are provided in ***Annex A – Report A: Model Information and System Identification and Annex B – Report B: Simulation results of the shaking table tests***.

In the next sections a brief description of the structure, installations, tests to be performed and the contest rules are presented.



a) b)

Figure 1: a) Test structure with installations: CAD-model, b) Structure on the shaking table

2. Description of the specimen

2.1 General description

The height of the physical model is 9.3 m. The foundation plate is made of reinforced concrete with the thickness of 0.4 m. The primary steel structure is a three strorey moment resisting steel frame with flexible diaphragm made of crossbeams. The ground-plan dimensions are 3.7 m x 3.7 m and the storey height is 3.1 m, which leads to a total height of 9.3 m. The rigid frame is fully clamped on the reinforced concrete base plate and the crossbeams are hinged connected to the frame beams. For more details see ***Annex C – Construction Drawings*** and ***Annex D – Foundation slab***.

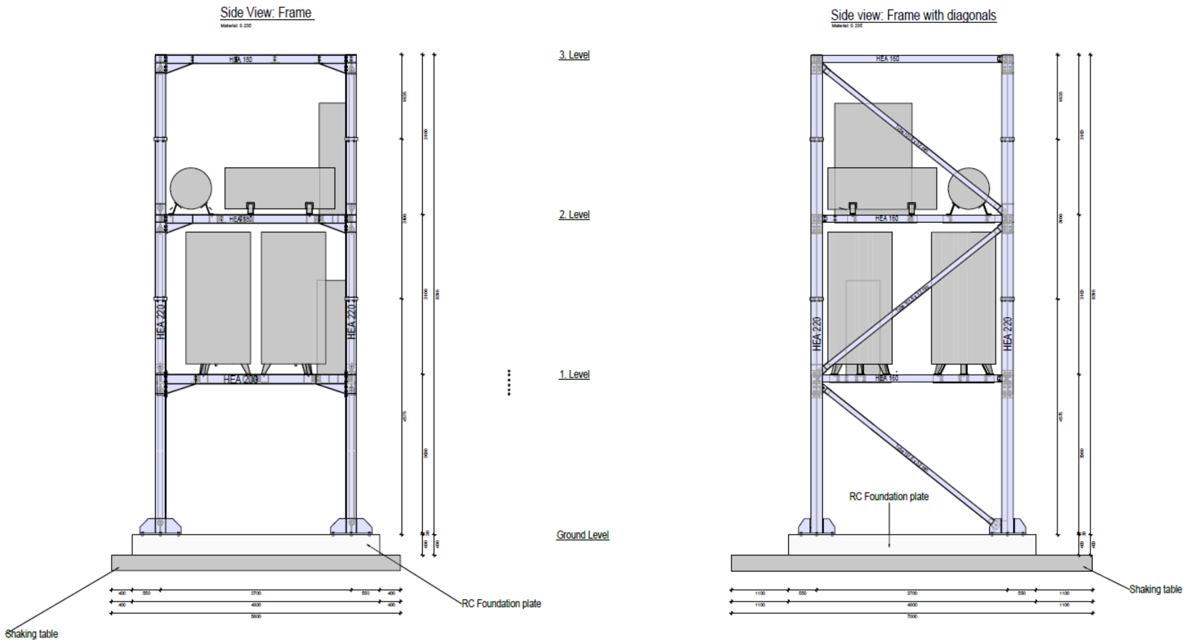


Figure 2: Plan views of the three-storey steel frame (further details: Annex C)

In total four tanks (Figure 3 and Figure 4) will be installed. Two vertical tanks on the first level and two horizontal tanks on the second level. The construction details, volume and self-weight of the tanks is given in ***Annex E – Tanks***. An operational filling level of 75% is assumed for horizontal tanks and 80% for vertical tanks.

Furthermore one electrical cabinet is placed on the first level. Mass and construction details of the cabinet are given in ***Annex F – Cabinet***. It is recommended to model the cabinet in a simplified manner as precise description of the static system is not available.

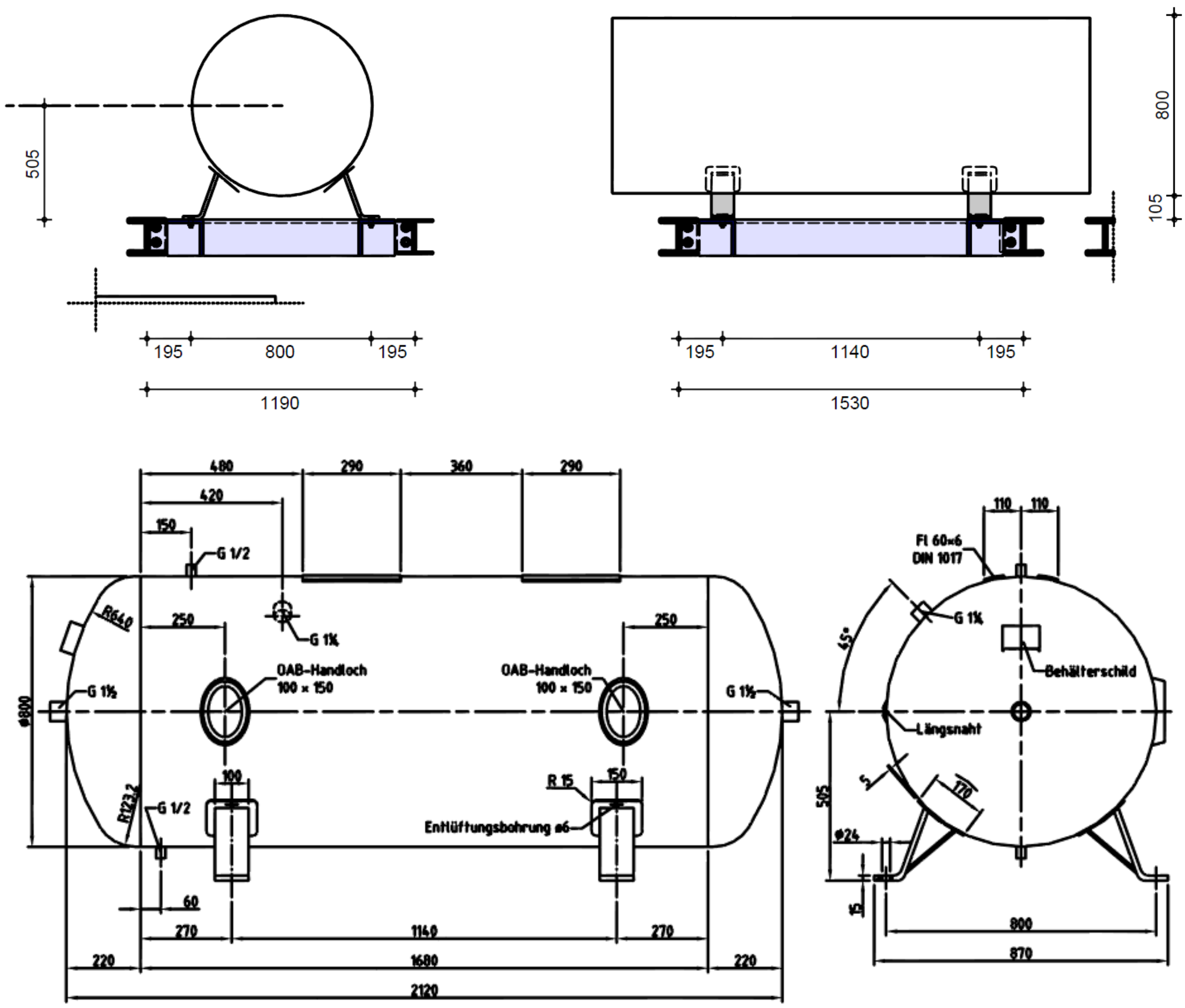


Figure 3: Horizontal tanks (further details: Annex E)

The pipe installations with description of material, supports, pressure and geometry are given in ***Annex G – Pipes***.

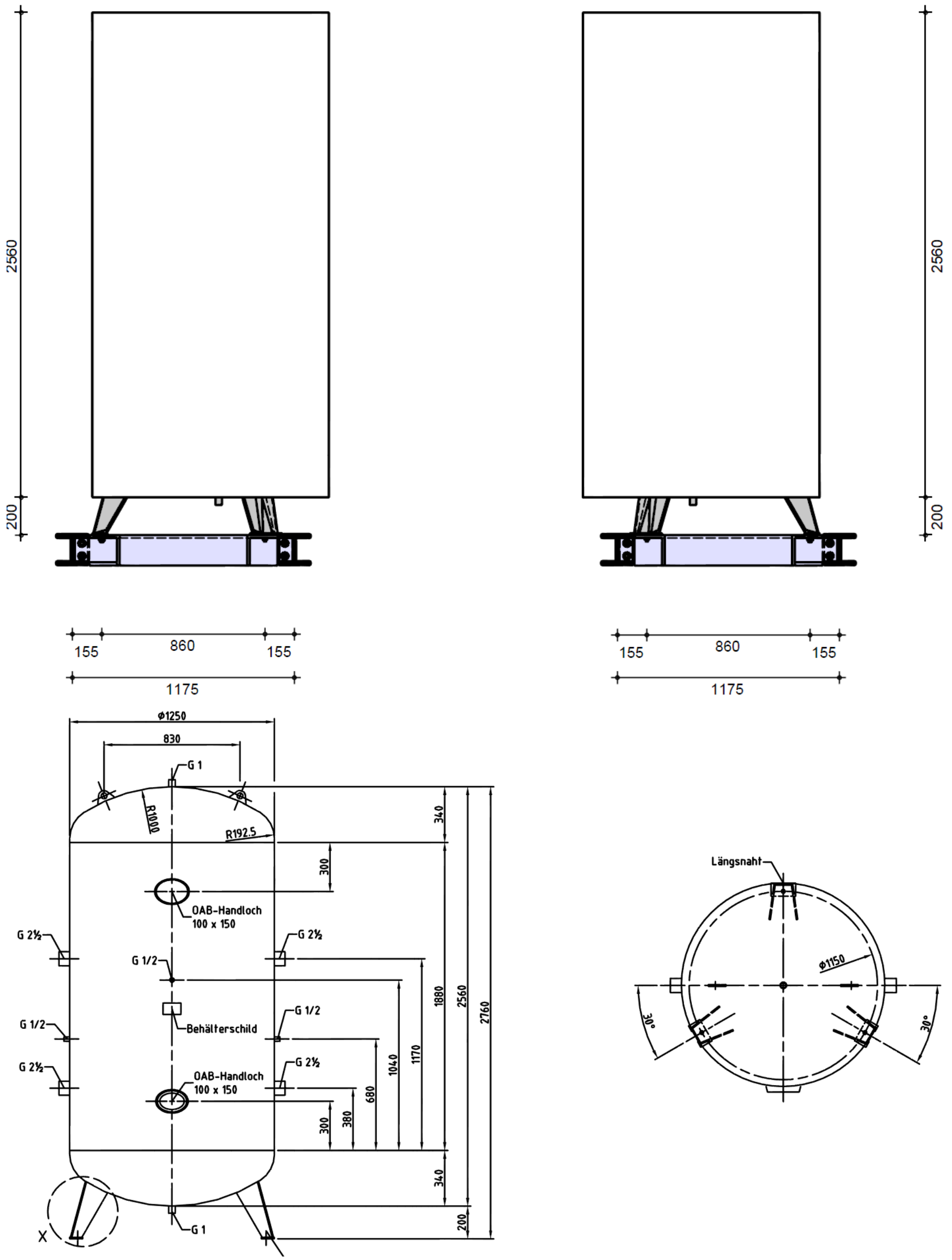


Figure 4: Vertical tanks (further details: Annex E)

2.2 Material parameter

Material characteristics of the components used are given in Table 2.1.

Table 2.1: Summary of material characteristics

Element	Material	Yiels strength	Young's modulus Shear modulus
Structure	S355-EN	355 N/mm^2	210.000 N/mm^2 81.000 N/mm^2
RC clab	C40/50		E = 35.000 N/mm^2 G = 14.600 N/mm^2
Tanks	S235-EN	235 N/mm^2	210.000 N/mm^2 81.000 N/mm^2
Pipes	P235GH/1.0345	235 N/mm^2	210.000 N/mm^2 81.000 N/mm^2

2.3 Masses of installations

Material characteristics of the components used are given in Table 2.1.

First storey	
Vertical tanks	M_g = 0.62 t (dead load), $M_F \approx$ 2.4 t (filling)
Cabinet C-1	0.14 t
Second storey	
Horizontal tanks	M_g = 0.3 t (dead load), $M_F \approx$ 0.75 t (filling)
Third storey	
Piping	See ***Annex G - Pipes***

3. Outline of the system identification and shake table tests

3.1 Static analysis and system identification

In the first step the eigenfrequencies of the structure and the installed vertical tanks are measured. The measured results are compared with the simulated frequencies of the participants provided in ***Report A: Model Information and System Identification.*** Furthermore, accelerations and displacements are compared at selected points of the structural system. Beside accelerations and displacements, Von-Mises stresses at the bottom of two columns and at two positions in the pipes, will be compared. These values should be inserted in ***Report B: Simulation results of the shaking table tests***.

3.2 Shaking table tests on the specimen

Two specimen configurations will be tested. The tests are carried out on the shaking table in the Laboratory of the EUCENTRE in Pavia-Italy. The characteristics of the shake table are:

Dimension:	5.6 m x 7.0 m
Peak acceleration:	1.8 g with 60 t playload
Maximum playload:	140 t
Peak velocity:	2.2 m/s
Required sampling rate:	256 Hz
Max. Displacements:	d = +/- 500 mm
Max. velocity:	v = 2200 mm/s

Additional information can be found at the website (https://www.eucentre.it/?lang=en). Input motions will be introduced to the shaking table in one direction, parallel with the moment frames. No vertical or rotational motions will be introduced to the shaking table.

3.2.1 Applied seismic actions

Artificial accelerogram used in the test is provided in ***Annex H – Accelerogram***. The accelerogram correspond to a standard Eurocode 8 elastic spectrum for ground type C, a_{gR} = 0.635g. The accelerogram was generated with a with trigonometric window function for a duration of 25s, a time step of 0.00391s, a rise time of 2s, a strong motion phase of 13s and a decay phase of 10s. The accelerogram is scaled to match different levels of peak ground acceleration (PGA) that are used as input signals for the shake table test.

3.2.2 Sequence of shaking table tests

Different levels of PGA will be imposed to the mockup. Actually, during the test program, a series of tests with small PGA levels will be performed for the shaking table tuning. All levels of PGA applied to the structure are shown in Table 2.

Table 2: Test runs and corresponding PGA levels

RUN	% LEVEL	PGA Level
1	ACC8_25%	0.159g
2	ACC8_37%	0.235g
3	ACC8_50%	0.318g
4	ACC8_37%	0.235g
5	ACC8_70%	0.445g
6	ACC8_100%	0.636g
7	ACC8_111%	0.706g

4. Rules and evaluation methodology

Template for the first report to be submitted is provided in ***Annex A – Report A: Model Information and System Identification.*** The second report to be provided by each participant includes the simulation results of the shake table tests. The simulation results of each participant must be summarized and submitted using the document ***Annex B – Report B: Simulation results of the shaking table tests*** and ***Annex I - Measurement points***.

All information regarding the SPIF–2020 may be obtained from the following website:

https://www.cwe.rwth-aachen.de/en/projects/earthquake-engineering-projects/spif/

A contest submittal may be from an individual or a team. One individual can be involved in only one team or as an individual. If an individual is part of a team, the individual may not submit separately as an individual. All data will be provided in SI units.

5. Important dates

2nd April 2020	Announcement of the SPIF–2020 and distribution of the documents with all required information.
31th May 2020	**Deadline for registration: SPIF–2020 International Contest.**
1st July 2020	Submission ***Report A: Model Information and System Identification.***
15th July 2020	Distribution of ambient vibration measurements of the three story steel structure and components. The measurement data can be used for the model calibration.
1st October 2020	***Report B: Simulation results of shaking table tests.***
31th October 2020	Information about the results of the SPIF–2020 International Contest. Provision of measurement data and final report by the coordinator.

6. Final remarks

The registered participants will be informed in case of alterations in the model detailing or in the definition of the input motions. If you have any questions regarding the SPIF – 2020 Contest, please do not hesitate to contact the coordinator:

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