Project Name: WALOWA
Notes on data postprocessing of impact loads
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1. Impact load measurement

The pressures were measured by pressure sensors flash mounted over the wall height. The forces were measured by load cells attached to a measurement plate flash mounted with the wall (Figure 1).

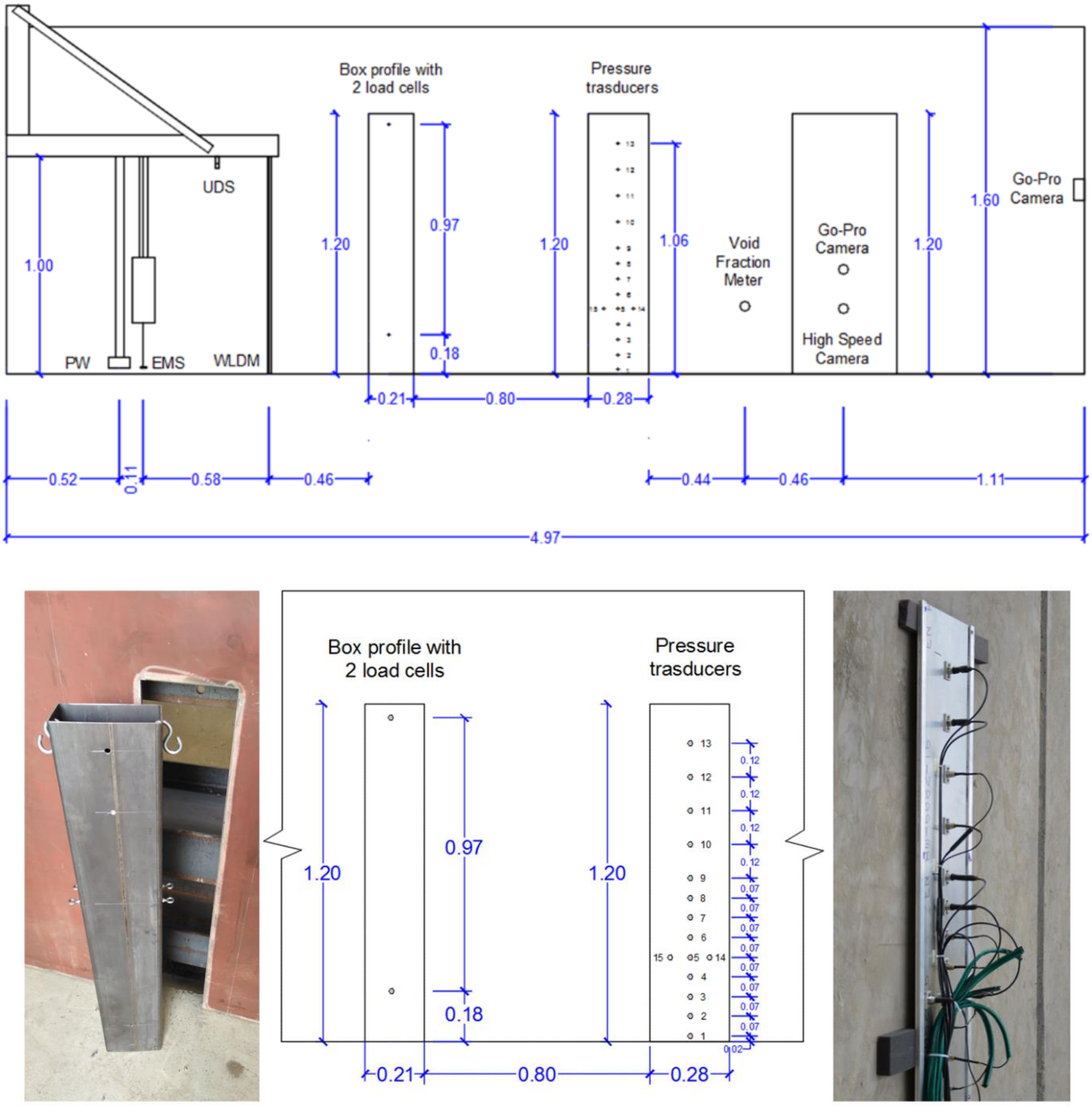


Figure 1: Wall set-up and measurement location pressure sensors and load cells.

The time series for force and pressure measurement was post-processed in three steps for all data-sets. The processing routines were implemented in Matlab and termed Impact-Analysis-Toolbox (IAT).

2. Filtering of impact loads

First, any long duration drift was removed from the signal using the 'detrend' functionality in Matlab. Furthermore an offset correction was applied, by fitting a polynomial best-fit line to the lower values of the time-series (the noise band, not including the force peaks) and subtracting the polynomial best-fit line from the time-series. In this way the entire time-series was shifted towards zero.

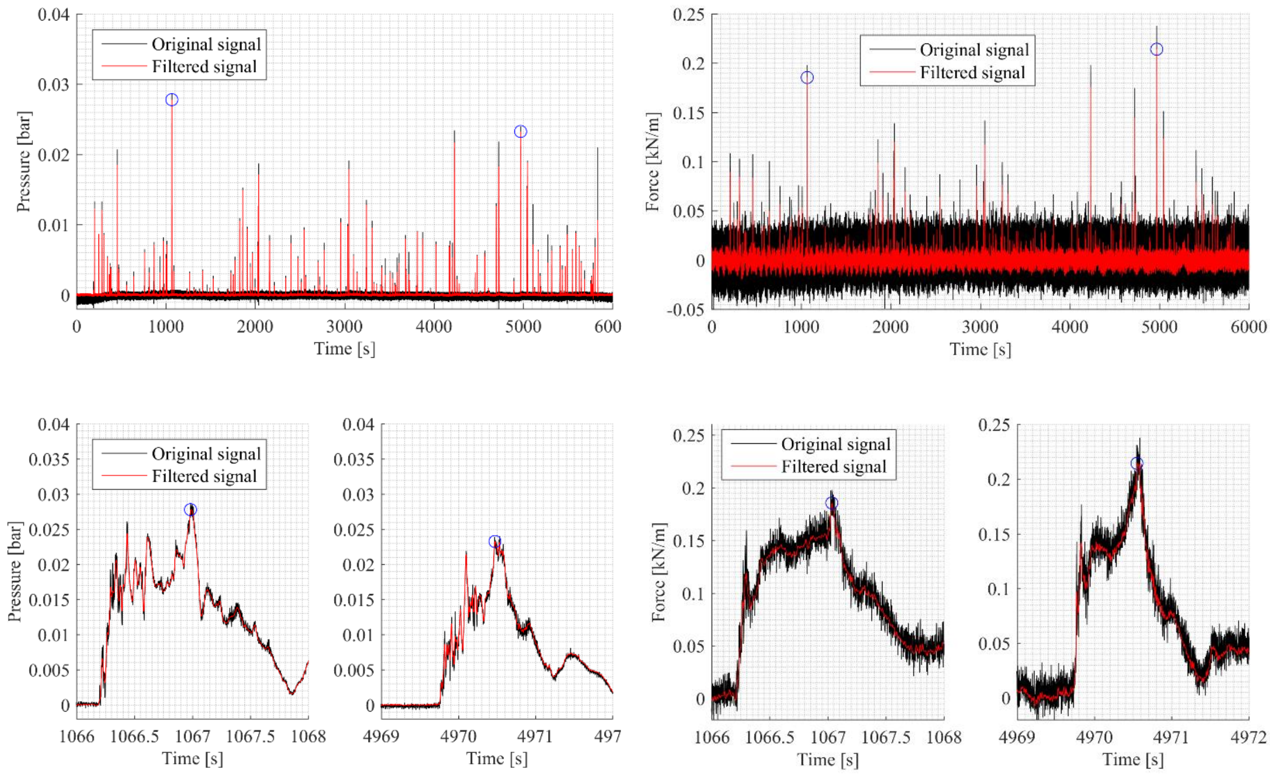


Figure 2: Pressure (left) and force (right) time-series before (black) and after filtering (red). A zoom on the two highest impacts was provided in the lower figures. The signal from the lower load cell (0.18m above the promenade) and the signal from pressure sensor P3 (0.16m above the promenade) of test Irr_4_F was displayed.

The time-series was then transformed into frequency domain with fast Fourier transformation and a set of frequency components and their according energy density obtained. In frequency domain the filters were set, to remove phenomena related to model effects (for example electronic current frequency, natural frequency of the measurement system/wall) from the time-series. A band-stop filter around 50Hz was used and for the load cells a low-pass filter at 100Hz to stay below the natural period of the measurement system. A Butterworth filter design of 4^{th} order was used. A reduction in force peaks after filtering was observed. Anyhow, a zoom on the two largest force peaks showed, that the reduction occurred within the noise band of the measurement. Generally, the noise bandwidth of the load cell measurement was higher compared to the pressure sensor measurement. Figure 2 showed the signal of pressure sensor 3 (installed approximately at the same height as the load cell measurement in Figure 2) before and after filtering. A zoom on the two largest pressure peaks showed that also for the pressure sensor signal the reduction in pressure peaks was within the noise bandwidth of the measurement.

The time-series of filtered impact force signals for the two load cells KRM1 and KRM2 are given in <Testname>_KRM_filtered.txt. The time-series for the 15 filtered pressure sensor signals DPO1-DPO15 are given in <Testname>_DPO_filtered.txt.

3. Summation of force and integration of pressures

Second, the signals of the two load cells, attached to the same measurement hollow steel profile, were added. The sum was divided by the width 0.2m of the measurement plate to obtain a horizontal force per meter width value. The pressure sensor signals from the 13 vertically spaced pressure sensors were integrated over the height of the pressure plate in this step. Rectangular pressure integration was applied using half the distance below and above a pressure sensor Δi, together with the measured pressure from location Pi (see Figure 3 and Equation 1).

$$F = \left(P_1 \cdot \frac{\Delta_1}{2}\right) + \left(P_{13} \cdot \frac{\Delta_{12}}{2}\right) + \sum_{i=2}^{12} P_i \cdot \frac{\Delta_{i-1} + \Delta_i}{2} \quad [\frac{N}{m}] \qquad \text{[Equation 1]}$$

The value from the lowest pressure sensor (P1) was assumed from the location of P1 until halfway between P1 and P2. The integration for the highest pressure sensor (P13) was done using half the distance between P12 and P13. The result was a horizontal force per meter width value. Comparing the time-series of integrated pressures and force measurement it was noted that the integrated pressure time-series showed a lower noise bandwidth, which was the effect of the generally lower noise bandwidth in the individual pressure sensor signals (compare Figure 2).

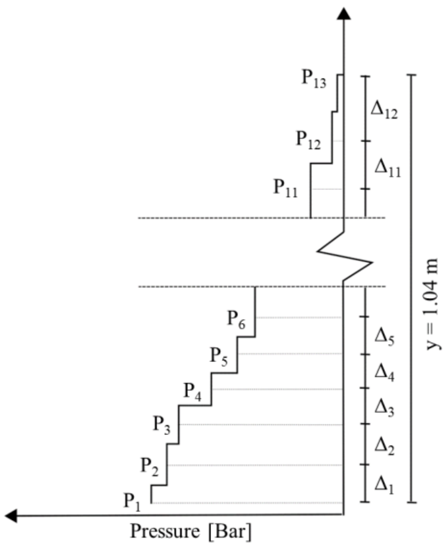


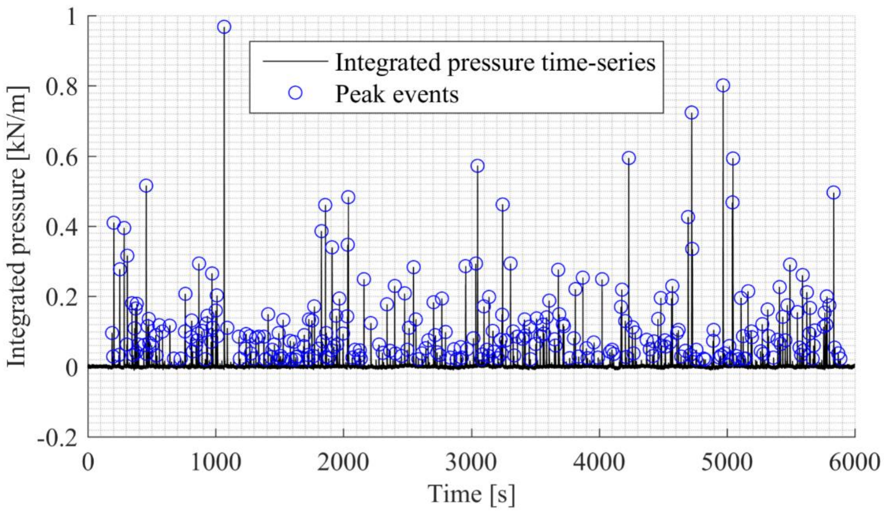
Figure 4: A total horizontal force from the pressure sensor signals was obtained by applying rectangular pressure integration. The distances Δi and pressures Pi were used during the calculation.

The force time-series of the sum of the tow load cells KRM1 and KRM2 is given in <Testname>_KRM_sum.txt. The force time-series from pressure integration and sensors DPO1-DPO13 is given in <Testname>_DPO_sum.txt.

4. Peak detection

Third, a half-automatic peak detection method was applied and the key events from the filtered time-series selected. A minimum time between force peaks was set to 2s. A high-pass threshold was set for each test as low as possible without entering the noise band in the signal.

The peak impact force and according time for each impact event is given in <Testname>_KRM_events.txt (force from the sum of the two load cells) and in <Testname>_DPO_events.txt (force from pressure integration).



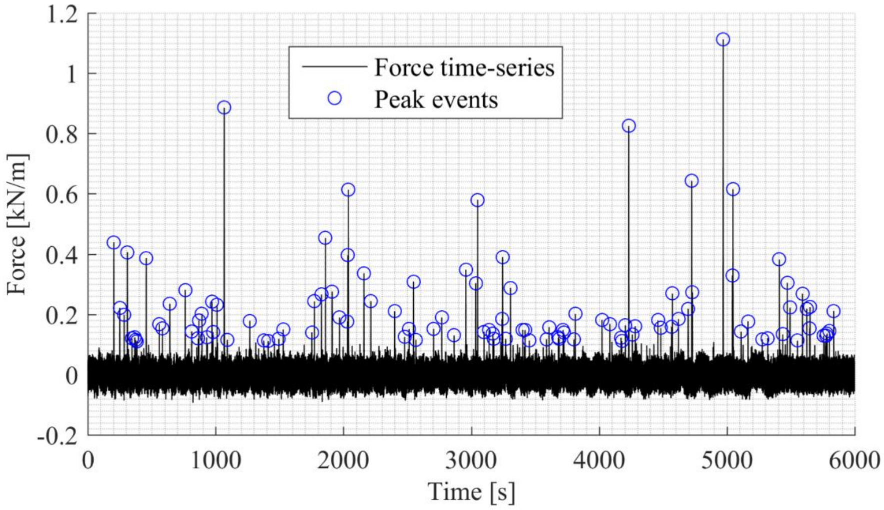


Figure 5: Selected peak events for test Irr_4_F for the integrated pressures (upper figure) and force measurement (lower figure).