## Concluding shake table tests of the Elephant Foot - seismic shock absorber from old tires:

By Ingemar Sävfors, 2016-03-31

The concluding shake table tests February 2016 at the Indian Institute of Technology, Guwahati have now been evaluated by Professor James Kelly, Department of Civil and Environmental Engineering, University of California, Berkeley:

"…The results are consistently favorable and they get better as the carried load increases. There is always some reduction from table to specimen (*Elephant Foot*) never any amplification. But *with higher load the reductions are excellent.* I think you can consider these results as definitive and begin the process of bringing the concept to the attention of the authorities in Nepal…
…I think you have got as much as you need from the shake table tests at Guwahati to publicize the system. Very best regards. JMK. "

**Short recapitulation of the test set up in Guwahati**

We configured four tires, one in each corner of the 2.5 x 2.5m shake table and confined them with timber frames. On each tire a precast Elephant Foot was mounted. On top was placed a steel plate of the same dimension as the table. The load was increased from 800 kg (by the top plate itself) up to totally 1600 kg. This shake table is operating only in the x-axis. However, the horizontal forces are the most devastating in an earth quake and the most relevant to measure.

Hence, 400 kg per tire, makes 7 kN per running meter if the tires are placed in the foundation ditch one after the other. This represents the proportional weight of a brick/hollow block wall, including a concrete foundation beam and a roof structure with corrugated sheets. This is by far the most typical construction mode in poor urban areas.

The first test series in September 2015 resulted in a revised design of the Elephant Foot. The main objective was to increase the pressure distribution over the whole tire.

Preselection of the most common tire sizes is an important procedure. In India a rim size of 13"-14" is predominant and hence the corresponding tires the most likely to find in abundance.

There are also important differences in the compression strength to investigate. Much depends on the steel content in the so called *steel belted radial tires.* A worn out pattern on the tire surface is irrelevant if the steel inside is intact and not corroded.

**The latest results**

In February 2016 the IIT, Guwahati carried out some 20 shake table tests simulating three historic earth quakes:
El Centro, CA, USA, 1940 (48 sec),
Koyna, India 1967 (38 sec)
Mexico City, 1985 (82 sec).
The load on the table was increased from 800 kg (by the top plate itself) up to totally 1600 kg. Scaling was applied from 0.5 to 1.0.
To get an overview from the some 17,000 records in the 20 Excel files, Professor Anjan Dutta, IIT has summarized the results as follows:

----------"Shake table testing was done for seismic response of specimen plate, with and without load, supported on elephant foot foundation system which was again supported on used rubber tyres.

Testing was done on 02.02.2016 for three earthquake records viz. the Elcentro (1940), Koyna (1967) and Mexico City (1985) ground motions. The table below has been prepared for comparison of the results obtained and the plots of the result data are shown in the subsequent pages.

| Earthquake | Test Condition | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No Load | | | | | | 400 kg load | | | | 800 kg load | | | |
| | Scaling factor | | | | | | Scaling factor | | | | Scaling factor | | | |
| | 0.50 | | 0.75 | | 1.00 | | 0.50 | | 1.00 | | 0.50 | | 1.00 | |
| | TA | SA | TA | SA | TA | SA | TA | SA | TA | SA | TA | SA | TA | SA |
| Elcentro 1940 PGA 0.32g | 0.29 | 0.27 | 0.54 | 0.31 | 0.72 | 0.46 | 0.33 | 0.23 | 0.52 | 0.46 | 0.41 | 0.20 | 0.69 | 0.45 |
| Reduction % | 6.9 | | 42.6 | | 36.1 | | 30.3 | | 11.5 | | 51.2 | | 34.8 | |
| Koyna 1967 PGA 0.49g | 0.34 | 0.30 | --- | --- | 0.83 | 0.46 | 0.29 | 0.25 | 1.16 | 0.51 | 0.30 | 0.25 | 1.16 | 0.55 |
| Reduction % | 11.8 | | --- | | 44.6 | | 13.8 | | 56.0 | | 16.7 | | 52.6 | |
| Mexico City 1985 PGA 0.17g | 0.20 | 0.12 | 0.26 | 0.17 | 0.44 | 0.25 | 0.19 | 0.13 | 0.42 | 0.25 | 0.22 | 0.14 | 0.46 | 0.26 |
| Reduction % | 40.0 | | 34.6 | | 43.2 | | 31.6 | | 40.5 | | 36.4 | | 43.5 | |

TA – Table acceleration, in g

SA – Specimen acceleration, in g " ----------

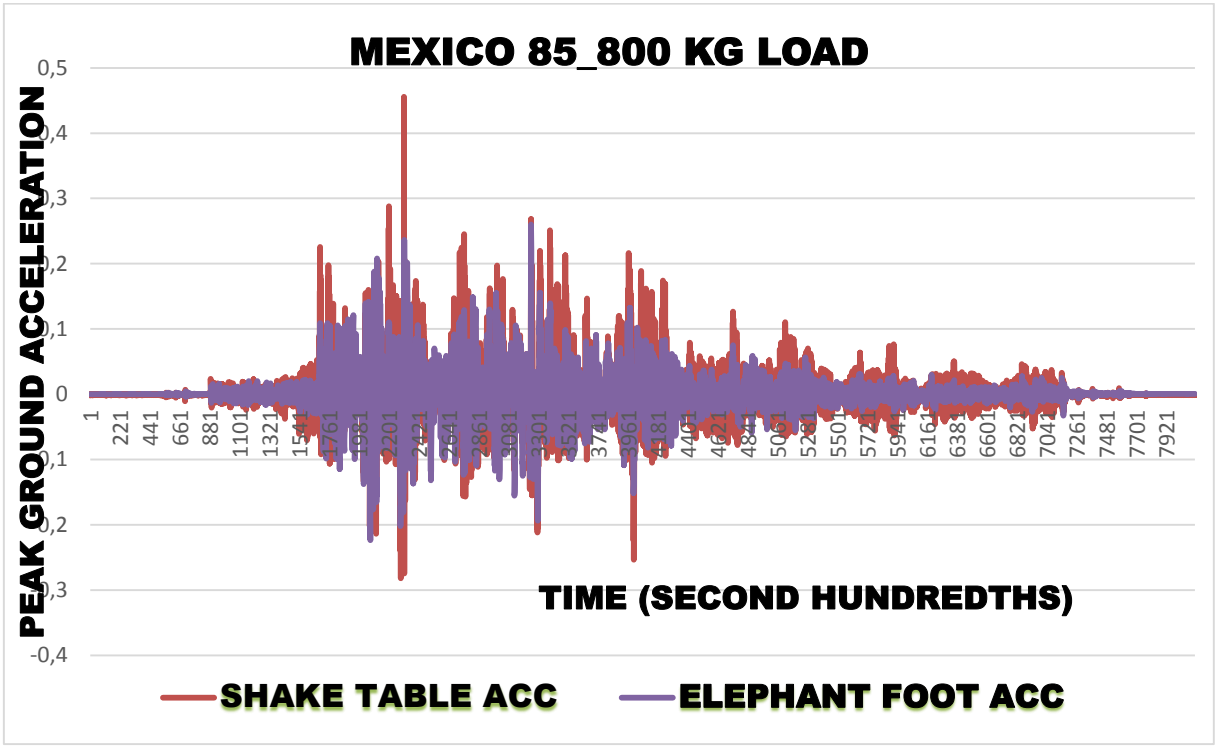
**Conclusions**

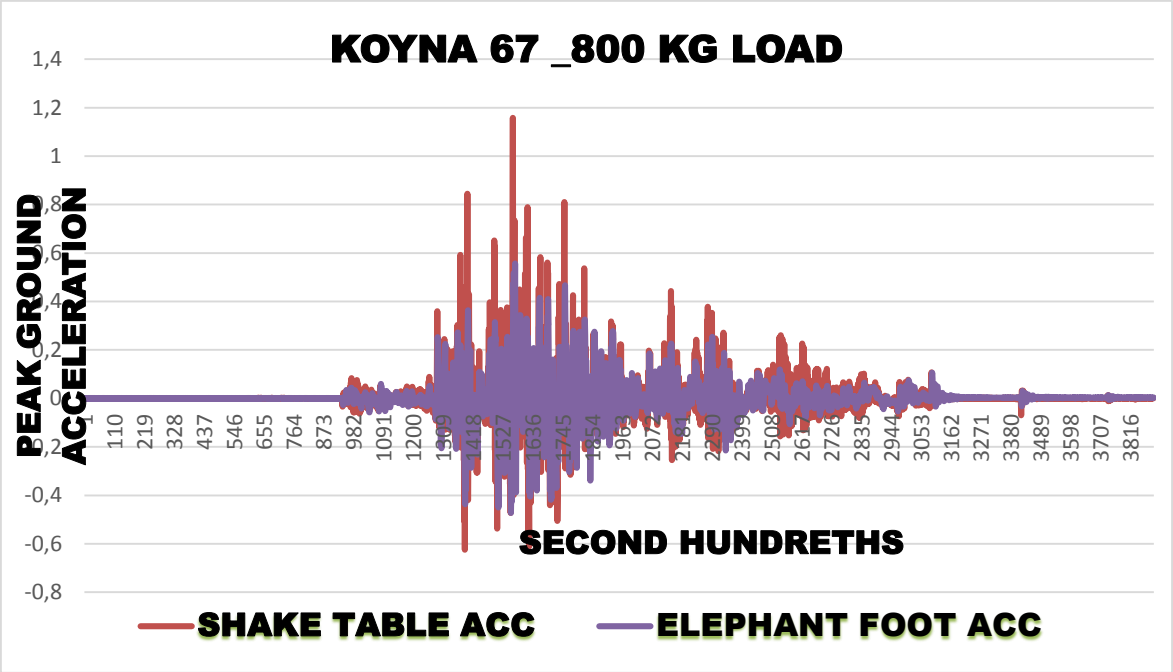
The performance of the Elephant Foot gets better with an increased weight. Over 52% reduction of the Peak Ground Acceleration was attained at the full scale test with the Koyna earth quake simulation.

The next research target should seek the maximum weight a used tire can take if systematically selected.

However, already now the capacity attained should be enough for construction of one level house foundations.

Some significant graphs:



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