Example of Successful Noise Abatement: Compacting Machines for the Production of prefabricated Concrete Parts

Martin Liedtke[1)] and Ralf Hertwig[1)]

Introduction

Looking at occupational diseases in Germany the highest number of approved cases is found for occupational hearing impairment. 6197 cases were reported by the German Gewerblichen Berufsgenossenschaften (Institutions for statutory accident insurance and prevention for industry) in the year 2000. The Berufsgenossenschaften are responsible for more than 43 million insured persons and reported in total about 16 thousand approved occupational diseases in 2000. About 8.5 % of insured persons are employed in the construction industry. But in this industry about 23 % of the approved cases of occupational hearing impairment were found. By that it is obvious that construction industry is still today one main focus of hearing impairment caused by occupational exposure to noise.

This paper deals with noise abatement at compacting machines. More detailed information was published by Saemann et al. [1985], Saemann [1989], Elmer [1992], and Arnold et al. [1973].

Noise abatement in construction industry

In construction industry noise abatement is often a difficult job: In many situations productive procedures cannot be substituted by noise reduced techniques; frequently the noise cannot be decreased at the source; furthermore the noise propagation cannot be reduced; and even in case there is a new noise reduced technology available it has to be successful under the severe conditions to be found in construction industry. An example for very successful noise abatement as described here is rare in construction industry.

Workplace situation at conventional vibrating compactors

In general flat parts like walls and ceilings but also bridge support, pipes, garages and stairs can be constructed from prefabricated concrete parts. In this study only flat parts like walls and ceilings up to dimensions of 15 m length, 3 m width, and 10 tons weight are considered. Those flat parts are from 5 to 10 cm thick. The workplaces at compacting machines are found in plant halls of 100 to 150 m length, 30 to 50 m width, and 8 to 12 m height. At the compacting machines employees' main activity consists of preparation of forms, e.g. positioning of sides, insertion of reinforcement, and preparation of built-in parts or sectors. Up to ten tables are used in one plant hall.

A main component of noise exposure in the production of prefabricated concrete parts is the sound emission generated by the vibrating form for concrete. The compacting period per part is about two to three minutes where an exposure of L_{Aeq} = 100 to 120 dB is found. Already several compacting processes result in a total sound exposure L_{Ar} (A-weighted noise rating level) of more than 90 dB(A). Although the period of compacting concrete is short the noise rating level is frequently found to exceed 90 dB(A). Those rating levels indicate the risk of hearing impairment. In plants with circular production, where 20 - 30 compacting processes per work shift are obtained, even higher exposure is observed.

Technical details of conventional vibrating compactors

Beneath the table of a conventional vibrating compactor unbalanced exciters - as shown in Figure 1 - are used to produce vibrations in the range of 50 to 200 Hz. Frequently they are electrical powered. To obtain a good transmission of vibrations to the concrete, exciters are fixed to the form in a way to generate bending waves in the form which result in accelerations in vertical direction. The accelerations necessary to compact concrete is 1.5 to 20 times of g (g: acceleration due to gravity, g = 9.81 m/s²).

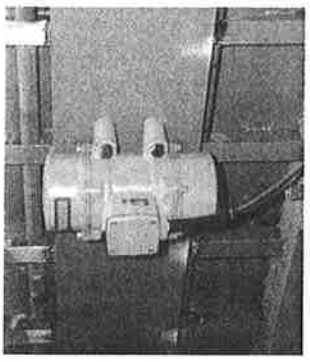

Figure 1: View from the bottom of a conventional vibrating compactor. One unbalanced electrical powered exciter can be seen.

For the compacting process one frequency of excitation would be sufficient. But not only the intended effective frequency is excited but also a broad band of vibrations at high frequencies resulting in high sound levels and therefore in a basic acoustic problem. In the sound pressure spectrum shown in Figure 4 high levels at 80 Hz (excitation frequency) as well as high levels at 2000 Hz are detected. The A-weighting of sound pressure spectra results in a quantum corresponding to the risk for a population to devel-

[1)] *Berufsgenossenschaftliches Institut für Arbeitsschutz (Institute for Occupational Safety and Health) - BIA, e-mail: martin.liedtke@hvbg.de*

op hearing impairment. Low frequency components are less critical for humans. The total sound pressure level is determined by high frequency components which are ineffective to the compacting process. Therefore the target is to reduce effects which are not useful for the production process: Decrease of ineffective high frequency components.

Noise reduced vibrating tables

A lot of studies have been performed with partly success in noise abatement, for example modification of vibrators, use of cave compactors. Most projects resulted in negligible reduction of employees' noise exposure. Therefore the situation in plants for the production of prefabricated concrete parts didn't change for a long time.

Based on calculations a new tilting table was designed. Using a large number of vibrators operating with a phase shift of 180 ° (= p) in relation to the adjacent vibrator sound levels during compacting process were reduced below 85 dB(A) as measured in 1985. To lower costs the number of vibrators was reduced by using shafts running the unbalanced exciters as shown in Figure 2.

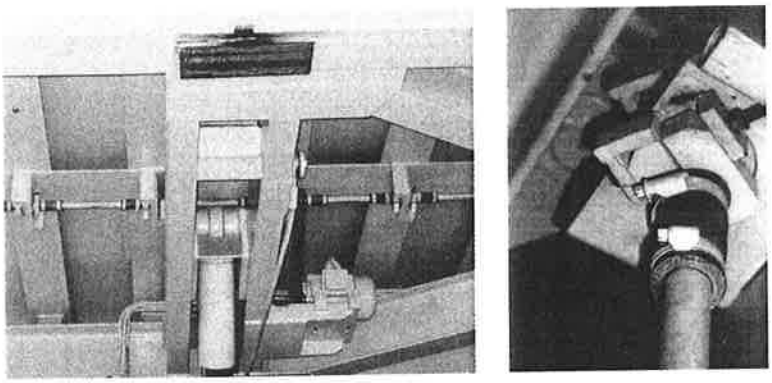

Figure 2: View from the bottom of a noise reduced vertical-shaking table. The vibrators operate with a phase shift of 180° (p) in relation to adjacent vibrators. On the right side one unbalanced exciter driven by a shaft is shown.

Figure 4 shows noise reduction especially in the frequency range 1000-4000 Hz, where human hearing is most sensitive. The noise reduction obtained is obvious.

A new principle: Horizontal shaking

Up to now, all compacting techniques were based on vibration. Another concept to obtain noise reduced compacting is the use of shaking in horizontal direction: Shaking is carried out as well in longitudinal axis as transverse axis and for electrical powered shakers sometimes in circular movement.

Shaking frequency and amplitude depend on the size of concrete parts to be produced, e.g. frequency: 5-20 Hz, amplitude: up to 12 mm. Excitation is performed also by hydraulic or electric power.

Horizontal shaking tables

Figure 3 presents the design of a tilting table shaking in horizontal direction. One of the four unbalanced exciters is shown. For compacting concrete horizontal shaking results in the advantage of very low sound emission during the compacting process.

By use of rod-spring (as shown in Figure 3) or rubber buffers a special ability of oscillation is obtained. Because of this special ability there is no additional resistance to movement except the moment of inertia. Therefor the excitation of the form itself is low. Furthermore the sound emitting surface in horizontal direction is small.

In 1994, the first sound measurement was carried out. The result of equivalent continuous sound pressure level of less than 70 dB(A) was astonishing (s. Figure 4). To measure sound generated only by the horizontal shaking table all other sound sources had to stop operation.

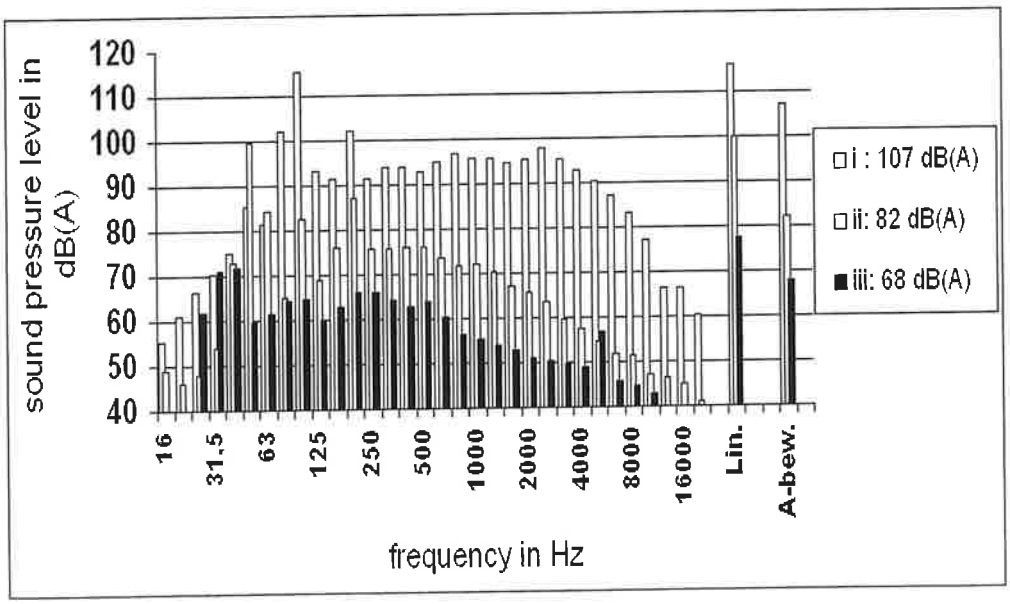

Figure 4: Comparison of sound pressure spectra for application of different compacting techniques: i) Conventional vibrating table, ii) noise reduced vibrating table, and iii) horizontal shaking table.

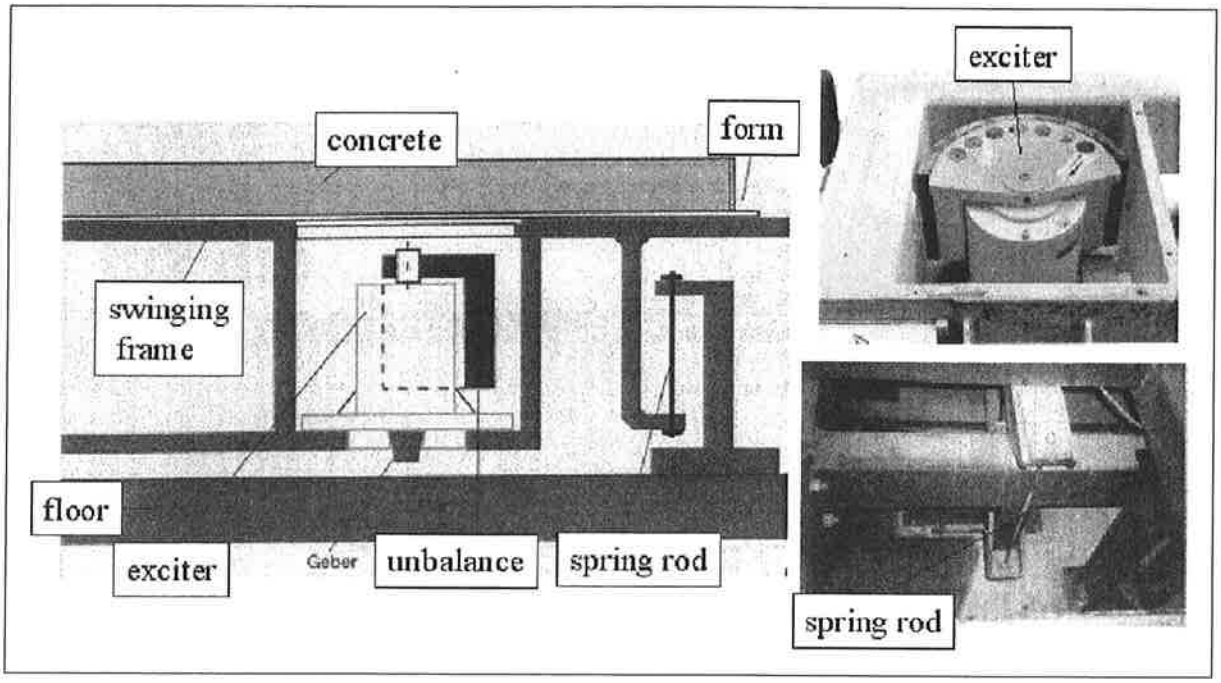

Figure 3: Drawing of a horizontal shaking table. On the right side one of the four unbalanced exciters is shown. At the bottom of this figure the rod-spring resulting in the special ability of oscillation is presented.

Conclusion

By application of noise abatement measures to conventional vibrating machinery in use for compacting prefabricated concrete parts the sound generation and emission can be reduced evidently. In case conventional machinery is replaced by noise reduced vibrating forms or low noise shaking forms for concrete the reduction of sound emission obtained may be up to unbelievable 40 dB(A). Step by step the new technique is introduced at workplaces in Germany. Because traditional compactors are still in operation also noise reduction has still to be applied to old compactors. Actual and future developments are focused on application of the new technique to production of other prefabricated concrete parts apart from flat parts like walls and ceilings.

References

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