03 Jun 1993, 4:30 pm - 5:30 pm

Discussions and Replies Session 4

M. R. Svinkin
Goble Rausche Likins and Associates. Inc., Cleveland, Ohio

G. M. S. Manyando
Woodward-Clyde Consultants St. Louis, Missouri

M. R. Lewis
Bechtel Corporation Palm Beach Gardens, Florida

J. R. Davie
Bechtel Corporation Palm Beach Gardens, Florida

X. J. Yang
4th Design and Research Institute, Ministry of Machinery and Electronics Industry, China

See next page for additional authors

DISCUSSIONS AND REPLIES
SESSION IV

Discussion by M. R. Svinkin
Goble Rausche Likins and Associates, Inc., Cleveland, Ohio, USA

on
Vibrations Due to Pile Driving

Paper No. 4.01

Piling operations are powerful sources of construction vibrations that often affect surrounding structures and harmfully influence sensitive devices and people. Presented paper is addressing the problem of making preliminary analysis to correctly evaluate potential problems which may arise at the time of pile driving. Authors use reliable practical approach for assessment expecting structural vibrations: for the most cases the peak particle velocity (PPV) of structural vibrations is less than allowable limits of 2 in/sec on distances exceeded 10 feet from pile installation. However, it is necessary to monitor the vibrations during pile driving. The comparison of predicted and measured PPV has shown in the paper. Prediction was made on the base of Wiss's so-called "scaled-distance" approach that is very useful for assessment of construction generated vibrations. Before prediction PPV preliminary measurements were done to refine values of n and k.

It should be pointed out that scaled distance approach has been developed for better practical applications. Woods and Jedele (1985) performed extensive field measurements for a source-energy study. These results were used by Svinkin (1992) in order to predict soil vibrations from pile driving. Velocity-distance-energy relationships for pile driving is shown in the Figure 1 below. Demonstrated plots were constructed with pile actual PPV (Y-axis), pile material and transferred hammer energy taken into account. On the basis of these plots limit curves of the expected PPV can be derived for various distances from pile driving source and different magnitude of transferred energy.

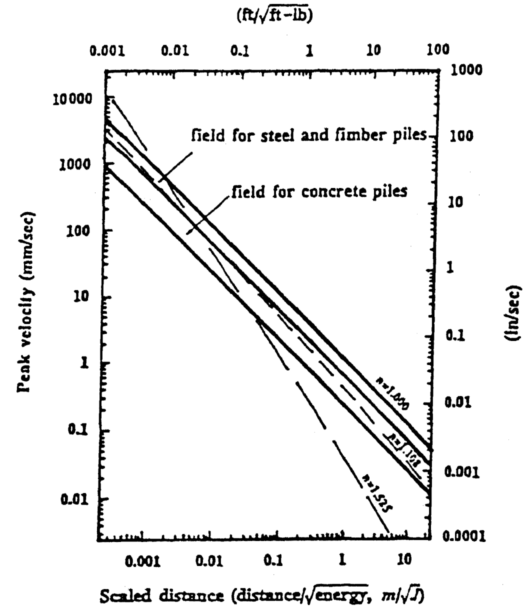

Fig.1 Peak ground velocity versus scaled distance for pile driving

The frequency is also important parameter of ground vibrations. Svinkin (1992) suggested simple formula to calculate the main frequency of ground vibrations. This frequency depends on the pile material, the ratio of wave velocity in the pile to pile length and the pile weight to ram weight ratio.

It can be agreed with authors that inspection of nearby structures has to be done before and during pile installation. It is necessary to assess correctly conditions of structures during pile driving operations. Similar case history was described by Svinkin (1993).

Reference

Svinkin, M.R. (1992), "Pile driving induced vibrations as a source of industrial seismology", Proc. of the Fourth Intern. Conf. on the Application of Stress-Wave Theory to Piles, The Hague, The Netherlands, pp.167-174.

Svinkin, M.R. (1993), "Analyzing Man-Made Vibrations, Diagnostics and Monitoring", Proc. of the Third Intern. Conf.on Case Histories in Geotechnical Engineering, St. Louis, pp.663-670.

Woods, R.D. & Jedele, L.P. (1985), "Energy-attenuation relationships from construction vibrations", Proc. ACSE Symp. Vibration Problems in Geotechnical Engineering, Detroit, pp:229-246.

Discussion by Dr. G.M.S. Manyando
Woodward-Clyde Consultants
St. Louis, Missouri

on
"Vibrations Due to Pile Driving"

Paper No. 4.01

The authors have presented values of K and n for a first approximation of the peak particle velocity (PPV) in the equation by Wiss (1981). They would also recommend the use of hammer transferred energy rather than rated hammer energy in the predictive equation.

On the basis of the presented data the recommendations are quite reasonable. The predicted PPV for distances of 150 and 250 are very close to the measured values. This is however not the case for predictions at distances of 3,000 or 3,200 ft where the predicted values are more than two times the measured values. Although at such distances the magnitudes of the PPVs are small and may be of no consequence to non-sensitive structures, the comparison at distances of less than 100 ft from the vibrations, which this discussant considers more critical, has not been addressed. It would appear that such a comparison could provide a better validation for the authors' recommendations.

It also appears that at a distance of 5 ft from the source the predicted PPV will be equal to or less than the commonly accepted 2 ips threshold. Would the authors comment on the use of this equation for predicting PPVs in the vicinity of young concrete?

Discussion by M. R. Svinkin
Goble Rausche Likins and Associates, Inc., Cleveland, Ohio, USA

on
Combined Isolation Foundation by Elastic Base Plate and Ground Barriers

Paper No. 4.04

This paper presents interesting results of a decrease in vibration level of a supporting plate under a sensitive and large semi-anechoic chamber. The chamber was mounted on the flexible concrete plate underlying with sand cushion and pile barriers used around the plate. Proper design of the flexible plate together with noncontinuous pile barriers provided the amplitude of the chamber floor under the action of dynamic load from testing vehicle in the allowable range.

Actually, only a screening effect was used for decreasing outside ground vibrations. The diminishing of vibrations for the account of the flexible plate laid on sand cushion was the result of soil-structure interaction. This was not vibration isolation.

The amplitude of the plate vibrations excited by four large tractors was 0.142 mm and this value is surprisingly close to plate amplitude of 0.124 mm from background with no disturbing source. Vibration transmission ratio of 0.229 for maximum exiting sources characterizes relatively weak decreasing of vibration effect. However, authors have noted the obtained vibration level was quite satisfactory for the sensitive chamber. Unfortunately information about natural frequencies of actual flexible plate and frequencies of measured vibrations is missing from the paper. It makes sense to keep in mind that the pile screening is not effective enough for vibrations with low frequency and gives inadequate reduction of vertical and horizontal component of the vibrations.

Some remarks do not bring down the quality of the work carried out. This is a good practical example for reduction of disturbing vibration level.

Discussion by M. R. Svinkin
Goble Rausche Likins and Associates, Inc., Cleveland, Ohio, USA

on
Rock Music Induced Damage and Vibration at Nya Ullevi Stadium

Paper No. 4.07

This paper presents an interesting case history about dangerous ground and structural vibrations excited by new contemporary kind of dynamic load created during rock music concert. Observed dynamic effects were impressive. The only ground vibrations with amplitude of displacement between 2 and 20 cm were unclear because these values did not correspond to vibrations with frequency of 2.4 Hz and maximum velocity of 24 mm/sec. Authors put forward hypothesis that the audience on the pitch excited clay layer from the ground surface and then, using numerical analysis, they explained high vibration levels developed during the concert by resonance of the soil deposit. High vibration levels were observed in the stadium structures, ground and surrounding buildings. Perceptible vibrations of buildings situated 400 m of the stadium could be explained by resonance of the buildings because exciting frequency of 2.4 Hz is very close to frequency range 2-5 Hz that corresponds the first mode of natural horizontal vibrations of multistory and toll one story buildings. Similar case has been described by Svinkin (1993). Dangerous ground and structural vibrations were induced by twenty-five thousand people standing on the field in the front of a stage. Obviously, those vibrations were amplified by pile foundations with low frequency of natural horizontal vibrations that could be very close or coincide with exciting frequency of 2.4 Hz. From the other hand, frequency of vertical natural vibrations of pile foundations is on the order larger the horizontal one. Indeed, thirty-five thousand people on the stands apparently jumped in time with the music. Even though, they did not create structural and ground vibrations, they themselves suffered from vibrations transferred from the audience on the pitch.

Probably, in the principle, three solutions are possible to eliminate the resonance of clay deposit and decrease vibration levels during the rock music concert.

At first, since particular reinforcement of clay deposit with relatively short lime columns decreased the vibration level on just 15-20 %, it can be suggested to make network of driven piles with length to bedrock. Artificial field for soccer may be laid on beams supported only by piles without contact with ground surface.

Secondly, low frequency vibration isolation can be considered. Unfortunately application of this method on a huge area is very difficult.

Thirdly, artificial field for soccer may be laid on a concrete slab underlying by sandy base. The thickness of the slab and sandy base has to be chosen in order to prevent resonance vibrations of clay deposit. These values should be calculated and verified through the dynamic test. Perhaps, it is the most economical feasible solution.

Reference

Svinkin, M.R. (1993), "Analyzing Man-Made Vibrations, Diagnostics and Monitoring", Proc. of the Third Intern. Conf.on Case Histories in Geotechnical Engineering, St. Louis, pp.663-670.

Replies by M.R. Lewis and Dr. J.R. Davie
Bechtel Corporation
Palm Beach Gardens, Florida

on
"Vibrations Due to Pile Driving"

Paper No. 4.01

The authors wish to thank the discussers for their interest in the paper. With respect to the comments by Svinkin, we agree that frequency is an important parameter and that field monitoring should be performed. These were two important conclusions reached in the paper. Further, the data presented by Svinkin and that presented by the authors are in good agreement.

Regarding the comments by Manyando, the authors believe that the predictive method described in the paper does address distances of less than 100 feet. Nevertheless, reliance on a predictive technique alone is not recommended. As described in the paper, monitoring (including use of instruments and visual walkdowns) of structures is essential. The use of a predictive technique simply alerts the designer that vibrations may be a concern.

The predictive equation given in the paper, or any other such equation can be used to predict peak particle velocity in the vicinity of freshly placed concrete. The question is what minimum distance should be maintained between piles being driven and freshly placed or "green" concrete. Our studies did not address this issue; however, the authors would suggest that distances on the order of 25 feet are not unreasonable. Fuller (1983) and Hulshizer (1992) discuss this topic at some length.

Fuller, F.M., (1983), Engineering of Pile Foundations, McGraw-Hill, Inc., pp 133-134.

Hulshizer, A.J., (1992), "Shock Vibration Effects on Freshly Placed (green) Concrete," ACI Committee 231 Session; Properties of Concrete at Early Strengths, American Concrete Institute, Arlington, VA.

Replies by X.J.Yang, G.Y.Gao
4th Design and Research Institute, Ministry of Machinery and Electronics Industry,China

on

Combined Isolation Foundation by Elastic Base Plate and Ground Barriers

Paper No.4.04

The flexible plate laid on sand cushion

The elastic plate on sand cushion could be used for decreasing outside ground vibration. The diminishing of vibrations for the account of the flexible plate laid on sand cushion was the result of soil and structure interaction. The elastic plate on sand cushion is here used as a barrier. With their energy ,the incident waves out of the plate or under the cushion are transmitted through the soil to the elastic plate which has a higher wave velocity and a longer wavelength (base period) than the soil, then a certain amount of the wave energy will be reflected and then traveled away. Further theorical analysis could be read in the references of J.E.Luco, H.L.Wang(1976) and W.A.Haupt(1977) following this reply.

The transmission ratio

The vibration tranmission ratio of 0.229 for maximum exiting sources characterizes relatively effective decreasing of vibration effect.The data shows that the vertical vibration reductive effect of the barrier is of the order of 77.1%. The result is very ideal and beneficial for practical use. The wave barriers are considered effective in reducing vibration if the amplitude reduction factor (ARF,in this paper described as Tu) is 0.25 or less (R.D.Woods,1968;S.Prakash,1988; F.E.Richart,Jr. et al 1970).

The vibration level of the sensitive chamber

It was described in table 1 and Fig.5 of the paper, and it was quite satisfactory for the sensitive chamber.

The vibration isolatoin effectiveness by pile barriers

The measurments were conducted before sand cushion and elastic plate had not been constructed. The transmission ratioes provided in the paper were merely the effectiveness of pile barriers. The pile barriers are very effective enough for screening to the low frequencys vibrations in the chamber.

REFERENCES

Haupt,W.A., 'Surface-waves in nonhomogeneous half-space', Proc.DMSR77, Vol.I Karlsruhe, P.P.335-367,(1977).

Luco,J.E.,Wang,H.L., Proc.6th World Earthqu. Engn.,(1976).

Prakarsh,S.,Puri,V.K.,Foundations For Machines : Anaslysis and Design, JOHN WILEY and SONS New York,1988.

Richart,F.E.Jr., Woods, R.D., Hall, J.R.Jr., Vibrations of Soils and Foundations,PRENTICE-HALL,INC. Englewood Cliffs,New Jersey, 1970.