DOI 10.52209/1609-1825_2023_1_226 UDC 624.131.55

Vibration Monitoring of Driving Piles on the an Existing Foundation

[1]**ZHUSSUPBEKOV Askar,** *Dr. of Tech. Sci., Professor, astana-geostroi@mail.ru,*
[1]***TLEULENOVA Gulshat,** *PhD, Acting Associate Professor, gulshattleulenova23@mail.ru,*
[1]*NPJSC «L.N. Gumilyov Eurasian National University», Kazakhstan, Astana, Satpayev Street, 2,*
**corresponding author.*

Abstract. *The purpose of the scientific work is to determine the smallest permissible distance of the pile driving device, excluding vibration impact on the foundation and ensuring the safe operation of the plant. The authors presented the effect of vibromonitoring from «New water treating facilities W1 area». The results of the vibration effect of pile driving at various distances from the foundation, taking into account the natural fluctuations of technological processes, the massiveness of the foundation, etc., as well as the results of the excitation of the soil mass itself at different distances from the source of the vibration impact (clogging) are presented. Vibration monitoring was carried out by the Profound VIBRA+ device, using a 3D seismic sensor. Vibration measurement was carried out every 5 seconds. The tests were carried out according to the requirements of DIN 4150-3, according to which the maximum permissible vibration level is 5.00 mm/s (from 0-10 Hz).*

Keywords: *driving of piles, vibromonitoring, testing, piles, distances, vibrations, sequence, testing program, fixed, natural fluctuations, seismic sensor.*

Introduction

Construction site «New water treating facilities W1 area» is located in Atyrau, Westerly Eskene (Figure 1).

Testing on site was performed from 15 to 25 June 2021. There are 5 tested locations to monitor vibration effects which are being caused by an 3 piles driving (Figure 2).

The vibrations on the construction site «NEW WATER TREATING FACILITES WP1 AREA» being caused by driving rig Junttan PM 25. On site are several vibration sources present being: Grader, Excavator, Loader.

The main purpose of the testing was to monitor the vibrations on different distances from the excitation source which are being caused by a pile driving rig Junttan PM 25 with hydraulic hammer of 7 ton of weight and drop height up to 1.0 m [1-2].

Prefabricated piles are concrete 40x40 cm and length of 12 m.

Table 1 presented technical characteristic of piles, cross section.

Description of equipment

Equipment is Profound VIBRA+ system, manufactured in The Netherlands. For all 5 locations the DIN/SBR mounting plate has been used.

System setup is monitoring job. Measuring interval is 5 second. In testing use normative standard [3]. Alarm level is 5.00 mm/s from 0-10HZ. Alarm type is smart velocity (frequency depending alarm; for higher frequencies a higher velocity is allowed).

Geophone is 3D geophone, belonging to Profound VIBRA+ system.

Research methods

Testing program

Location 1 (Pile LTP-1): 87 meters away from the driving rig and during the driving Pile 1 (LTP-1). The geophone was fixed to block of Turbo compressor foundation. Monitoring was performed before (16-17 hours of pile driving) to monitor vibration of compressor itself and during the pile driving.

Location 2 (Pile CTP-1): 88 meters away from the pile driving rig during the driving Pile 1 (CTP-1). The geophone was fixed on panel foundation before (to monitor vibration being caused by plant itself) and during the piles driving (Figure 3).

Location 3 (Pile TTP-1): 75.7 meters away from the pile driving rig during the driving 1 (TTP-1). The geophone was fixed on foundation estocade before to monitor vibration being caused by plant itself and during the piles driving (Figure 4).

Location 4 (Pile TTP-1): 89 meters away from the pile driving rig during the driving Pile 2 (TTP-1). The geophone was fixed on foundation estocade before to monitor vibration being caused by plant itself and during the piles driving.

Location 5 (Pile TTP-1): 69 meters away from the pile driving rig during the driving.

(TTP-1). The geophone was fixed on foundation estocade before to monitor vibration being caused by

Figure 1 – Construction site «New water treating facilities W1 area»

Table 1 – Pile information

Pile	Pile 1, LTP-1	Pile 2, CTR-1	Pile 3, TTR-1
Cross section, cm×cm	40×40	40×40	40×40
Pile length, m	12	12	12

plant itself and during the piles driving [4].

Result and Discussion

According to the requirements of DIN 4150-3, the maximum permissible vibration speed at a frequency of up to 10 Hz is 3 mm/s, according to British Standards Institution BS 7385 – 5 mm/s [4-6].

The X-direction of the geophone was pointing in the direction of the Pile driving rig (Fig. 5-6).

The pile driving and vibration monitoring sequence is presents in table 1.

The vibration impact characteristics were measured in 3 directions (planes) X, Y, Z. At the same time, the X axis was oriented towards the source of excitation (pile driving). Figure 5 shows the test results.

Figure 5 shows the measurement of the vibration velocity at the time of the tests.

Figure 6 shows the frequency velocity. The test results are also presented in the table 1, where the numerical values of the maximum speed indicators before scoring and during scoring for each of the positions in three directions are given.

Values of peak particle velocity (mm/s) as you

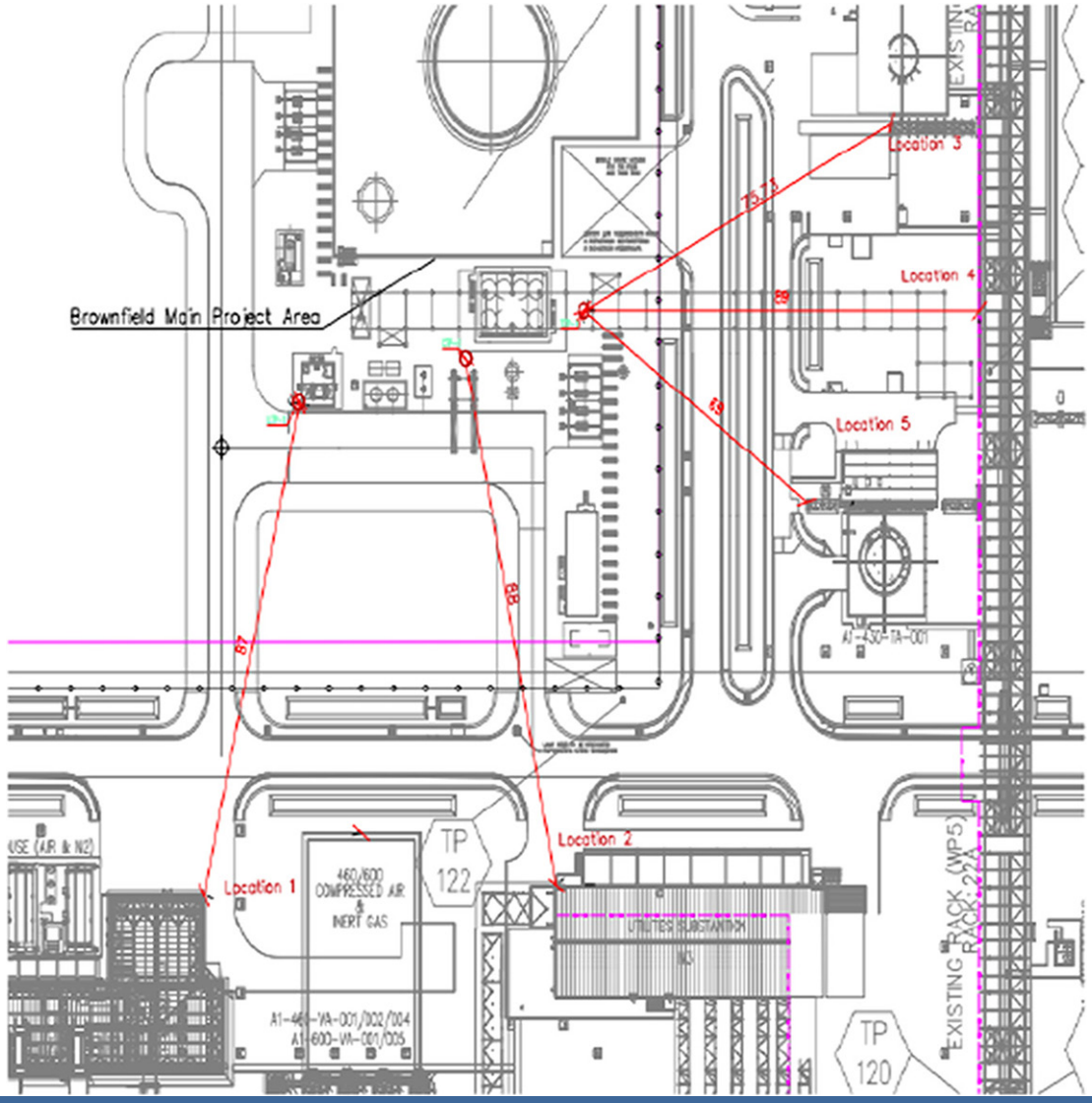

Figure 2 – Layout of tested pile area

Figure 3 – Location 2

Table 2 – Pile driving and vibration monitoring sequence

NEW WATER TREATING FACILITIES WP1 AREA Pile Driving & Vibration Monitoring sequence			
Drive Pile	Take Vibration Test on Pile	Distance (approx) m	Comments
	Compressed Air & Inert Gas	87	Take background vibration readings on pump foundation before or after pile driving Vibration monitor fixed to foundation block
LTR-1	Compressed Air & Inert Gas	87	Vibration monitor fixed to foundation block
CTR-1	Utilities substation 3	88	Vibration monitor fixed to foundation plate
TTP-1	Sideline estocade	75.73	Vibration monitor fixed to foundation block
TTP-1	Axis estocada	89	Vibration monitor fixed to foundation block
TTP-1	Sdenline estocade	69	Vibration monitor fixed to foundation block

Figure 4 – Location 3

Table 3 – Vibration monitoring before driving/during the driving piles of max velocity

№	Measurement / Location	No driving / Driving	Max velocity	X	Y	Z
1	Measurement 1 Location 1	No driving	-	0.2	0.11	0.26
2	Measurement 2 Location 1	Driving Pile LTP-1	before driving	0.06	0.08	0.07
			during the driving	0.31	0.3	0.91
3	Measurement 3 Location 2	Driving Pile CTP-1	before driving	0.08	0.06	0.07
			during the driving	0.26	0.29	1.19
4	Measurement 4 Location 3	Driving Pile TTP-1	before driving	0.10	0.07	0.06
			during the driving	0.17	0.16	0.15
5	Measurement 5 Location 4	Driving Pile TTP-1	before driving	0.15	0.05	0.14
			during the driving	0.64	0.35	0.27
6	Measurement 6 Location 5	Driving Pile TTP-1	before driving	0.09	0.05	0.09
			during the driving	1.45	0.98	1.61

move away from the source of excitation for every 10 m. The values of peak particle velocity (hereafter – PPV, mm/s) along the vertical y axis (perpendicular to the wave propagation axis), in the horizontal x axis (wave propagation axis). It can be seen from the graphs that the peak values of the vibration effect (both on the x-axis and on the y-axis) when driving piles fall to a depth of 4 to 8 meters, which is explained by the presence of a more elastic and durable layer represented by stable soil [4-9].

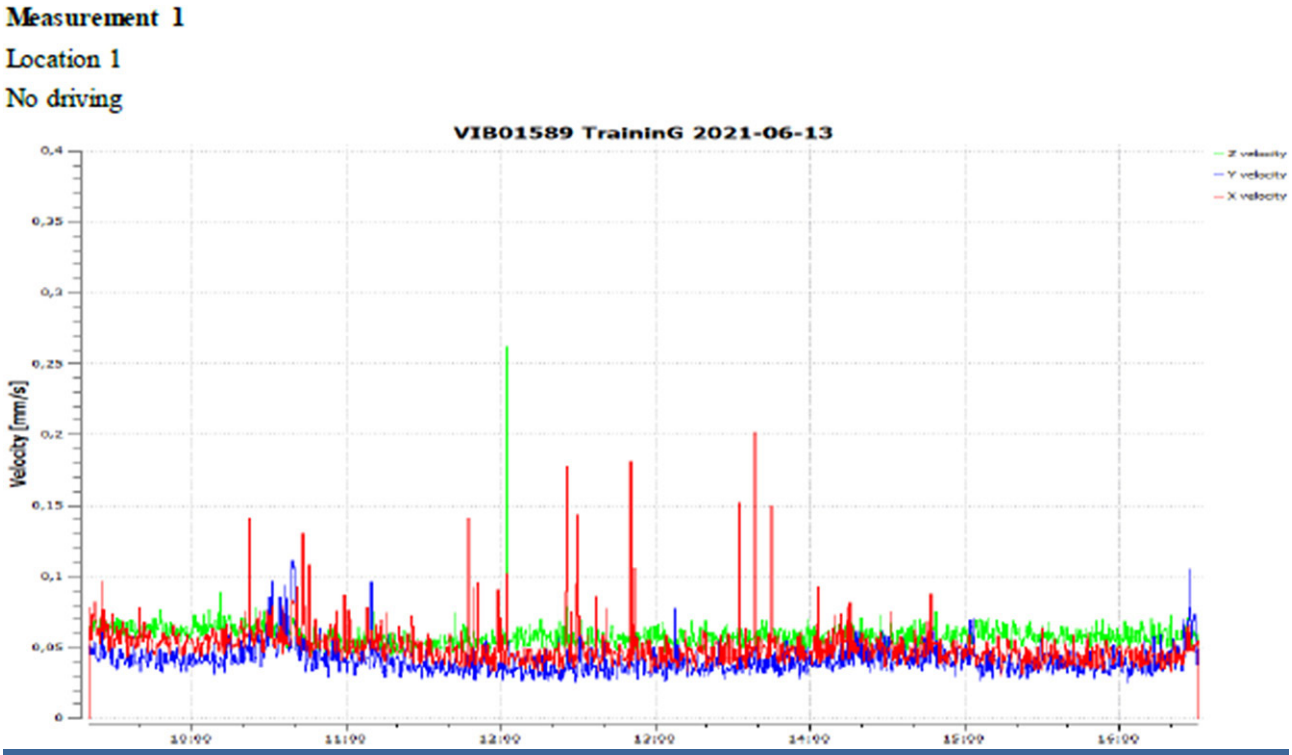

Figure 5 – Velocity & time diagram

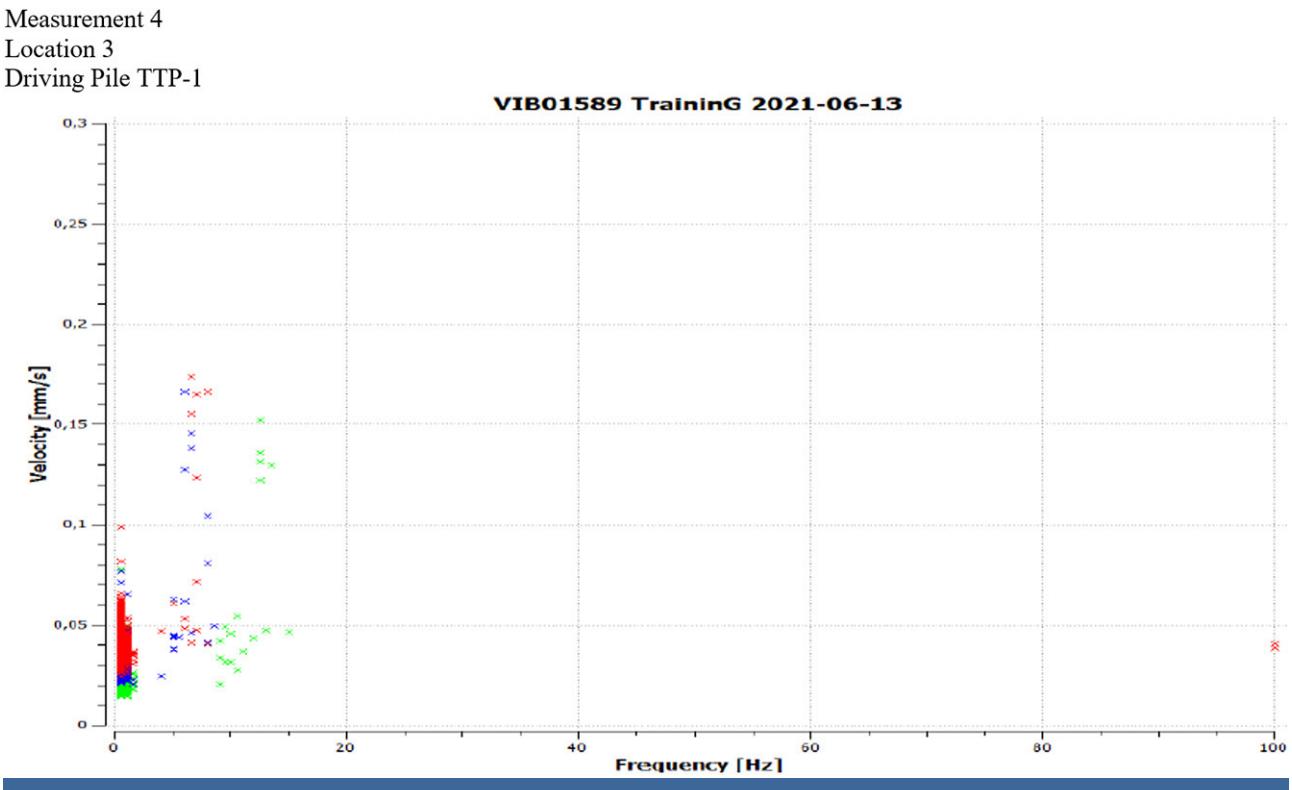

Figure 6 – Velocity & frequency diagram

Conclusion

Measured vibration velocity of plant itself equal: z=0,26; y=0,11; x=0,20. The highest value of vibration velocity was fixed in z direction – vertical axes (Diagram of measurement 1).

Influence of pile driving to the compressor foundation is relatively small: z=0,91; y=0,30; x=0,31 for plate foundation (87 m away from the driving rig) and z=1,19; y=0,29; x=0,26 for single pile CTP-1 (63 m away from the driving rig). It is explained by the massive foundation which is partially damping the vibration effect.

The highest values of vibration velocity during the driving were measured at the middle of pile driving (about 5 to 6 m of pile length).

According to the standard the vibration rate during pile driving is within the permissible range.

Natural vibrations do not have a significant effect on the change in the vibration effect. Taking into account the massiveness of the foundation plate, pile driving has practically no vibration effect on the safe operation of a functioning complex at a distance of more than 63 m.

REFERENCES

1. Report of vibration monitoring. KGS-Astana, Project: PU-341 Sour Gas Dehydration, Atyrau, 2012. – 32 p.
2. Report of vibration monitoring. KGS-Astana. Project: New water treating facilties WP1 area, Atyrau, 2021. – 31 p.
3. DIN 4150-3. Vibrations in construction, Germany, 2001. – 12 p.
4. Lukpanov, R., Awwad, T., Tsygulev, D., Zhumadilov, I. Numerical modeling and natural research of the influence of piling filling on the existing base of the functioning oil and gas complex // Vestnik SU Shakarim, Volume 2, 2019. – Pp. 207-213.
5. Dowding, C.H. Blast Vibration Monitoring and Control: Textbook. – NJ: Prentice Hall Inc., 1996. – 620 p.
6. Zhussupbekov A.Zh., Omarov, A.R. Analysis of effect of pile driving on the existing foundation. // Bulletin Construction and Architecture, Volume 7, 2016. – Pp. 132-138.
7. SNIP RK 5.01-03-2002. Pile foundations, Almaty: KazGOR, 2003. – Pp. 27-29.
8. SNIP RK 5.01-01-2002. Foundations of buildings and structures, Almaty: KazGOR, 2003. – Pp. 18-22.
9. Krizek, R.J., Dowding, C.H., Somogyi, F. The Practice of Foundation Engineering: Textbook. – Chicago: Northwestern University, 1985. – 435 p.

Қолданыстағы ірғетасқа қадаларды соғу кезінде діріл мониторингі

[1]***ЖУСУПБЕКОВ Аскар Жагпарович,*** *т.ғ.д., профессор, astana-geostroi@mail.ru,*

[1]****ТЛЕУЛЕНОВА Гульшат Толеувна,*** *PhD, доцент м.а., gulshattleulenova23@mail.ru,*

[1]*«Л.Н. Гумилев атындағы Еуразия ұлттық университеті» КеАҚ, Қазақстан, Астана, Сәтпаев көшесі, 2,*

**автор-корреспондент.*

Аңдатпа. *Ғылыми жұмыстың мақсаты ірғетасқа діріл әсерін болдырмайтын және қондырғының қауіпсіз жұмыс істеуін қамтамасыз ететін қадаларды соғуға арналған құрылғының ең аз рұқсат етілген қашықтығын анықтау болып табылады. Авторлар «Жаңа су тазарту қондырғысы W1» объектісіне діріл мониторингінің әсерін ұсынды. Технологиялық процестердің табиғи тербелістерін, ірғетастың массивтілігін және т.б. ескере отырып, ірғетастан әртүрлі қашықтықтағы қадаларды бітеудің діріл әсерінің нәтижелері, сондай-ақ діріл әсер ету (бітелу) көзінен әртүрлі қашықтықтағы топырақ массасының қозу нәтижелері ұсынылған. Дірілді бақылауды Profound VIBRA+ құрылғысы 3D сейсмикалық сенсорды пайдаланып жүргізді. Дірілді өлшеу әр 5 секунд сайын жүргізілді. Сынақтар DIN 4150-3 талаптарына сәйкес жүргізілді, оған сәйкес дірілдің ең жоғары рұқсат етілген деңгейі 5,00 мм/с (0-10 Гц бастап) құрайды.*

Кілт сөздер: *бітеу, дірілді бақылау, сынау, қадалар, қашықтық, діріл, реттілік, сынақ бағдарламасы, бекітілген, еркін тербеліс, сейсмикалық сенсор.*

Вибромониторинг при забивке свай на существующий фундамент

[1]***ЖУСУПБЕКОВ Аскар Жагпарович,*** *д.т.н., профессор, astana-geostroi@mail.ru,*

[1]****ТЛЕУЛЕНОВА Гульшат Толеувна,*** *PhD, и.о. доцента, gulshattleulenova23@mail.ru,*

[1]*НАО «Евразийский национальный университет имени Л.Н. Гумилева», Казахстан, Астана, ул. Сатпаева, 2,*

**автор-корреспондент.*

Аннотация. *Целью научной работы является определение наименьшего допустимого расстояния устройства для забивки свай, исключающего вибрационное воздействие на фундамент и обеспечивающего безопасную эксплуатацию установки. Авторы представили эффект вибромониторинга на объекте «Новое водоочистное сооружение площадью W1». Результаты вибрационного воздействия забивки свай на различных расстояниях от фундамента с учетом естественных колебаний технологических процессов, массивности*

фундамента и т.д., а также результаты возбуждения самой массы грунта на разных расстояниях от источника вибрационного воздействия (забивания) представлены. Мониторинг вибрации осуществлялся устройством Profound VIBRA+ с использованием 3D сейсмического датчика. Измерение вибрации проводилось каждые 5 секунд. Испытания проводились в соответствии с требованиями DIN 4150-3, согласно которым максимально допустимый уровень вибрации составляет 5,00 мм/с (от 0-10 Гц).

Ключевые слова: *забивка свай, вибромониторинг, испытания, сваи, расстояния, вибрации, последовательность, программа испытаний, фиксированные, свободные колебания, сейсмический датчик.*

REFERENCES

1. Report of vibration monitoring. KGS-Astana, Project: PU-341 Sour Gas Dehydration, Atyrau, 2012. – 32 p.
2. Report of vibration monitoring. KGS-Astana. Project: New water treating facilties WP1 area, Atyrau, 2021. – 31 p.
3. DIN 4150-3. Vibrations in construction, Germany, 2001. – 12 p.
4. Lukpanov, R., Awwad, T., Tsygulev, D., Zhumadilov, I. Numerical modeling and natural research of the influence of piling filling on the existing base of the functioning oil and gas complex // Vestnik SU Shakarim, Volume 2, 2019. – Pp. 207-213.
5. Dowding, C.H. Blast Vibration Monitoring and Control: Textbook. – NJ: Prentice Hall Inc., 1996. – 620 p.
6. Zhussupbekov A.Zh., Omarov, A.R. Analysis of effect of pile driving on the existing foundation. // Bulletin Construction and Architecture, Volume 7, 2016. – Pp. 132-138.
7. SNIP RK 5.01-03-2002. Pile foundations, Almaty: KazGOR, 2003. – Pp. 27-29.
8. SNIP RK 5.01-01-2002. Foundations of buildings and structures, Almaty: KazGOR, 2003. – Pp. 18-22.
9. Krizek, R.J., Dowding, C.H., Somogyi, F. The Practice of Foundation Engineering: Textbook. – Chicago: Northwestern University, 1985. – 435 p.