Gas Processing, LPG Recovery Plant and Allied Facilities at Nashpa Field

Down Hole Seismic Survey

(Report)

Geotechnical Investigation & Survey of Gas Processing, LPG Recovery Plant and Allied Facilities at NASHPA Oil Field

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Zealcon Engineering (Pvt) Ltd.

ZEALCON ENGINEERING PVT. LTD

NASHPA GAS PROCESSING AND LPG RECOVERY PLANT

DOWNHOLE SEISMIC SURVEY REPORT

1. INTRODUCTION

1.1 GENERAL

ZealCon Engineering (Pvt.) Ltd. was commissioned by HBP to carry out a Downhole Geophysical Survey for NASHPA Gas Processing and LPG Recovery Plant Karak, KPK.

The aim of the survey was to determine the in-situ P-wave (Vp_h - Vertically propagating P-wave) and S-wave (Vs_{hv} - Horizontally propagating, vertically polarised S-wave) velocity of the ground material to a maximum depth of 30 m for each borehole. From the measured velocities dynamic elastic modulli could be determined, specifically:

P= Poisson Ratio
B= Bulk Modulus
E= Young's Modulus
G= Shear Modulus

Downhole Seismic measurements were used to record parameters of P-wave and S-wave by utilizing 1No, Tri axial geophone-3, Channel Bison 4000 Digital Seismograph and 10 kg sledge hammer.

2. DESCRIPTION OF THE SITE

The Downhole geophysical survey was conducted within the boundaries of the proposed new NASHPA Gas Processing and LPG Recovery Plant, Karak. The site is located on supper high way Karak, KPK.

Downhole Seismic Survey was conducted in two boreholes, which have been drilled up to the depth of 30 m, installed with 4" PVC casing.

3. SCOPE OF WORK

3.1 Down hole Seismic Survey

Downhole seismic survey is used for determining in-situ compression (P-waves) and shear (S-wave) velocities with depth, which are further used to determining the elastic moduli, like.

- P= Poisson Ratio
- B= Bulk Modulus
- E= Young's Modulus
- G= Shear Modulus

In this method, time for body waves to travel between the surface and points within the soil are measured. Wave velocities are calculated from the corresponding travel times once the travel distances have been determined.

3.2 Methodology

For downhole seismic survey, the boreholes were equipped with 4 inch in Dia PVC pipes up to the depth of 30 meters. The annular space between PVC pipe and borehole wall was grouted with cement and bentonite grout. After giving sufficient time for setting of grout, the downhole seismic measurements were taken in the PVC pipe. For this purpose, a triaxial geophone with air bladder attached to it was lowered into the PVC pipe and clamped at the depth of measurement by inflating the air bladder through air hose. The triaxial geophone was connected to 3-channel Seismograph.

An embedded concrete block with two angle steel rods, perpendicular to each other, was used as a source for generation of shear waves. Schematic diagram of downhole seismic survey is shown on Figure-1.

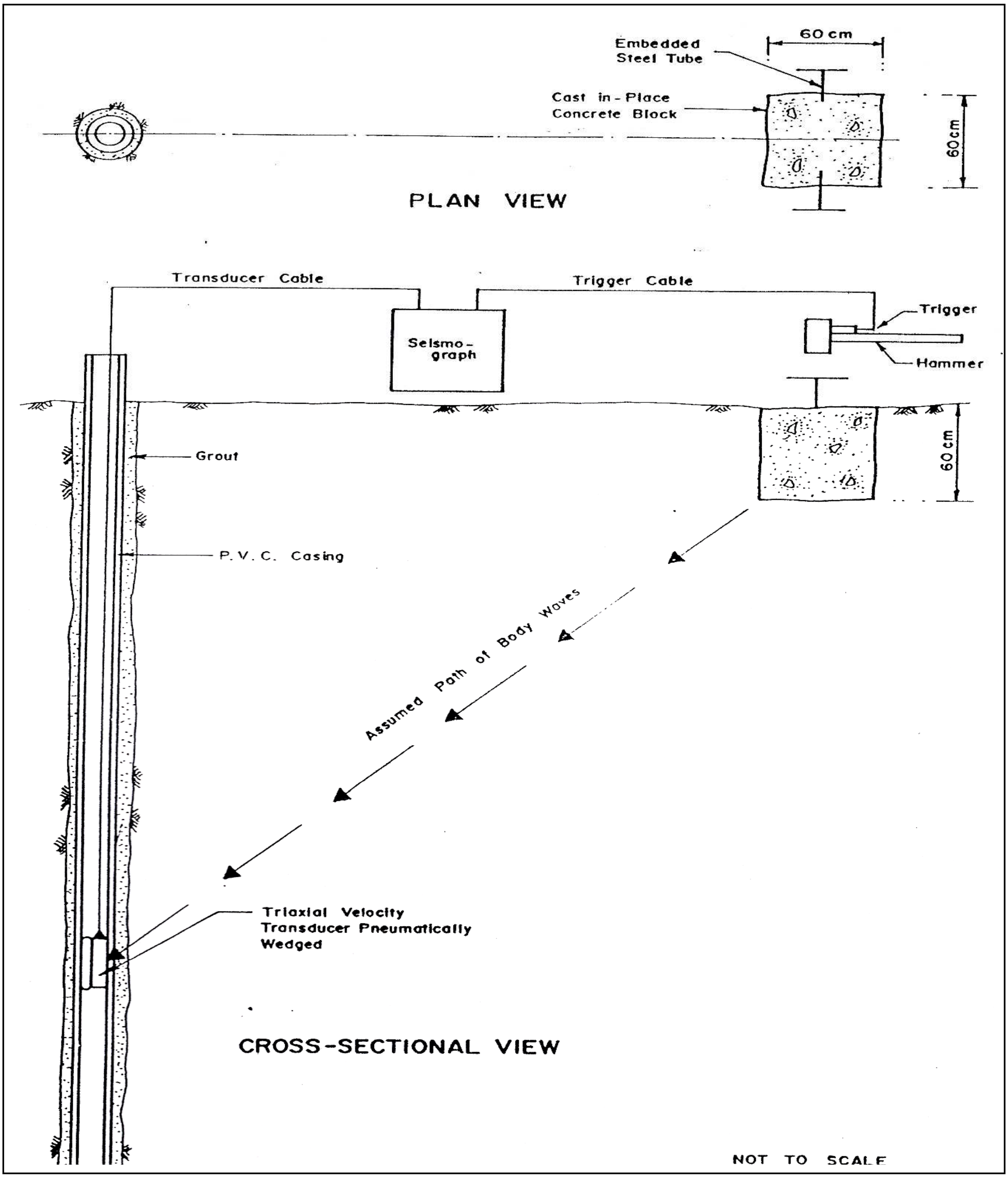


FIGURE- 1. Diagram of Seismic Downhole Survey

Horizontal distance between the downhole source and each borehole was measured and used to obtain downhole source-to-sensor distances. For shear wave measurements using the concrete block source, source-to-sensor distances were measured from the center of the block to each borehole. For compression wave measurements using a steel plate, source-to-sensor distances were measured from the center of the steel plate.

Downhole seismic survey was performed at one-meter interval starting from depth of 1 meters to a maximum depth of 30 meter for each borehole.

At each depth of testing, two sets of compression and polarized shear wave records were obtained. Each set consisted of two records: one record to obtain a general definition of the shear wave, and the other record to obtain an accurate definition of the compression and shear wave arrivals. A typical set of downhole compression and shear wave travel time records is presented on Figure-2.

During the downhole survey, accuracy of the seismograph and triggering system was monitored.

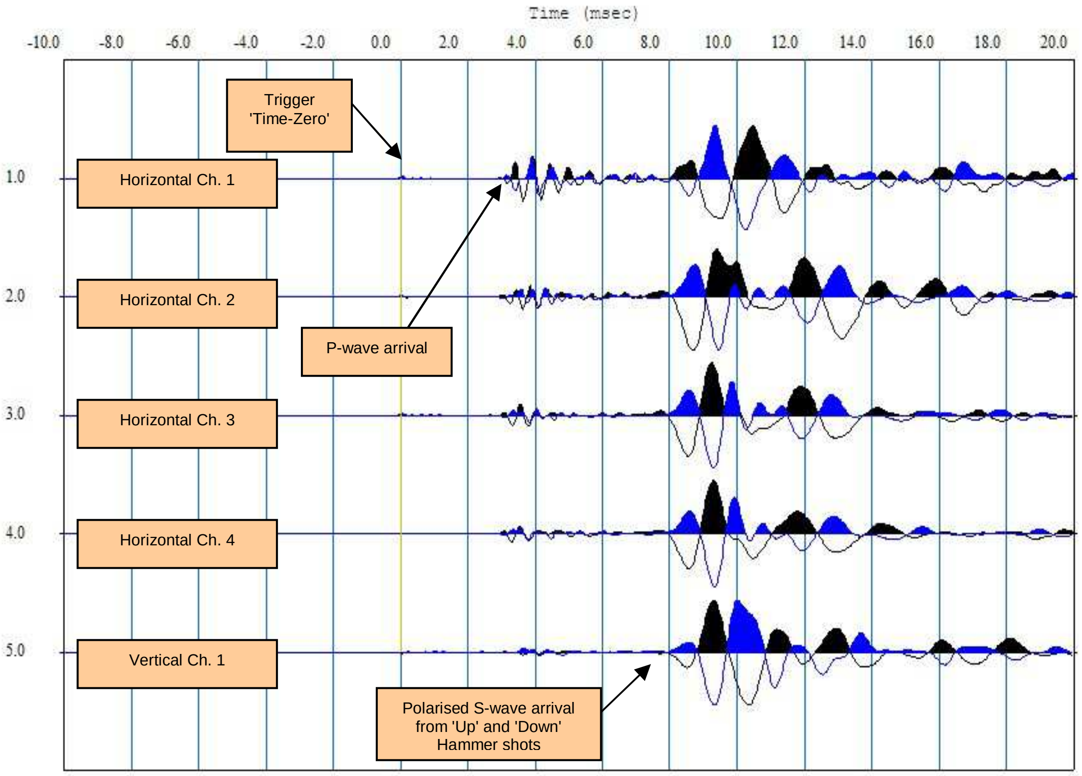


Figure. 2 – Typical Shot Gather from a Downhole Seismic Survey

Data acquisition parameters are normally selected after an initial trial survey of a number of shots. Record lengths and noise filters are tested to provide optimum data quality. A noise test will also be undertaken before survey if the environment proves to be excessively noisy in seismic terms.

3.3 ENGINEERING PARAMETERS

The arrival times of shear waves and longitudinal waves obtained from seismic records were not vertical but had a slanting path as receiver gradually moving downwards at 1m interval for recording and the source was at a distance of 5 meters from the top of boreholes. The measured travel times are plotted against depth for shear as well as longitudinal waves.

Utilizing the P & S-wave velocities determined at each test depth, and bulk density values established from the laboratory tests on samples taken from the boreholes, it is possible to calculate the following engineering parameters:

$$B = d\,(Vp^2 - 1.333Vs^2)$$
$$P = ((0.5x\,(Vp/Vs)^2)-1)/\,((Vp/Vs)^2-1)$$
$$G = d*Vs^2$$
$$E = (2*d)*(Vs^2)*(1+P)$$

Where;

Vp = primary wave velocity (km/sec)
Vs = shear wave velocity (km/sec)
d = density (kg/m^3)
B= Bulk Modulus
P= Poisson Ratio
G= Shear Modulus
E= Young's Modulus

It is worth noting that the Bulk Density values were obtained from preliminary laboratory test results. Where bulk density values were not available for each test location, a value has been interpolated. Should further bulk density information be made available the parameters calculated in this report may also change.

The profiles of the P-wave velocity, S-wave velocity, for each borehole presented in Graphical section respectively. The relevant S-wave velocity and P-wave velocity behaviour are also provided in tabular format below (Tables 1 and 2).

Presented below are the tabulated results of the direct measurement P and S wave velocities.

4. RESULTS

4.1 TABLES

Table1: BH-30

Client:	OGDCL
Project:	NASHPA Gas Processing and LPG Recovery Plant, Karak
Down Hole:	BH#30
Test No:	1
Total Test Depth (m):	30.00m
Record Length:	200 ms
Shot-offset (m):	5.00m
Stick up Height (m)	0.00m

Table2: BH-05

Client:	OGDCL
Project:	NASHPA Gas Processing and LPG Recovery Plant, Karak
Down Hole:	BH#5
Test No:	2
Total Test Depth (m):	30.00m
Record Length:	200 ms
Shot-offset (m):	5.00m
Stick up Height (m)	0.00m

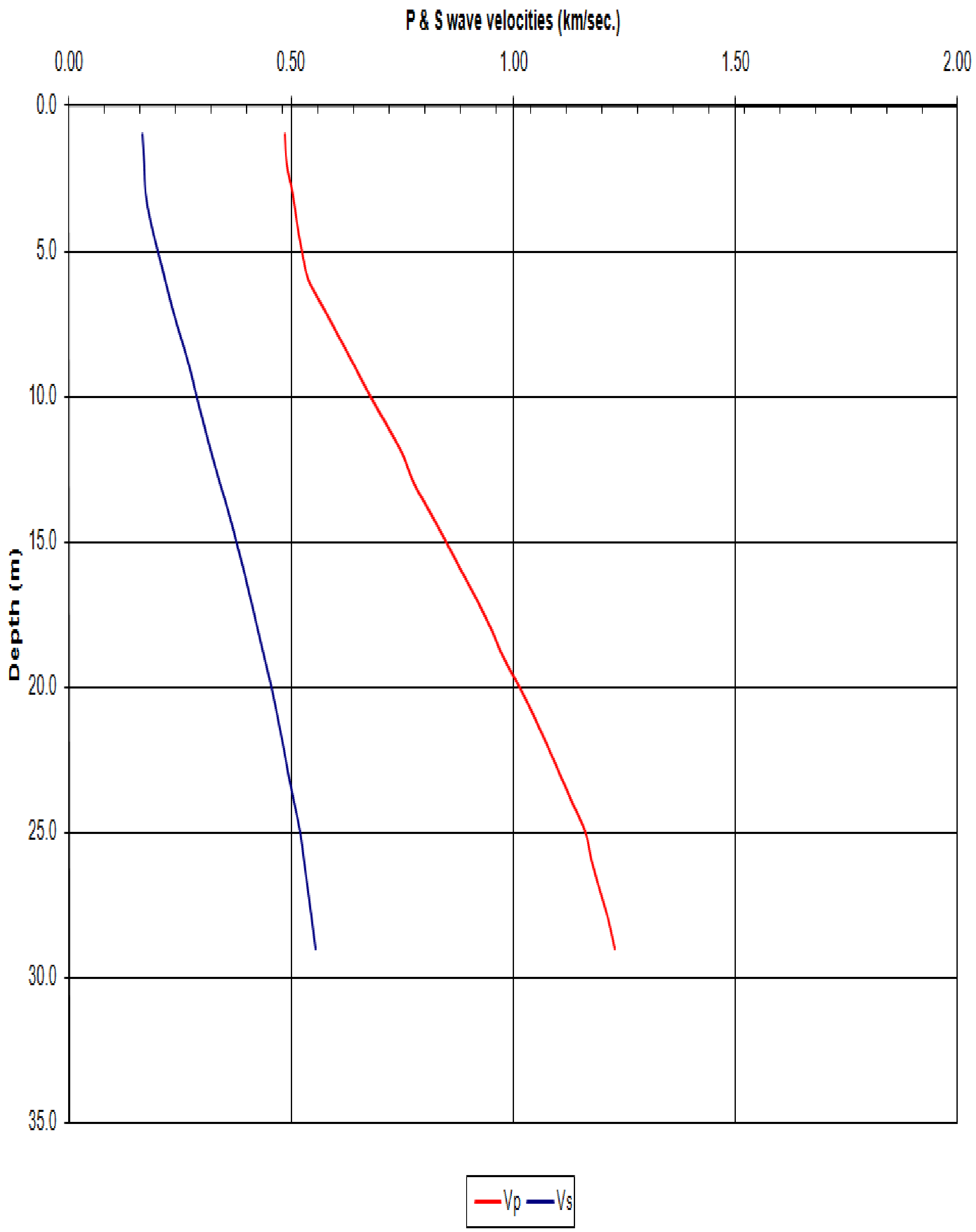
Table1: BH-30

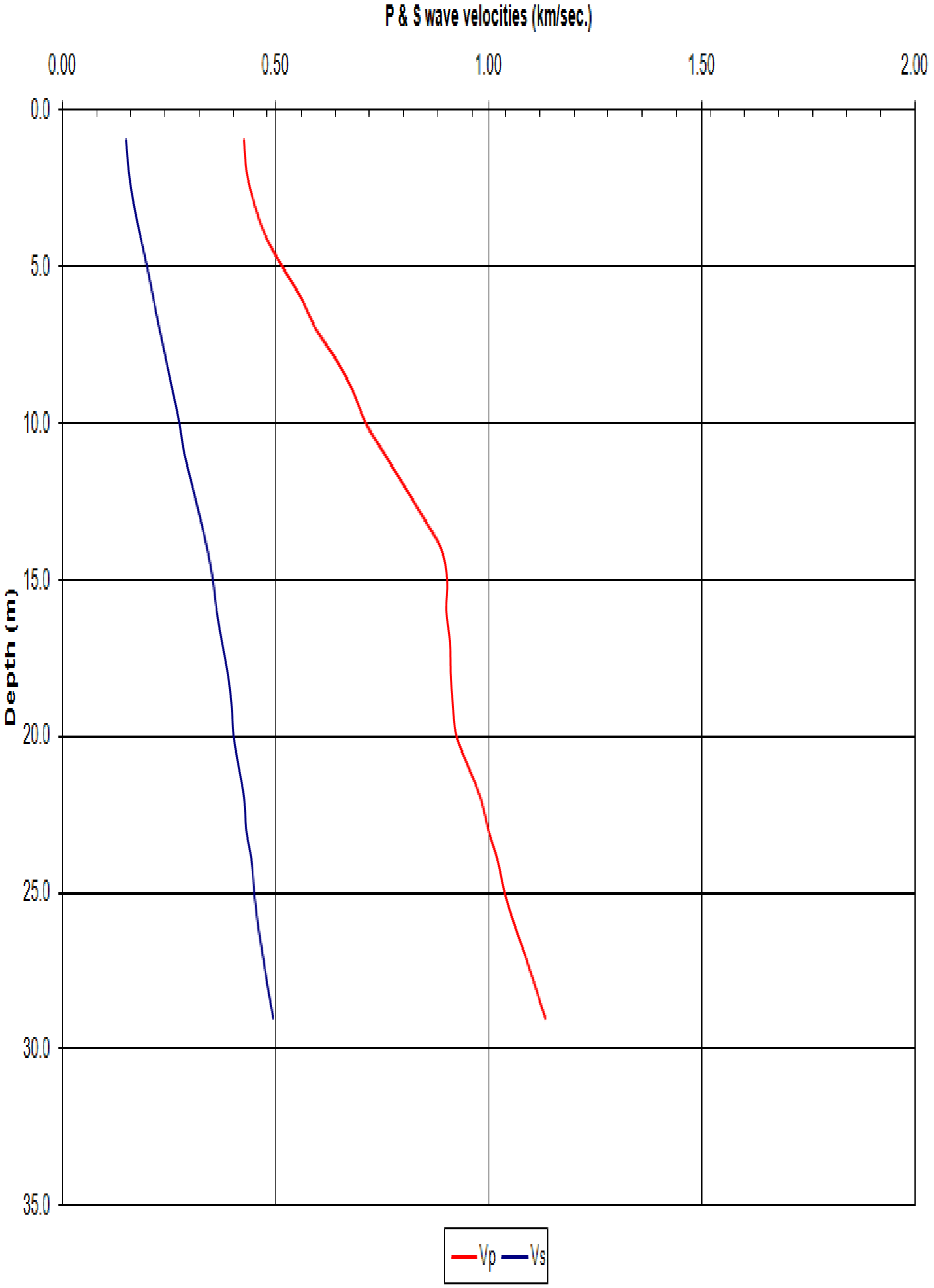
Depth (m)	Distance (m)	P-wave time	S-wave time	Vp (km/s)	Vs (km/s)	Vp/Vs	(Mg/m^{3})	Bulk Modulus GPa	Shear Modulus GPa	Poissons Ratio	Young's Modulus GPa
1.0	5.099	10.500	31.000	0.49	0.16	2.95	2.00	0.40	0.05	0.435	0.16
2.0	5.385	11.000	32.000	0.49	0.17	2.91	2.00	0.40	0.06	0.433	0.16
3.0	5.831	11.600	34.000	0.50	0.17	2.93	2.30	0.49	0.07	0.434	0.19
4.0	6.403	12.500	35.000	0.51	0.18	2.80	2.30	0.50	0.08	0.427	0.22
5.0	7.071	13.500	35.500	0.52	0.20	2.63	2.30	0.51	0.09	0.415	0.26
6.0	7.810	14.500	36.200	0.54	0.22	2.50	2.30	0.52	0.11	0.404	0.30
7.0	8.602	15.000	37.000	0.57	0.23	2.47	2.30	0.59	0.12	0.402	0.35
8.0	9.434	15.500	37.500	0.61	0.25	2.42	2.30	0.66	0.15	0.397	0.41
9.0	10.296	16.000	38.000	0.64	0.27	2.38	2.30	0.73	0.17	0.392	0.47
10.0	11.180	16.500	39.000	0.68	0.29	2.36	2.30	0.80	0.19	0.391	0.53
11.0	12.083	16.900	39.800	0.71	0.30	2.36	2.30	0.89	0.21	0.390	0.59
12.0	13.000	17.325	40.500	0.75	0.32	2.34	2.30	0.98	0.24	0.388	0.66
13.0	13.928	17.952	41.000	0.78	0.34	2.28	2.30	1.03	0.27	0.381	0.73
14.0	14.866	18.300	41.400	0.81	0.36	2.26	2.30	1.12	0.30	0.379	0.82
15.0	15.811	18.650	42.000	0.85	0.38	2.25	2.30	1.22	0.33	0.377	0.90
16.0	16.763	19.000	42.600	0.88	0.39	2.24	2.30	1.32	0.36	0.376	0.98
17.0	17.720	19.320	43.300	0.92	0.41	2.24	2.30	1.42	0.39	0.376	1.06
18.0	18.682	19.680	44.000	0.95	0.42	2.24	2.30	1.52	0.41	0.375	1.14
19.0	19.647	20.100	44.650	0.98	0.44	2.22	2.30	1.60	0.45	0.373	1.22
20.0	20.616	20.350	45.230	1.01	0.46	2.22	2.30	1.72	0.48	0.373	1.31
21.0	21.587	20.650	46.000	1.05	0.47	2.23	2.30	1.84	0.51	0.374	1.39
22.0	22.561	20.980	46.800	1.08	0.48	2.23	2.30	1.95	0.53	0.374	1.47
23.0	23.537	21.320	47.650	1.10	0.49	2.23	2.30	2.06	0.56	0.375	1.54
24.0	24.515	21.650	48.320	1.13	0.51	2.23	2.30	2.16	0.59	0.374	1.63
25.0	25.495	21.950	48.950	1.16	0.52	2.23	2.30	2.27	0.62	0.374	1.71
26.0	26.476	22.520	50.000	1.18	0.53	2.22	2.30	2.32	0.64	0.373	1.77
27.0	27.459	23.000	51.000	1.19	0.54	2.22	2.30	2.39	0.67	0.372	1.83
28.0	28.443	23.450	52.000	1.21	0.55	2.22	2.30	2.47	0.69	0.372	1.89
29.0	29.428	23.980	53.000	1.23	0.56	2.21	2.30	2.52	0.71	0.371	1.94
30.0	30.414	24.390	54.000	1.25	0.56	2.21	2.30	2.60	0.73	0.372	2.00

Table2: BH-05

Depth (m)	Distance (m)	P-wave time	S-wave Time	Vp (km/s)	Vs (km/s)	Vp/Vs	(Mg/m$^{3)}$	Bulk Modulus GPa	Shear Modulus GPa	Poissons Ratio	Young's Modulus GPa
1.0	5.099	12.000	34.500	0.42	0.15	2.88	2.00	0.30	0.04	0.431	0.13
2.0	5.385	12.500	35.000	0.43	0.15	2.80	2.00	0.31	0.05	0.427	0.14
3.0	5.831	13.000	35.340	0.45	0.16	2.72	2.00	0.33	0.05	0.422	0.15
4.0	6.403	13.500	35.600	0.47	0.18	2.64	2.30	0.42	0.07	0.416	0.21
5.0	7.071	13.750	36.000	0.51	0.20	2.62	2.30	0.49	0.09	0.415	0.25
6.0	7.810	14.000	37.000	0.56	0.21	2.64	2.30	0.58	0.10	0.416	0.29
7.0	8.602	14.500	38.000	0.59	0.23	2.62	2.30	0.65	0.12	0.415	0.33
8.0	9.434	14.690	39.000	0.64	0.24	2.65	2.30	0.77	0.13	0.417	0.38
9.0	10.296	15.124	40.000	0.68	0.26	2.64	2.30	0.86	0.15	0.417	0.43
10.0	11.180	15.750	41.000	0.71	0.27	2.60	2.30	0.93	0.17	0.413	0.48
11.0	12.083	16.000	42.500	0.76	0.28	2.66	2.30	1.06	0.19	0.417	0.53
12.0	13.000	16.250	43.000	0.80	0.30	2.65	2.30	1.19	0.21	0.417	0.60
13.0	13.928	16.500	43.500	0.84	0.32	2.64	2.30	1.32	0.24	0.416	0.67
14.0	14.866	16.750	44.000	0.89	0.34	2.63	2.30	1.46	0.26	0.415	0.74
15.0	15.811	17.524	45.000	0.90	0.35	2.57	2.30	1.49	0.28	0.411	0.80
16.0	16.763	18.620	46.500	0.90	0.36	2.50	2.30	1.47	0.30	0.405	0.84
17.0	17.720	19.500	47.500	0.91	0.37	2.44	2.30	1.47	0.32	0.399	0.90
18.0	18.682	20.518	48.340	0.91	0.39	2.36	2.30	1.45	0.34	0.390	0.96
19.0	19.647	21.468	49.700	0.92	0.40	2.32	2.30	1.45	0.36	0.385	1.00
20.0	20.616	22.320	51.550	0.92	0.40	2.31	2.30	1.47	0.37	0.385	1.02
21.0	21.587	22.684	52.400	0.95	0.41	2.31	2.30	1.56	0.39	0.385	1.08
22.0	22.561	23.000	53.145	0.98	0.42	2.31	2.30	1.66	0.41	0.385	1.15
23.0	23.537	23.560	54.845	1.00	0.43	2.33	2.30	1.73	0.42	0.387	1.17
24.0	24.515	24.000	55.478	1.02	0.44	2.31	2.30	1.80	0.45	0.385	1.24
25.0	25.495	24.587	56.897	1.04	0.45	2.31	2.30	1.86	0.46	0.385	1.28
26.0	26.476	25.000	57.984	1.06	0.46	2.32	2.30	1.94	0.48	0.386	1.33
27.0	27.459	25.320	58.654	1.08	0.47	2.32	2.30	2.03	0.50	0.385	1.40
28.0	28.443	25.650	59.209	1.11	0.48	2.31	2.30	2.12	0.53	0.384	1.47
29.0	29.428	25.980	59.650	1.13	0.49	2.30	2.30	2.20	0.56	0.383	1.55
30.0	30.414	26.350	60.230	1.15	0.50	2.29	2.30	2.28	0.59	0.382	1.62

4.2 GRAPHICAL REPRESENTATION OF DATA FOR EACH BOREHOLE





P & S wave velocities (km/sec.)
0.00
0.50
1.00
1.50
2.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Depth (m)
Vp
Vs

5.0 SUMMARY AND CONCLUSIONS

ZealCon Engineering (Pvt.) Ltd. was commissioned by HBP to carry out a Downhole Geophysical Survey for NASHPA Gas Processing and LPG Recovery Plant, Karak.

The aim of the survey was to determine the in-situ P-wave (Vp_h - Vertical propagating P-wave) and S-wave (Vs_{hv} - Horizontally propagating, vertically polarised S-wave) velocity of the ground material to a depth of 30 m for each borehole. From the measured velocities dynamic elastic modulli shall be determine, specifically:

P= Poisson Ratio
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The following geophysical techniques were utilized to conduct the survey:

Downhole Seismic measurements were used to record parameters of P-wave and S-wave by utilizing 1No, Tri axial geophone-3 Channel Bison 4000 Digital Seismograph and 10 kg sledge hammer.

The corrected travel times and velocities are plotted against depth for shear as well as longitudinal waves shows increasing trend with an increase of depth.

In general, the sections showed good correlation with the major lithological units derived from intrusive information, in particular, a change in velocities, shown with depth due to the hardness in lithology with respect to depth.

It's also concluded that, the underlain velocities were all greater than the overlain velocities at all the two locations.