TECHNICAL NOTE

STRONG MOTION RECORD FROM TURANGI, 5 MARCH, 1984

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An accelerogram recorded at the Turangi telephone exchange during the earthquake centred just southwest of Lake Taupo on 5 March 1984, at 1407 NZST has been digitised and processed by computer to produce corrected records of ground vibration.

The earthquake that generated the accelerogram had a Richter local magnitude of 5.6, and a hypocentral location 12 kilometres (±4 kilometres) NNW of Turangi at a depth of 12 kilometres (see Figure 1). Minor damage was reported in the township of Turangi, with the intensity level being estimated at MM VI. Significant damage was reported for sensitive equipment at the Tokaanu power station some 3.5 kilometres closer to the epicentre (Figures 6 and 7); a report of this damage will be published elsewhere by Electricity Division. It is hoped that an examination of the Turangi accelerogram may lead to some insights into the seismic excitation characteristics at Tokaanu.

The three-component accelerogram recorded at Turangi is shown in Figure 2. This 35 mm film record was digitised using a newly-developed automatic line-following system, using computer software to drive a reflectance digitiser mounted on a digital plotter. This system, which is to be described in a separate report, significantly reduces the concentrated manual effort required to digitise an earthquake accelerogram, and allows greater repeatability than the previously-used manual method described in (1).

Computer processing of the digitised data follows techniques outlined in (2) to perform correction for static and dynamic instrumental characteristics, band-pass filtering and digital integration. Corrected acceleration, velocity and displacement records are produced, along with estimates of spectral content made using Fourier transform methods. In addition, engineering response spectra are calculated: these provide the maximum responses which would be induced, in single degree of freedom oscillators with a range of natural vibration periods and damping values, by the measured accelerations.

The peak horizontal ground acceleration at Turangi was found to be 1080 mm/sec², approximately 11% of the acceleration of gravity. This moderate acceleration is quite consistent with the small amount of damage caused at Turangi. The peak horizontal velocity was calculated as 75.7 mm/sec, with a peak displacement value of 16.5 mm. These peak values all occur in a transverse epicentral direction, that is, perpendicular to the line joining the site and the epicentre. The total duration of the excitation was quite short, with the bracketed duration above a threshold acceleration of 200 mm/sec² (2% g) being less than 6 seconds.

In the graphical results that follow (Figures 3-5) data are presented separately for each of the three components. The two horizontal components are aligned with the MO2 instrument case, and are in directions NS9E (59°) and N31W (329°), while the third component is vertical. Corrected acceleration, velocity and displacement signals are shown first, followed by the Fourier amplitude spectrum of acceleration (plotted on a linear and a logarithmic scale) and the acceleration response spectrum. Note that the Fourier spectra are plotted as a function of frequency in Hertz, while the response spectra are plotted against oscillator natural period in seconds.

Dominant spectral peaks of the three individual components are given in Table 1. For the horizontal components of motion, most energy is restricted to narrowly-defined frequency bands centred at 2.1 Hz, 3.7 Hz and 7.7 Hz, while in the vertical direction the dominant vibrational frequencies are 1.9 Hz, 3.8 Hz and 14.7 Hz, these characteristics found from the Fourier spectra. The peak undamped acceleration response exceeds 1 g, with a value of 11.35 m/sec² at a period of 0.130 sec. The peak undamped displacement response is 82 mm for an oscillator with 3 second vibration period. These peak values are for component N59E, the larger of the two horizontal components, which is aligned approximately perpendicular to a line between the epicentre and the site.

ESTIMATED GROUND MOTION AT TOKAANU POWER STATION

It is difficult to predict accurately the detailed nature of ground excitation at the Tokaanu power station on the basis of the single accelerogram recorded at Turangi. There are, however, a number of reasons to expect that the intensity of vibration at Tokaanu could have been somewhat higher than that experienced at Turangi.

First, Tokaanu power station is approximately 3.5 kilometres closer to the earthquake source than is Turangi. Using a statistically determined attenuation model based on world-wide strong-motion data (3), the mean peak horizontal acceleration 12 kilometres from an event with Richter local magnitude 5.6 is 0.12 g, which agrees quite well with the recorded peak acceleration of 0.11 g. The same relationship predicts a peak acceleration of 0.15 g at the power station, 9.5 kilometres distant from the earthquake.

Second, the geological conditions at Tokaanu are significantly different from those existing at Turangi. Beneath the recorder, there is a pumice alluvial layer perhaps 30 metres deep; this layer reduces

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PEAK No.	Component N59E FREQ.(Hz)	Component N59E REL AMPL	Component N31W FREQ.(Hz)	Component N31W REL AMPL	Component UP FREQ.(Hz)	Component UP REL AMPL
1	1.90	1.00	3.76	1.00	1.88	1.00
2	2.15	0.99	3.66	0.98	3.78	0.79
3	3.71	0.82	2.25	0.79	14.70	0.71
4	3.88	0.73	7.76	0.67	2.10	0.65
5	3.42	0.61	2.08	0.59	2.95	0.56
6	7.67	0.59	7.37	0.55	5.76	0.54
7	0.61	0.51	3.15	0.54	7.30	0.53
8	0.76	0.50	4.64	0.52	2.29	0.52

TABLE 1: Spectral Peaks for Turangi Accelerogram A84081A8

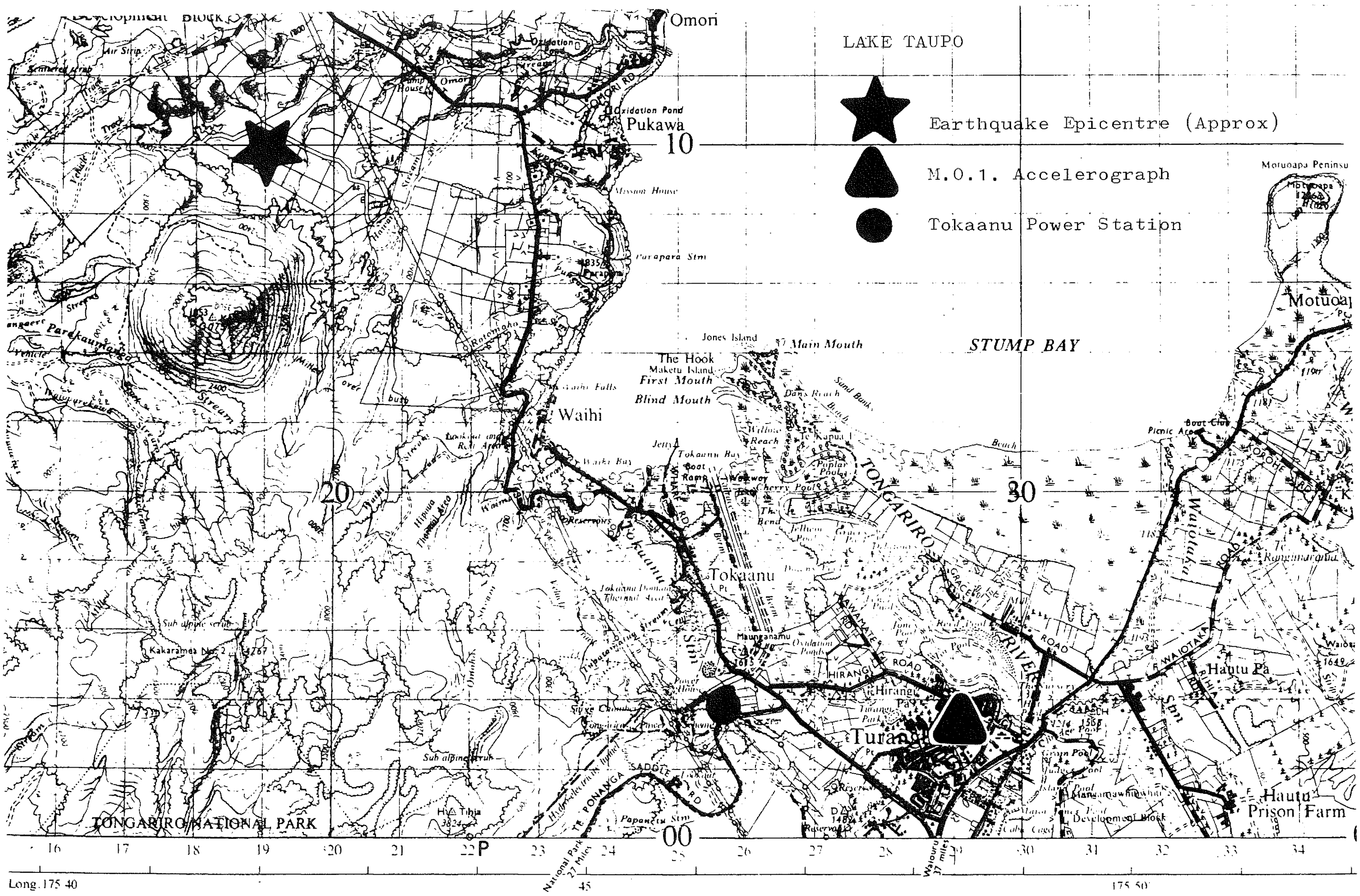

Figure 1: Geography of region rear epicentre

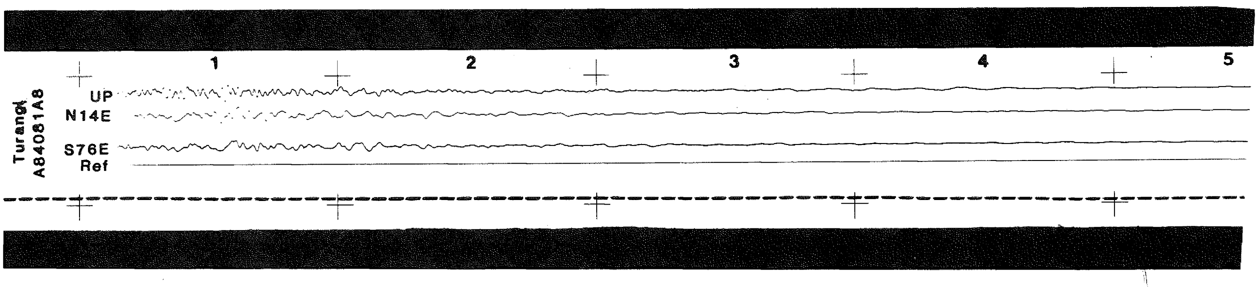

Figure 2: Accelerogram recorded at Turangi.
Approximate sensing directions : S76E, N14E, UP

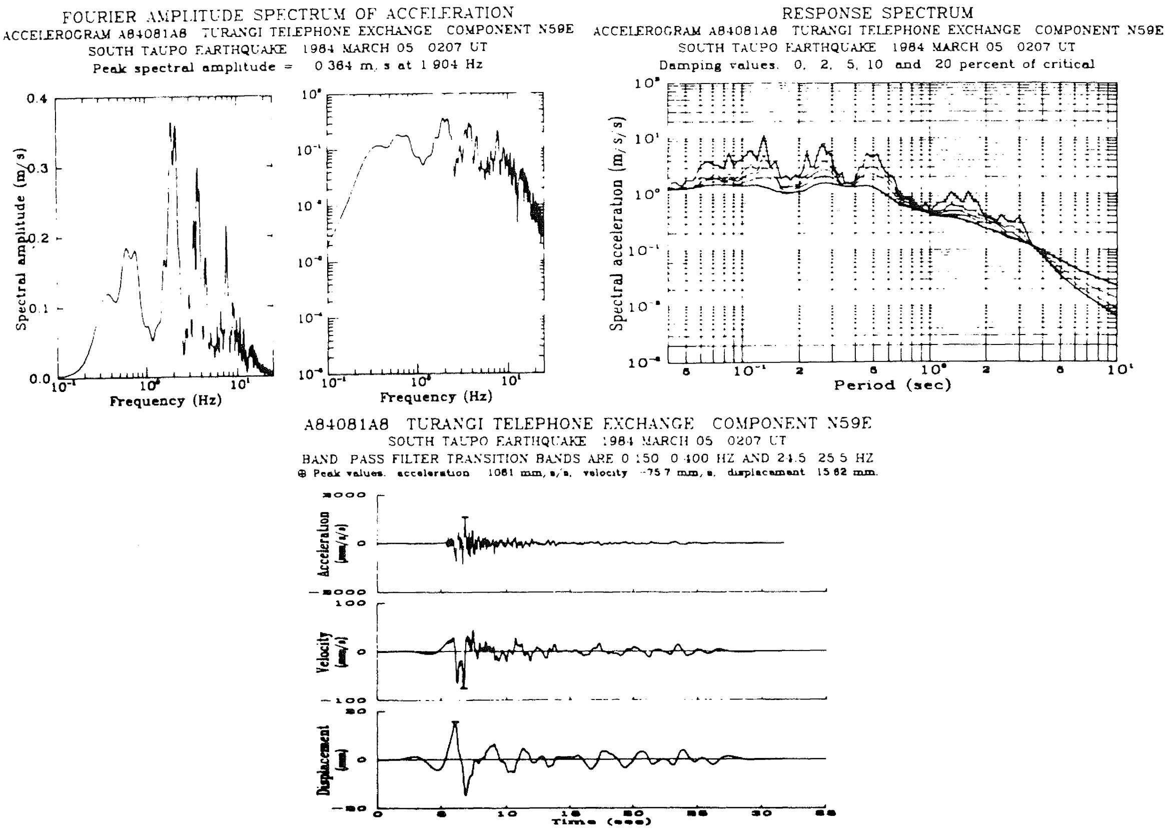

Figure 3: Ground motion (a), Fourier spectra (b) and response spectra (c) for component N59E

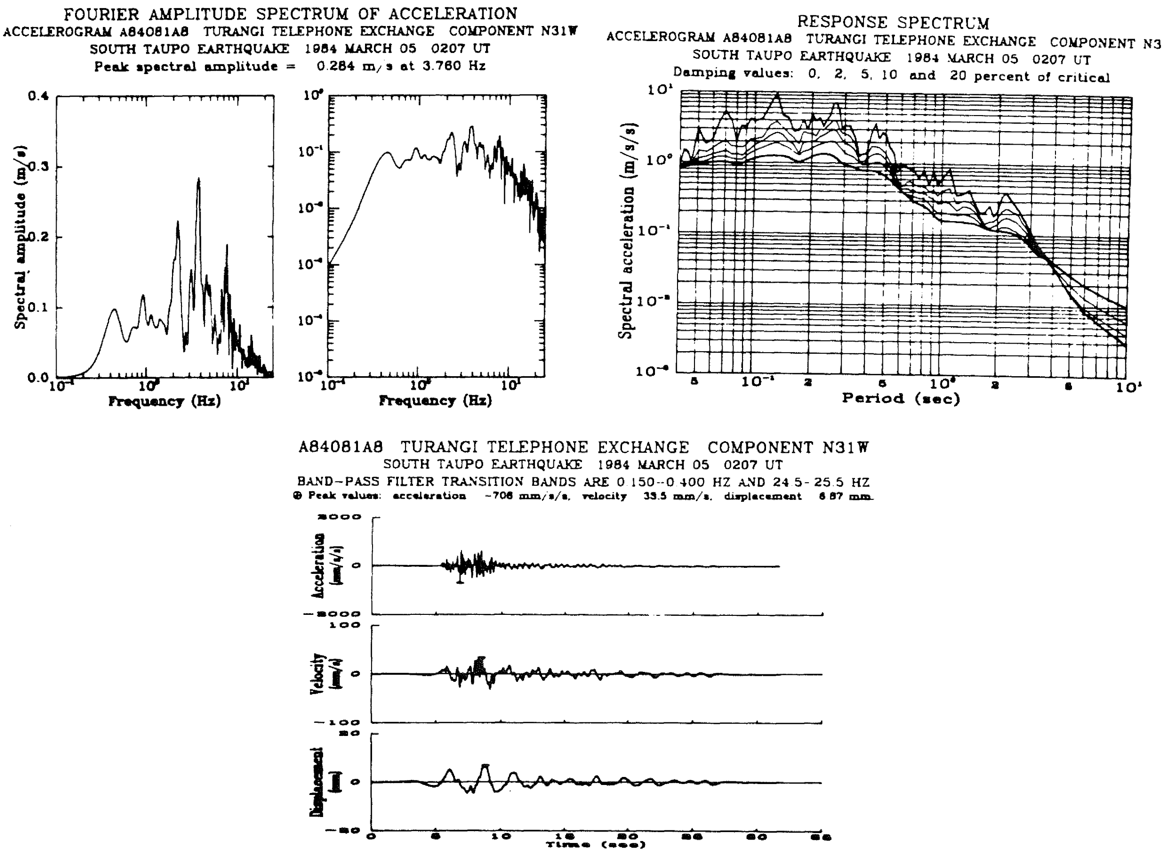

Figure 4: Ground motion (a), Fourier spectra (b) and response spectra (c) for component N31W

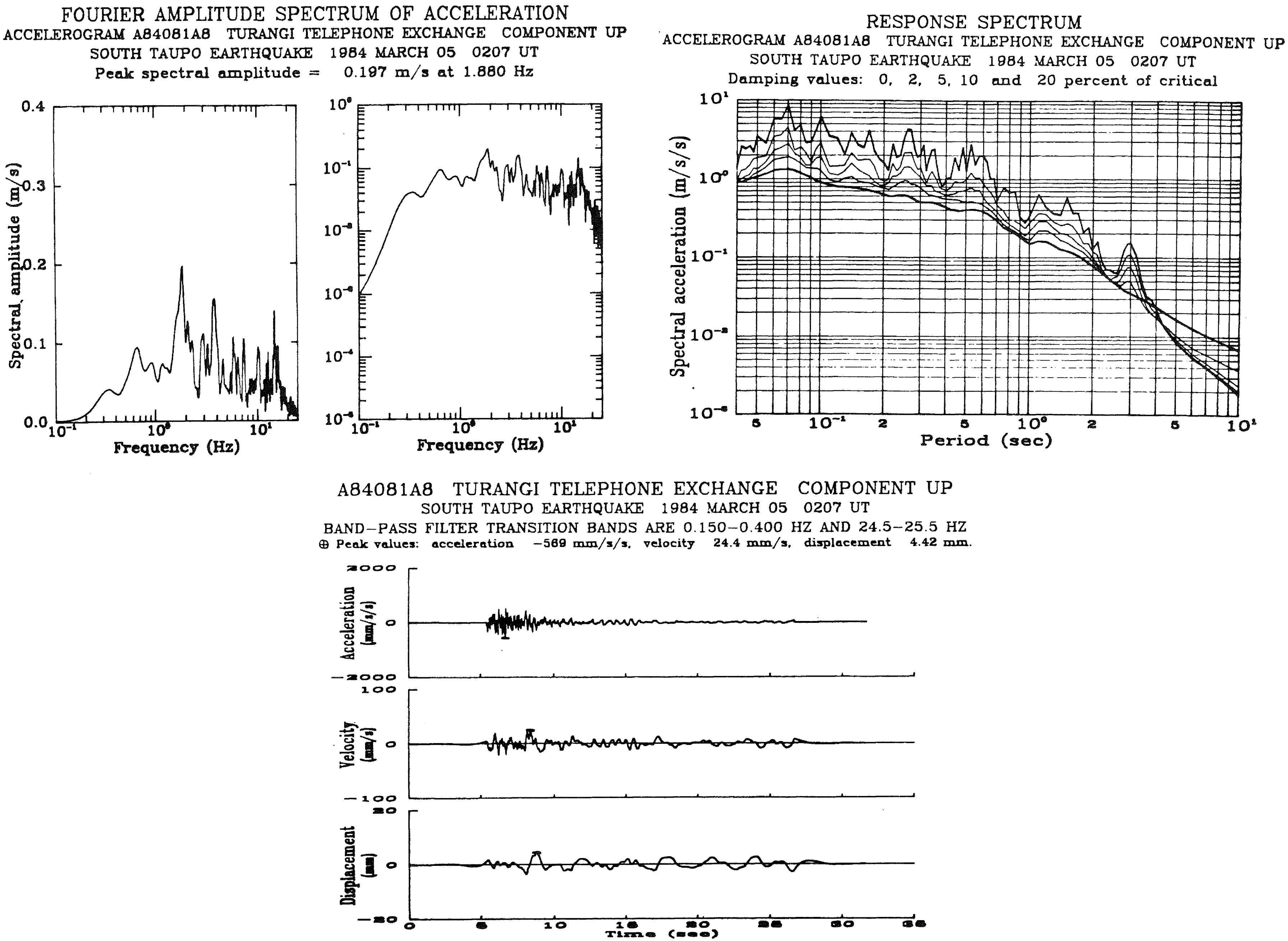

Figure 5: Ground motion (a), Fourier spectra (b) and response spectra (c) for component UP

in depth towards the west, so that at Tokaanu it has reduced significantly. A tapering low-velocity layer such as this can lead to amplified motion at the shallow end of the layer. In this case, however, the direction of wave propagation would not have caused a focusing of energy near the layer tip, and the effect would be somewhat reduced. The differing site conditions and epicentral distances between Tokaanu and Turangi imply that the dominant vibrational frequencies would be slightly higher on the firmer soil conditions closer to the epicentre. Thus the dominant frequencies of excitation at Tokaanu would be expected to be higher than those determined at Turangi.

In summary, it would be expected that the ground vibration occurring at Tokaanu could be perhaps 50% higher than that at Turangi in amplitude, with a slightly richer high frequency content. The detailed motion at Tokaanu is unavailable, however, and it is possible that local microzone effects could alter the character of the motion over relatively short distances.

EQUIPMENT RESPONSE AT TOKAANU

Information supplied by Electricity Division on the vibrational characteristics of equipment damaged at the Tokaanu power station indicates that the natural periods are in the range 0.21 to 0.29 seconds (4.75 to 3.4 Hz), with relatively low damping values in the range of 2 to 3% of critical. The equipment frequencies are thus close to the centre of the dominant peaks in the response spectra calculated at Turangi (Figures 3(c) and 4(c)). Such equipment would have experienced peak horizontal accelerations in the range 0.2 to 0.4 g if located at Turangi, a magnification of from two to four times the peak ground accelerations.

It is possible to obtain a crude estimate of the equipment response at Tokaanu using this information. Assuming that the dominant energy input at Tokaanu is not vastly dissimilar in frequency content to that at Turangi, it could be expected that similar ground acceleration magnification would occur. The estimated peak horizontal ground acceleration of 0.15 g at the Tokaanu power station could thus correspond to a peak response in the equipment of 0.3 to 0.6 g. The role of local microzone effects is again extremely difficult to quantify, and it is possible that significant changes in equipment response could occur over relatively short distances.

NEW ZEALAND ELECTRICITY INVESTIGATION

A thorough investigation into the failures is being carried out by New Zealand Electricity Head Office Records Section in conjunction with the DSIR and Ministry of Works and Development. One of the lines of investigation is to determine the quality and strength of the porcelain shells of the CVTs and CTs both by full-scale tests and by testing of porcelain samples. The adequacy of the damping arrangements at the base of the insulators is an important part of this investigation.

REFERENCES

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