NEW BASE-LINE CORRECTION METHOD FOR GROUND-MOTION DATA

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SUMMARY

It is common knowledge that any ground-motion data is contaminated with low and high frequency errors, out of which the former is significance to base-line correction. Here the Fourier analysis of the raw ground-motion data is done, which shows erratic undulations in the initial portion. If this contamination is filtered out, the velocity and displacement records attain a meaningful form. The results obtained by this new method, Filtering Technique, are compared with the standard, Berg's method.

INTRODUCTION

It is common knowledge that any ground-motion data is contaminated with errors inherent in instrumentation, photographic processing errors and the methods for eliminating them are not directly relevant to the present scope of study. On the other hand errors arising out of the presence of low frequencies, being always present, are likely to be important for accuracy of digitization technique adopted. Careful digitization retain almost all essential information contained in the analog trace. The long-period errors present in the accelerogram are random digitization errors. The unknown distoration introduced in ground-acceleration during recording and digitization can be corrected to some degree by adjusting the base-line. The velocity and displacement curves, computed from the raw accelerograms appear non-oscillatory and also indicates that the velocity and displacement curves continuously drift away from the base-line. The maximum values occuring at or near the end of record and the amplitudes are much more than what one would normally except, as reasonable. Thus the criteria for base-line should be such that the velocity and displacement records attain a meaningful form. To eliminate such errors, the base-line of the raw data needs adjustment, which is generally done by one of the following methods :

i) Straight line method
ii) Parabolic base-line correction - Berg's Method
iii) End-Time zero technique
iv) Trifunac's method (Trifunac, 1970)

The straight line method is, however, far from satisfactory and even inaccurate. Berg has suggested a second degree parabolic base-line correction, which has been accepted as the standard technique, although there appears to be no rigorous justification for its application to all types of data, not withstanding the fact that his procedure involves implicitly filtering out some of the frequencies. Poppitz has proposed a cubic parabola for the base-line, which is found to give excessively high displacements. Trifunac has adopted a method of fitting straight lines to acceleration and velocity curves and then filtered out the low frequencies. This iterative procedure is however tedious for practical application. It

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appears therefore, that there is a need for new method, which is based on directly filtering out the low-frequencies and evolving automatically a base-line of ground-motion.

NEW BASE-LINE CORRECTION METHOD - FILTERING TECHNIQUES

Fourier Analysis :- The basic feature of the Fourier Integral or the transform or some times even called as the generalised Fourier-series, originally developed from the simple notion of the ordinary Fourier or the trignometric series, is its ability to distinguish waves of different frequencies that are superimposed on one and another. If a function, X(t), is periodic then Fourier-transform, F(f), is a weighted sum of impulses at frequencies that are integer multiples of fundamental frequency of X(t) and the weights associated with the impulses are the Fourier-series Coefficient associated with one period of X(t). The Fourier-transformed quantity, F(f), is usually a complex quantity. Fourier-spectrums expresses the coefficients in terms of real and imaginary parts and generally, the quantity of interest is the magnitude of complex quantity. The Fourier-spectra, is the plot of this magnitude versus frequency content of function X(t).

Filtering Technique :- As the initial portion of the trace is not clearly defined, the straight line correction is first applied, before the new technique is applied. For defining criteria for filtering out, the unwanted frequencies, Fourier-analysis of the observed data is done by discritizing the analog curve, at appropriate time interval. The Fourier-spectra, thus obtained from raw data exhibits erratic undulations in the initial portion of the spectra. It is therefore, necessary to filter out the frequency band corresponding to this erratic undulations. The discrete Fourier transform used for mapping out from time-domain to frequency-domain and vice versa is therefore employed as a digital filter for eliminating the unwanted frequency-band. The final data that is obtained after filtering out these frequencies is automatically corrected with respect to a new base-line. This procedure is followed in detail and applied to Koyana earthquake (India) dated 10th December, 1967. The validity of the procedure (presented in Flow Diagrams - I & II) is evaluated by comparing the results with standard, Berg's parabolic base-line method vide Fig. 1 & 2.

CONCLUSION

The results obtained by new method are quite meaningful and are in close agreement with Berg's method. It has also been studied and proved (Mulay, 1975) that the frequencies filtered in new method and Berg's method are almost the same. Thus the results obtained by new method are quite satisfactory and encouraging.

REFERENCES

Trifunac, M.D. (1970) "Low frequency digitization errors and a new method for base-line correction of strong motion accelerograms". C.I.T. Pasadena California Report No.EERL 70-07

Mulay, J.M. (1975) "Shock wave in underground Media-Some studies". Ph.D. thesis - I.I.T. Bombay, India.

FLOW DIAGRAM - I

(Criterion for filtering a particular frequency-band)

Steps		Details of each step
1	Read	raw digitized ground acceleration data.
2	Fit	a straight base-line to raw data by method of least squares.
3	Call	FFT to find discrete Fourier-transform of raw data read.
4	Find	the modulii of complex coefficients.
5	Find	the fundamental frequency (fo = 1/T) and integer multiple frequencies of it.
6	Plot	a graph of modulii of step 4 Vs frequencies of step 5. This graph is Fourier-amplitude-spectrum. (FFT=Fast Fourier Transform)

FLOW DIAGRAM - II

(Proposed base-line method)

Steps		Details of each step
1	Read	raw digitized ground acceleration.
2	Fit	a straight base-line to ground motion data by the least square method.
3	Call	FFT to find discrete Fourier-transform of data.
4	Find	the modulii of complex coefficients evaluated in steps 3.
5	Obtain	the fundamental frequency (fo = 1/T) and integer multiple frequencies of it.
6	Plot	a Fourier-amplitude-spectrum of modulii of steps 4 Vs frequencies of step 5,
7		from erratic undulations in the plot select the frequency-band to be filtered out.
8	Make	the coefficients (step 4) corresponding to selected frequency-band as zero.
9	Invert	the Fourier-transform to time-domain.
10		Real part obtained in step 9 is the filtered accelerogram in time domain.
11	Compute	Velocity and displacement curves by numerical integration from data obtained in step 10.

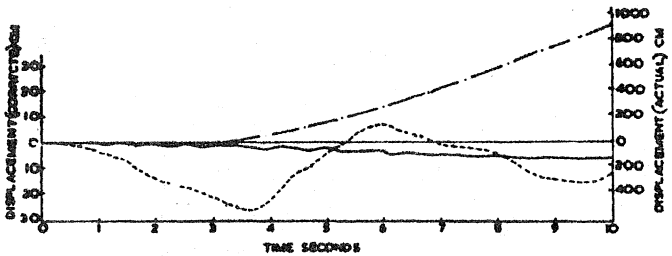

FIGURE 2 b

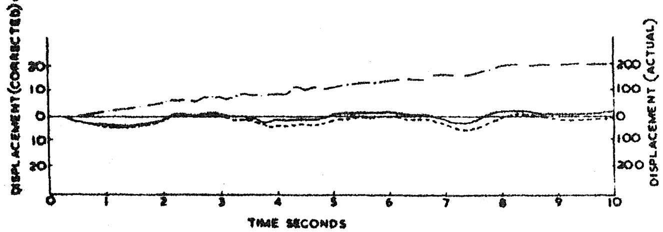

FIGURE 1 b

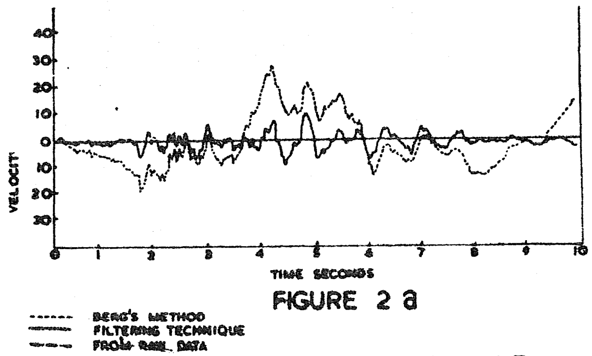

FIGURE 2 a

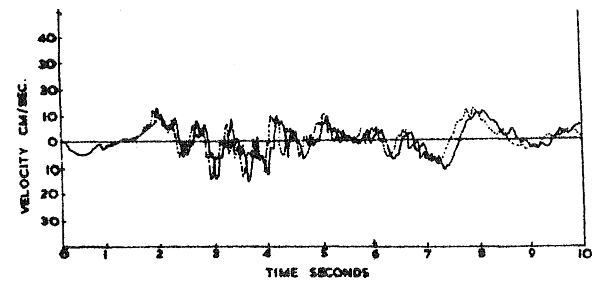

FIGURE 1 a

COMPARISON OF VELOCITY-DISPLACEMENT RECORDS