International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

A Study on Processing and Analysis of Digital Strong Motion Accelerogram and Its Importance

Prof. S.B Shinde [1], M. A. Kumbhar [2], A. D. Kadam [3], R. R. Maske [4], A. S. Shelke [5]
[1]Prof. Supriya Shinde, Affiliated to Department of Civil Engineering,
Anantrao Pawar College of Engineering & Research,
[2]Mr. Mayur Kumbhar, [3]Mr. Akshay Kadam, [4]Mr. Rohan Maske, [5]Mr. Ajinkya Shelke
UG Students Affiliated to Department of Civil Engineering, Anantrao Pawar College of Engineering & Research,
Pune, India

Abstract: **On 25th April 2015, a large earthquake of Magnitude 7.8 occurred along the Himalayan Thrust fault in central Nepal. It was caused by a collision of the Indian Plate below the Eurasian Plate. Gorkha region is an epicenter, and the rupture travelled from epicentral region to the east, passing through the Kathmandu Valley. 8000 people were killed during this event, mostly in Kathmandu and the adjacent districts. We collected a strong ground motion raw data of following earthquake from United State Geological Survey (USGS) organization. We observed that raw data consist of many errors in it, and it is needed to correct and to be used in engineering application, using different routines (steps).**

Keywords: 2015 Gorkha Nepal earthquake, Kathmandu Valley, Strong ground motion, USGS

1. INTRODUCTION

The earth vibrates continuously at periods ranging from milliseconds to day and the amplitude may vary from nanometers to meters. It is pertinent to note that most vibrations are quite weak to even be felt. Such microscopic activity is important for seismologist only. The motion that affects living beings and their environment is of interest for engineers and is termed as strong ground motion.

Vibration of the earth's surface is net consequences of motions, vertical as well as horizontal, caused by seismic waves that are generated by energy release at each material point within the three dimensional volume that ruptures at the fault. These waves arrive at various instants of time, have different amplitudes, and carry different levels of energy. Thus, the motion at any site on ground is random in nature, its amplitude and direction varying randomly with time.

Large earthquakes at great distant can produce weak motions that may not damage structure are even be felt by humans. However, from an engineering viewpoint, strong motion that can possibly damage structure are of interest. This many occurs with earthquake in the vicinity or even with high intensity earthquake at medium to large. The motion of the ground can be described in terms of displacement, velocity or acceleration.

To measure the above parameters, mainly two types of instruments are used namely 1) Analog Instrument & 2) Digital Instrument. The data recorded in analog instruments which has to be stored, needs to be converted in digital data manually by humans, whereas digital instrument records data directly in digital format which actually minimizes human error. Hence now a days digital instruments are used widely.

Meanwhile human error is not the only error recorded. There are many errors recorded in the instrument which needs to be analyzed and processed.

2. METHODOLOGY

The raw data obtained from a strong-motion instrument may include errors from several possible sources. Each of which must be carefully evaluated and corrected to produce an accurate record of the actual ground motion. Raw data often include background noise from different sources. This noise may be caused due to traffic, construction activity, wind (transmitted to the ground by vibration of bees, buildings, etc.), and even atmospheric pressure changes. Obviously, this range sources can produce non-seismic noise at both low and high frequencies. To isolate the motion actually produced by the earthquake, background noise must be removed or at least suppressed. This errors in the recorded data thus needs to be processed through various routine (steps) which are given below:-

2.1 Collection of Raw Data

The seismic raw data are available from different organizations such as International Seismological Center (ISC), United States Geological Survey (USGS), Indian Metrological Department (IMD) etc. In this present report we will analyze the data of Nepal Earthquake occurred on 25th April 2015, data downloaded from USGS website.

2.2 Errors in Strong Motion Records

Errors are introduced into recorded motion at various stages in the processes leading to their final form. The source of these errors and approximations for their magnitudes wherever possible, are summarized below.

2.3 Scaling Error

This error arises from the inherent limitations of the resolving power of any scaling device. For most instruments now in use it is of the order of 0.01 in.

2.4 Random Error in Time and Acceleration Records

The thickness of the line defining the record makes the choice of points at which discernible changes of slope occur and the scaling of magnitudes a matter of individual judgment. This leads to errors in both time and acceleration coordinates. If the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

same record is digitized by different persons, the standard deviations of the random errors in time and acceleration typically may be 0.018 secs and 0.001 g respectively. These reading errors may in turn, causes errors up to 20 percent in undamped spectra calculated from the records.

2.5 Baseline Errors

The unknown distortion introduced into the ground acceleration during recording and digitization is corrected to some degree by adjusting the baseline, herein by a technique which minimizes the resulting ground velocity.

2.6 Baseline Correction

A major problem encountered with both analog and digital accelerograms are distortions and shifts of the reference baseline, which result in unphysical velocities and displacements. One approach to compensate these problems is to use baseline adjustments, whereby one or more baselines, which may be straight lines or low-order polynomials, are subtracted from the acceleration trace. The raw digitized data points are interpolated to obtain equal interval sampling, if necessary and converted to acceleration units using the sensitivity constant of the accelerometer. At least a first-order base-line operation is performed, to make the data zero-mean. More involved baseline correction may also be performed on particular records, in some cases. In general an equivalent to complex baseline correction is performed via long-period

2.7 Band Passed Filtering

Band pass filtering consist of High Frequency filtering as well as low frequency filtering. To filter out the high frequency noise introduced by digitization and interpolation steps, which may create undesirable amplifications during transduction error correction, an ORMSBY type digital filter is employed. The currently adopted values for cut off and cutoff termination frequencies are 20.0 hz and 25.0 hz. This may vary from person to person. Also low frequency filtering is carried out for the elimination of inherent low frequency noise. Here also, ORMSBY filter is used to filter out low frequency noise.

2.8 Output Preparations

The acceleration, velocity and displacement time histories obtained using the final filter are plotted for presentation in reports and saved as files for distribution.

3. RESULT

The records from the instrument from the digital strong motion accelerographs do not represent correct ground acceleration for use in analysis of the structure. A better data processing procedure is required for a good quality accelerographs for use in various engineering application. Mainly three accelerograms recorded at station 'Kanti Path' have been processed by using various corrections as discussed in present study. It is suggested that these corrected accelerographs can be used in various engineering applications.

3.1 Uncorrected Accelographs

3.1.1 East Component

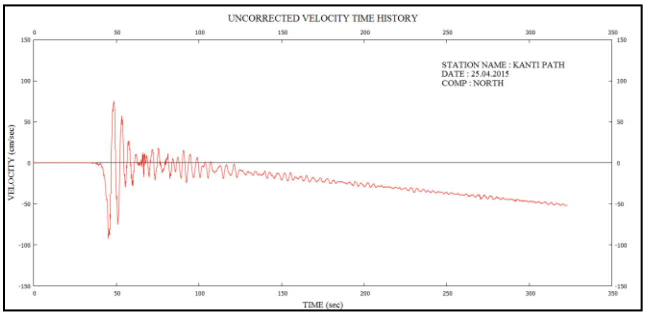

Fig. 1- Uncorrected Acceleration Time History

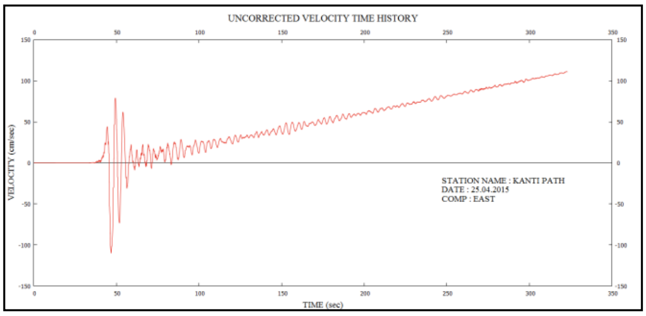

Fig 2- Uncorrected Velocity Time History

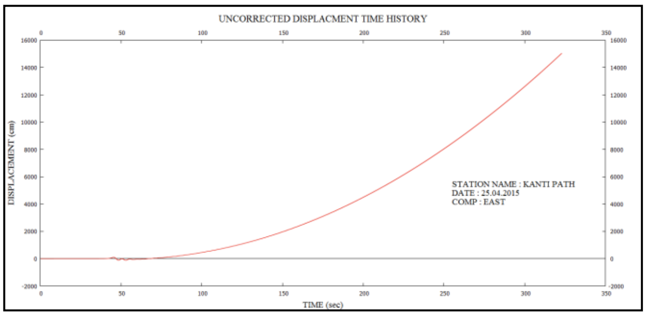

Fig 3- Uncorrected Displacement Time History

3.1.2 North Component

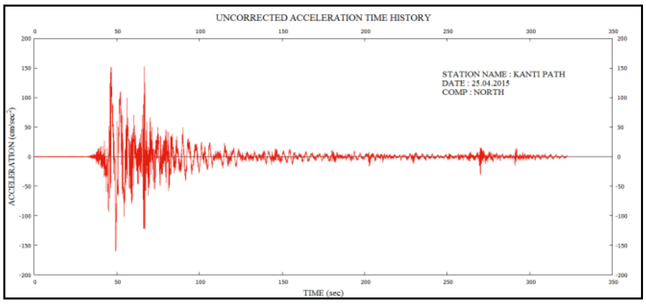

Fig 4- Uncorrected Acceleration Time History

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

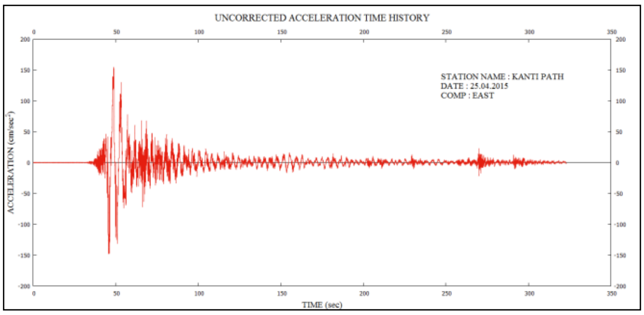

Fig 5- Uncorrected Velocity Time History

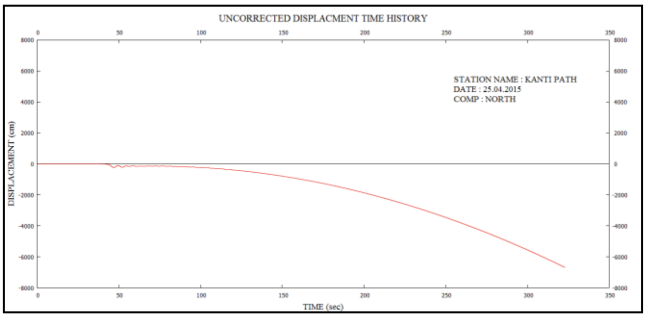

Fig 6- Uncorrected Displacement Time History

3.1.3 Vertical Component

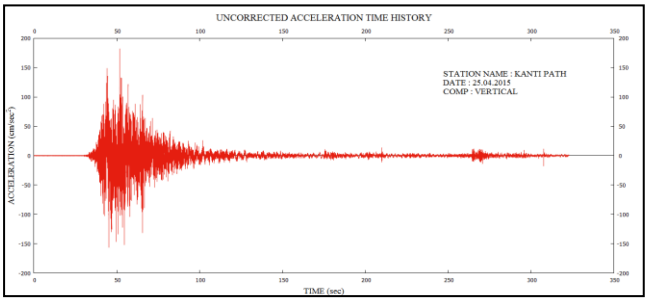

Fig 7- Uncorrected Acceleration Time History

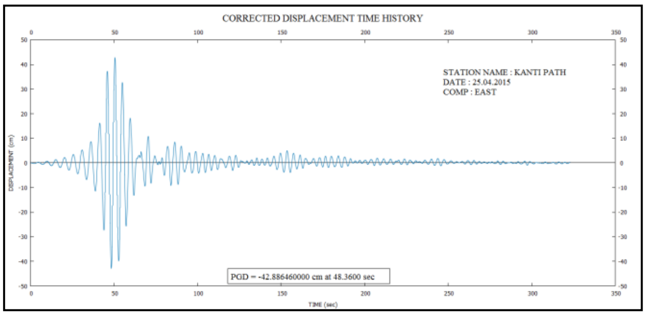

Fig 8- Uncorrected Velocity Time History

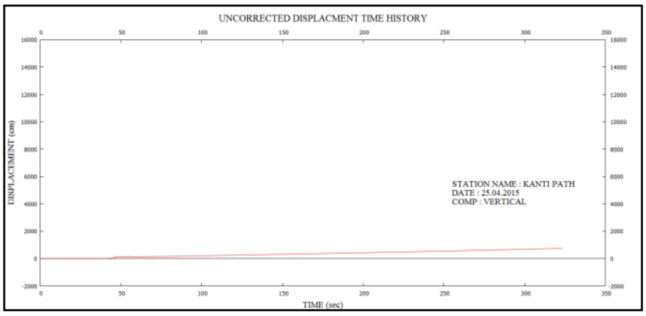

Fig 9- Uncorrected Displacement Time History

3.2 Corrected Accelographs

3.2.1 East Component

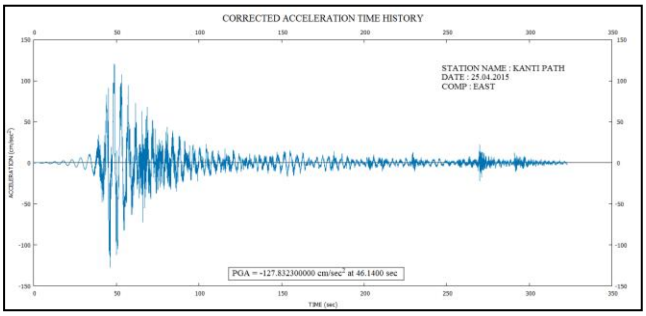

Fig 10- Corrected Acceleration Time History

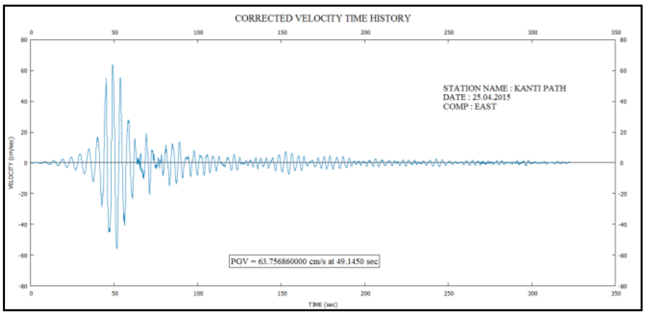

Fig 11- Corrected Velocity Time History

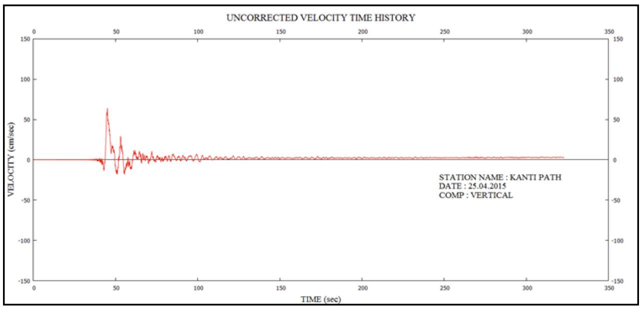

Fig 12- Corrected Displacement Time History

3.2.2 North Component

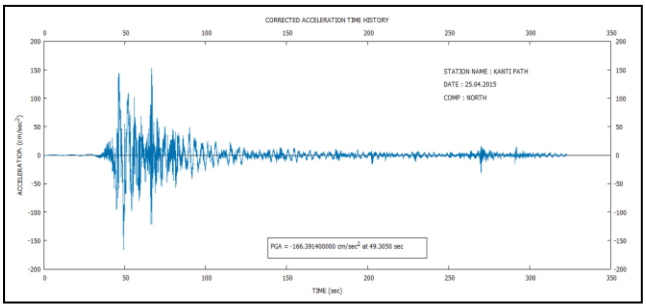

Fig 13- Corrected Acceleration Time History

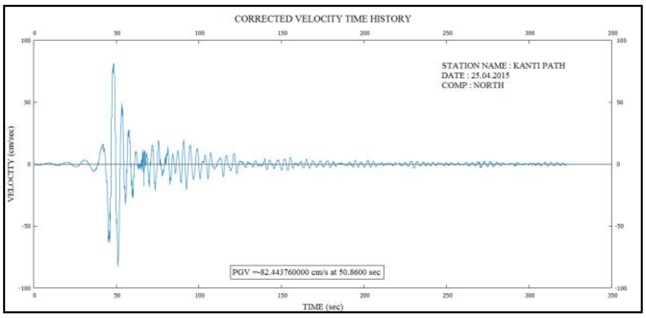

Fig 14- Corrected Velocity Time History

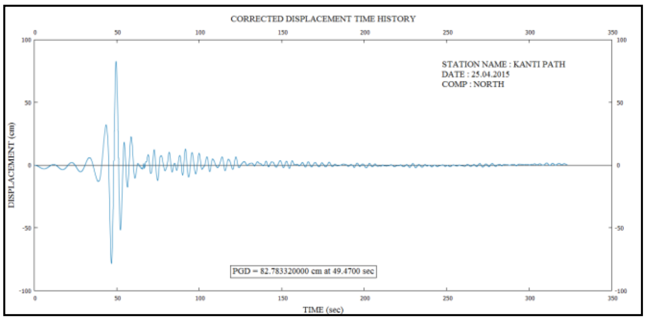

Fig 15- Corrected Displacement Time History

3.2.3 Vertical Component

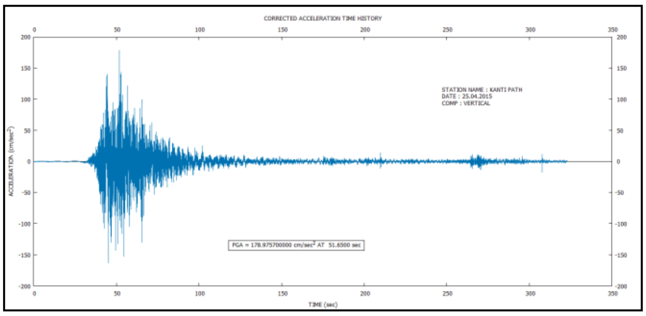

Fig 16- Corrected Acceleration Time History

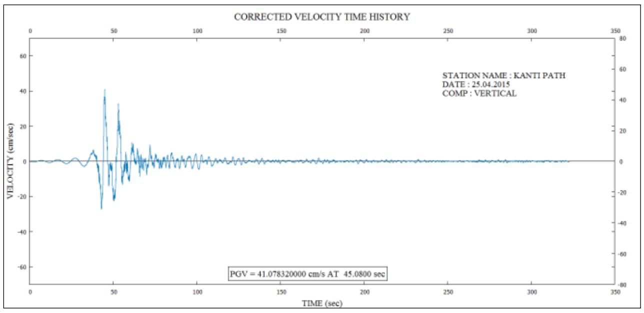

Fig 17 - Corrected Velocity Time History

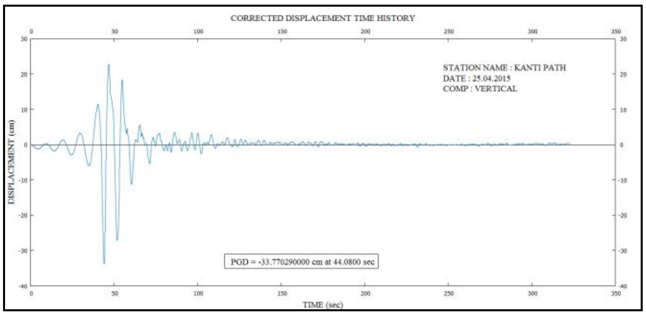

Fig 18- Corrected Displacement Time History

Table -1: Ground Motion Parameters for Corrected Accelerograms

Station	Date	Ground Motion Parameters			
		Components	PGA (cm/sec^2)	PGV (cm/sec)	PGD (cm)
KATNP	25.04.15	East	-27.83	63.76	-42.88
		North	-166.39	-82.44	82.78
		Vertical	178.97	41.07	-33.77

4. CONCLUSION

The digital instrument records from the digital strong motion accelerographs do not represent the true ground accelerations for use in dynamic response analysis of structures. Thus, robust data processing procedure for digital data is essential to obtain good quality acceleration time history for use in engineering application and seismology studies.

ACKNOWLEDGEMENT

We are thankful to Dr. (Mrs.) V.V.Bhosekar, Director, Central Water and Power Research Station (CW&PRS), Pune for permitting to undertake our project work at CW&PRS under the guidance of Scientist ‘B’ Dr. Suman Sinha. We also would like to thank Shri R.S. Jagtap, Joint Director for his valuable help.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

REFERENCES

[1] Prof. S.B Shinde, M. A. Kumbhar, A. D. Kadam, R. R. Maske, A. S. Shelke, "A Study on Processing and Analysis of Digital Strong Motion Accelerogram and its Importance", IJERT Vol. 7 Issue 03, March 2018

[2] Jessica R. Murray, Jerry Svarc, "Global Positioning System Data Collection, Processing, and Analysis Conducted by the U.S. Geological Survey Earthquake Hazards Program," Seismological Research Letters (2017) 88 (3): 916-925.)

[3] J. J. Bommer, N. N. Ambraseys, "An earthquake Strong Motion databank and database", Earthquake engineering, World Tenth Conference 1992 Balkema, Rotterdam

[4] David M. Boore, Julian J. Bommer, "Proccessing of strong motion accelerogram: needs options and consequences," In Proceedings of the IEEE Congress on Evolutionary Computation (CEC), pp. 1951-1957, 1999. (conference style)

[5] V.W. Lee, "Digitization, Data Processing and Dissemination of Strong Motion Earthquake Accelerogram",ISET Journal of Earthquake Technolgy, Paper No. 417, Vol. 39, No.1-2, March-June 2002, pp. 55-72

[6] Hu Guorui, Lu Tao, "Review on Baseline Correction of Strong-Motion Accelerogram", International Journal of Science, Technology and Society 2015; 3(6): 309-314 Published online December 25, 2015

[7] Hung-Chie Chiu, "Stable Baseline Correction of Digital Strong-Motion Data", Bulletin of the Seismological Society of America, Vol. 87, No. 4, pp. 932-944, August 1997

[8] M. D. Trifunac, F. E. Udwadia, A. G. Brady, "Analysis Of Errors In Digitized Strong-Motion Accelerograms", Bulletin of the Seismological Society of America. Vol. 63, No. I, pp. 157-187. February 1973

[9] Trifunac MD, Udwadia FE, Brady AG, "Analysis of errors in digital strong-motion accelerograms", Bull Seismol Soc Am 1973; 63:157–87.

[10] Hudson DE, "Reading and interpreting strong motion accelerograms", Earthquake engineering research institute monograph, Berkeley, California. vol. 1 1979. p. 112.

[11] Trifunac MD, Todorovska MI, "Evolution of accelerographs, data processing, strong motion arrays and amplitude and spatial resolution in recording strong earthquake motion", Soil Dyn Earthquake Eng 2001; 21: 537–55

[12] Shakal AF, Ragsdale JT, "Acceleration, velocity and displacement noise analysis for the CSMIP acceleration digitization system", Proceedings of the Eighth World Conference on Earthquake Engineering, San Francisco 1984; vol. II:111–8.

[13] Lee VW, Trifunac MD, "Current developments in data processing of strong motion accelerograms", Report 84-101. Los Angeles: Department of Civil Engineering, University of Southern California; 1984 [Report 84-01].

[14] Skarlatoudis AA, Papazachos CB, Margaris BN, "Determination of noise spectra from strong motion data recorded in Greece",J Seismol 2003; 7:533–40.

[15] Bommer JJ, Elnashai AS, "Displacement spectra for seismic design" J Earthquake Eng 1999; 3(1):1–32.

[16] A.F.Shakal, M.J.Huang, V.M. Graizer, "CSMIP Strong-Motion Data Processing" California Strong Motion Instrumentation Program 2002.

- Books

1. Basic Geotechnical Earthquake Engineering : Kamalesh Kumar, by New Age International Publication
2. Earthquake Resistant Design of Structures: S. K. Duggal, by OUP India, 2013