International Journal of the Physical Sciences Vol. 6(16), pp. 3923-3928, 18 August, 2011
Available online at http://www.academicjournals.org/IJPS
DOI: 10.5897/IJPS11.702
ISSN 1992-1950 ©2011 Academic Journals

Full Length Research Paper

Earthquake time history for Dhaka, Bangladesh as competent seismic record

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Accepted 2 June, 2011

The time varying forces in the ground generates earthquake loads and the pattern of load specified as a time history of ground excitation is the most accurate means of representing earthquake actions. The difficulty with carrying out analysis procedures to compute the responses of a structure for this type of load is that the form of the acceleration time history is to be clearly known. As there is lack of earthquake data for Dhaka, Bangladesh, which is in risk of attack by severe earthquakes, the engendering earthquake time history data of this region for precise dynamic analysis is of utmost importance. So, the objective of this research is to develop the reliable Dhaka earthquake time history, functioning as a competent seismic record. Seismic data have been measured *in-situ* with proper seismographic instruments at the recently occurred local earthquake near the Dhaka vicinity. Choosing the nearby seismic record, probable acceleration time history of Dhaka has been properly scaled as per the seismicity and ground acceleration characteristics of its own, following the widely accepted Bangladesh National Building Code (BNBC). Generated EQ time history is then evaluated with the prominent seismic records available in literature. This seismic data essentially yield the responses at every little incremental state of numerous time extents. The research acquaints us with suitable Dhaka earthquake time history data which can be reliably exploited as advance future seismic record.

Key words: Earthquake data, competent seismic record, peak ground acceleration, time history, scaling, seismic source, earthquake record, time varying forces, BNBC, seismographic instrumentation.

INTRODUCTION

Recent earthquakes with low to moderate magnitude very close to Dhaka are certainly indications of its earthquake source and vulnerability. In addition, micro-seismicity data also supports the existence of at least four earthquake source points in and around Dhaka (Ansary et al., 1999, 2001; Ansary, 2005; Hussain et al., 2010; Islam et al., 2010a, 2010b; Islam and Ahmad, 2010). The earthquake disaster risk index has placed Dhaka among the 20 most vulnerable cities in the world (Khan, 2004). Several earthquakes of large magnitude (Richter magnitude 7.0 or higher) with epicenters within Bangladesh and in India close to Indo- Bangladesh have occurred (Ali and Choudhury, 1992). There are lists of the major earthquakes that have affected besides and in between Bangladesh (Islam et al., 2011a). Furthermore the country is divided into three zones determined from the earthquake magnitude for various return periods and the acceleration attenuation relationship (Ali and Choudhury, 1994) namely zones 1, 2, 3 being most to least severe gradually. The recently measured plate motions at six different sites of Bangladesh including Dhaka; (the research being jointly conducted by Lamont-Doherty earth observatory, Columbia University, USA and the department of Geology, Dhaka University) clearly demonstrate that Dhaka is moving 30.6 mm/year in the direction northeast. In addition, the rate of strain accumulation is relatively high in and around Dhaka. It may precipitate in an earthquake of magnitude 6.8 in the event of the release of accumulated strain (Khan and Hussain, 2005). However Dhaka, the capital of Bangladesh is one of the most populous towns in the world. The infrastructure and life safety here against seismic hazard is now a burning concern.

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The time history analysis procedure cannot be applied by using composite, envelope motions, as can be done for the response spectrum procedure. Rather, multiple time histories that together provide a response that envelops the expected motion must be used. Seismology is unlikely ever to be able to predict with precision what motions will occur at a particular site and so multiple time histories are likely to be a feature of this procedure in the foreseeable future. There is a broad aspect of earthquake motions but each project will require individual selection of appropriate records. However, for site specific earthquake data is of widely needed to deal the dynamics of structures. So development of earthquake time history for the region Dhaka vicinity, Bangladesh to carry out seismic analysis is of utmost important concern. The study covers the extent to propose earthquake time history of Dhaka, Bangladesh region to consider it apposite for practical dynamic design.

SEISMIC RECORD IN TERMS OF TIME HISTORY

The time history method is the only reliable method of accurately assessing performance. But code requirements for selecting time histories result in much higher levels of input than alternative methods such as the response spectrum procedure. It is required to use records in accordance with the applicable code requirements. Wherever possible, one should get advice from the seismological consultant about near fault effects and both the return period for earthquake magnitude and the probability of the site being subjected to near fault effects. This is also desired that the seismologist provides appropriate time histories to use for representing both the design basis earthquake and maximum credible earthquake. Actual idealization of structural parameters in every time spot can be carried out through the time history.

Recommended records for time history analysis

The best method of selecting time histories is to have the seismologist supply them. However, this option is not always available and, if not, some guidance can be obtained from codes as to means of selecting and scaling records. Obtaining an Earthquake data from nearest region the values are practiced to be scaled as per site ground acceleration. If so, then the scaling factor for any particular record would depend on the other records selected for the data set.

Anticipation of earthquake time history

Code requirements for time history selection require use of records appropriate to fault proximity and so often one or more records similar to the obtained result may be used. The manner of scaling specified by codes such as UBC (1997) and FEMA-273 (1997) also result in relatively large scaling factors. Naeim and Kelly (1999) discussed these phenomena in some details. Proper scaling in accordance with the ground acceleration suited for the target location is to be carried out. It is also preferred that the scaled earthquake data be evaluated with eminent seismic records in literature to search the adequacy of its own.

DEVELOPMENT OF DHAKA EARTHQUAKE TIME HISTORY

As there is lacking of suitable earthquake data in Bangladesh, for generating Dhaka time history (Islam et al., 2011b, c) recently occurred Natore earthquake was considered. Dhaka is located in distance of around 200 km from the seismic sources. In this study the earthquake record obtained at Natore (Ansary, 2009) is selected for use ground acceleration data for recent earthquake at station ID: ALTUS S/N 2928, 06^{th} Jan 2009 16:04:03 (GMT), Magnitude 4.0, place: Natore, Bangladesh is shown in Figure 1. Measured time histories for velocity and displacement of Natore EQ are omitted here. But scaled time histories for these two parameters is being presented in succeeding section. The seismographic instrumentation has been discussed in detail by Al-Hussaini et al. (2004). The data has been collected with proper seismographic measuring while perusing the Jamuna Bridge Seismic Instrumentation project (2009) on the spot of Jamuna Bridge construction site at Natore, Bangladesh. The time history record for Dhaka city (Longitude 90°24' and Latitude 23°43') has been constructed here by scaling up the recent earthquake record in Natore. In the Natore earthquake record the peak ground acceleration is 2.43 cm/s^2 at 11.425 s. Seismic zone coefficient of moderate seismicity region (Zone II) Dhaka is 0.15 (BNBC, 1993). So, the maximum ground acceleration for Dhaka comes accordingly following the code is 0.15 g ≈147.15 cm/s^2 which is 61.58≈62 times greater than that of Natore data. Scaling factor is rounded to 62. This essentially means that all the values are to be multiplied by scaling factor 62. Obviously the time series of acceleration, velocity and displacement have been obtained as in Figure 2. Time history of seismic loading is mostly used in terms of acceleration parameter merely. The sketches of acceleration time history for projected Dhaka earthquake have been shown in Figures 3 to 4 in most acquainted unit as cm/s^2 for ground acceleration. This outcome is compatible for dynamic analysis as |time history input at numerous analysis programs. Figure 3 shows the acceleration

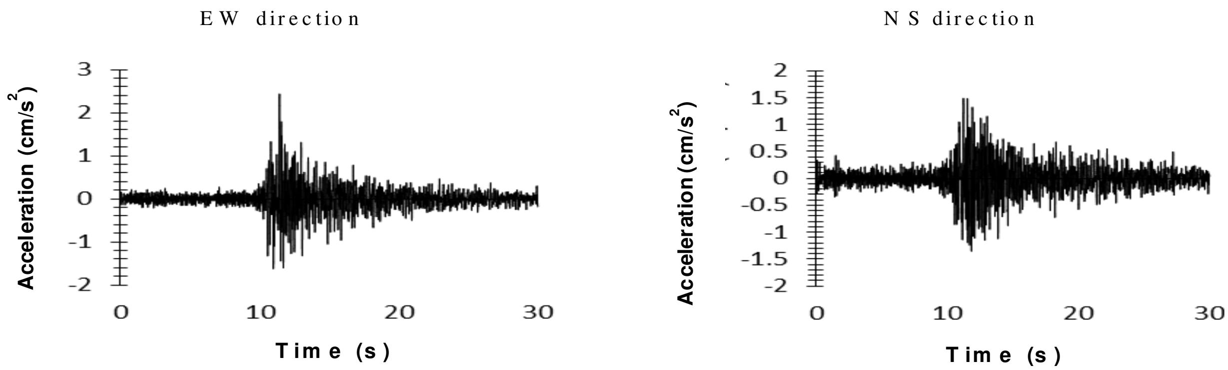

Figure 1. Acceleration time history of Natore EQ.

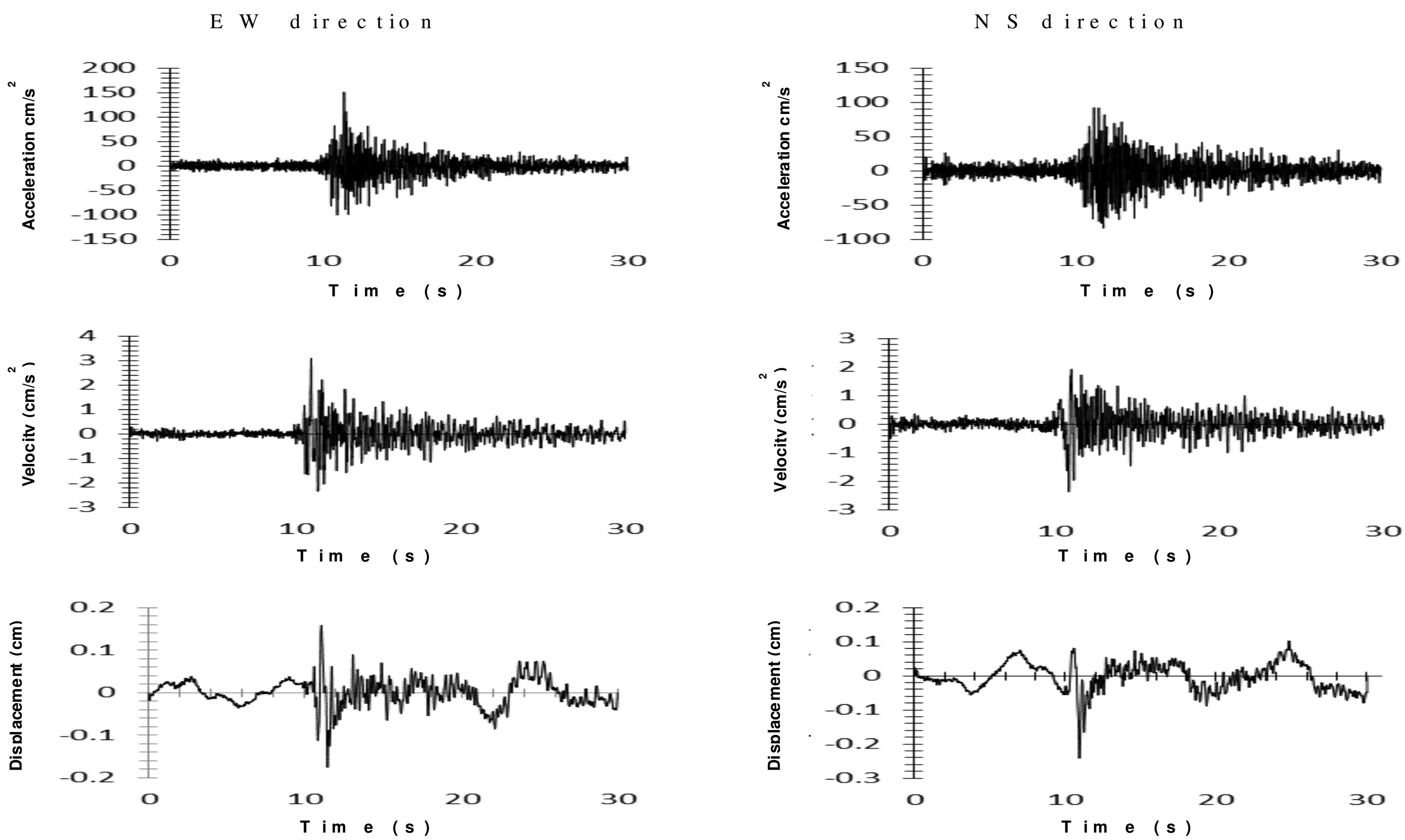

Figure 2. Variation of ground acceleration, velocity and displacement for earthquake in Dhaka.

time history in east-west direction whereas Figure 4 demonstrates north-south directional data as well.

EVALUATION OF DHAKA EARTHQUAKE TIME HISTORY

The developed time history for Dhaka, Bangladesh region ensures data for bilateral direction. In this record, the maximum acceleration for Dhaka, the peak value in east-west (EW) direction resembles to 0.154 g. North-south (NS) directional maximum ground acceleration occurs at0.094 g. This data has been compared with the prominent seismic records of 1952 Kern County and 2008 Pomona earthquake record. The 1952 Taft Lincoln school tunnel (component N21E) record of July, 1952 at the Kern County, California earthquake denotes the peak acceleration 0.173 and 0.152 g in EW and NS direction respectively. Figure 5 illustrates the time history of ground acceleration in east-west direction for Kern

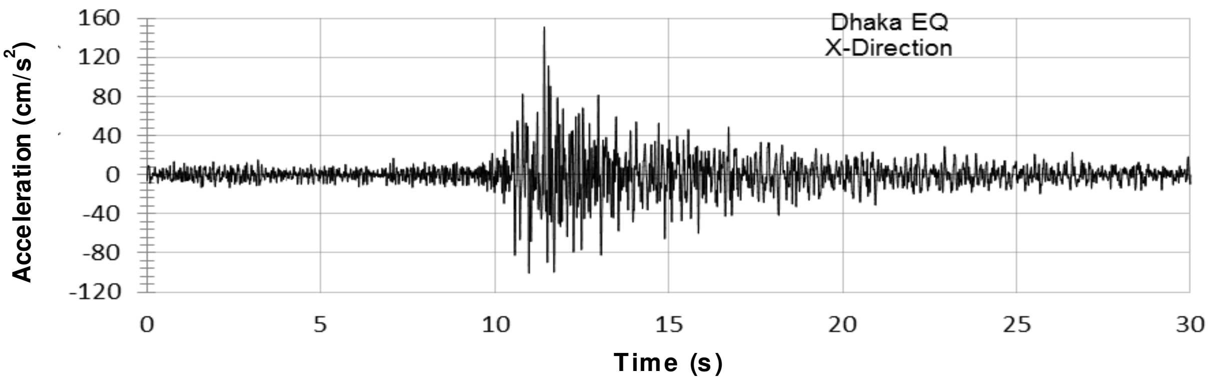

Figure 3. Dhaka earthquake time history in EW direction.

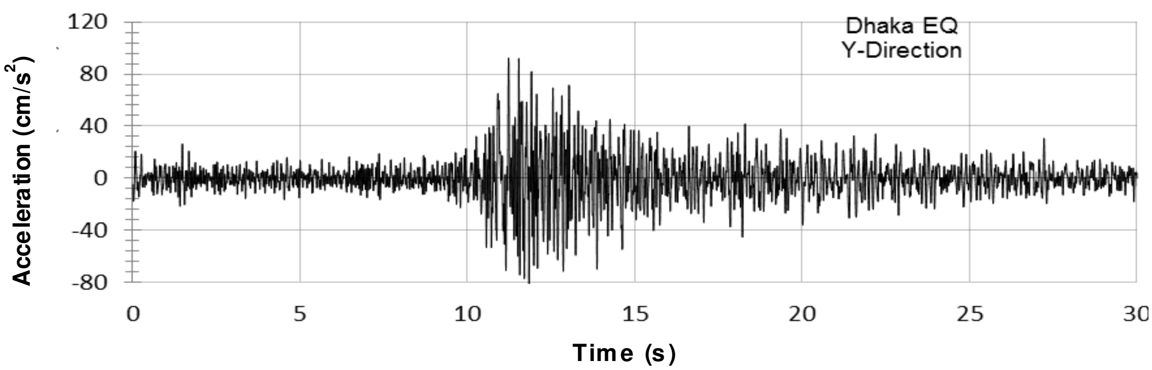

Figure 4. Dhaka earthquake time history in NS direction.

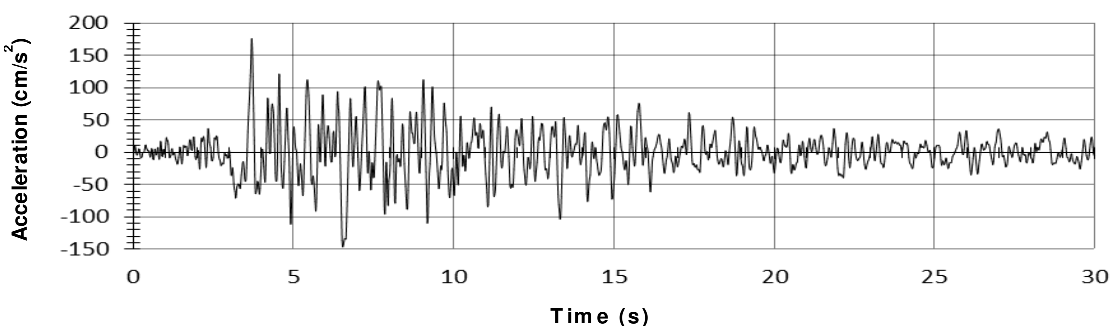

Figure 5. 1952 Kern County Earthquake Time History in EW direction.

County earthquake. The acceleration data of north-south direction in Kern county EQ has been given in Figure 6 in addition. The pattern of acceleration fluctuations with time is identical. The peak values are about 16% higher in EW direction than that of Dhaka EQ time history. However, the peak value of NS path shows larger value which is nearer to EW directional peak of forecasted Dhaka EQ data. This illustration is expected as because of occurrence of larger magnitude earthquake in that region.

The 2008 Pomona, California (33.955◦N, 117.765◦W) record of July, 2008 at the Pomona & Chino Hills, Los Angeles, California earthquake has been presented in Figure 7 for east west direction. Subsequent data of north south direction is duly shown in Figure 8. The data denote the peak accelerations as 0.185 g and 0.119 g in EW and NS direction respectively. Though the former peak is slightly greater than the engendered time history peaks, the pattern of time series is quite similar. It is

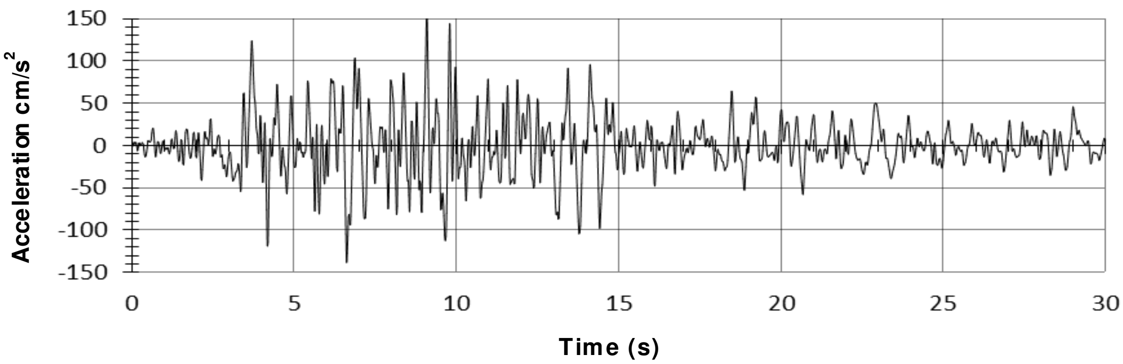

Figure 6. 1952 Kern County earthquake time history in NS direction.

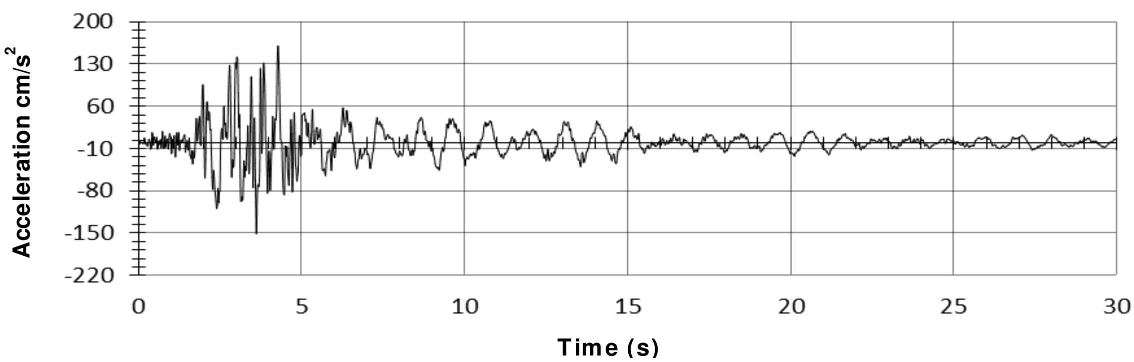

Figure 7. 2008 Pomona earthquake time history in EW direction.

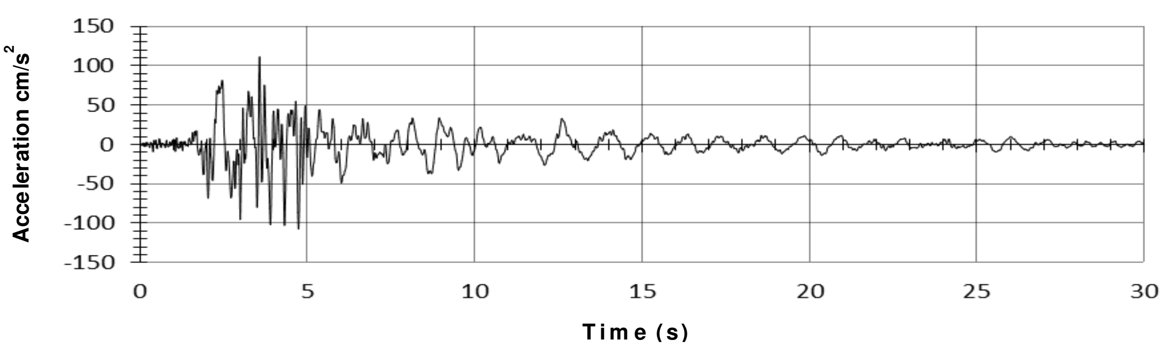

Figure 8. 2008 Pomona earthquake time history in NS direction.

mentionable that there is a little alteration of acceleration history at NW direction for this and projected seismic record. Tabular comparison addressing critical evaluation for the proposed Dhaka earthquake time history with the proverbial seismic data of Kern County and Pomona earthquake has been presented in Table 1. From the mentioned investigation, comparative discussion clarify that the bi-directional time history developed for Dhaka earthquake in EW and NS direction ensures a useable tool for dynamic analysis of structure. This seismic input essentially yields the responses at every little incremental state of numerous time extents. From this time history data, the soil characteristics, site location, seismic coefficients and seismic response coefficient, response spectrum for Dhaka, Bangladesh can be generated. Further research is needed to take challenge of generating site specific precise response spectrum for this region towards aid in rapid dynamic structural analysis.

Table 1. Evaluation of developed Dhaka earthquake time history.

Earthquake	Record Description	Magnitude (Richter)	Peak Ground Acceleration
Taft	Kern County, July 1952	7.7	0.173 g in EW direction 0.152 g in NS direction
Pomona	Pomona, California, July 2008	5.4	0.185 g in EW direction 0.119 g in NS direction
Dhaka	Dhaka, Bangladesh	-	0.154 g in EW direction 0.094 g in NS direction

CONCLUSIONS

In fact Bangladesh lacks heavily on seismic instruments and enough data of earthquake records is not available especially of Dhaka. So nearby natural earthquake record has been considered to develop acceleration time history for this region. As highly nonlinear dynamic analysis requires more precise data to be executed, this time history will be very useful in Dhaka, Bangladesh vicinity for structural context. The study reveals that the generated time history is of similar pattern to the prominent earthquake records selected for evaluation of the generated data. The obtained time history is supposed to be exploited as suitable seismic data for dynamic analysis of structures. It is imperative to install suitable number of seismic stations so that in future, site specific real earthquake records for all over Bangladesh can be developed.

ACKNOWLEDGMENTS

The authors thankfully wish to acknowledge the effort by Bangladesh earthquake society, Bangladesh university of engineering and technology as well as the support provided by research university grant, No. RG093/10AET, university of Malaya to enhance the research works coming round at success.

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