Seismic monitoring network and earthquake hazard mitigation

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ABSTRACT: *Pakistan Atomic Energy Commission (PAEC) is operating a seismic monitoring network since 1975 and recently installed a 24-bit digital seismograph network of four stations to improve the quality of the seismic data, seismic event detection and location capability. The high quality seismic data now available to the scientists will be very helpful to understand the earthquake source process, Earth structure and seismotectonics of the region. The accurate location of seismic event will help in providing the immediate emergency relief in the affected areas.*

INTRODUCTION

In Pakistan, not much attention has been paid to the seismic design and to achieve appropriate counter measures against earthquakes. The safety of the non-engineered buildings from the fury of earthquakes is subject of highest priority. To reduce the impact of the earthquake hazard different aspects including seismic monitoring, emergency response and counter measures considering seismic design for nuclear facilities and other civil structures of national importance were undertaken by Pakistan Atomic Energy Commission (PAEC).

PAEC is operating a seismic network in Pakistan since 1975 (Mubarak et al., 1977). The purpose of this seismic network is to monitor seismic activity with a view to determine accurate hypocenters of local earthquakes and its spatial distribution, orientation and nature of faults. The high quality seismic data available is supplementing the geological information and is leading to a better evaluation of the seismic hazard associated with different sites of national importance.

The PAEC seismic network is described in the following section.

SEISMIC NETWORK

The seismic monitoring network of Pakistan Atomic Energy Commission is located between 69° to 74°E and 28° to 34°N. It consists of short period and broadband seismometers to record the whole frequency spectrum generated by the local, regional and teleseismic events. The purpose of this network is to monitor closely the seismic activity in the Sulaiman Range, Salt Range and Northern regions of Pakistan. Fig. 1 shows the distribution of the Seismic Network and Table-1 gives the location parameters of the stations. The station distribution is based on the following criteria.

* The stations are located in the area of interest
* Lowest short- period noise level
* Most competent rock available in the area of interest
* Acceptable topography

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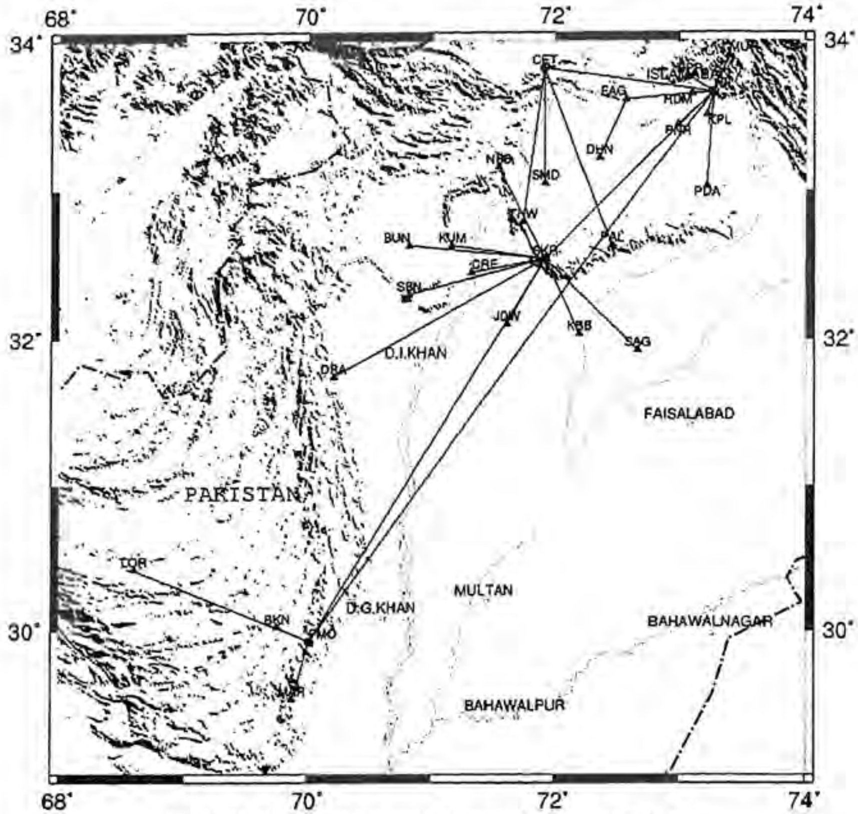

Fig. 1: PAEC Seismic Network. Names of stations in Table 1.

- Availability of power and communications
- Isolation from natural and man-made noise generating sources
- Logistic support
- Proximity to restricted areas.

The typical short period seismic noise at the seismic stations of the network is shown in Fig. 2 and is about 6 to 20 dB higher (depending upon the type of rock and cultural noise at the station site) compared to New Peterson Low Noise model (Peterson, 1993). The detection capability of the network is as low as 0.7 m_b if the earthquake is within the network (Qaisar et al., 2003). Fig. 3 shows a block diagram of the seismic station. The data from individual station is received in near real time at a central recording station at Nilore Islamabad via radio telemetry and satellite data transmission (Fig. 4) where it is processed for location and magnitude determination as soon as possible. Events of magnitude 5.0 and above are immediately reported to the concerned authorities for necessary action.

INSTRUMENTATION

The instrumentation employed for the network is shown in Fig. 3. A seismometer (1 Hz natural period and 20 Second natural period for broad band), an amplifier, a voltage-controlled oscillator (24 bit Analog to Digital converter for digital stations) a radio transmitter and an antenna are installed at each seismic station. The seismometer (for technical specifications please see Table 2) is buried in the ground at a depth of few feet preferably on bedrock (One borehole type broad band seismometer is installed in a 70 meter deep hole). The electronic package is also buried in the ground in most cases to

TABLE-1

STATIONS INFORMATION

Sr. No.	STATION NAME	CODE	LATITUDE (N)	LONGITUDE (E)
1.	Bannu	BUN	3237.90	7048.83
2.	Chashma (Right Bank)	CRB	3227.16	7119.07
3.	Cherat	CET	3349.41	7154.54
4.	Dera Zinda	DRA	3144.64	7012.17
5.	Dhulian	DHN	3312.90	7221.47
6.	Fateh Jang	FAG	3336.79	7234.35
7.	Jandawala	JDW	3206.00	7136.80
8.	Khushab	KBB	3202.00	7212.00
9.	Kirpa	KPL	3336.38	7313.44
10.	Kurram	KUM	3238.05	7109.81
11.	Murree	MUR	3354.00	7323.20
12.	Niarob	NBB	3309.72	7132.27
13.	Nilore	NIL	3339.50	7315.85
14.	Pail	PAL	3237.88	7227.88
15.	Parri Darveza	PDA	3302.00	7313.00
16.	Pinglar	PNR	3332.15	7259.45
17.	Rawal Dam	RDM	3341.65	7308.20
18.	Said Pur	SPP	3344.60	7304.50
19.	Sakesar	SKR	3232.45	7155.00
20.	Sargodha	SAG	3155.29	7240.31
18.	Shah Mohammadi	SMD	3302.81	7155.26
19.	Shiekh Budin	SBN	3217.98	7048.43
20.	Thame Wali	THW	3247.66	7144.56
21.	Lora Lai	LOR	3021.00	6805.40
22.	Fort Munroe	FMO	2955.26	7000.59
23.	Mari	MAR	2931.36	6952.25
24.	Bar Khan	BKN	3001.63	6944.84

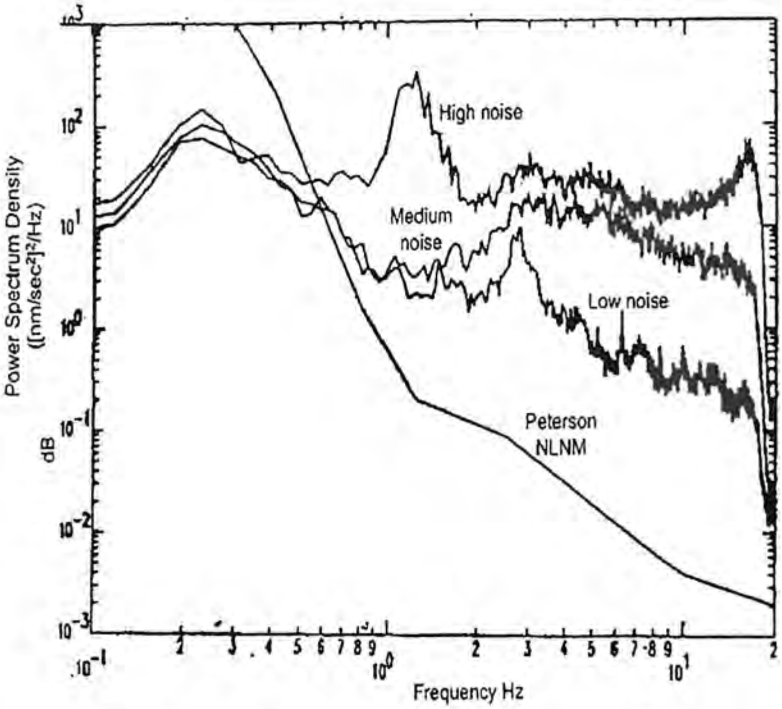

Fig. 2: Medium, High Seismic Noise compared to Peterson's NLNM

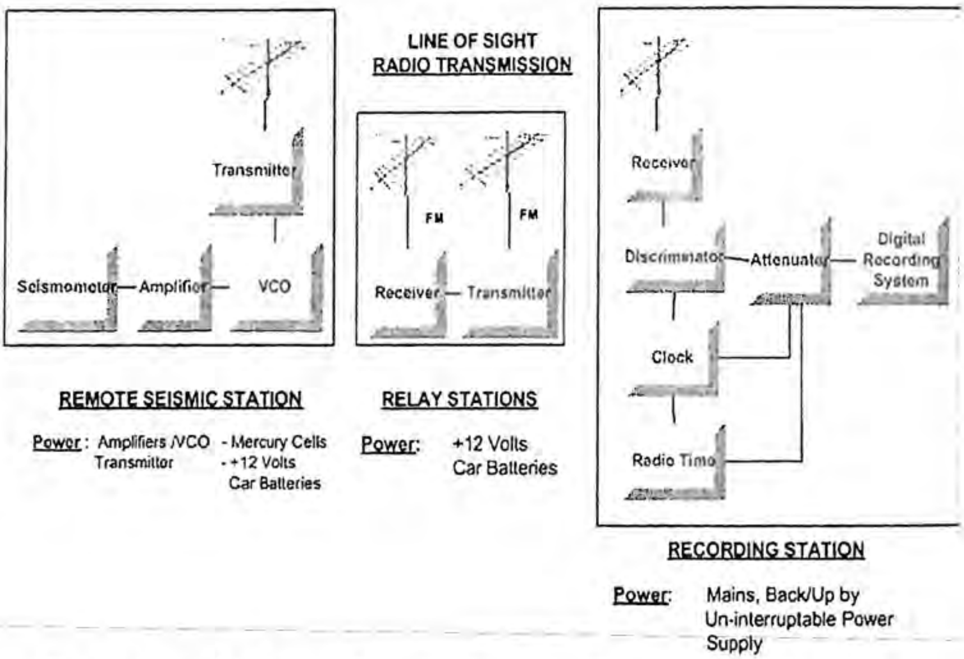

Fig. 3: Schematic flow diagram of remote seismic stations, data transmission and recordings.

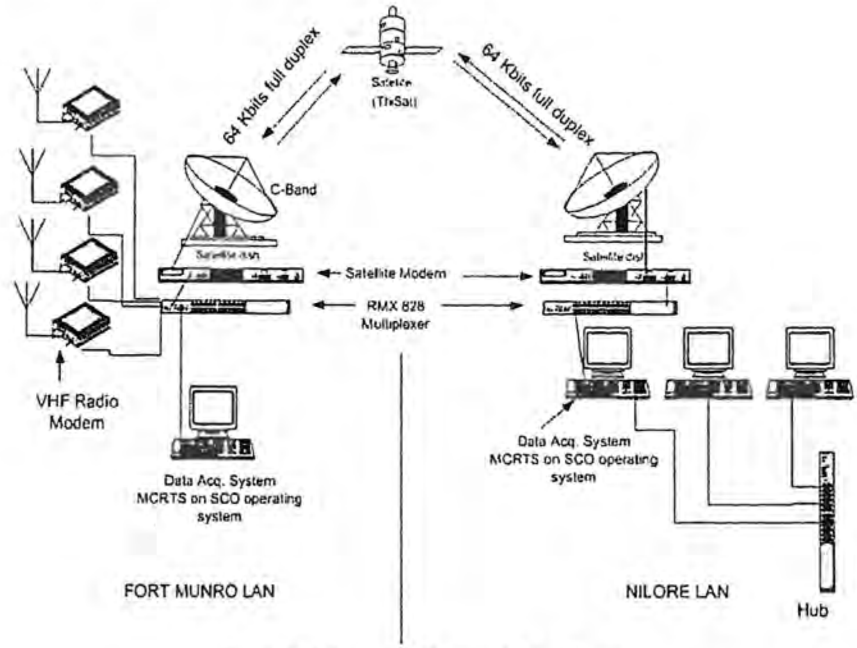

Fig. 4: Link between Nilore and Fort Munro.

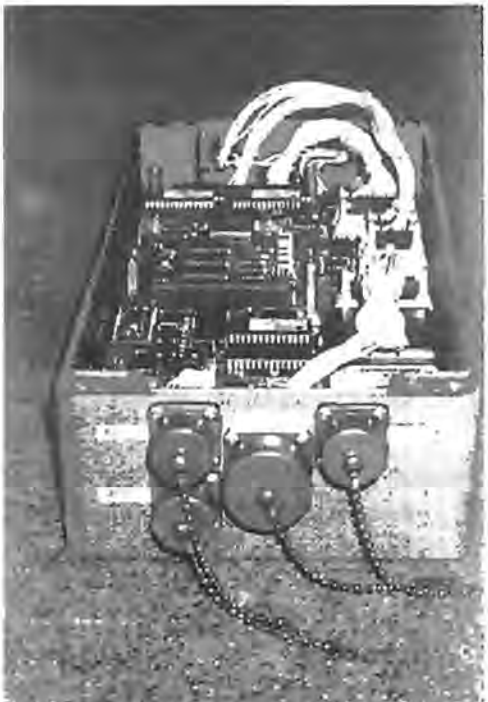

Fig. 5: 24-bit Analog to Digital Converter.

eliminate the effect of changes in temperature. The equipment operates on 12 Volts car batteries and solar panels keep these batteries to operate for about six months.

CENTRAL RECORDING AND ANALYSIS LAB

Seismic data from all the field stations is received and is recorded on computer based data acquisition systems. The continuous data is recorded round the clock. The real time automatic detection and location software generates an audible alarm as soon as an event is declared. The operators refine this automatic location. The lab is equipped with different types of seismic analysis codes, which are useful for research and development activities.

DISCUSSION AND CONCLUSIONS

1. The data produced by the network has been successfully used for the location and magnitude determination in near real time, which is very important for the earthquake hazard mitigation. Kohat earthquake of May 20 1992

TABLE -2

TECHNICAL SPECIFICATIONS OPERATING CHARACTERISTICS

Mode of Operation	Convertible, vertical and horizontal
Natural frequency	0.75-1.1 Hz, typical 1 Hz
Tilt	Operates within 4° of vertical at 0.8 Hz
Inertial mass	5.0 kg (11.0 lbs.)
Temperature Range	-51 to +60 °C (-60 to +140 °F)
Transducer type	Moving coil (velocity)
Damping	Electromagnetic
Generator constant	629 V/(m/sec)
Coil resistance	3600 Ohms
Maximum Mass Travel	±3.0 mm (0.12 in.)
Calibration Coil Resistance	23 Ohms, maximum current 100 mA,

1220 GMT (33° 162 N 71° 17.31 E, $m_b = 6.0$, 35 km from Kohat city and toll deaths 20 to 25 persons) was successfully located and reported in near real time. An other example is Fateh Jang Earthquake of 17th Feb. 1993 at 1606 GMT 33° 35.50 N 72° 30.02 E, $m_b=5.3$ and depth 7.0 km that caused minor damages to the property was reported in time.

2. The seismic data collected has been used in a project on compilation of seismic zoning map of Pakistan, earthquake producing potential of each zone and return period of earthquakes.

3. The seismic data available can be used in earthquake prediction research program, which can strengthen the role of experts and minimize the non-scientific earthquake forecasts.

4. To reduce the impact of the earthquake hazard different aspects including earthquake monitoring, fast determination of earthquake source parameters, emergency response and counter measures should be given due consideration

5. A national seismic monitoring network, which should cover the whole of Pakistan, will be very useful for hazard mitigation and research work.

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