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QNO 1:

Answer:

Earthquakes are usually caused when rock underground suddenly breaks along a fault. This sudden release of energy causes the seismic waves that make the ground shake. When two blocks of rock or two plates are rubbing against each other, they stick a little. They don't just slide smoothly; the rocks catch on each other. The rocks are still pushing against each other, but not moving. After a while, the rocks break because of all the pressure that's built up. When the rocks break, the earthquake occurs. During the earthquake and afterward, the plates or blocks of rock start moving, and they continue to move until they get stuck again. The spot underground where the rock breaks is called the **focus** of the earthquake. The place right above the focus (on top of the ground) is called the **epicenter** of the earthquake.

Earthquakes proved to be the most devastating natural disaster with a high mortality rate and wide spread destruction. Earthquake induced ground shaking plays a key role in excessive ground deformation and infrastructure damage, and in triggering secondary hazards such as landslides, flooding, tsunamis, fire and liquefaction. The intensity and duration of an earthquake induced ground shaking depends on magnitude, depth of hypocenter, medium traversed by seismic waves; and physical and geotechnical characteristics of the site. Tools of GIS and remote sensing are frequently and effectively used for earthquake hazard, vulnerability and risk assessment and assist in developing risk reduction strategies. Pakistan is located in one of the most earthquake prone region with many devastating earthquakes in the past and active tectonic shows that there might be more earthquakes in future. Hence it is crucial to perform earthquake hazard assessment across the country and subsequently develop and implement strategies for earthquake risk mitigation. Subsequent to facing extensive devastation by the 2005 Kashmir earthquake, the government has realized the importance of earthquake management and hence encouraged the scientific research aiming for earthquake hazard assessment and strategies for risk reduction. Moreover, organizations have been established mainly dedicated for natural disaster management. However, the magnitude of prevailing earthquake induced risk needs detailed earthquake hazard assessment, design earthquake resistant structures; implement the seismic building codes and public awareness to adopt for earthquake risk reduction.

QNO 2:

Answer (a):

History of seismology:

Every day: There are about 50 earthquakes strong enough to be felt locally; several of these produce distant seismic waves that can be measured with sensitive instruments anywhere on the globe.

Every few days:

There is an earthquake strong enough to damage structures.

Seismology is the scientific study of the seismic waves generated by earthquakes.

Scientific & Practical Objectives of Seismology:

To learn about the structure of the earth (direct observation To learn about the structure of the earth (direct observation of the deep earth is impossible) and the physics of of the deep earth is impossible) and the physics of earthquakes earthquakes To make the engineered human environment safer To make the engineered human environment safe.

Seismology is a young science, only about 150 years old. Before scientific studies began, ideas about earthquakes were largely based on myth and superstition.

Early 1800s The theory of elastic wave propagation in solid♣ materials is developed by Cauchy, Poisson, Stokes, Rayleigh, and others. They describe primary and secondary body waves (P- and S-waves) and surface waves. (Theory is way ahead of observation.) “Introduction To Seismology” by Peter Shearer, Cambridge University Press

1857 R. Mallet, an Irish engineer, travels to Italy to study♣ damage caused by an earthquake near Naples. His work is generally considered to be the first serious attempt at observational seismology. His contributions: earthquake waves radiate from a central focus earthquake waves radiate from a central focus♣ earthquakes can be located by projecting these waves earthquakes can be located by projecting these waves♣ backward toward the source backward toward the source observatories should be established to monitor earthquakes observatories should be established to monitor earthquakes♣ “Introduction To Seismology” by Peter Shearer, Cambridge University Press.

1875 F. Cecchi builds the first time-recording seismograph♣ in Italy. Higher quality instruments are then developed by♣ British scientists in Japan. These early instruments are undamped, and therefore♣ inaccurate after the first few cycles of shaking. “Introduction To Seismology” by Peter Shearer, Cambridge University Press 1897 First seismograph in North America is installed at♣ Lick Observatory near San Jose, California. This instrument will later record the 1906 San Francisco earthquake. “Introduction To Seismology” by Peter Shearer, Cambridge University Press

1897 E. Wiechert develops the first seismometer with♣ viscous damping, capable of producing a useful record for the entire duration of ground shaking. “Introduction To Seismology” by Peter Shearer, Cambridge University Press Early.

1900s B. B. Galitzen develops the first electromagnetic♣ seismograph in which a moving pendulum generates electric current in a coil, and establishes a network of seismic stations across Russia. The new design will prove to be much more accurate♣ and reliable than previous mechanical instruments; all modern seismographs are electromagnetic. “Introduction To Seismology” by Peter Shearer, Cambridge University Press 1906 H. F. Reid, an American engineer, studies survey♣ lines across the San Andreas fault measured before and after the 1906 San Francisco earthquake. He proposes an “elastic rebound” theory for the origin of earthquakes, where accumulated elastic energy is released suddenly by slip on the fault. “Introduction To Seismology” by Peter Shearer, Cambridge University Press.

1900-1910 Seismograms from many earthquakes recorded at♣ many distances become widely available. R. Oldham identifies P-, S-, and surface waves in♣ earthquake records, and detects liquid earth’s core from the absence of direct body waves at certain distances. A. Mohorovicic identifies velocity boundary between♣ earth’s crust and mantle (Moho). The first widely-used travel-time tables are published♣ by Zöppritz.

QNO 2:

Answer (b):

The essence of successful seismic design is three-fold. First, the design team must take a multi-hazard approach towards design that accounts for the potential impacts of seismic forces as well as all the major hazards to which an area is vulnerable. Second, performance-based requirements, which may exceed the minimum life safety requirements of current seismic codes, must be established to respond appropriately to the threats and risks posed by natural hazards on the building's mission and occupants. Third, and as important as the others, because earthquake forces are dynamic and each building responds according to its own design complexity, it is essential that the design team work collaboratively and have a common understanding of the terms and methods used in the seismic design process.

A. Origin And Measurement Of Earthquakes

PLATE TECTONICS, THE CAUSE OF EARTHQUAKES

Earthquakes are the shaking, rolling, or sudden shock of the earth's surface. Basically, the Earth's crust consists of a series of "plates" floating over the interior, continually moving (at 2 to 130 millimeters per year), spreading from the center, sinking at the edges, and being regenerated. Friction caused by plates colliding, extending, or subducting (one plate slides under the other) builds up stresses that, when released, causes an earthquake to radiate through the crust in a complex wave motion, producing ground failure (in the form of surface faulting [a split in the ground], landslides, liquefaction, or subsidence), or tsunami. This, in turn, can cause anywhere from minor damage to total devastation of the built environment near where the earthquake occurred.

EASURING SEISMIC FORCES

In order to characterize or measure the effect of an earthquake on the ground (a.k.a. ground motion), the following definitions are commonly used:

- *Acceleration* is the rate of change of speed, measured in "g"s at 980 cm/sec^2 or 1.00 g.

    - For example,
        - 0.001g or 1 cm/sec^2 is perceptible by people
        - 0.02 g or 20 cm/sec^2 causes people to lose their balance
        - 0.50g is very high but buildings can survive it if the duration is short and if the mass and configuration has enough damping
- *Velocity* (or speed) is the rate of change of position, measured in centimeters per second.
- *Displacement* is the distance from the point of rest, measured in centimeters.
- *Duration* is the length of time the shock cycles persists.
- *Magnitude* is the "size" of the earthquake, measured by the Richter scale, which ranges from 1-10. The Richter scale is based on the maximum amplitude of certain seismic waves, and seismologists estimate that each unit of the Richter scale is a 31 times increase of energy. *Moment Magnitude Scale* is a recent measure that is becoming more frequently used.

If the level of acceleration is combined with duration, the power of destruction is defined. Usually, the longer the duration, the less acceleration the building can endure. A building can withstand very high acceleration for a very short duration in proportion with damping measures incorporated in the structure.

Intensity is the amount of damage the earthquake causes locally, which can be characterized by the 12 level *Modified Mercalli Scale* (MM) where each level designates a certain amount of destruction correlated to ground acceleration. Earthquake damage will vary depending on distance from origin (or epicenter), local soil conditions, and the type of construction.

B. Effects Of Earthquakes On Buildings

Seismic Terminology (For definitions of terms used in this resource page, see Glossary of Seismic Terminology)

The aforementioned seismic measures are used to calculate forces that earthquakes impose on buildings. Ground shaking (pushing back and forth, sideways, up and down) generates internal forces within buildings called the *Inertial Force* ($F_{Inertial}$), which in turn causes most seismic damage.

$F_{Inertial}$ = Mass (M) X Acceleration (A).

The greater the mass (weight of the building), the greater the internal inertial forces generated. Lightweight construction with less mass is typically an advantage in seismic design. Greater mass generates greater lateral forces, thereby increasing the possibility of columns being displaced, out of plumb, and/or buckling under vertical load (P delta Effect).

Earthquakes generate waves that may be slow and long, or short and abrupt. The length of a full cycle in seconds is the *Period* of the wave and is the inverse of the *Frequency*. All objects, including buildings, have a *natural* or *fundamental period* at which they vibrate if jolted by a shock. The natural period is a primary consideration for seismic design, although other aspects of the building design may also contribute to a lesser degree to the mitigation measures. If the period of the shock wave and the natural period of the building coincide, then the building will "resonate" and its vibration will increase or "amplify" several times.

QNO 3:

Answer:

Pakistan is situated within a hazard-prone region and is exposed to a variety of natural disasters such as floods, cyclones, earthquakes, landslides and droughts. Rapid population growth, uncontrolled development and unmanaged expansion of infrastructure are the most common factors that result in more people being vulnerable to natural hazards than ever before (Cardona *et al*. 2003). The burden of natural disasters in Pakistan can be underlined by the fact that they have been responsible for the deaths of 6037 people in the period from 1993 to 2002, with a further 8.9 million people also affected (World Disasters Report 2003). More than 80 000 people died and 3.5 million lost their homes in a single event: the earthquake of 8 October 2005. A consistent major problem for Pakistan's authorities is that natural hazards occur more or less regularly at all scales. Furthermore, disaster management in Pakistan, particularly with regard to natural hazards, focuses mainly on rescue and relief processes. There is a dearth of information and little understanding of the processes involved in hazard identification, risk assessment and management, and the relationship between people's livelihoods and disaster preparedness (WCDR 2005). Disaster management policy in Pakistan does not make adequate use of recent developments in scientific methodologies, methods and tools for cost-effective and sustainable interventions.

As our conceptual basis we started from the hypothesis that every hazard has a spatial dimension that determines when a hazard turns into a disaster, and hence may influence vulnerability to spatially relevant natural hazards (Cutter 1996 a,b).

The impacts that disasters have on humans are not solely dependent on their exposure to the hazard, but also on how capable they, and their surroundings are of anticipating, resisting, coping with, and recovering from, their effects (Wisner *et al*. 2004, Greiving 2006). We may consider particular environments to be hazard or disaster agents and the origins of risk and disaster to lie in the physical environment (Gilbert 1995). From this perspective disasters are regarded as a function of external agents and communities as the victims of extreme events (Hewitt 1983, Flint and Luloff 2005). Alternative perspectives also exist that place societal conditions at the centre of the disaster descriptions and interpretations, in which disasters are not necessarily the inevitable outcome of a hazard's impact but a result of intersections between hazards and everyday vulnerabilities (Hewitt 1998, Flint and Luloff 2005). Spatial planning may therefore become crucial to keeping a balance between the two viewpoints. Spatial planning may contribute effectively to disaster risk reduction but according to the United Nations Development Programme (UNDP), many countries still lack clear guidelines on how to deal with hazards and risk on a spatial planning level (UNDP 2004). The Kashmir earthquake 2005 increased awareness in the general public and public administration of the overall high level of risk in Pakistan, and the fact that it is steadily increasing. It is however not sufficient to restrict policies to the response phase of the disaster management cycle: hazard mitigation activities are also crucially important if lives are to be saved and damage reduced, and preparedness is an essential component of any sustainable planning practice. Evidence from scientific literature and best practice examples around the world makes it clear that Pakistan does not have in place appropriate spatial planning tools. Even if we accept that awareness of natural hazards and their associated risks has increased over recent years in Pakistan, the effectiveness of the majority of planning and management related activities will remain limited while they remain based on single hazard approaches.

One assessment of social vulnerability to environmental hazards that used county-scale indicators across the United States (Cutter *et al*. 2003) has provided guidance for this study of Pakistan, but in this case the available data are incomplete. Some simplifications are therefore necessary when designing a methodology for Pakistan, as there is insufficient hard data available for an understanding of social vulnerabilities at a local level, or of the interactions between biophysical and social vulnerabilities. Proxy indicators have instead been derived: some were derived directly from census data while others were developed from auxiliary data using GIS analyses. Studies of relevant literature (e.g. Cutter 1996a, b, Clark *et al*. 1998, Tralli *et al*. 2005, Greiving 2006, Fleischhauer 2006, Birkmann and Wisner 2006, Birkmann 2007) have revealed that integrated multi-hazard risk approaches are still rare in many parts of the world. This is despite improved scientific understanding and the ability to disseminate temporal geospatial information that can potentially be integrated with demographic and socioeconomic data. The means are available to develop comprehensive risk mitigation planning and improved disaster response. The scientific community recognizes the manifold interactions between the hydrosphere, atmosphere, biosphere and solid Earth as a complex system (Tralli *et al*. 2005), and that geospatial information in general, and GIS and remote sensing in particular, today provide a synoptic planning perspective for a multiplicity of spatial scales with variable temporal resolution. There is clear evidence that the use of recent technologies, internationally coordinated observation systems, and modelling, can help characterize, monitor and possibly forecast a wide range of devastating events and their effects. Remote sensing and geospatial information tools and techniques, including numerical modelling, have advanced considerably in recent years (Tralli *et al*. 2005, Joyce *et al*. 2009).

The nature of spatial planning requires a multi-risk approach that analyses all relevant hazards as well as the vulnerability of a particular area. In §3.2 of this article we integrate socio-economic, environmental and physical dimensions of vulnerability in order to estimate the damage potential and coping capacity. Our approach cannot, however, be regarded as all-inclusive due to the versatile nature of vulnerability, and also due to the limitations on data availability as explained in §3.1.1.

QNO 4:

Answer:

Vulnerability is a relatively new approach that links hazard distributions with risk research and refers to the susceptibility of individuals, communities or regions to natural or technological hazards (Cutter 1996a, b, Cutter *et al*. 2003, Kumpulainen 2006, Birkmann, 2007). Vulnerability is a condition, but at the same time it is also a process resulting from physical, social and environmental factors that increase the susceptibility of a community or area to the impact of a hazard (ADRC 2005). Vulnerability also encompasses the concepts of response and coping, since it is dependent on the potential of a community or area to withstand or react to a disaster. Westgate and O'Keefe (1976) suggested vulnerability has a social character and is not limited to potential physical damage or to demographic determinants. It is stated that disasters only occur when the losses exceed the capacity of the population to support or resist them.

Pakistan lies between 23° 35′ to 37° 05′ N latitude and 60° 50′ to 77° 50′ E longitude (figure 1). It touches the Hindukush Mountains in the north and extends from the Pamirs to the Arabian

Sea. The country has a total area of 796 095 km^2. It consists of such physical regions as: (a) the Himalayas, which cover its northern part, and K-2 in its north western part; (b) the Balochistan plateau; (c) The Potohar Plateau and salt range; and (d) The Indus plain, the most fertile and densely populated area of the country. It gets its sustenance from the Indus River and its tributaries. Most of Pakistan has a generally dry climate and receives less than 250 mm of rain per year, although northern and southern areas have noticeable climatic differences. The average annual temperature is around 27°C, but temperatures vary with elevation from −30°C to −10°C during the coldest months in mountainous and northern areas of Pakistan. The plains of the Indus valley are extremely hot in summer with cold and dry weather in winter. The coastal strip in the south has a moderate climate. Due to the rainfall and high diurnal range of temperature, humidity is comparatively low. Only the coastal strip has high humidity.