Discourse on Earthquakes

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Summary

The article addresses the historical way in which earthquake science has moved forward, overcoming the many hurdles of political, religious and social nature. The article also goes on to show, how many great men were ahead of their time and set forth the real truth over the imposed truth. Moreover, it seeks to encourage professionals in the field, to reflect upon the material herein put forward, so they may understand that absolute truths imposed by a minority, are not the best for a society endeavouring to grow under concepts of equity, balance and justice.

Keywords: Earthquake Engineering, History of earthquakes, development of science, performance of nature, nature of earthquakes, Philosophy of quakes, natural disasters.

Discourse

The study of earthquakes and the way to deal with them are nothing new to man who, has had to face them since the very beginning of mankind. There are written records in China dating as far back as 3000 years into the past in which, earthquakes are described in surprising detail, telling us how they saw them, in much the same way as we perceive them today. 1600 year old Eastern Europe and Japanese records, give us detailed accounts of earthquake effects on populations in those regions. Records are far more recent in America, though. Nevertheless, codexes have surfaced where Mayan and Aztec tribes were able to describe these extraordinary phenomena. There is also documentation from the Colonial era (Indies archives) that relate in detail the main events affecting the Meso-American regions. Compared to the millions of years that quakes have been shaping the present form of our planet, human experience with this behaviour of nature has been rather short. (Leon Portilla, 1979).

From ancient times, right through to the Hellenic age, and during the Middle Ages (and in some cultures even up to this day) it was attributed to earthquakes, as well as, to all other unknown phenomena a mythical explanation associated to punishment of some sort, divine wrath and the like. I.e. in Japan earthquakes used to be attributed to a great catfish called Namazu which lived under the earth and, was controlled by a god called Daimyojin who kept its head buried under a stone. When the god dropped his guard or his attention would waver, Namazu moved and with the fierce lashings of it's tail made the earth to shake. In Siberia, earthquakes were attributed to the passing by of a god on a sledge under the earth. The Maori believed that a god called Raumoko who was accidentally buried by his mother earth, growled and caused earthquakes.

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Aztecs thought that human life was periodically extinguished due to all kinds of different calamities at the end of each age called «*Sol*» (Sun). The fifth Sol (Sun), the current one, whose sign was Nahui Ollin, meaning «fourth movement» was to meet it's demise by reason of an earthquake. The Aztecs intended to defer the cataclysm that was to put an end to the fifth Sol (Sun), through Chalchíhuatl, the precious water of the sacrifice. (León-Portilla,1979)

In the Savannah where Colombia's capital city is located, Pre-Columbian Chibcha tribes held the belief, that when the earth was created it sat supported by three long wooden beams. But, one day the god Chibchacum decided that it would be rather amusing to see the Savannah of Bogotá submerged under water. He then proceeded to flood the land. This earned him a punishment for which, he was then forced to bear the world on his shoulders and, the Savannah of Bogotá was slipped through the Tequendama Falls. Every now and then, Chibchacum was wroth because of it, and he would stamp on the ground, thereby making the earth to shake. (Espinosa, 2003). Pre-Columbian cultures in Central-America tended to be more pragmatic, and simply thought that the earth was square, and was upheld by four gods who grabbed each corner. When these gods felt that the earth was overpopulated, they would shake it up so as to remove the surplus.

Religious fanaticism, encouraged for the most part by the Catholic Church, understood these phenomena only based on the literal interpretations of the Bible which considered these effects as divine punishment for wicked human behaviour. In the Old Testament in the book of Numbers chapter 16 for instance, the natural phenomenon is mentioned as a punishment in the following manner:

...And Moses said, hereby ye shall know that the Lord hath sent me to do all these works; for I have not done them of mine own mind. If these men die the common death of all men, or if they be visited after the visitation of all men; then the Lord hath not sent me. But if the Lord make a new thing, and the earth open her mouth, and swallow them up, with all that appertain unto them, and they go down quick unto the pit ; then ye shall understand that these men have provoked the Lord. And it came to pass, as he had made an end of speaking all these words, that the ground clave asunder that was under them: And the earth opened her mouth, and swallowed them up, and their houses, and all the men that appertained unto Korah, and all their goods. They, and all that appertained to them, went down alive into the pit, and the earth closed upon them: and they perished from among the congregation.....

The Bible also mentions catastrophes which were in all probability the result of earthquakes. Such as, the story about the walls of Jericho circa 1100 B.C, and the destruction of Sodom and Gomorrah. Notwithstanding, this was not always the case, since, prior to the existence of Christianity, the effects of earthquakes were all too often the stuff legends are made of; as shown in the chronicle of the sinking of Atlantis twelve centuries ago, narrated by Plato in the classic «*The Flood of Ogiges*» in 1900 B.C most probably caused by the effects of an earthquake and a Tsunami.

Moreover, earthquakes were in those days the source of many a superstition. According to Tucicides, the armies of the Peloponnese that marched toward Beocia, were shaken by earthquakes in 476 B.C. At that time they were considered bad omens, due to which the invasion was cancelled. Imagination, the collective subconscious and fears outweighed scientific principles. Howbeit, they were all somewhat more amusing and fun, since, earthquakes, based on ignorance, would exert influence even on politics. (Gause and Nelson, 1981).

Great buildings destroyed by fierce earthquakes, went on to become legends and myths, like the destruction of the Colossus of Rhodes in 225 A.C, and the lighthouse of Alexandria

which was destroyed by an earthquake in 800 A.C. Both structures were part of the seven wonders of the ancient world. Their destruction and motive was documented in detail adducing divers supernatural causes. Although for the population, whom in those days were for the most part illiterate, the affair was reduced to being an issue of the gods, who in a fashion not unlike that of Atlas in Greek mythology, who bore the world upon his shoulders, and Poseidon god of the seas who made Atlas totter, thus generating earthquakes.

It was the Philosophers in ancient Greece who were the first to assign natural causes to earthquakes. Anaximenes (5th century B.C) and Democritus (4th century B.C) used to think that, water, humidity and vapour used to cause them. On the other side of the world, in ancient China, it was believed that earthquakes announced imminent changes in government, due to which a very complete seismic report system was developed.

Thales of Miletus (6th century B.C) considered that the earth floated upon water, and that earthquakes were none other thing than the earth crashing against the water, and eruptions of new water through the earth, just like a ship would on the waves. Notwithstanding, Seneca and others dismissed these ideas for violating basic principles of nature. Shortly afterwards emerged the idea that earthquakes were the result of explosions due to gases being released against the ether, which, in those days was supposed to make up the universe. Anaximenes (6th century B.C) originally based the birth of earthquakes on the collapse of deep rock caverns.

At the same time Democritus (4th century B.C) thought that strong inner storms of mixtures of water and air were responsible for earthquakes. These thinkers considered that there was an inner atmosphere within the planet, and parted from the true assumption of a spherical earth. Other successors of the Greek classical thinkers different from Seneca, such as, Straton, considered earthquakes to be the product of the struggle between cold air and hot air within the inner atmosphere of the earth.

The theory that earthquakes were produced by sudden outbursts of hot air, was proposed by Anaxagoras and Empedocles in the 4th century B.C. and picked up by Aristotle in the same era. He gave it such respectability that it reached through to Romans like Seneca and Pliny the elder up to the middle ages. During this time it was spread out by Avicena, Averroes and the Dominican Albertus Magnus and Thomas Aquinas. Nevertheless, during the middle ages naturalistic explanations of earthquakes were formally banned as heretical. The only cause accepted in Europe was Divine wrath. it was not until the beginning of the 17th century that natural causes were once again speculated on. (Udias, 1985).

The middle ages would have come and gone without much progress having been made, had it not been for thinkers such as Albertus Magnus who, was the brightest man of the era along his disciples Thomas Aquinas and Saint Agustine. Notwithstanding, Albertus Magnus, continued with Aristotle's ideas almost literally saying in his original Latin words that:

«Terraemotus causa materiales est, vapor siccus, et grossus valde et terrestres efficiens causa estcalor solis penetrants in viscera terrea: locus est terra oppilata in superficie.»

Thomas Aquinas was, religiously speaking, rather more fanatic than his master and, actually backed down on several issues putting the Christian doctrine before scientific knowledge. He thought that earthquakes were primarily caused by God and, secondly that they were caused by underground thunder, namely;

«Terraemotus causatur princioaliter a Deo; secundario autem á vento impelente alium ventum in terram»

In the middle ages Albertus Magnus also exerted influence upon different naturalists such as; the German Konrand Von Megenberg, who,

wrote the first natural history volume in German. He described the earthquakes that destroyed the city of Villach in Austria in 1341 as winds called Dünst which, would cause the tremors in caverns within the earth, by trying to burst out into the surface. At that time ecclesiastical authorities, mainly of the Catholic Church, purported that earth and life were created according to the description in the book of Genesis some 6000 years back, and that their current condition was determined by that very creation and the effects of some catastrophe of Divine origin, such as, the Flood. This assertion is known as, the catastrophism principle which prevailed for most of the middle ages up until the 18th century.

Despite the fact that, earth crust movement ideas and orogenic surface changes related to this phenomenon were already circulating around, mainly due to the Geographer Strabon (4th century B.C), these hypotheses were never really developed, and were forgotten until the renaissance period. In 1669 the Danish Nikolaus Steno indicated that, sedimentary rock layers are originally formed in a horizontal position, and that if they are now to be found in a sloping position it is due to tectonic processes of our planet. Fortunately for mankind the drop in repressive church power at the turn of the 17th century, made possible the free expression of human thought once again, and a number of thinkers applied themselves to the task of exploring and explaining a world to a great extent still unknown.

It goes without saying that, a stage of such great import as this could not begin without the greatness of someone like Leonardo Da Vinci, who began by interpreting the interior of the planet. Leonardo developed even further Copernicus's theories. He tried to explain earthquakes from the hydrostatic viewpoint, with compensation mechanisms between solid matter and liquid volume, which he reckoned made up the earth. He spoke quite a bit of Archimedes's principles to explain the equilibrium that, if violated would create sudden movements, keeping in mind all along, the concept of a spherical planet. He also put forward the origin of earthquakes as the movement of great masses of the planet. In fact, when he tried to explain the seaquake near Rhodes in the Satalia Sea in 1489, he interpreted it as a collapse of the sea bed. Something quite staggeringly descriptive of what actually took place. He also went on to compare the earth to a giant living organism upon whose skin human civilisation reposed. Trees were it's hair and every thing in nature had it's parallel. Leonardo surmised that earthquakes were nothing more than a manifestation of sickness of that animal, much in the same manner as when a human who has a fever would shiver. Nevertheless, his close friendship with the popes and the high society of the modern world, afforded him the opportunity of speaking out these theories quite unencumbered.

However, affairs turned out rather differently for Giordano Bruno, though. He reinforced Leonardo's idea of the earth as a living being complete with spirit and illnesses, as well as, proposing for the first time the idea of the existence of extraterrestrial beings, which needless to say, led him to the holy burning at the stake for heresy in 1600.

Not long after that, the then rather young Johannes Keppler picked up the idea of animated celestial bodies, and tried to explain the origin of earthquakes in his classic work «*Misterium Cosmographicum*» starting from the soul or «*anima*» of the planets as the driving mechanism behind earthquakes. In the 17th century the French philosopher Rene Descartes and the Prusian Gottfried Wilhem Leibniz were the first ones to present our planet as a developing body. According to them the earth was initially smelted like the sun. However, as it started to cool down the earth's crust was formed on it's surface. Contraction phenomena then brought forth the mountains. This thesis was called the contraction theory and, was defended by the French naturalist Buffon.

Descartes and Leibniz explained the development of the planet in their book «*Protogaia*» based on the ideas of Agricola. Such as that the earth emerged from a smelted body whose surface cooled down by the presence of water, and where the inner nucleus kept boiling at it's core. They believed that earthquakes and eruptions were ruptures created to cool down the hot interior of the earth.

This movement which associated the development of the earth to exogenous processes was coined Neptunism. Contrariwise, the tendency that showed the development of the planet as a result of endogenous processes was termed Plutonism. The success of Descartes, Leibniz and Buffon was the postulation of the first hypothesis of creation, origin and development of the earth. Neptunism was the most widely accepted geological theory in the 18th century. The most well known representative of this theory was Abraham Werner (Espindola 1997). Due to the hierarchy of it's defenders the Neptunistic position was maintained in many cases as Immanuel Kant's cosmogonical hypothesis which, Elie de Beaumont used as the basis to explain the formation of the mountain belts. This selfsame position was applied by Eduard Suess to support the origin of the folding structure of the Alps. Nonetheless, towards the end of the 19th century several events took place which were responsible for knocking down the contraction theory and it's Neptunistic origin.

The Plutonistic theory was reinforced at the beginning of the 18th century, when, several years after a fierce earthquake in Italy in 1707, the isle of Santorini emerged from the sea, leading them to believe that land comes from within the planet's inner core. At that time Antón Lázaro Moro judged the event based on the theory that the earth has a hot core surrounded by a crust which had been covered by water. The rupturing of this crust in some places would then bring forth not only earthquakes but, also volcanoes and continents.

Records of earthquakes are as old as writing itself. The first earthquake of which we have an account, was described in China in 1177 B.C. There is actually a Chinese catalogue of earthquakes which makes mention of a few dozen more of such phenomena that took place in subsequent years (Lomnitz, 1999). In the history of Europe the first earthquake is mentioned in the year 580 B.C. But the first one to be described in detail is not recorded until the middle of the 16th century.

Subsequently The Lisbon earthquake is very well documented. The earliest earthquakes of which we have an account in America, took place in Mexico towards the end of the 14th century, and in Peru in 1741. Although we do not have an accurate description of their effects, most of them were greatly exaggerated and distorted.

Going back to the explanations on the origin of earthquakes the German Jesuit physicist Athanasius Kircher, at the turn of the 17th century, put forward the notion that earthquakes originated in fire conduits which run through the earth (not bad at all considering the period). Shortly afterwards Martin Lyster in conjunction with N. Lesmerg set forth the theory of inner fires within the earth of a chemical origin set off by sulphurs. K. Schulte later endorsed Lyster's theories and published them in «*Philosophical Transactions of Royal Society Num* 157» of 1683.

These theories were accepted by Newton and Buffon. Yet other hypotheses proposed «*modern*» causes, i.e underground electrical discharges proposed by William Stukeley (1750) a theory that went on into the 19th century (Nava, 1987). Up until the 18th century, objective records of earthquakes are at best scarce and, there was no real understanding of the phenomenon. They were, at best, mere speculations with not an awful lot of decent scientific material to back them up, not to mention the supernatural influence attributed to them.

From the explanations related to divine punishment or earth responses to human bad behaviour, they moved on to pseudo-scientific explanations such as, that they were caused by the releasing of air from caverns deep down within the planet, which were described by Seneca centuries before, (Nava 1997). A more forward thinking with respect to this subject turned out to be that of Robert Hooke's who, saw the tectonic disruption origin in earthquakes or volcanic activity, that is to say, from the associated phenomena within the earth. Hooke wrote in 1668 a book titled «*Discourse on earthquakes*». Said book wasn't published while the author was alive, for fear of incurring in reprisals, for the which it came out rather posthumously in 1705, showing all the abovementioned concepts it considerable detail, which, no doubt, would have led him alive to be burnt at the «*holy stake*».

The Lisbon earthquake on 1 November 1755, caused more than 40.000 deaths and was the boost for Kant to produce three treaties about earthquakes, and which subsequently led Voltaire to write poems about it, which were criticised by Rousseau; for Tobias Mayers to try to describe the phenomenon from a mathematical viewpoint in conjunction with Johan Friederich Jacobi and, for others, such as, Johann Gottlob Krüger to write the book entitled «*History of the earth*» where the origin of earthquakes was mentioned based on sulphur auto ignition. Shortly afterwards, in England, Jhon Michell used for the first time volcanic concepts to explain the Lisbon phenomenon. In Michell's opinion undulating movements on the earth's surface, were nothing more than the sudden outbursts of gases under high pressures, and mountains were the result of the deformations caused by those movements, as written in his classic article of philosophical transactions of Royal Society «*The nature and origin of the earthquakes*» circa 1760.

At that time, towards the end of the 18th century and, at the turn of the 19th century, Plutonist stances propped up the Thomas Burnet approach, who wrote a book explaining the seismic phenomena titled «*Telluris Teoria Sacra*». Finally the Plutonist theory prevailed over the Neptunist one, due to, the cosmogonists change of mind with respect to Immanuel Kant's and Laplace's hypothesis, to accept that the origin of planets was not hot but cold and, as a result of the discovery of radioactivity by Henry Becquerel and the beginning of the basis for quantum mechanics by Marx Plank in 1900, with the initial calculations of radioactive matter content in the granites, which led to conclude that the earth should, under the radioactive disintegration effect, not grow cold but, quite to the contrary, grow hot at least until this phenomenon dissipates, which could take millions of additional years.

Peter Simon Pallas was the first to hold a position somewhere between Neptunism and Plutonism. He considered that the origin of the earth came about as a result of the extraction of matter from the sun and, that we have been in a state of constant cooling since then. Notwithstanding, he showed the cause of earthquakes as an inner evolution of the planet. In his viewpoint earthquakes were nothing more than the sudden collapse of internal regions of the globe.

Alexander Von Humboldt, a pupil of Werner, who also had the opportunity of travelling around the world and record many natural phenomena, was probably the first one to establish a correlation between Geological faults and earthquakes. Humboldt also travelled around the Gran Colombia (Colombia, Venezuela, Panama and Ecuador, unified) and was able to experience many a seismic event including the one at Cumaná. He established a connection between earthquakes and volcanoes, by comparing the eruptions of the Vesuvius and it's tremors with the ones felt at the hillsides of the Guagua Pichincha in Ecuador and Puracé in Colombia. Moreover, he also proposed a direct relation between accumulated vapours and earthquakes. To quote his own words, he men-

tioned that: «*active volcanoes are like safety valves for neighbouring regions.*»

On November 4th 1799, Humboldt experienced for the first time a big earthquake, the one in Cumaná which took place at four in the afternoon. Two strong tremors that lasted fifteen seconds each, one after the other. The house where he lived in Caracas during the earthquake on 12 march 1812 fell down and, many of his friends and colleagues met their demise there. Afterwards Humboldt and his French co-worker Bonpland survived earthquakes in what is currently Colombia, Ecuador, Peru and Mexico, which afforded him a considerable advantage in the knowledge of said phenomenon, as opposed to, his colleagues. Since they lived in Germany, they had never experienced an earthquake in their lives. Descriptions of earthquakes by Humboldt are outstandingly reliable. In his volumes of *Kosmos*, he relates with extraordinary precision, the different aspects of the events, such as, vertical and horizontal strong ground motions, duration, sounds, lights, etc.

Given the evidence about volcanic eruptions in the Antilles near Venezuela, after the earthquake of Cumaná, of another volcano in Saint Vincent island after the earthquake in Caracas, and also what he saw in Mexico during the eruption of the Jorullo volcano, as well as, his experience in mineralogy, Humboldt decided to abandon the thesis of his master, Werner, who died maintaining that earthquakes were the result of local causes linked to layers of molten iron pyrite in hot coal deposits.

On the other hand, Jean Baptiste Boussingault who lived in the Gran Colombia from 1823 until 1828, and who later became The Liberator Simon Bolivar's army coronel, discredited Humboldt's theory and put forth the idea that, earthquakes were caused by the subterranean landslide of mountains. Although, these theories were in error at the time, they showed with considerable accuracy the behaviour of volcanic earthquakes. These were very common in their surrounding zones. Jesus Emilio Ramirez (a Colombian Seismologist and pupil of Jesuit priest James Malcewane in Saint Louis University) mentions that years later Vergara and Velasco (a Colombian geographer), who published an atlas of Colombia at the turn of the 20th century said that: «*in Colombia, as in other parts, the ordinary independence of seismic and volcanic phenomena is clearly evident*». Assorted explanations about the origin of earthquakes sprung up in the 19th century.

According to Ramirez (1975), empirical laws abounded which linked the phenomenon to local causes. A relation between earthquakes and the earth's rotation, weather and seasons, the distances to the moon during the apogee and perigee and even the appearance of comets and shooting stars.

Catastrophic natural events such as, earthquakes that transform the geographic landscape, turn into disasters when man interferes. These are factors of feared disarray, of social disorder and lack of organisation, that make evident the inner articulation of a community bringing it almost to the point of destroying it, as well as, the image that society holds of itself. Amongst, the most remembered earthquakes in Colombia during the 19th century lies the one in 1805, it is remembered by the destruction of the Honda Town, with a death toll of two hundred to its claim; by the end of the same century the destruction of Cucuta city with more than five hundred people dead also left an indelible mark etched in people's memories. The Ruiz volcano eruptions are not new and they took place with the earthquake in 1845, with a devastating flow of mud or lahar's that cicatrized the Magdalena's valleys on Colombia. (Jurado, 2001)

Colombia's Colonial society was, in centuries past, rural and peasanty. Therefore, the population's lifestyle was, more often than not, governed by natural cycles. The natural world was not perceived in the same way it is by contemporary Western societies, that is to say, frag-

ile, dependent and mostly at the mercy of man. Contrariwise, it was actually seen as, threatening, terrifyingly powerful and uncontrollable. It both overpowered and overcame man with frightening ease. An acquaintance with an uncontrollable and threatening nature, the lack of effective medical aids to ward off contagion and illness, as we know them today, could have given rise to feelings of resignation to fatalism, something all the more evident in moments of anguish, when life was at the mercy of death and there was nothing they could do about the calamity at hand. While faced with said calamity, the authorities would exert strict controls on the trading of the already scarce food supplies, and on practical measures in order to deal with it.

Religion offered answers on the supernatural origin of the evils befalling the community. In that catholic society, it was a terrifying prospect to die suddenly in the middle of a catastrophe, without being administered the last rites, risking the loss of their soul for eternity. Therefore, feelings of powerlessness were experienced all the more strongly, and they would turn with anxiousness to the Divine Majesty through prayers, processions and novenas, given both the unworkability and ineffectiveness of human remedies. In Medellin for instance, the recurrence of earthquakes forced the town council in 1730, to entrust the borough to St Francisco de Borja as the protecting patron saint against earthquakes, squalls and storms. An intercessor was sought who would stand in the presence of God on behalf of the community, since , that was the only means to alleviate and end the evils that befell them, and the recourse to appease the Divine wrath which punished them for their sins.

Repeatedly, in many writings, reference was made to a vengeful God who was responsible for the punishment or the atonement for collective guilt, due to their sinful condition. Nonetheless, references were also made to a kind God, who provides the remedy, as well as, the mercy; as Renan Silva (Colombian Historian) has pointed out, Divine punishment was the explanatory and cultural representation of catastrophes, an interpretation which gained impetus with the precariousness of the means available i.e. technical and medical to deal with them. According to Archbishop Virrey from Nueva Granada (Today Colombia), Antonio Caballero and Gongora: «*hunger, war, plague were the three great awakeners used by the Lord to punish sin and human ungratefulness*». Thus, the political use of catastrophes is suggested when the functionary himself related the attack of the plague in 1782 with the «*ungodly uprising*» of the previous year. In the collective subconscious, Satan and his hosts of wizards could also be the authors of evil. The old relationship between devil, evil and witchcraft as the cause of natural disorders came from the inquisitory Europe.

It was common to abandon oneself in a simultaneous manner to various saints at the same time, as we can see from the earthquakes of Santafe (today Bogotá) already mentioned by Jose Maria Caballero (a Colombian Historian), amidst a baroque religiousness full of prayers and Novenas and the worship of sacred relics. Caballero himself pointed out all the religious activities that followed the earthquake of the 19th November as follows: «*on the 21st (November 1814, after the earthquake of the 19th of November also described by Caballero) a prayer was offered to San Francisco de Borja by the Canon lords of the Cathedral. By the 20th the crucified Christ of the snows which was in Veracruz, was taken out at night, and was paraded in a very pompous procession to the Third and a mission was set up. On the 22nd a prayer was offered to his Majesty, St. Emigdio, St Nicolas and St Francisco de Borja, in the neighbourhood of Candelaria. On the 23rd yet another prayer commenced in Santo Domingo to San Emigdio and to Our Lady of Guadalupe. On the 24th a new altar was set up to Santa Barbara in Santo Domingo, and paraded in a procession were Saint Feliciano's bones with much greatness and sumptuousness, and were placed on the same altar as Santa Barbara's.*

and the next day her novena commenced « (Jurado, 2001).

The city of Santafé (today Bogotá) was greatly affected by the earthquake on 12th of July 1785. Indubitably, this event altered the city's daily life, and became a habitual motive for conversation. Rumours and gossip came and went, everyone offered their exaggerated or diminished version of it. it was purported that the earthquake «*lasted more than seven minutes*» there were those who surmised that it was a punishment from God, although for others that had been an affair to be attributed only to the devil, for instead of saving the churches, it protected breweries where aguardiente was produced and also gun powder factories. Religious fanaticism prompted people to pray with greater impetus, and maybe as it had happened with the «*violent earthquake that battered the city of Trinidad del Muzo, on 3rd April 1646, endless processions took place, as well as, countless religious ceremonies*» and pulpits were filled to the brim outpouring sermons with insistent allusions to the urgent need for keeping «*an uprightness of living and manners*».

Earthquakes brought out the collective subconsciousness of the common peoples and of the colonial authorities. The event caused such a deep commotion that it sparked off the printing of the first booklet published in the Nueva Granada (today Colombia), entitled «*Aviso de Terremoto*», of the which three copies were made. Moreover, around the same time other devastating ground motions were added to this earth tremor of nature, which were induced directly by man: A peninsular Royal Order determined that certain harmful books were to be gathered and burned, such as, Copernicus' teachings, the philosophy of natural rights, the encyclopaedia and Montesquieau's works, among others.

The earthquake had left its marks in the world of ideas and politics. On the one hand, by that time, knowledge and science censure had extended. On the other hand however, the publication of «*Aviso de Terremoto*» shook the world of clandestine ideas, as it brought about conditions conducive to the use of the printing press and diffusion, nine years after the Rights of Man and the Citizen by Antonio Nariño (Precursor of independence of Colombia). (Gonzalez S, 2003)

Other similar testimonies to that of the earthquake in 1785 are kept in the Colombian General Archive. Multiple events records are kept there, of several natural disasters, among others, the which allow for urban and rural groups to recreate the way in which they faced their fears when it came to dealing with an uncontrollable nature. Catastrophes that frightened and scared the Indians to death. These catastrophes made mountain peaks to come tumbling down damming fast flowing rivers, bursting and drying water sources, much in the same way as it happened during other telluric movements in other provinces and towns.

Humanity ought to have waited until interim circumstances of a political, religious and economic nature, such as, the industrial revolution in Europe in order to find scientific reasons for the origin of earthquakes. Robert Mallet, who carried out the first study of an earthquake (Naples earthquake) set forth the idea that the earth's crust could break due to stress. However, he did set aside the probability of an explosive origin. The relationship between faults and earthquakes was put forth again by Eduard Suess in 1875, and adopted by the pioneers of seismology, namely, Montessus de Ballore and Iceberg.

It was perhaps Humboldt who, represented the transition between old theories and new scientific postulates based on modern physics, in modern instrumentation and in seismology's pioneering notable figures. Humboldt, who at the turn of 19th century was more famous than even Napoleon himself, was big enough to accept the criticisms mainly by Mallet from England, and had a fast and definitive decline due to another English man who having read him,

adventured to travel to South America to find new naturalist principles of evolution: Charles Darwin.

Notwithstanding, the theory of faults as an origin of seismic energy was proposed by the Japanese Koto and the English man Jhon Milne as a consequence of an earthquake in 1881 in Japan. This research gave rise to the making of the first modern seismograph. It was Harry Fielding Reid, a civil engineer of John Hopkins University who, due to research done on the earthquake in San Francisco California on 1906, proposed the first mechanical model of the seismic source. Refined versions of this model are the ones currently being utilised for research.

The precondition for the development of knowledge on the origin of earthquakes was undoubtedly due to the creation of devices for the measuring of the phenomenon, sufficiently accurate as to begin setting forth an irrefutable theory on the origin and behaviour of earthquakes. During the time when there was political dominion by the church, there was quiet a restriction on knowledge of the origin of natural phenomena.

But, curiously enough, it was, from the church itself, and more specifically from the Jesuits like Athanasius Kirtcher, that the path of knowledge of natural phenomena was opened using earth sciences, such as, seismology and meteorology, that at the beginning worked on the physical problem of the origin and the explanation of associated concepts. Albeit, not on the social, political, economic and environmental nature. A few decades more had to go by before a science was consolidated, that would group together the general context of the effects of earthquakes upon mankind and society.

Despite the fact that, since 1922 as a result of an express request by the president of the Colombian republic Marco Fidel Suarez, the first seismological station was set up by Jesuit Priest Simon Sarasola, the country had to wait many years to interpret and give a meaning to the different records for design purposes that were produced by those devices. In this first seismological and meteorological station that had *Wiechert* and after *Bennioff* and *Wood-Anderson* torsion-seismographs, there have been produced uninterrupted records since then, of the many great earthquakes of the 20th century in Colombia where it is located in the San Bartolome School on the eastern mountains of Bogota.

In 1940 under the sponsorship of the Carnegie Corporation of New York, the Jesuit Priest J. E. Ramirez founded the Andes Geophysics Institute at the Javeriana University with meteorology and seismology departments. This institution constituted for several decades the only research centre at a national level on seismic and seismological aspects. For many years the only institution that published communiqués on magnitude and positions of earthquakes in Colombia to the nation, was this institute through a network that never reached the size and coverage required to guarantee enough credibility on the results.

Today, the science that works in an integral way on the seismic phenomenon from its very beginning up to its formation right through to the effects it has on society, economy, environment and the development of the country, is called Earthquake Engineering, and it makes part of civil engineering. It is not this way due to the whims of some, but rather, because engineers were the only ones that: «*Digging deep into the earth sciences, and based on modern classical naturalists like Buffon, Leibniz and Humboldt. Decoding the labyrinths of phenomenological erudition of Montesus de Ballore, Suess, Mallet, Wegener and Milne, interpreting and giving a practical applications to the geologic terms of Hutton, Holmes and Lyell, making use of the classical theory of wave propagation of Stokes, Rayleigh, Lamb, Thomson and Haskell. Coherently understanding and applying the seismologic theory of Richter, Benioff, Kanamori,*

Brune and Aki; comprehending the seismometry of Wiechert, Galitzin, Wood and Anderson, exploiting geotechnics and its derivatives, the soil dynamics of Terzagui and his disciple Seed, reading and re-reading Den Hartog, Timoschenko, Biggs and Rubinstein in order to transform his machine dynamics into building dynamics through the development of structural analysis of Przemienieki and Wilson. Rummaging through the reliability theory of Mayer, Madsen, Hasofer and Freudenthal for Second World War aeroplanes. Taking advantage of Cornell's probabilistic theory so that uncertainties associated with loads and resistences, maybe taken into account. Scrutinising the random vibration theory of Papoulis, Powell, Davenport and Vanmarcke, extracting basic non-linear design concepts from Newmark, Hudson, Blume and Rosenblueth. Estimating the loses and optimising the construction cost, building up legal obligations between proprietors, government and builders by means of codes and researching like Shah and Esteva the insurance and re-insurance industry with its macro-economic components and the effects of earthquakes on different economic, social and environmental aspects».

Thus, these engineers were able to develop the newest and most multi-disciplinary of engineering sciences, «*Earthquake Engineering*», which is the only one that travels the entire path from the beginnings of the phenomenon right through to the particular consequences on each and every inhabitant, and that emerged from sciences, such as, seismology, geology, structural engineering, risk analysis and other technical disciplines.

Colophon

The objective of Earthquake Engineering is related to the assessment of the effects on population, environment, and the economy of earthquake in a region, as well as, with the development of techniques for the reduction of these effects through rational means that optimise the resources allocated to that end. Therefore, although the problem has an important technical component, its fundamental principles are grounded on the social problem that surfaces after a catastrophe of this kind has taken place.

The Earthquake Engineering is the combination of a number of natural laws, concepts and principles which taken in an integral way, allow for the design and construction of a building capable of withstanding the effects of reasonably stronger earthquakes that could arise in the future. Earthquake Engineering is neither made up of an strict volume of seismology in its original or local components nor response analyses when faced with seismic charges nor of the study of the seismic response of the soil: quite to the contrary it is actually all of these combined and much more.

Starting From the definition herein presented, it is understood that Earthquake Engineering is a branch of modern civil engineering, for the end goal of the same is construction and seismic engineering must study and assess the integral effect of earthquakes on buildings and society's assets.

Earthquake Engineering is an area relatively recent of engineering related to the conception of works in general, whose, structuring and maturity was reached on the decade of 60's. The grounds of seismology and of the mechanics of material are older. Nevertheless, its adaptation to the seismic and dynamic problem on civil works has required new options and improvements, or sometimes the revision of all concepts and the adaptation of mathematical processes far more complex than those used in the mechanics for static problems (Sarria 2002).

Due to the fact that, for the solution of any problem it is required an explicit knowledge of the situation that originates it, and that in the case of earthquakes this can not be different, mankind has dedicated itself for the last few decades to get to know the phenomenon in a deeper way. This then has allowed many

countries to establish prevention policies, in order to stop loosing in a sudden and frustrated way the headway made with much effort and sacrifice. It is also desirable to know the effects of earthquakes which allows for the establishing of environmental, structural defence and even economic policies against an event which up to very recently was considered as divine punishment, and it is the coherent way of making a long term saving to consolidate however little or much development we achieve and leave to our future generations.

As the origin of earthquakes is intimately linked to terrestrial dynamics, it becomes expedient to study de origin and development of our planet in order to grasp an understanding of nature and the places where earthquakes originate. This is accomplished by means of divers sciences amongst which seismology, tectonics and geology stand out, and that we need to know in detail in order to have an accurate understanding of science. Contrariwise to what has taken place in the last few years where the blind following of laws, that act as an only instrument of knowledge, have demeaned and degraded human ingenuity and, has contributed to the particular interest of those who write them.

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