

ΕΛΛΗΝΙΚΗ  
ΕΠΙΣΤΗΜΟΝΙΚΗ  
ΕΤΑΙΡΕΙΑ  
ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ  
& ΓΕΩΤΕΧΝΙΚΗΣ  
ΜΗΧΑΝΙΚΗΣ

# Τα Νέα

27

## της Ε Ε Ε Ε Γ Μ

### THE HAITI EARTHQUAKE OF 2010

<b>Magnitude</b>	<b>7.0</b>
<b>Date-Time</b>	<b>Tuesday, January 12, 2010 at 21:53:10 UTC</b> Tuesday, January 12, 2010 at 04:53:10 PM at epicenter
<b>Location</b>	18.457°N, 72.533°W
<b>Depth</b>	13 km (8.1 miles) set by location program
<b>Region</b>	HAITI REGION
<b>Distances</b>	25 km (15 miles) WSW of <b>PORT-AU-PRINCE, Haiti</b> 130 km (80 miles) E of <b>Les Cayes, Haiti</b> 150 km (95 miles) S of <b>Cap-Haïtien, Haiti</b> 1125 km (700 miles) SE of <b>Miami, Florida</b>
<b>Location Uncertainty</b>	horizontal +/- 3.4 km (2.1 miles); depth fixed by location program
<b>Parameters</b>	NST=312, Nph=312, Dmin=143.7 km, Rmss=0.93 sec, Gp= 25°, M-type=teleseismic moment magnitude (Mw), Version=9
<b>Source</b>	USGS NEIC (WDCS-D)

Αρ. 27 – ΙΑΝΟΥΑΡΙΟΣ 2010



(U.S.G.S.)



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ΜΗΧΑΝΙΚΗΣ

ΣΥΛΛΟΓΟΣ  
ΑΠΟΦΟΙΤΩΝ  
IMPERIAL  
COLLEGE



## **6<sup>η</sup> ΑΘΗΝΑΪΚΗ ΔΙΑΛΕΞΗ ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ**

**Δευτέρα, 25 Ιανουαρίου 2010, ώρα 18:00**

στην

Αίθουσα Εκδηλώσεων του  
Κτιρίου Διοίκησης ΕΜΠ  
στην Πολυτεχνειούπολη Ζωγράφου

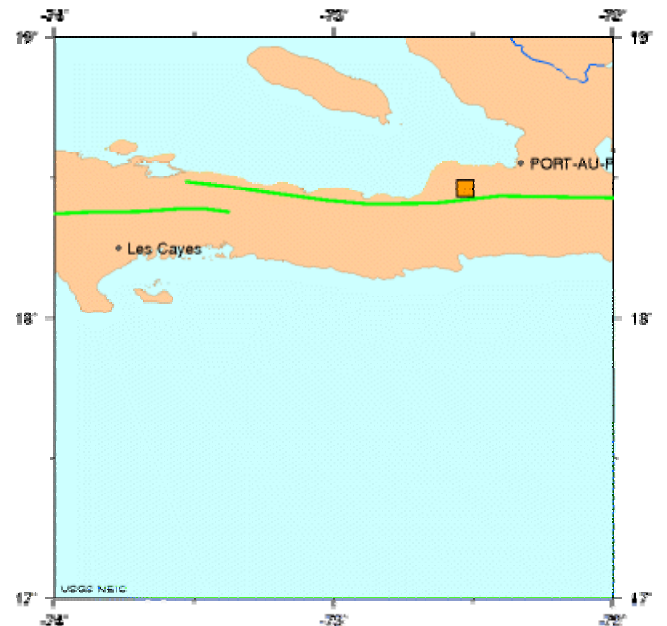
**«Interaction between geotechnical and structural engineers»**

από τον

**Prof. John Burland, CBE, DSc(Eng), FEng, FRS**  
**Emeritus Professor, Soil Mechanics Section, Department of Civil and Environmental Engineering,**  
**IMPERIAL COLLEGE, London**

# HAITI EARTHQUAKE OF 2010

## Earthquake Summary

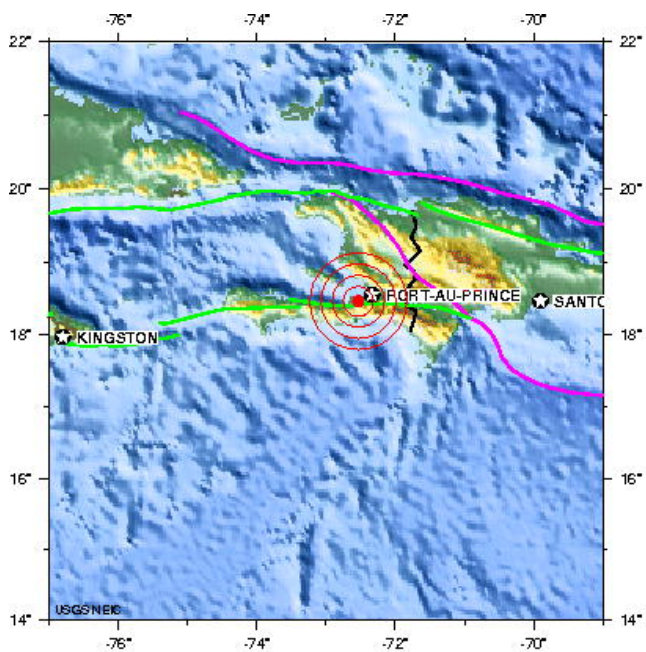


### HAITI REGION

2010 01 12 21:53:10 UTC 18.46N 72.53W Depth: 13.0 km, Magnitude: 7.0

### Earthquake Location

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green



### HAITI REGION

2010 01 12 21:53:10 UTC 18.46N 72.53W Depth: 13.0 km, Magnitude: 7.0

### Earthquake Location

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green



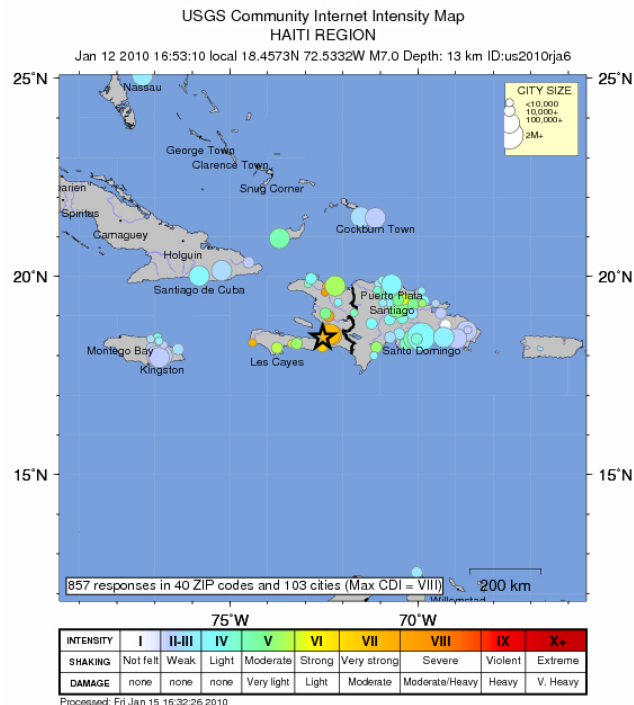
Map of HAITI

## Preliminary Earthquake Report

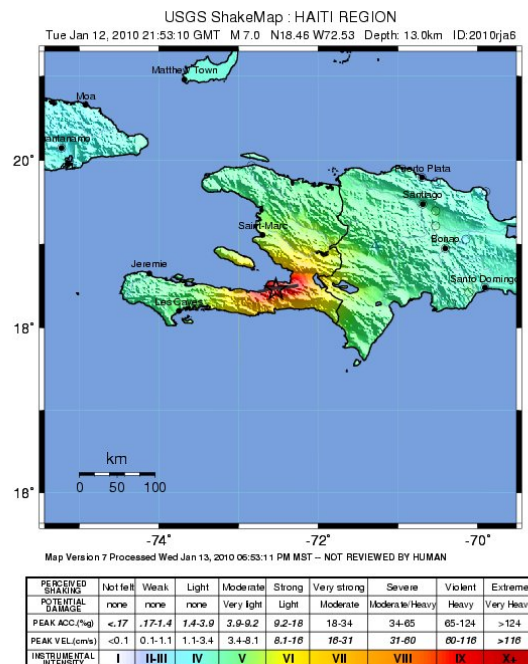
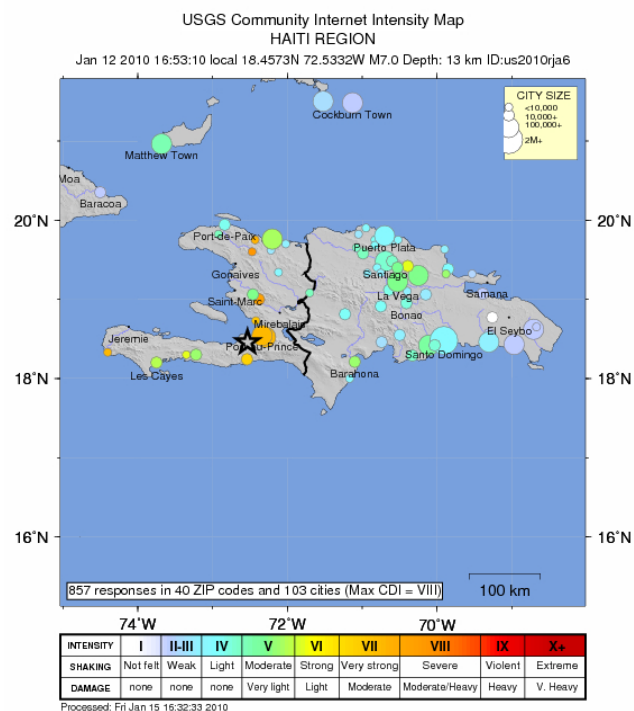
U.S. Geological Survey, National Earthquake Information Center  
World Data Center for Seismology, Denver

### M7.0 – Haiti Region

Tuesday, January 12, 2010 at 21:53:10 UTC  
Tuesday, January 12, 2010 at 16:53:10 Local



Epicenter: 18.46°N 72.53°W - Depth: 13km



### Felt Reports

Severe damage and casualties in the Port-au-Prince area. Felt throughout Haiti and the Dominican Republic, in Turks and Caicos Islands, southeastern Cuba, eastern Jamaica, in parts of Puerto Rico and the Bahamas, and as far as Tampa, Florida and Caracas, Venezuela.

### Tectonic Summary

The January 12, 2010, Haiti earthquake occurred in the boundary region separating the Caribbean plate and the North America plate. This plate boundary is dominated by left-lateral strike slip motion and compression, and accommodates about 20 mm/y slip, with the Caribbean plate moving eastward with respect to the North America plate.

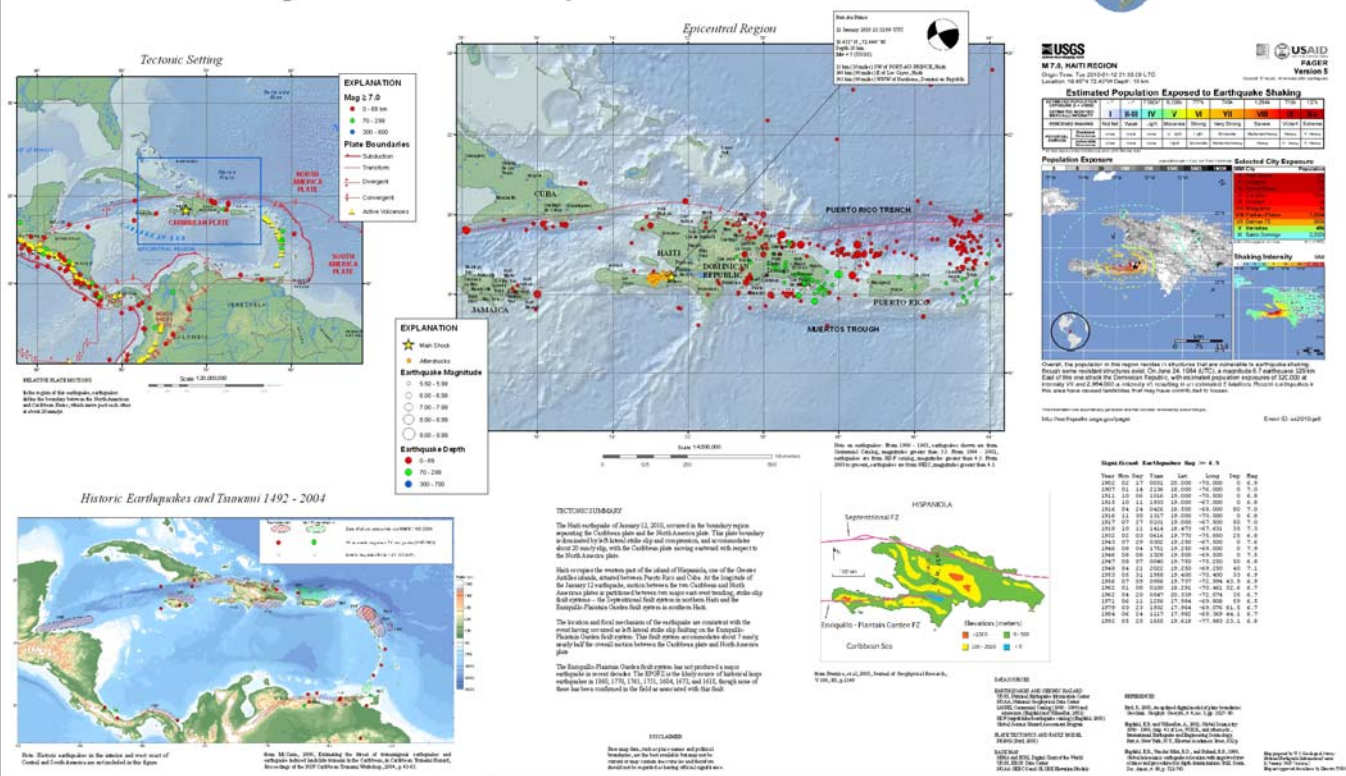
Haiti occupies the western part of the island of Hispaniola, one of the Greater Antilles islands, situated between Puerto Rico and Cuba. At the longitude of the January 12 earthquake, motion between the Caribbean and North American plates is partitioned between two major east-west trending, strike-slip fault systems -- the Septentrional fault system in northern Haiti and the Enriquillo-Plantain Garden fault system in southern Haiti.

The location and focal mechanism of the earthquake are consistent with the event having occurred as left-lateral strike slip faulting on the Enriquillo-Plantain Garden fault system. This fault system accommodates about 7 mm/y, nearly half the overall motion between the Caribbean plate and North America plate.

The Enriquillo-Plantain Garden fault system has not produced a major earthquake in recent decades. The EPGFZ is the likely source of historical large earthquakes in 1860, 1770, 1761, 1751, 1684, 1673, and 1618, though none of these has been confirmed in the field as associated with this fault.



## M7.0 Haiti Earthquake of 12 January 2010



Haiti's national palace in Port-au-Prince was severely damaged by the quake (Reuters Tv/Reuters)

The New York Times / by Simon Romero and Marc Lacey  
(Published: January 12, 2010)

SANTO DOMINGO, Dominican Republic — A fierce earthquake struck Haiti late Tuesday afternoon, causing a crowded hospital to collapse, leveling countless shantytown dwellings and bringing even more suffering to a nation that was already the hemisphere's poorest and most disaster-prone.

The earthquake, the worst in the region in more than 200 years, left the country in a shambles. As night fell in Port-au-Prince, Haiti's capital, fires burned near the shoreline downtown, but otherwise the city fell into darkness. The electricity was out, telephones were not working and relief

workers struggled to make their way through streets blocked by rubble.

In the chaos, it was not possible for officials to determine how many people had been killed and injured, but they warned that the casualties could be substantial.

The physical toll was easier to assess. The headquarters of the United Nations mission was seriously damaged, the United Nations said in a statement, and many employees were missing. Part of the national palace had collapsed, The Associated Press reported.

A hospital collapsed in Pétionville, a hillside district in Port-au-Prince that is home to many diplomats and wealthy Haitians, a videographer for The Associated Press said. And an American government official reported seeing houses that had tumbled into a ravine.

Tequila Minsky, a photographer based in New York who was in Port-au-Prince, said that a wall at the front of the Hotel Oloffson had fallen, killing a passer-by. A number of nearby buildings had crumbled, trapping people, she said, and a Unibank bank building was badly damaged. People were screaming.

"It was general mayhem," Ms. Minsky said.

The earthquake, with a magnitude estimated at 7.0, struck just before 5 p.m. about 10 miles southwest of Port-au-Prince, the United States Geological Survey said. Many aftershocks followed and more were expected, said David Wald, a Geological Survey seismologist.

"The main issue here will probably be shaking," he said, "and this is an area that is particularly vulnerable in terms of construction practice, and with a high population density. There could be a high number of casualties."

Oxfam, an antipoverty group, said that Kristie van de Wetering, a former employee based in Port-au-Prince, had described houses in rubble everywhere.

"There is a blanket of dust rising from the valley south of the capital," agency officials said. Ms. van de Wetering had told them. "We can hear people calling for help from every corner. The aftershocks are ongoing and making people very nervous."

The earthquake could be felt across the border in the Dominican Republic, on the eastern part of the island of Hispaniola. High-rise buildings in the capital, Santo Domingo, shook and sent people streaming down stairways into the streets, fearing that the tremor could intensify.

Haiti sits on a large fault that has caused catastrophic quakes in the past, but this one was described as among the most powerful to hit the region. With many poor residents living in tin-roof shacks that sit precariously on steep ravines and with much of the construction in Port-au-Prince and elsewhere in the country of questionable quality, the expectation was that the quake caused major damage to buildings and significant loss of life.

"Everybody is just totally, totally freaked out and shaken," Henry Bahn, an official of the United States Department of Agriculture who was visiting Haiti, told The Associated Press. "The sky is just gray with dust."

Haiti's many man-made woes — its dire poverty, political infighting and proclivity for insurrection — have been exacerbated repeatedly by natural disasters. At the end of 2008, four hurricanes flooded whole towns, knocked out bridges and left a destitute population in even more desperate conditions.

The United States and other countries have devoted signifi-

cant humanitarian support to Haiti, financing a large United Nations peacekeeping mission that has recently reported major gains in controlling crime. International aid has also supported an array of organizations aimed at raising the country's dismal health and education levels.

The Caribbean is not usually considered a seismic danger zone, but earthquakes have struck here in the past.

"There's a history of large, devastating earthquakes," said Paul Mann, a senior research scientist at the Institute for Geophysics at the University of Texas, "but they're separated by hundreds of years."

Most of Haiti lies on the Gonave microplate, a sliver of the earth's crust between the much larger North American plate to the north and the Caribbean plate to the south. The earthquake on Tuesday occurred when what appears to be part of the southern fault zone broke and slid.

The fault is similar in structure to the San Andreas fault that slices through California, Dr. Mann said.

Such earthquakes, which are called strike-slip, tend to be shallow and produce violent shaking at the surface.

"They can be very devastating, especially when there are cities nearby," Dr. Mann said.

Victor Tsai, a seismologist at the National Earthquake Information Center of the United States Geological Survey, said the depth of Tuesday's earthquake was only about six miles and the quake was a 9 on a 1-to-10 scale that measures ground shaking. "We expect substantial damage from this event," he said.

Simon Romero reported from Santo Domingo, and Marc Lacey from Mexico City. Reporting was contributed by Elisabeth Malkin from Mexico City, Damien Cave from Miami, and Kenneth Chang and Liz Robbins from New York.



A massive earthquake struck Haiti just before 5 p.m. on Jan. 12, about 10 miles southwest of Port-au-Prince, the country's capital. The quake was the worst in the region in more than 200 years, and as many as 50,000 people were feared dead.

The quake left the country in shambles, without electricity or phone service, tangling efforts to provide relief. Governments and private groups from Beijing to Grand Rapids pledged assistance, but two days after the quake only the barest trickle of aid had arrived.

The day after the quake, Haiti's president, René Préval, called the destruction "unimaginable."

On Jan. 14, Secretary of State Hillary Rodham Clinton said that "there will be tens of thousands of casualties - we don't have any exact numbers." She said that about three million people -- a third of the country's population -- had been affected.

More than 30 significant aftershocks of a 4.5 magnitude or higher rattled Haiti through the night of the 12th and into the early morning, according to Amy Vaughan, a geophysicist with the United States Geological Survey.

Huge swaths of the capital, Port-au-Prince, lay in ruins, and thousands of people were feared dead in the rubble of government buildings, foreign aid offices and shantytowns. Schools, hospitals and a prison collapsed. Sixteen United Nations peacekeepers were killed and at least 140 United Nations workers were missing, including the chief of its mission, Hédi Annabi. The city's archbishop, Msgr. Joseph Serge Miot, was feared dead.



The poor who define this nation squatted in the streets, some hurt and bloody, many more without food and water, close to piles of covered corpses and rubble. Limbs protruded from disintegrated concrete, muffled cries emanated from deep inside the wrecks of buildings - many of them poorly constructed in the first place.

### Relief Efforts

On Jan. 13, as Ban Ki-Moon, the secretary general of the United Nations, warned of a humanitarian disaster, President Obama promised that Haiti would have the "unwavering support" of the United States.

But while world leaders pledged hundreds of millions of dollars and thousands of troops, delivering on these promises was a logistical nightmare. On Jan. 14, aid was arriving only in a trickle to those thought to need assistance.

Power was still out and telecommunications rarely functioned. Most medical facilities had been severely damaged, if not leveled. Supplies of food and fresh water were dwindling. Ships could not bring their cargoes of supplies into Haiti's damaged port; the airport was functioning with severe limits; roads were blocked not only by debris but also by people with no safe shelter to retreat to.

Mr. Obama said that United States aid agencies were moving swiftly to get help to Haiti and that search-and-rescue teams were already en route. Mr. Obama did not make a specific aid pledge, and administration officials said they were still trying to figure out what the island needed. But he urged Americans to dig into their pockets and to go to the White House's Web site, [www.whitehouse.gov](http://www.whitehouse.gov), to find ways to donate money.

Aid agencies from around the world geared up to help. Agencies already in Haiti said they would open their storehouses of food and water there, and the World Food Program was flying in nearly 100 tons of ready-to-eat meals and high-energy biscuits from El Salvador. The United Nations said it was freeing up \$10 million in emergency relief funds, the European Union pledged \$4.4 million, and groups like Doctors Without Borders were setting up clinics in tents and open-air triage centers to treat the injured.

Supplies began filtering in from the Dominican Republic, as charter flights were restarted between Santo Domingo and Port-au-Prince. But efforts to administer emergency services and distribute food and water were halting, and in some places seemingly nonexistent. A few S.U.V.'s driven by United Nations personnel plied streets clogged with rubble, pedestrians and other vehicles. Fuel shortages emerged as an immediate concern as motorists sought to find gas stations with functioning fuel pumps.

### Earthquakes in the Caribbean

Haiti sits on a large fault that has caused catastrophic quakes in the past, but this one was described as among the most powerful to hit the region.

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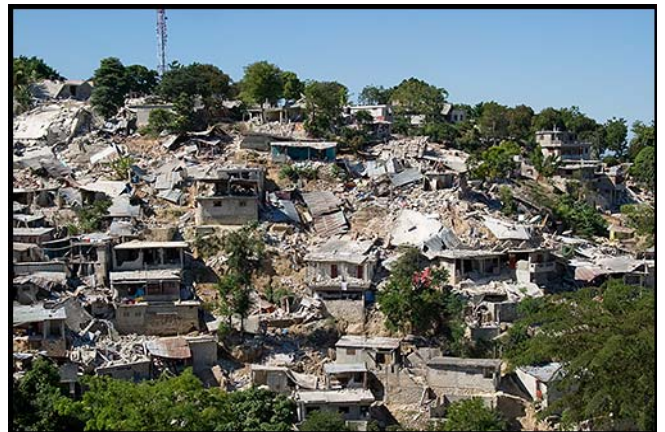
Such earthquakes, which are called strike-slip, tend to be shallow and produce violent shaking at the surface.

"They can be very devastating, especially when there are cities nearby," Dr. Mann said.

David Wald, a seismologist with the Geological Survey, said that an earthquake of this strength had not struck Haiti in more than 200 years, a fact apparently based on contemporaneous accounts. The most powerful one to strike the country in recent years measured 6.7 magnitude in 1984.



The devastation from the earthquake as seen from above Port-au-Prince on Wednesday (Logan Abassi / United Nations, via Reuters)



The slums of Canapé Vert were devastated (Frederic Dupoux / Getty Images)



The Canapé Vert area in Port-au-Prince on Wednesday (Eduardo Munoz / Reuters)



## Γενικές Πληροφορίες για την Αϊτή

**Επίσημο Όνομα:** Republic of Haiti  
**Πρωτεύουσα:** Port-au-Prince  
**Πολίτευμα:** Republic  
**Πληθυσμός:** 8.71 million  
**Έκταση:** 27,737 km<sup>2</sup> (10,714 square miles)  
**Γλώσσες:** French (official), Creole (official)  
**Έτος Ανεξαρτησίας:** 1804

**Haiti**, West Indies, on the western third of the island of Hispaniola. It is bounded on the north by the Atlantic Ocean, on the south by the Caribbean Sea, and on the east by the Dominican Republic. Jamaica lies to the west and Cuba to the northwest. The offshore islands of Tortuga and Gonâve also belong to Haiti. The capital and largest city is Port-au-Prince (Columbia Encyclopedia).



Η «Ισλα Εσπανιόλα», δώρο του Χριστόφορου Κολόμβου στο ισπανικό στέμμα, πέρασε το 1697 εν μέρει υπό τον ζυγό των Γάλλων, οι οποίοι εισήγαγαν σκλάβους από την Αφρική για τις φυτείες τους. Μετά την Αλωση της Βαστίλλης, το 1789, οι μαύροι της Αϊτής πήραν στα σοβαρά τη Διακήρυξη των Δικαιωμάτων του Ανθρώπου και εξεγέρθηκαν ζητώντας την ελευθερία τους, την οποία ο επαναστατημένο Παρίσι τους αναγνώρισε, το 1794. Στη συνέχεια, όμως, ο Ναπολέων έστειλε τον αυτοκρατορικό στρατό προσπαθώντας να αναστυλώσει, διά πυρός και σιδήρου, τη δουλεία. Τελικά, οι Γάλλοι αποσύρθηκαν και το 1804 ιδρύθηκε η πρώτη δημοκρατία μαύρων.

Εναν αιώνα αργότερα, η Αϊτή δοκίμασε στην πράξη τη συνέπεια της άλλης μεγάλης δημοκρατίας του δυτικού κόσμου. Υπακούοντας στις εκκλήσεις αμερικανικών τραπεζών, που ανησυχούσαν για τα δάνειά τους στην Αϊτή, ο πρόεδρος Γούντροου Γουίλσον, διαπρύσιος θιασώτης της αυτοδιάθεσης των εθνών, επέβαλε το 1915 κατοχικό καθεστώς, το οποίο θα διαρκούσε μέχρι το 1934. Αμερικανοί έγραψαν το Σύνταγμα της Αϊτής και ανέλαβαν τα υπουργεία Οικονομικών και Δημοσίων Έργων, την αστυνομία και τα τελωνεία. Το 1929 πεζοναύτες έπνιξαν στο αίμα μεγάλη διαδήλωση αγροτών.

Μετά τον Β' Παγκόσμιο Πόλεμο, η Αϊτή βρέθηκε κάτω από τον ζυγό των πατρών και υιού Ντιβαλιέ, μέχρι τη λαϊκή εξέγερση που οδήγησε στην εξουσία τον χαρισματικό καθολικό ιερέα Ζαν Μπερτράν Αριστίντ, ο οποίος εκλέχτηκε δημοκρατικά δύο φορές από τον λαό του και ισάριθμες ανετράπη από τον στρατό και τους ισχυρούς προστάτες του.

Αναγνώρισε πρώτη την ελληνική ανεξαρτησία

Σε αυτό το μικρό, υπερήφανο έθνος της Καραϊβικής εμείς οι Έλληνες οφείλουμε κάτι περισσότερο από σεβασμό. Η Αϊτή ήταν το πρώτο κράτος που αναγνώρισε την ελληνική ανεξαρτησία και έσπευσε να βοηθήσει την Επανάσταση του 1821. Αν και ηγείτο μιας κατεστραμμένης, από τον δικό της εθνικοαπελευθερωτικό αγώνα, χώρας, ο πρόεδρος Μπουαγιέ έστειλε στον Αδαμάντιο Κοραή, στο Παρίσι, 25 τόνους καφέ για να πωληθούν ώστε να αγορασθούν ελληνικά όπλα, αλλά και 100 μαύρους εθελοντές, οι οποίοι, για αδιευκρίνιστους λόγους, δεν έφτασαν ποτέ στα χώματά μας, χωρίς αυτό να μειώνει το ηθικό μας χρέος.

Πετρος Παπακωνσταντίνου, Η ΚΑΘΗΜΕΡΙΝΗ, Πέμπτη 14 Ιανουαρίου 2010



Residents camped outside their houses for fear of a recurrence of the earthquake (Carlos Barria / Reuters)



An aerial view of the damage in downtown Port-au-Prince (Logan Abassi / MINUSTAH via Getty Images)



A poor neighborhood sustained extensive damage in Port-au-Prince (Logan Abassi / MINUSTAH via Getty Images)





Residents walk in a destroyed area of Port-au-Prince (Jorge Silva / Reuters)



The neighborhood of Pétionville, a hillside district in Port-au-Prince that is home to many diplomats and wealthy Haitians (Reuters)



Displaced residents gathered in an empty field in Port-au-Prince (U.S. Coast Guard, Petty Officer 2<sup>nd</sup> Class Sondra-Kay Kneen, via Associated Press)



People searched for survivors in the rubble of a supermarket in Port-au-Prince. The earthquake had an estimated magnitude of 7.0 (Frederic Dupoux / Getty Images)



Makeshift tents went up after the earthquake (Logan Abassi / MINUSTAH via Getty Images)



A collapsed bank building on Rue Capois in the downtown area of the capital (Tequila Minsky for The New York Times)





Bodies lay in the rubble of a collapsed building in Port-au-Prince (Michael Appleton for The New York Times)



The streets were strewn with rubble (Damon Winter / The New York Times)



Lionel Michaud cried after finding his 10-month-old daughter among the bodies outside the central morgue. His wife was also killed when the building they lived in collapsed while he was at work (Damon Winter / The New York Times)



Residents sorted through the rubble of buildings. Power and phone service were out. Flights were severely limited at Port-au-Prince's main airport (Damon Winter / The New York Times)



Residents searched through hundreds of bodies piled up outside the central morgue, looking for their relatives (Damon Winter / The New York Times)



Damaged church in the capital (Damon Winter / The New York Times)





A woman walked through a residential area near Place Jeremie, where many homes were destroyed (Tequila Minsky for The New York Times)



A woman in the rubble on Tuesday. Countries rushed to the aid of the impoverished nation on Wednesday, pledging resources and aid (Daniel Morel / Agence France-Presse — Getty Images)



A woman was helped from the rubble of a damaged building in Port-au-Prince (Daniel Morel / Agence France-Presse — Getty Images)



People sorted through the rubble in Port-au-Prince (Tequila Minsky for The New York Times)



Destruction to homes built on the hillsides above Port-au-Prince.



Even modern houses were destroyed

### Flawed Building Likely a Big Element

By Henry Fountain (Published: January 13, 2010)

Engineers and architects who have worked in or visited Haiti say that substandard design, inadequate materials and shoddy construction practices likely contributed to the collapse of many buildings in the earthquake that struck Tuesday.

Cameron Sinclair, executive director of Architecture for Humanity, a nonprofit design group based in San Francisco, said he was "horrified" when he visited Port-au-Prince and Gonaïves last October to assess the quality of construction there.

Mr. Sinclair said that design and construction were far worse than in other developing countries he had visited. "In Haiti, most if not all of the buildings have major engineering flaws," he said.

Most houses and other structures are built of poured concrete or block, there being very little lumber available due to mass deforestation, said Alan Dooley, a Nashville architect who designed a medical clinic, built of reinforced concrete, in Petite Rivière de Nippes, a fishing village 50 miles west of Port-au-Prince.

Concrete is very expensive — much of the cement for it comes from the United States, Mr. Dooley said — so some contractors cut corners by adding more sand to the mix. The result is a structurally weaker material that deteriorates rapidly, he said. Steel reinforcing bar is also expensive, he said, so there is a tendency to use less of it with the concrete.

Building codes are limited or nonexistent, so columns and other elements made from concrete are often relatively thin, designed without proper margins of safety. "We would double the design strength, just to give it a factor of safety," Mr. Dooley said, referring to practices in the United States. "There they'd design it to what it would hold."

Concrete blocks are often substandard too, said Peter Haas, executive director of Appropriate Infrastructure Development Group, a nonprofit organization that is working on several projects in Haiti. Many of them are made in small batches at people's homes, and the quality can vary. "When you're buying blocks at the store you really have no idea of where they're from," Mr. Haas said. "And all it takes is for the block that was made at home to collapse."

When builders in Haiti do take disasters into account in their designs, their most recent experience has been with hurricanes, the last major earthquake having occurred two centuries ago. "Newer construction has been developed to withstand hurricanes, not earthquakes," said John McAslan, a London architect who has studied Haitian buildings, working with the Clinton Global Initiative. "If you engineer for one you're not necessarily covering the other."

Mr. Dooley said that his original design for the medical clinic called for a steel roof, but that was changed to a reinforced concrete one to better withstand hurricane-force winds. The building survived the earthquake with apparently little damage, he said.

But many other concrete roofs presumably collapsed, adding to the loss of life. Mr. Sinclair said he had seen houses where builders put concrete roofs on top of low-grade blocks. "Then it just pancakes," he said.



## **ΕΕΕΕΓΜ**

Τομέας Γεωτεχνικής  
ΣΧΟΛΗ ΠΟΛΙΤΙΚΩΝ ΜΗΧΑΝΙΚΩΝ  
ΕΘΝΙΚΟΥ ΜΕΤΣΟΒΙΟΥ ΠΟΛΥΤΕΧΝΕΙΟΥ  
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