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QMST 4320.251
27 April 2023

Project Phase 13

Abstract:

The goal of our research is to employ the statistics of the earthquake to figure out which areas were hit the hardest and to connect that with foundation types and building age. The factors of consideration include but are not limited to foundation type, building age, geographic region and used materials. We use 2015 Nepal Gorkha earthquake data to help determine which factors are important to withstand any future earthquakes. We build a model from using Classification Analysis to figure out the connection between the variables, and their importance.

Introduction:

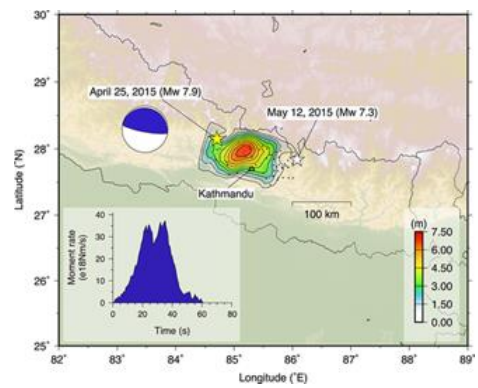
In 2015, an earthquake hit Nepal (Known as the Gorkha Earthquake) that had affected roughly 30,000 lives. The earthquake occurred on Saturday, April 25th , 2015, and recorded a magnitude of 7.8Mw in the city of Kathmandu and the surrounding areas. The earthquake was one-hundred twenty kilometers long and eighty kilometers wide with the largest Mw 7.3 aftershock on the 12th of May 2015.

The earthquake had propagated eastward at a rupture velocity of roughly three kilometers per second. When all was done, statistics showed that 8,970 lives were taken, 22,303 people seriously injured, 604,930 buildings were demolished, and another 288,856 buildings being partially destroyed, which after review, comes to about seven billion USD in damages.

Seeing how badly Kathmandu was affected with the occurrence of the Gorkha Earthquake in 2015, we wanted to see what variables were associated with each other. Using two variables to generate a plot showed that there was indeed an association between multiple variables and the damage that was done to the buildings. Taking the amount of floors each building had and the number of buildings that were affected, we would be able to determine that the amount of floors directly affected how badly a building was destroyed. With this, it could be deployed into real life use and reduce the number of floors in buildings to deter future earthquakes.

Literature Review:

Starting this review of other sources with findings on the 2015 Nepal Earthquake, we hope to come to a conclusion on our own findings that could be similar to the others. Taking a look at the article "Integrated seismic source model of the 2015 Gorkha, Nepal, earthquake," it states that the earthquake had hit on April 25th, 2015, at 06:11 UTC. The earthquake was felt by just a little more than one-hundred kilometers wide, and with the article stating that it occurred on a “low-angle fault plane” which was consistent with the tectonic stress field in the region. The data pictured on the right details how much area was struck and points the epicenter of it all. The map is color-coordinated with the severity of the earthquake in certain areas. Authors Ryo Okuwaki and Yuji Yagi noted that they had used the data methods they had used was waveform inversion and HBP methods to teleseismic body waves, along with data covariance matrices. What they found was that the area of the earthquake was one-hundred twenty kilometers long and eighty kilometers wide with the largest M_w 7.3 aftershock on the 12th of May 2015. Concluding the article, it is noted that the earthquake had a distribution of “high-frequency radiation sources shows that a strong high-frequency event, propagated eastward with a rupture-front velocity of about three km/s” for about thirty seconds. This article was able to pinpoint the location of the epicenter, how much area was affected, and analyzed the aftershocks of the earthquake.



The following article “The 2015 Gorkha earthquake: A large event illuminating the Main Himalayan Thrust fault,” indicates that Main Himalayan Thrust fault is one of the largest and fastest slipping megathrust on Earth. The largest recorded seismic activity in this area is the M_w 8.2 Bihar earthquake that occurred in 1934. Through mapping for coseismic and postseismic landslides, it shows “positive associations with slope and shaking intensity, where the highest areal densities of landslides are developed on the down dropped northern tectonic block.” Fortunately, the earthquake did not cause any glacier lake outburst of floods in the area. The figure on the right shows the Langtang Valley before and after the 2015 earthquake. The area was completely demolished through the following landslides that nothing was left to show. The earthquake took roughly nine-thousand lives and damaged a large region. In the Durbar Square of Downtown Kathmandu, had many historical architectures, dating back to at least 1690. Out of the five observed, two architectures were damaged but not fully, and the other three were completely flattened. For the residential buildings, images show that one with reinforced-concrete frames were not affected all that bad, with newer RC-Framed that performed even better and with more confinement. Most of the heavily damaged or even collapsed buildings, were found in the northern region, along the Ring Road in the Gongabu, which lays on two different types of soil. The earthquake had originated northwest of Kathmandu , where, as stated before, the rupture propagated eastwards for about one-hundred forty kilometers. Looking at the map, Nepal is located on the MHT, which is where the subducting Indian plate and the overriding Eurasian plate interact. These two plates on the Modified Mercalli Intensity Scale (mm), make up for about twenty mm every year, give or take.

Learning about the Gutenberg-Richter law and the modified Omori law, where the former describes the “frequency-magnitude characteristics of an aftershock sequence, whereas the modified Omori law models a temporal decay of an aftershock occurrence rate.” These laws were used to give confirmation from “seismic risk management viewpoints because initial estimates of aftershock-related hazard can be obtained from the empirical aftershock models.” Another comparable earthquake the happened somewhat close was in 1505 in western Nepal with a moment magnitude of 8.2, however it was occurred too far from the rupture zone the the 1934 Bihar and 2015 Gorkha earthquake took place. The Bihar event devastated the area, taking more than ten-thousand lives (compared to Gorkha’s nine-thousand), which shows the MHT fault both regions sit in to come with devastating results from earthquakes.

The 2015 Gorkha, Nepal earthquake showed that the weak structures were found to be the major cause of damage, which “underlines the need for strict compliance of building codes.” More in depth statistics of the 2015 earthquake shows that 8,970 lives were taken, 22,303 people seriously injured, 604,930 buildings were completely destroyed, and another 288,856 buildings being partially destroyed, which after review, comes to about seven billion USD in damages. Following the information currently gathered from all resources, our group research would continue to deduce the problems in building structure to be able to find out which material used and how they were used, caused the most damage.

<u>Data, Methodology, & Key Variables:</u>

<u>Data set:</u> Modeling Earthquake Damage by Gorkha Earthquake
<u>Problem:</u> Predict level of damage to buildings
<u>Source link:</u> https://www.drivendata.org/competitions/57/nepal-earthquake/page/136/

<u>Data:</u>
· Test Set values: The independent variables that need prediction

· Training set labels: The dependent variable (geo_level_1_id) for each of the rows in training set values
· Training set values: The independent variables for the training set

Analytical Method

Classification Analysis and/or Ordinal Regression Analysis will be used for this problem

Key Variables of interest:
· **geo_level_(1-3)_id** - label to show which buildings are in a certain region of where the earthquake hit.

· **Damage_grade** - How badly a building has been hit on a scale from 1-3

· **Building_id** - Unique id's for each building hit
    · 1 – Low Damage
    · 2 – Medium Damage
    · 3 – Complete Destruction
· **foundation_type** - Type of foundation that each building has
· **age** - How old the building is
· **area_percentage** - area of the building footprint
· **height_percentage** - height of the building footprint

Methodology

After looking at the dataset and determining which variables we would indicate as our "key variables," we came to a conclusion that we would be using a decision tree or logistic regression. The decision tree path came to a hard close as it just was not working out for us and we had produced a satisfying result with our logistic regression. Following the Logistic Regression, it was then decided to fit it into a confusion matrix to see the predicted and actual values of the damages.

The visualized data showed us multiple routes to go about providing a solution to future damage. We put our damage grade variable up with multiple other variables such as age, number of floors, and what type of foundation that was used.

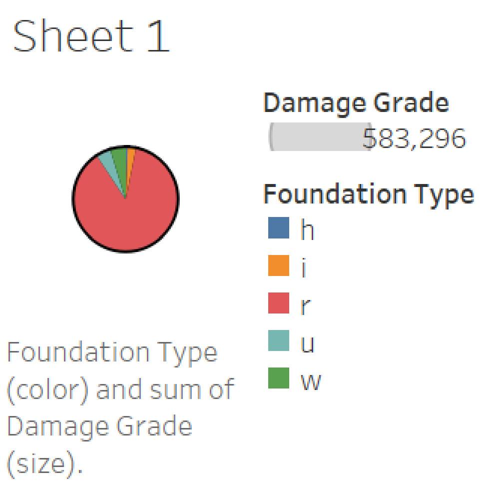
What we found out:

1) The more floors, the more damage is done to a building.

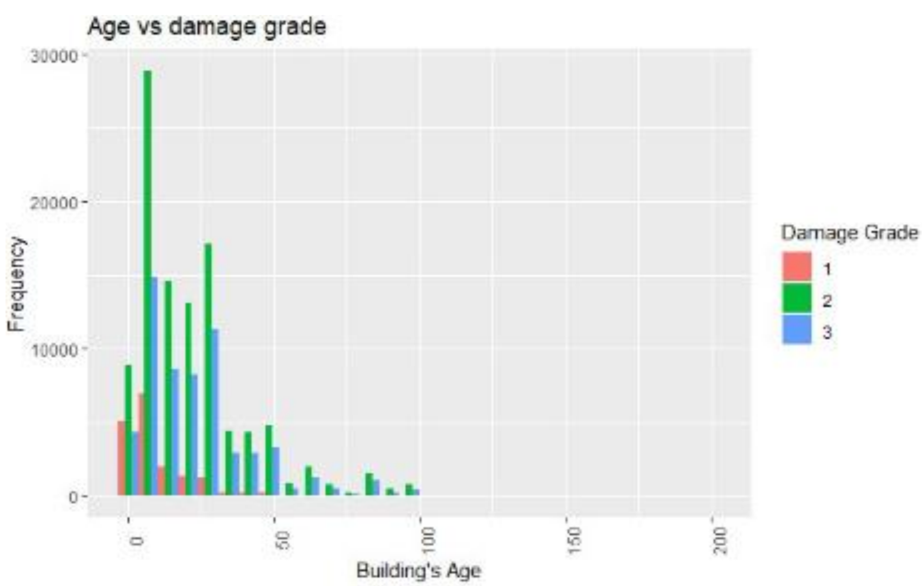
2) The youngest buildings had the most devastating damages.

3) The most frequently affected buildings were those with the foundation type “r.”

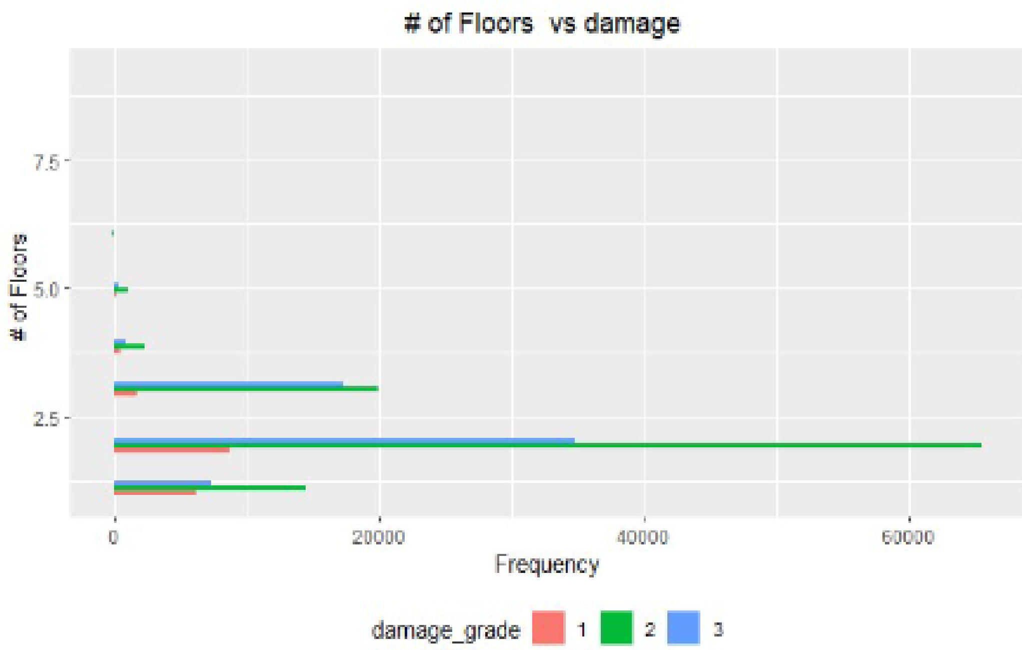
Graphs Produced:



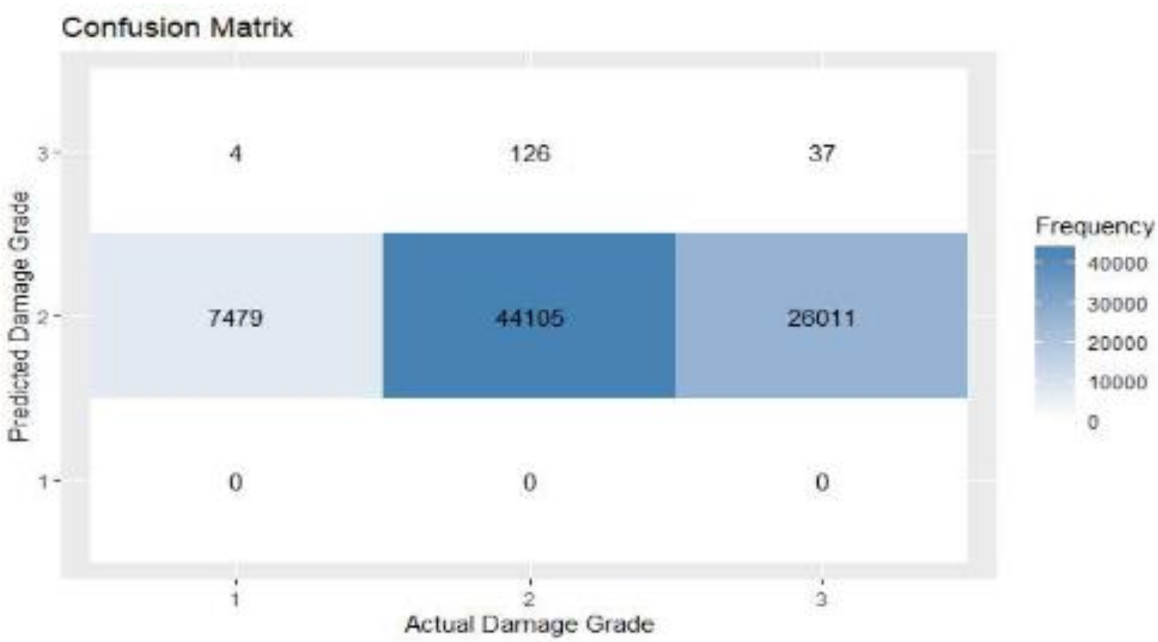
Graph showing how much of each foundation was damaged



Building age association with the damage that was dealt to it.



Building floors association with the damage that was dealt to it.



Finished Confusion Matrix Table showing predicted and actual values.

<u>Conclusion & Recommendations:</u>

We have concluded our research by generating useful information to be able to provide a clear solution to reduce damage from future earthquakes. This one that occurred in Kathmandu, Nepal, dealt catastrophic damage to the area that is still affecting the area. Their recovery process has been very slow and what they have rebuilt up to today is still only a small percentage of the total amount that was destroyed.

To reduce damage from future earthquakes, we can look at the plots and determine that the number of floors and the building age directly affected the amount of damage a building endured. We would recommend that buildings are more frequent but have a reduced number of floors. Another is that they would need to be sure they kept buildings well equipped with modern technology and keep with new structural integrity strategies.

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