AIM:

The problem with quake caster model is that it is unable to justify the hypothesis and unable to predict the earthquake.

So, our aim is to justify these hypotheses and predict the earthquake more efficiently with modified quake caster model.

Introduction:

- An earthquake (also known as a quake, tremor or temblor) is the shaking of the surface of the Earth resulting from a sudden release of energy in the Earth's lithosphere that creates seismic waves.
- Once the fault has locked, continued relative motion between the plates leads to increasing stress and, therefore, stored strain energy in the volume around the fault surface.
- This continues until the stress has risen sufficiently to break through the asperity, suddenly allowing sliding over the locked portion of the fault, releasing the stored energy.
- This process of gradual build-up of strain and stress punctuated by occasional sudden earthquake failure is referred to as the elastic-rebound theory.

The Parkfield section of the San Andreas Fault is the best documented and the most periodic earthquake sequence known on the planet, but its event sequence is neither time- nor slip-predictable. The Parkfield fault section data, at first glance, appear to be roughly periodic, with magnitude 6 earthquakes roughly every 20–30 years. Christopher Scholz (2002) assessed Parkfield data from an earlier time period, 1850–1988. However, 11 Scholz points out that the 1934 Parkfield earthquake occurred roughly a decade earlier than the average interval, and since his work, we now know that the 2004 Parkfield earthquake struck about 1–2 decades late (fig. 7B). This data emphasizes the fact that even the most predictable earthquakes deviate from slip- or time-dependent hypotheses. Also, Murray and Segall (2002) found that the Parkfield magnitude 6 earthquake is not time-predictable. Based on the 1850–1966 inter-event times, the most recent earthquake after 1966 should have occurred sometime between 1973 and 1987, but it did not strike until 2004, about 1–2 decades late, and it was also somewhat larger than its recent predecessors. This record emphasizes that even the most predictable earthquakes deviate from slip- or time-dependent hypotheses. If these hypotheses do not fit a simple, seemingly periodic fault, then how can they apply to a larger and more complex fault? Even though the magnitude (M) ~6 Parkfield shocks are not periodic, time-, or slip-predictable, there is a class of very small (M=1–3) shocks, known as repeaters, whose seismic waveforms are nearly identical, and so are thought to occur at the same location and have the same size and slip. Rubinstein and others (2012a and 2012b) show the time history for Parkfield repeating earthquake sequence #1 (fig. 7C). At first glance, this set of M~2 repeaters appears periodic, and is certainly more periodic than the QuakeCaster shocks in figure 3A and the M~6 shocks in figure 3B. But upon closer inspection, the repeaters are not periodic, nor are they time- or slip-predictable, as demonstrated by Rubinstein and others (2012a and 2012b). The QuakeCaster stacked-slider earthquakes are M~ -4.5. This means that the scale difference between the M~6 and the repeating M~2 events at Parkfield is about the same as the difference between the repeaters and QuakeCaster events. To estimate the QuakeCaster magnitude we calculated the seismic moment of a typical event from the slip (~10 cm), slider area (~100 square centimeters, cm2), and the rubber band crosssection (~0.1 cm2), Poisson's ratio (~0.25) and length change of the rubber band in response to a fixed tension to calculate its Young's modulus (~6×106 dyne-cm-2). We converted Young's modulus to the shear modulus, arriving at the seismic moment (~3×109 dyne-cm), which was then converted to magnitude. Students can easily perform these calculations by measuring the change in length of the rubber band for a given force on the dial scale. Young's modulus, E, is the tensile stress/tensile strain, which equals the force on the rubber band (F) multiplied by the original length of the rubber band (Lo) divided by the original cross section of the rubber band (Ao) multiplied by the length change (ΔL); the full equation is FLo / AoΔL. Young's modulus can be converted to the shear modulus G, by G = E/2(1+v), with Poisson's ratio v about 0.25. The seismic moment (Mo) is calculated by multiplying the slip (u), by the area of the fault (A), by the shear modulus (G). Then the magnitude equals 2/3(logMo - 16.1). A comparison of QuakeCaster Trial 1 (from fig. 4A), Parkfield M~6 shocks, and Parkfield M~2 repeaters is shown in figure 7.

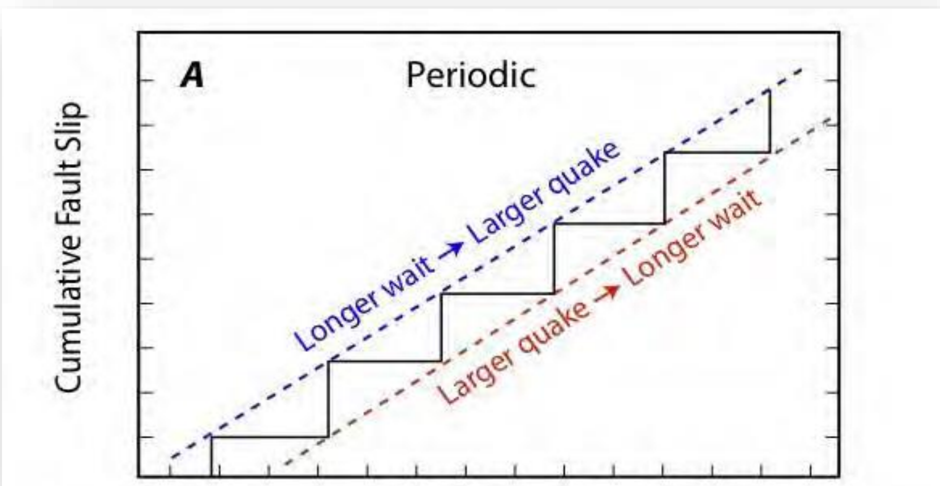
PRINCIPLE of Quake Caster Model :

There are few **Predictions Hypothesis (Principles)** that are used in this model :

Hypothesis 1: (Earthquakes are Periodic)

In this hypothesis , same amount of FAULT SLIP is separated by same amount of Time.

i.e., if longer earthquake occurs so it takes longer time to rebuild and vice versa.

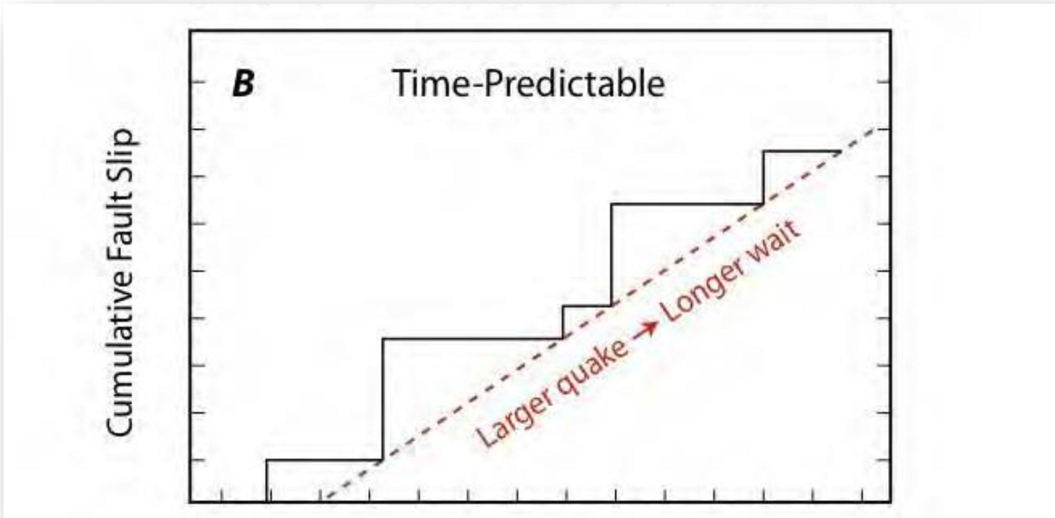


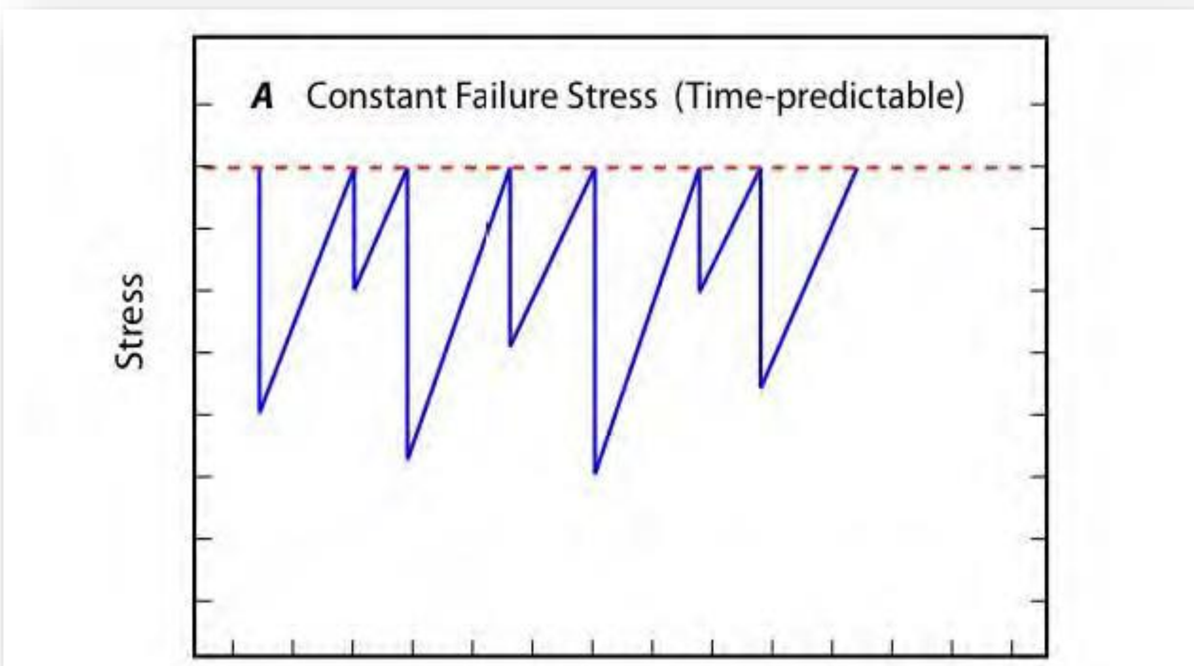
Hypothesis 2: (Earthquakes are time-predictable)

In this hypothesis, larger the amount of slip in the last earthquake , longer the time until the next earthquake.

In other way, Earthquake occurs only when the failure stress is reached.

i.e., certain amount of stress accumulates along a fault.

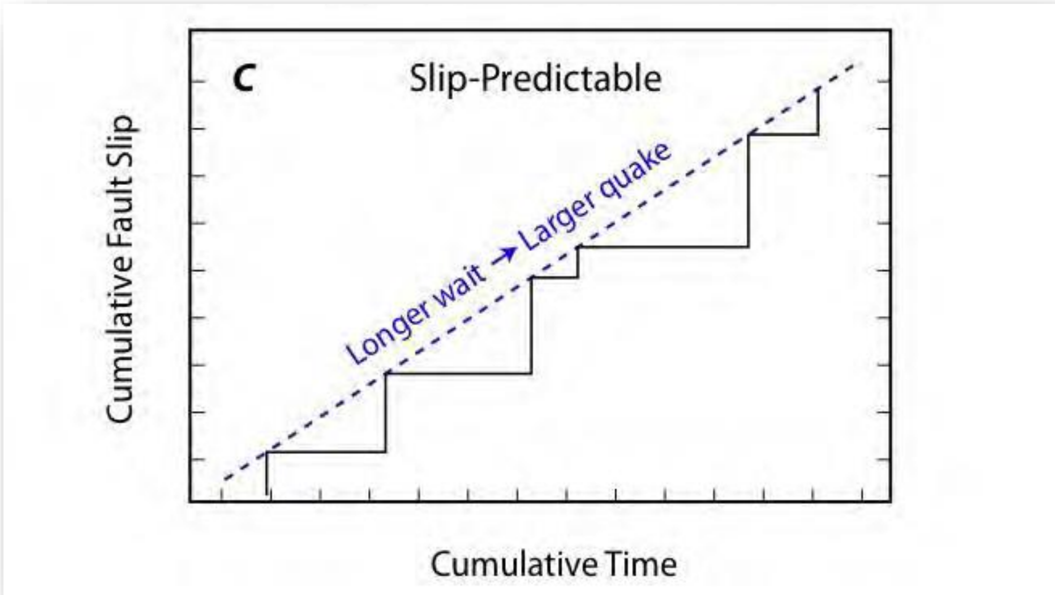


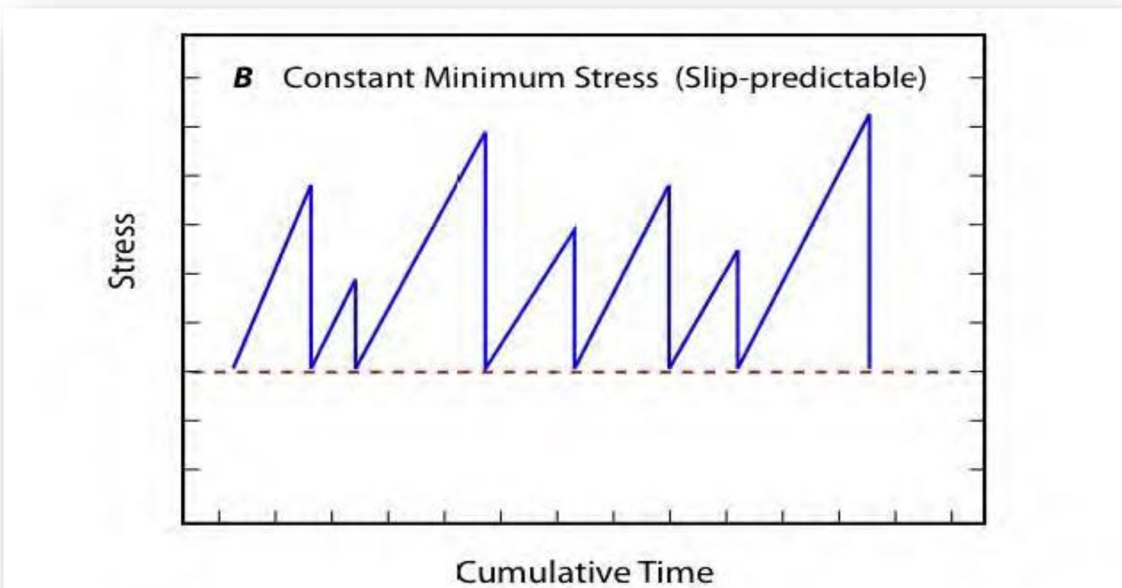


Hypothesis 3: (Earthquakes are slip-predictable)

In this hypothesis, longer the time stress accumulates, the greater the amount of fault slip in the next earthquake.

In other way, that earthquakes decrease the amount of stress along a fault to a fixed minimum amount.



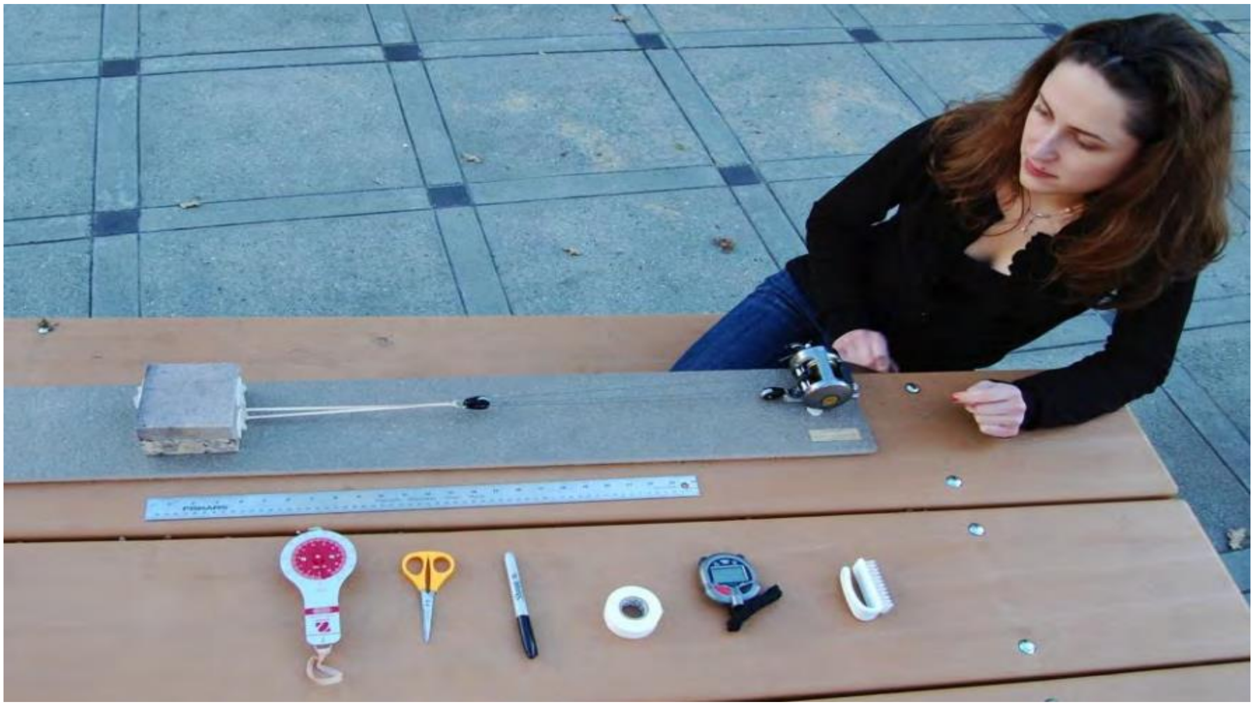


Hypothesis 4: (Earthquakes occur randomly and have randomly varying size)

In this case, Poisson Hypothesis is used , particularly when little information about a fault and its past earthquakes is available.

QUAKE CASTER

- Quake Caster is an interactive, hands-on teaching model that simulates earthquakes and their interactions along a plate-boundary fault. Quake Caster contains the minimum number of physical processes needed to demonstrate most observable earthquake features.
- A granite slider in frictional contact with a nonskid rock-like surface simulates a fault at a plate boundary. A rubber band connecting the line to the slider simulates the elastic character of the Earth’s crust.
- By stacking and unstacking sliders and cranking in the winch, one can see the results of changing the shear stress and the clamping stress on a fault. By placing sliders in series with rubber bands between them, one can simulate the interaction of earthquakes along a fault, such as cascading or toggling shocks.
- By inserting a load scale into the line, one can measure the stress acting on the fault throughout the earthquake cycle. As observed for real earthquakes, Quake Caster events are not periodic, time-predictable, or slip-predictable. Quake Caster produces rare but unreliable “foreshocks.”
- When fault gouge builds up, the friction goes to zero and fault creep is seen without large quakes.
- Quake Caster events produce very small amounts of fault gouge that strongly alter its behavior, resulting in smaller, more frequent shocks as the gouge accumulates.



Modification in QUAKE CASTER MODEL:

1. Changes in Slider Blocks.
2. Changes in Rubber band (Dimension and Elasticity).
3. Changes in Pulley System
4. Changes in Force applying Mechanism

Changes in Slider Blocks:

It doesn't represent the true lithology of the earthquake area. So, we modify three things

- No. of block
- Types of blocks
- Arrangement of block

We have modified three block into five block.

We have used five different types(material) of block

Blocks are arranged lithostatic graphical.

Changes in Rubber band (Dimension and Elasticity):

- We are using more stiffer rubber band in compare to original quake caster model. as we have higher load(blocks).

Changes in Pulley System:

- We are using 6 pulley system because higher load and a greater number of blocks.

Changes in Force applying Mechanism:

- We are replacing hand rotation mechanism to the Electric motor.

MODEL DESIGN:

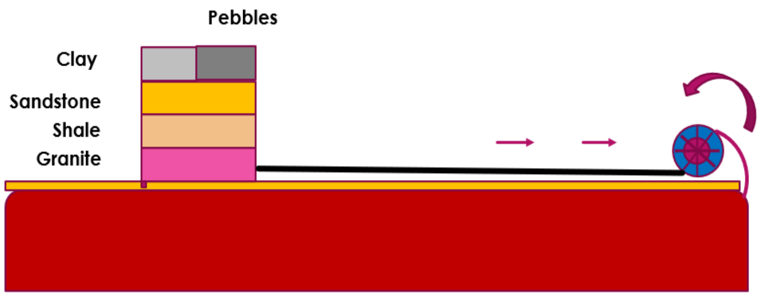
Parts and Equipment required for this Model :

- 5 sliders (Granite, Shale , Sandstone , Clay , Pebbles)
- 48×6-inch plastic board (foamed PVC ⅛ inch thick)
- Sandpaper
- 4 photo clips
- Ruler
- Marking tape
- Marine Adhesive Sealant
- Electric Motor (Force applying Mechanism)
- Thin metal wire
- Cork
- X-Acto knife
- Spray-on adhesive
- Size 74 rubber bands
- Force (stress gauge)
- Stopwatch
- Small brush
- Corvalus 300 fishing reel
- Drill, screws
- 2 small pieces of rubber
- 6 pulleys
- White electrical tape
- Marker
- Pelican case
- Extra foam for Pelican case

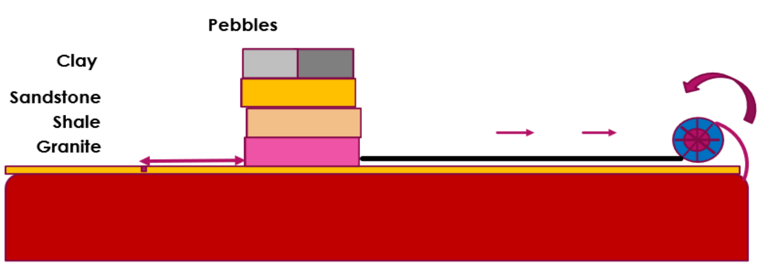
Steps for MODEL DESIGN:

- Take sliders three should be approximately 4×4 inches, two should be 2X2 inches and around 1¼ inch thick and PVC plastic board to desired length of size is 48×6 inches , ⅛ inch thick.
- Using the spray adhesive, adhere sandpaper to one side of the plastic board then glue the sandpaper backing directly to the board so it can be removed and replaced easily.
- Now with Slider, use sandpaper to roughen the backs of 2 photo clips and by ruler mark the center of on both side of a slider. Use big dollop of Marine Adhesive Sealant on the back of one photo clip. Attach it to the center of one slider's side. Let dry.
- The rough side of the slider should be sandblasted to increase the friction with the sandpaper.
- Now, we use Electric Motor for applying forces in Blocks**.**
- Attach fishing reel to foam board, measure the furthest distance the reel can be placed from the tile edge. Put two more screws at the front edges of the track to ensure the track will not wiggle side to side.
- Set up pulley system to alleviate the weight using electric motor, glue three of the kite pulleys together using strong adhesive . Use a C-clamp to hold them in position.
- Before attaching the wire to the screw, add a pulley to the wire. Thread the spectra through the pulley. Spectra is a low-stretch line. It is braided filaments of high-modulus material.
- Add a layer of cork to the bottom of the nonskid-covered foam board, using an X-Acto knife, cut around the edges. Spray one side of the cork with spray-on adhesive and attach the cork to bottom of nonskid-covered foam board.
- Attach a size 74 rubber band to a photo clip on a granite slider. Attach the *Ohaus* scale to the other end of the rubber band. Link the scale with the pulley.

Working Of MODEL :



Working of model starts with the rotation of electric motor, motor rotates at a constant speed. Because of rotation, stress starts building in the rubber band, but it doesn't move because of the frictional force acting between the block and sandpaper but opposite to the movement. The motor continues to rotate, and stress is continuously increasing and so the frictional force. When this force overcomes the frictional force block will move towards the motor and will stop where the stress becomes less than the frictional force. Here we will note the time after which the block is moved and amount of slip. This movement is continued for several time and time & slip will be noted. We will plot this time on x-axis and cumulative slip-on y-axes. We will compare this obtained graph with the original hypothesis and with the real time earthquake data to test how close our model is working.



Conclusion:

- Earthquakes are dangerous to human life and the infrastructure build by them.
- There are some models which attempted to test the hypothesis but failed.
- We modified quake caster model with the actual lithostratigraphy of Parkfield area.
- Our model is a modified attempt to test the earthquake hypothesis and will solve the prediction problem.

References:

- **USGS Quake Caster model** By Kelsey Linton and Ross S. Stein.
- **https://www.youtube.com/watch?v=ekTG-qjVHxc**
- **https://www.youtube.com/watch?v=Y3Xt3qgV63c**

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