

## HOW WERE THE MOAI MOVED FROM THEIR QUARIES TO THE SHORELINE OF EASTER ISLAND?

One of the remotest places on earth is Easter Island (Rapu Nui) lying in the middle of the south-east pacific about half way between Tahiti and the coast of south America. One of the most intriguing features of the island are its 900 or so megalithic structures termed Moai. We know that they were sculptured at quarries on the slopes of one of their inactive volcanoes. They all have the same stylized faces which makes up nearly half of the statue height. Here is a picture of a few of the Moai moved from the quarries to a point inland -

TYPICAL MOAI OF EASTER ISLAND CUT FROM VOLCANIC TUFF  
(Apparent density 1.5 -2.0 gm/cm<sup>3</sup>)



apparently set up inland and not along the island shoreline. The Moai were carved without the aide of metal tools from porous volcanic tuff of quite low density of just 1.5 to 2 times that of water. The stone is easy to carve with stone tools and their relatively low density allowed for the creation of such huge megaliths. Typically a Moai, without headgear , has a height of 13 ft with a base of about 5 x 3 ft. This gives them a weight of approximately  $13 \times 5 \times 3 \times 1.75 \times 62.3 = 21,260 \text{ lb} = 10.6 \text{ tons}$ . The largest of the Moai is approximated to have been twice as high and weigh about 85 tons.

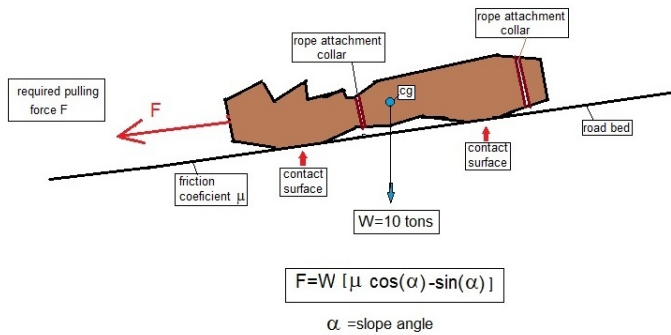
One is quite certain from missionary reports of the early 18 hundreds that the purpose of the Moai was ancestor worship. The statues were mounted on a wall (Ahu) along the Easter Island shoreline facing inward with their back to the ocean. Some of the statues were adorned with stone hats(Pukao) possibly representing former chiefs. Clan rivalry probably lead to the tremendous building effort by the Easter Island Polynesians between 1300 to 1600 (shades of gothic cathedral building in medieval Europe). When the first Europeans arrived (Jacob Rogtgeveen 1722) at Easter Island some 900 positioned Moai existed on the island. However, by the early 1800 hundreds all had been torn down and partially destroyed believed due to tribal warfare. Only in the 20<sup>th</sup> century was an effort made to restore the statues to their former intended positions. Here is one of these restored arrangements I took a photo of during my 2006 visit to Easter Island-



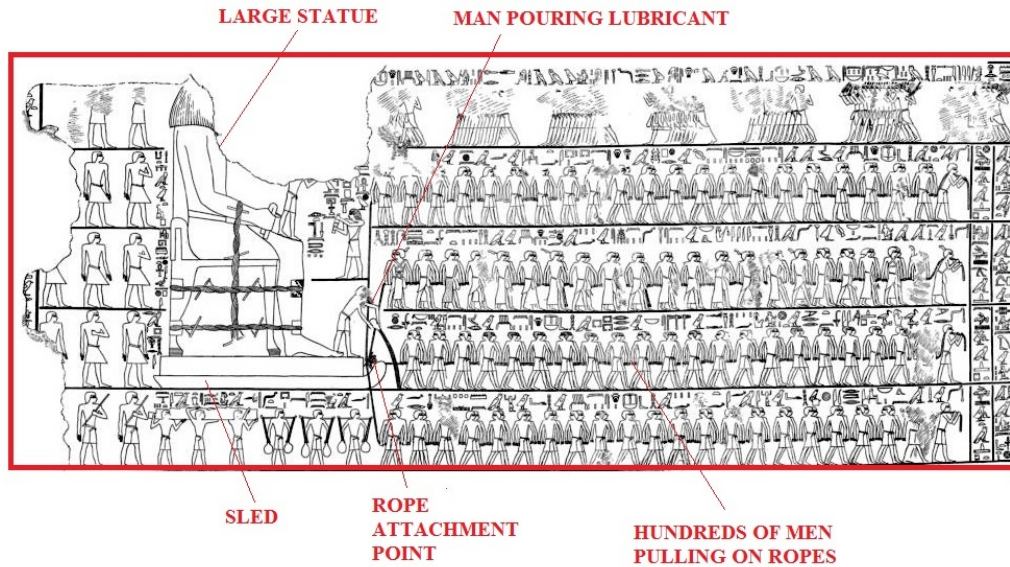
Note the central Moai with its partially destroyed head on the back Ahu. Also you can see our cruise ship (Crystal Serenity) on the horizon. As one notices, the original form of these statues has been heavily eroded since their construction over four hundred years earlier.

The biggest mystery remaining about the Moai on Easter Island is how they were transported from the known quarry at Rano Raraku on the slopes of one of their extinct volcanos to the island shoreline involving distances of as much as seven miles. Numerous methods have been proposed in the past of how this was done. They range from the use of log rollers to walking the statues upright. Both these approaches have major shortcomings. Remember that the natives had no concept of the wheel and the available palm trees were made of a soft wood not suitable for rollers even if they understood the concept of rollers. The walking approach, discussed at length in a recent NOVA program on PBS, also makes no sense for longer distance transport. Without overhead crane support used in the program the statues would easily tip over even with only the slightest error of the two rope team causing the walking. These facts leave one with just one approach for moving the Moai and that is by dragging the statues horizontally along a rigid road bed either directly or by use of an A frame type sled. The lubrication to reduce the pulling force requirement could be provide by a thin sand or pumace layer between the statue or A frame and the roadbed as shown-

**SCHEMATIC OF THE PROPOSED MOAI MOVEMENT  
ALONG A LUBRICATED SURFACE**



Ropes made from palm fronds could be constructed to any desired strength and there was plenty of manpower to use four of such ropes attached to the indicated collars in the schematic and be pulled by four groups of 50 men each. The idea for such a simple approach became clear to me from the following wall painting found on the walls of an ancient Egyptian tomb. It shows them moving a huge statue (larger than any Moai) on a wooden sled being pulled by several hundred men-



In the picture you also see an individual pouring oil onto the roadbed in front of the sled to reduce the coefficient of friction. The Easter islanders undoubtedly did something similar but used fine sand(or pumice) as their lubricant.

It is an easy task to calculate the required total pulling force on the reclined Moai. On an decline of  $\alpha$  the friction force will be  $\mu W \cos(\alpha)$  and the pulling force required parallel to the roadbed will be-

$$F=W\{\mu\cos(\alpha)-\sin(\alpha)\}$$

If we now take  $\alpha=5\text{deg}$  ,  $\mu=0.4$ , and  $W=20,000\text{lb}$ , one gets that the required pulling force will be  $F=6217\text{ lb}$ . Using fifty men on each rope would require that each man contribute just 31lb to the effort. To keep the Moai on track is an easy task made possible by adjusting the pull force on the ropes much like one does for a rudder. The fact that the Moai were chiseled out of volcanic tuff with their bodies horizontal and face pointing up lends further support for the proposed reclined position pull approach. The natives were quite familiar with the making of strong ropes from palm fronds obtained from the numerous palm trees originally found on the island. It is a technology familiar to most Polynesians and was essential in their boat building and sail controls.

Once a Moai arrived at its final destination it could be pulled up an artificial ramp to the top of the Ahu wall and then made upright via appropriated manipulation of the four ropes and the slow removal of the ramp. Some finishing touches such as eye whites made from white coral with dark stone pupils were added at this point. Also any damage such as scratches due to transport were smoothed out and some, as yet undecipherable symbols, were added to the back of some of the Moai.

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