Pyramids of Giza – an incredible art of ancient human civilization

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The seven wonders of the ancient world noted in poetry and other arts; narrate how civilizations left their marks on the earth. The oldest of those seven wonders is the 'Pyramids of Giza' and is the only one which is still standing. These amazing monumental structures were constructed some 4500 years back during the time of the Old Egyptian Dynasty.

Fig.1: Pyramids of Giza (Source: National Geographic)

Egypt is a country located in the north-eastern corner of the second largest continent Africa. Initially there were two states, namely Upper Egypt and the Lower Egypt and were formed by the combination of the primitive villages. Later those two states were united into one country, the Egypt. Giza is the third largest city (by area) in Egypt and located on the west bank of the river Nile.

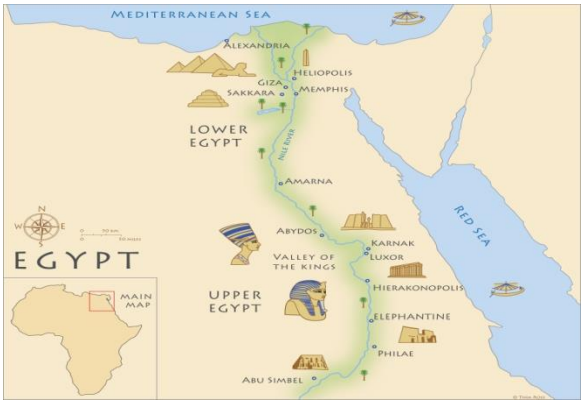

Fig.2: Map of Ancient Egypt (Source: World History Encyclopedia)

Construction of these monuments is really surprising. The spoke wheel was not invented then, the people had only copper tools, had no idea about the machineries such as cranes and had only limited knowledge of astronomy. Still they did it using huge human labor typically working day and night for about twenty years per pyramid. The rational explanation of their achievement is as follows.

The pyramids of Giza are each oriented almost in the direction of the principal compass points North, East South and West (N-E-S-W). The views in N-E-S-W directions are clear from the center of each pyramid base. The actual departure from the true N-S line for the Great Pyramid of King (Pharaoh) Khufu is about 1/15th degree. This orientation was probably achieved as follows. The Egyptian astronomers would have knowledge on the location of the North Star and they had the idea on the direction in which a vertical object casts its shadow at local noon. Thus, connecting these observation points, a perfect N-S line could be drawn.

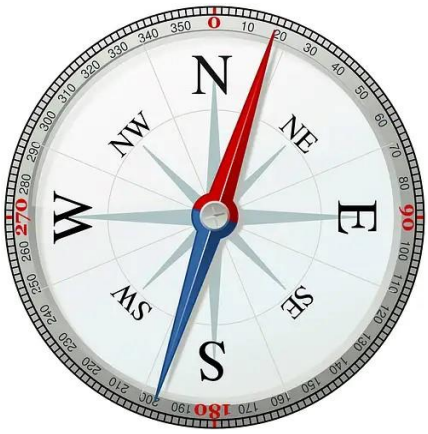

Fig.3: Compass (Source: Internet)

Then the center of the pyramid was placed at a point on the N-S line drawn. A circle was drawn around that point with the help of a rope of length equal to one half the pyramid base. Next two N-S lines parallel to the original N-S line were drawn so that they were just tangent to the circle. Then an E-W line was drawn through those two tangent points. A pair of lines parallel to that line were drawn too which just touched the circle at the N-S line intersections. The result was a perfect square oriented in the N-E-S-W directions.

Regarding the transportation of the rectangular stones to the construction site, the blocks were mostly limestone of density 2.6 gm./cm^3 some cut in a quarry near Cairo, the capital of Egypt but majority coming directly from the Giza Plateau. Limestone is relatively soft and thus can be worked with hardened copper chisel, a tool with a sharpened edge**,** existing at the time. Then, levers (used to move heavy objects) were utilized to loosen the stones. The transport was most likely by men pulling on ropes attached to a sled which was a land vehicle that slides across a surface. Use of such sleds was indicated by the tomb paintings.

The blocks (mostly of limestone) used for the construction purpose were from a fraction of a ton to several tens of tons in weight. The heaviest blocks were fewer in numbers and were of granite material. Those blocks were imported from Aswan, another

city in the Egypt. The average block was about $1m^3$ in volume and weighed around 2.86 tons each. Assuming a sled transport to the construction site, one will have a friction force of μW, resisting motion on a horizontal surface. Where, W is the sum of stone and sled weight, μ implies the coefficient of friction between the sled runner and the horizontal ground. When moving uphill at an angle of θ, the force F required to move the block up the incline will be

$$F \geq W [\sin(\theta) + \mu \cos(\theta)]$$

When no force is applied the sled and attached block will slide backwards unless $\mu > \tan(\theta)$. The ancient Egyptians were smart enough to perceive that pouring of water and oil mixtures onto the sled runners will significantly reduce the friction and thus require less man power to move a given block. Maintenance of proper lubrication between hard oak sled runners against a smooth stone surface can probably bring the μ down to 0.1. As a result, the manpower needed for the same work reduces considerably.

They also used the concept of Golden ratio to bring the aesthetic harmony in their art. In mathematics, the golden ratio satisfies the relation,

$$x/y = (x + y)/x$$

Where, x and y are two positive numbers with $x > y$ and x and y are said to be in the golden ratio if the ratio between the larger number (x) and the smaller number (y) is equal to the ratio between their sum and the larger number. This ratio is denoted by the Greek letter Φ (phi). The numerical value of phi is approximately 1.618. In case of pyramids, the ratio of the slant height to half the base dimension is 1.61804, which is extremely close to the Golden Ratio.

The ancient human civilization applied the concept of physics and mathematics in their spectacular work. Proper application of knowledge made their art unique and at the same time became an inspiring work in the field of Science and Technology. Modern civilization is not only being encouraged by the ancient but it's a pride of human race for their ancestors.

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