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The artistic Perspective and the Science behind The Structure of Kites

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Abstract

The craft of kite making is an age old tradition of the Subcontinent and the kite makers has a practice based specialized knowledge of kite making. Through oral transmission of knowledge there is a repertoire of kite making conventions that is fully consistent with the laws of aero dynamics. This paper discusses the laws of physics, particularly in relation to forces that act upon a kite and then explores the shapes and structures of kites in the light of practices that go into their making. The paper shows that each convention that kite makers follow corresponds to a scientific consideration although the kite makers are oblivious of it.

Introduction

Kite making may seem to be a simple mechanical work but on a closer analysis, one realizes that each and every part of a kite's structure obeys and uses the laws of

physics in order to provide a smooth flight. The steps of making a kite are simple enough that even a child can make a kite, however, if one aims to make a perfect kite, the considerations and qualifications become utterly different. The kite paper, the thread, the bamboo sticks, each and every component must be of exceptional quality and mathematically precise in terms of measurement. With the change in shape of kite, the placement of component in the new structure and their treatment also alters. The decision making involved in selecting and then putting the components together in line with the shape of required kite is what makes the kite makers important. The professional kite fighters always seek for best made kites and like every other field there are experts of kite making.

In Pakistan, the tradition of kite flying and the craft of kite making have had their time. Before the recent ban on kite flying by Government of Pakistan, kite making was a developing cottage industry. The craft of kite making had its secrets which were transferred from one generation to the other in a guild like system. The experts who made their name in kite making nostalgically remember the past and boast on the expertise they had in making a perfect kite. In the light of various discussions with local kite makers and on the basis of the laws of physics involved, it has been found that each and every aspect of knowledge that has been used in the kite making tradition had an underlying scientific basis. The kite makers are fully aware of the defects in kite structure that may lead to disaster after the kite is airborne. The kite makers are not aware of the laws of physics involved but in their own dialect they have a clear understanding of the mechanics at work. Their knowledge is practical and it is through an analysis of their conventions that one realizes how the tradition has preserved science.

In the following article, a brief explanation of the physics involved and a description of conventions used in the local tradition of kite making in Pakistan have been integrated. The various kinds of kites that were expressions of the expertise of local kite makers are discussed in terms of their shapes and structures particularly in relation to the flight of a kite.The first section is about the physics involved in the flight of kite. The information in this section provides a context for the second section. The second section describes the structural organization of locally flown kites along with identification of various conventions that expert kite makers of the region follow.

The Physics of Flight

A kite can be seen as either a single surface or a series of surfaces that connected with a line flies against wind pressure. As the kite moves in the air the wind pressure acts on the kite in the form of various forces. The shape and structure of kite respond to the applied forces in a way that a state of equilibrium is achieved. The thickness of paper, the weight of kite, location of edges in the structure, the surface area, the tension of bamboo frame and the movement caused by the line all contribute to the equilibrium. Another qualification for an ideal kite is more than mere equilibrium; it is required that it must follow the course of action that the kite fighter intends. The movement produced through line includes actions leading to pulling, lifting, drifting and diving of the kite, and it is made sure that these movements must not produce sagging, darting, or undesired spinning of the kite. For this purpose, the bridle plays a very important role as depending upon variation in length the weight of the kite alters for the kite fighter as well as its maneuvering.

The forces that act on a kite can be identified as follows:

1. The general wind pressure which acts upon the whole structure of kite. This may include the pressure produced by air friction. The general wind pressure acts on each and every component of kite as well.
2. The force of gravity also acts on kite and translated into the weight of kite determines its maneuverability.
3. The restraining force of the fastened line that pulls the kite. This force, unlike gravity is variable depending upon the speed at which a line is pulled. A greater speed results into a greater general wind pressure on the kite.
4. The weight of the line, which depending upon the thickness of thread can affect the flight of a kite.
5. The general wind pressure that acts on the kite also acts on the line, and creates a cumulative effect that affect the stability and maneuvering of the kite.
6. If a tail is added to a kite, the application of all forces assume an additional dimension as the tail acts as a component that can move as a separate entity. The tail itself exerts force on the kite.
7. The components of the kite which are functioning as one structure also exert force on each other under general wind pressure. For instance, when the bamboo framework receives pressures or a pull by the kite flyer, it exerts pressure on the kite paper and the glue joinery. The curvature of bamboo stick applies a continuous force on the kite paper.

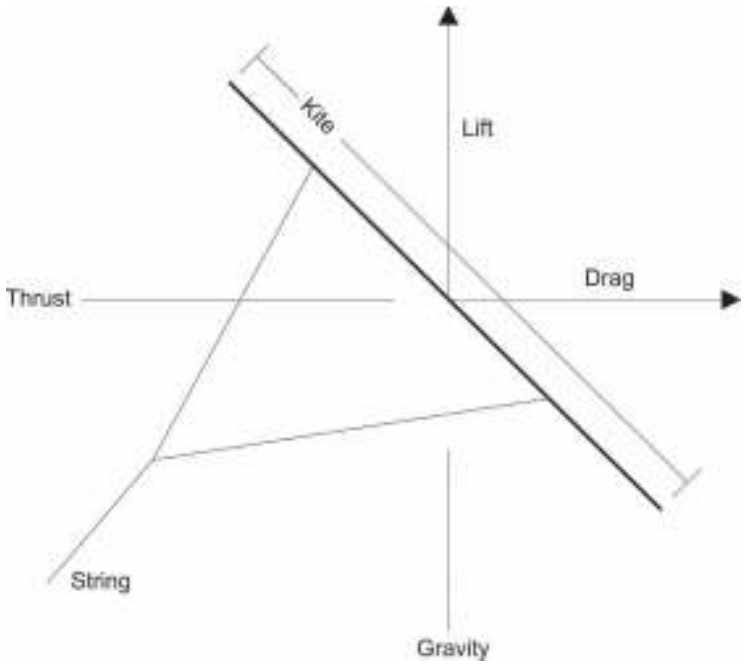

Figure 1. A description of forces acting upon kite I

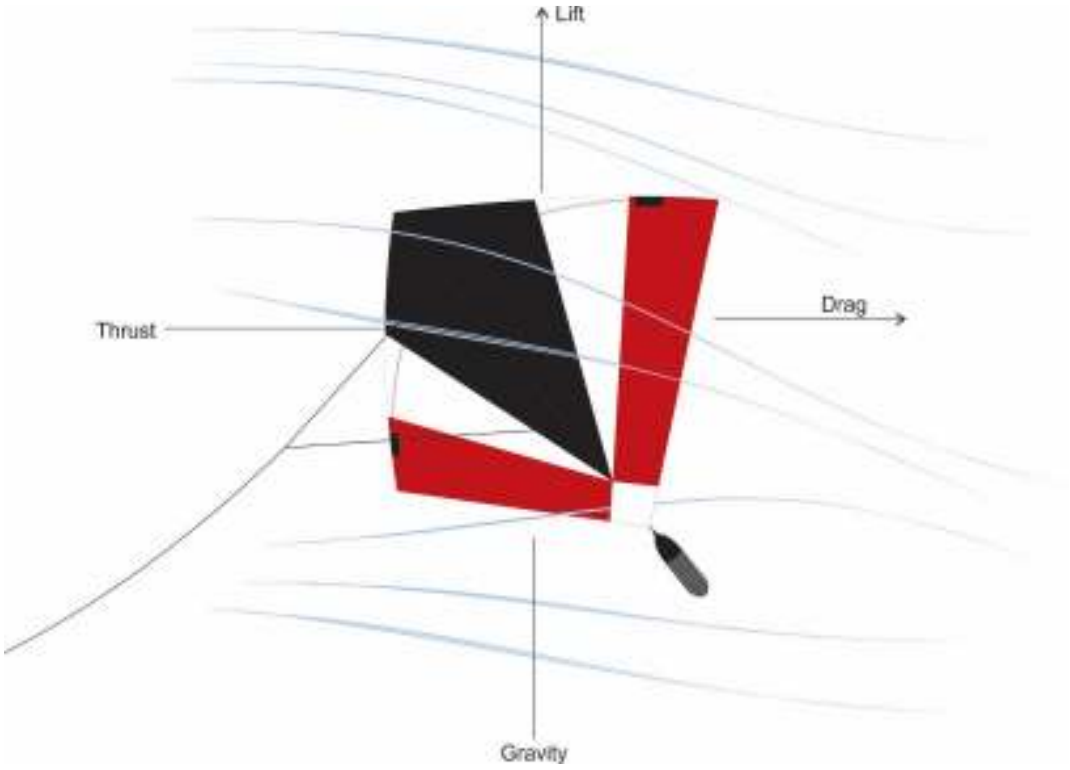

Figure 2. Wind Pressure acting upon kite.

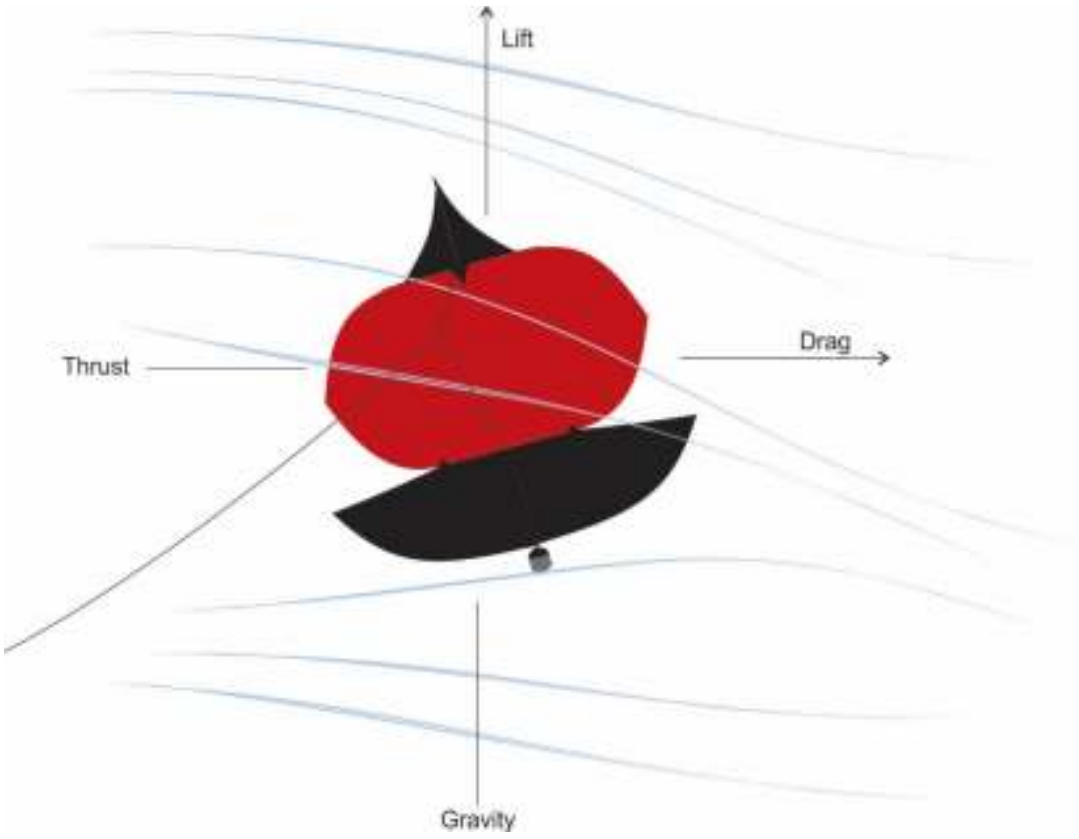

Figure 3: Air flow acting different in case of Patang by bending corners.

For a greater appreciation of all the above forces, consider for a moment, a kite in mid-air fastened with a line (Figure 1 and 2). The line gets pulled and the kite moves in a certain direction, the upward movement is against gravity, the downward movement is towards the direction of gravitational force. Moreover, in both directions the wind pressure also counts, due to the pull of line the wind pressure strikes the bamboo frame and the whole surface area of kite paper, the edges are bent and the joinery resists the pressure. The horizontal movement also creates strong points of pressure on the kite. In a kite competition, the line instead of being

pulled is slowly released, this is where the weight of kite, its structure and shape, the bridle function in an altogether different way. Moreover, the role of the tail, the variation in wind both in terms of direction and pressure, and the continuous interplay between state of equilibrium and disequilibrium actually test the expertise of kite maker. Let us now examine two major categories of kite structures that prevailed in Pakistan, and see how the kite makers used certain conventions that correspond to the scientific facts stated above.

The Kite Making Conventions

In Pakistan, the most popular form of kite has been the Rhombus shaped. In this category, *Gudda*, Lucknow Cut, *Sharla*, *Pari*and *Machhar* are the four types which have been mainly used. Interestingly, kite flying in Pakistan meant kite fighting, therefore, the makers always kept that at the forefront. In all the Rhombus shaped kite the basic process of preparing the structure is the same with minor but highly functional and useful adjustments. A typical Rhombus shaped kite, two bamboo sticks create the main skeleton. One stick is placed vertical over a finely cut piece of the kite paper andhorizontally divides it into two equal sections, and extends from the bottom to the top of kite paper. The other stick which is placed horizontal is then bent and is glued to the kite paper on the corners and tied to the vertical stick in the center. These two sticks appear as an arrow and bow and therefore called as *teer* and *kaman* in local dialect.The sticks are peeled with knife and their elasticity is tested. The kite maker Ustad Muhammad Ashraf told that the quality of the bamboo is top priority. The required strength at a certain degree of bending is the ultimate aim therefore, bamboo sticks of certain quality and thickness are used. There is no rule for this, it depends upon experience and expertise of the kite maker. We have certain

measurements which are tested by generations and we use them(Ashraf, Conventions in Kite Making 2017). The kite makers use oil lamps for heating the bamboo sticks at certain points in order to straighten it. It has been observed that this treatment is only applied in for the large sized kites. Sometimes, the use of the lamp is just for the sake of designing the central stick. Expert kite makers peel the corners of the *kaman* so that they can be properly glued with kite paper. Zulfiqar Haider Bhutto who is a kite maker from the Walled City informed that it is necessary to check whether the *kaman* has equal tension on the both ends or not. A slight variation in this tension will result in an imperfect kite and a lopsided flight. Moreover, it can result into a kite being torn apart by air pressure (Haider 2017). Again, we do not find a gauge or an instrument for checking the strength, it is tested by an experienced hand.

The weight and quality of the kite paper are quite important considerations. Kite paper, mostly used in Pakistan ranges from 16 grams to 24 grams per sheet, with a sheet being 20 X 30 inches and is also the unit of measurement of the size of kite. The quality of the paper is determined by its durability and smoothness of surface. There is an equation that kite makers use in which the weight of the paper is seen in relation to the size of the kite. The greater the size, the more weighty paper will be suitable(Ashraf, Conventions in Kite Making 2017). Similarly, smooth surface will help in lessening the friction of air and the reward will be greater and efficient manoeuvring. The expert kite makers have special vendors to ensure the good quality of kite paper. Shahid, who hails from an Indian family of kite makers told thata couple of decades back, the kite paper from Germany and England was considered best since it had a smooth and shiny surface. Later on China and Malaysia stormed the market and then Pakistan too started producing paper but none of them could compete the

German kite paper. Professional kite makers still prefer German kite paper due to its quality.

The gluing of kite paper with the bamboo structure is a sensitive procedure of kite making due to two reasons. One is that the technique rolling the paper on stick has to be perfect and the other is the quality of glue being used. The rolling of paper ensures the strength of the joinery. A kite maker avoids any folds that may result in friction and on both corners carefully ensures that the rolled paper should be of equal size. The kite maker then ties a thread to all four corners in order to secure the boundary of kite paper from tearing. All outer edges of the kite paper are folded and pasted over the thread. Small pieces of paper-tape and in some cases of cloth are used to further protect the joinery at the corners. In some cases, the joinery is burnished in order to remove any rough surface. Since pasting at the joinery and on all the edges creates a weak spot against air pressure therefore special care is given to glue preparation. It is kept in mind that it should be lighter and thinner, and dry quickly. It must have a resistance for humidity and could tolerate extreme weather. The binding force should be such that the air pressure is successfully handled. The kite makers use *Ata Suraish* as binding material with a mixture of sugar, salt and water. Ustad Muhammad Ashraf told that the quantities of sugar and salt in the mixture in certain weather conditions is the best kept secret(Shahid 2016).

The common kites that fall under the Rhombus shape category have variations in structure which are basically innovations to help improve the flight of kite. For instance, the *gudda* has an additional triangular piece of kite paper pasted at the bottom, this is called *pan*. The size of the pan usually covers almost half of the length of the vertical bamboo stick and the base of triangle extends on both sides. Its

function is to enhance manoeuvrability of the kite as the fins flutter in air and produce a movement of swimming.

In another popular shape, called the Pari, the pan is replaced with a tail, known locally as *phumman*. The *phumman* is a thinly cut kite paper, the strips are tied with thread and are rounded into a tassel like shape. The size is kept one-eighth of the vertical length of the pari. The *phumman* serves two purposes, one is that it adds an additional weight to the bottom and helps the kite fighter to easily adjust the direction of manoeuvring, the weight at the bottom also helps the *pari* to remain steady. The second purpose is aesthetic as it adds beauty to the kite. An elongated version of the *pari* is called *machhar.* The kite holds a ceremonial position as it is not a fighter kite. The manoeuvring is far less as compared to other kites and is therefore only flown by amateurs.Its tail is kept longer and on both corners, two additional tails are used, which enable it to stand still even under greater air pressure.

A special kite in this category is Lucknow cut. The name comes from the Indian city Lucknow, which is famous for kite making. The pan of this kite is smaller in size and has thin bamboo sticks supporting the edges of the pan. The pan is prepared by joining two identical triangular pieces of kite paper holding the sticks within. The fins do not flutter in air but the kite is known for its remarkable balance and steadiness(Butt 2016). This kite is used both as a fighter kite and a specialist for capturing kites in the air, called *chamerna* in local dialect. Due to enhanced and controlled manoeuvrability this kite can spin whenever the kite fighter intends, and through spinning it captures a kite in the air. The patang, which is the most preferred choice of kite fighters represents an altogether different structure. The skeleton is made from bamboo sticks and consists of two main oval shaped parts called the dhol

and *paindi*. The *dhol* is prepared by joining two *kamans* curved towards each other while the *paindi* has a *kaman* at the lower side. At the top of the patang is a triangular shape which is called nukka and a *phumman* is attached on the bottom of lower part. Expert kite makers keep the central bamboo stick or *gaz* thicker in the upper half. This convention serves two functions. One is that the upper part of the fighter kite remains more stable and provides a strength to the *nukka* that splits the air(Hanif 2017). This part takes on the air pressure as the kite is lifted upwards. The lower part of *gaz* which is thinner gives flexibility to the paindi which helps in manoeuvring the kite. The dimensions of each part of the *patang* are precisely measured and it is the most difficult kite in terms of making.[1]

A smaller sized gudda which is called sharla is favorite amongst junior kite fighters and kids. In this kite the pan is not a separate kite paper. The same kite paper is cut in a way that the lower portion assumes the shape of a pan and acts like fins in the air. The sharla is best known for its straight upwards flight. Another popular kite amongst the kids is *Tifli guddi*.

All the Rhombus shaped kites follow a strict rule of proportion as shown below.

[1]For a detailed study of the making of patang see Amjad Parvez. *Fighter Kite of Punjab: Material Structure and Making, Khoj* (Lahore: University of the Punjab)Vol 80 (2) Jan-Jun 2018.

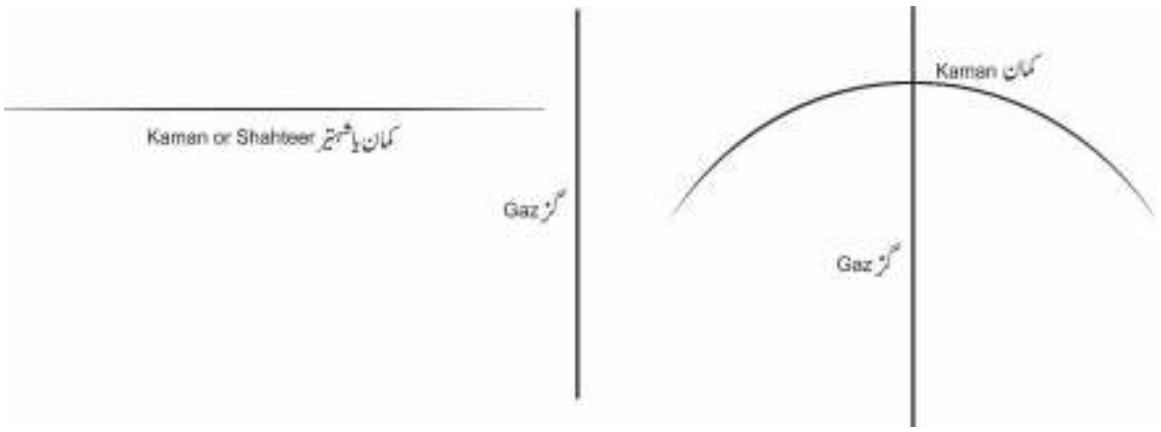

Figure 43: Illustration of Gaz and Kaman.

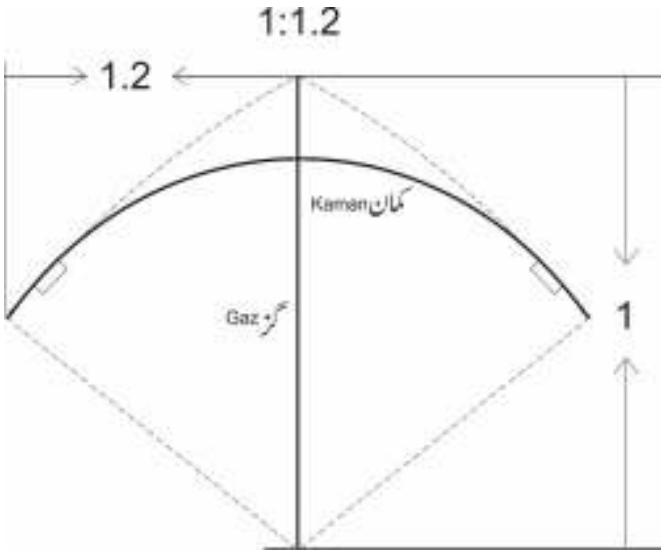

Figure 5: A measure of proportion.

The following figures visually explain the structure of these kites.

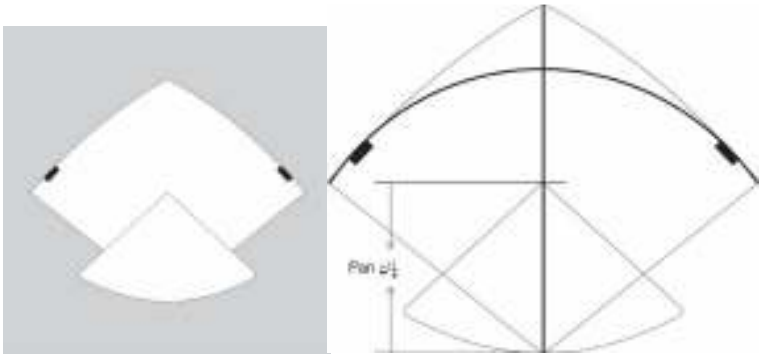

Figure 6: The basic shape of*gudda with pan being the half of the total height*

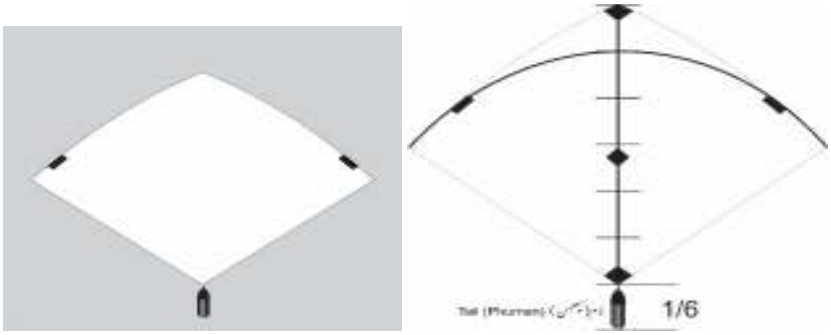

Figure 7:Basic shape and structure of*pari.*

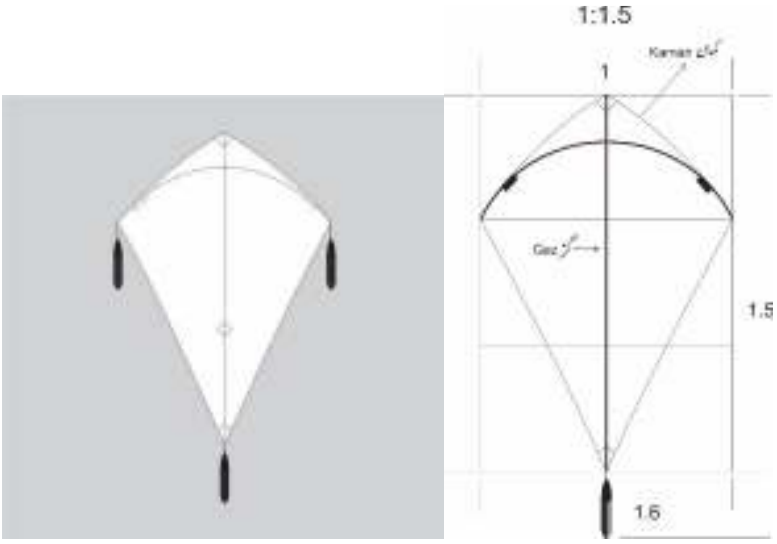

Figure 8: Basic shape, structure and proportions of *Machchar*.

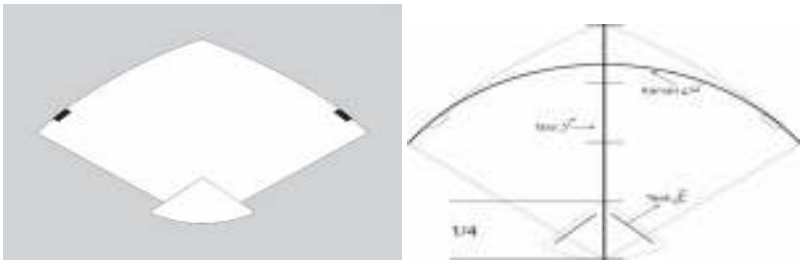

Figure 9:Basic structure of *Lucknow Kat.*

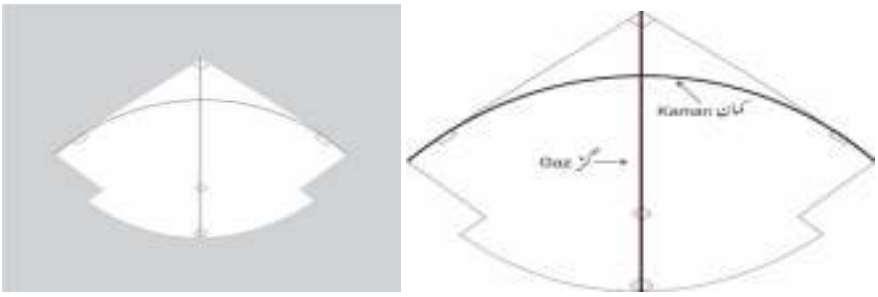

Figure 10.Basic shape of *sharla with pain being cut from same kite paper*.

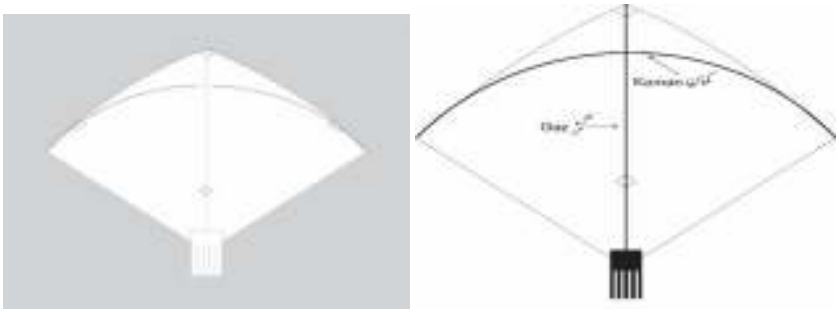

Figure 11: Basic structure of *Tifli guddi*.

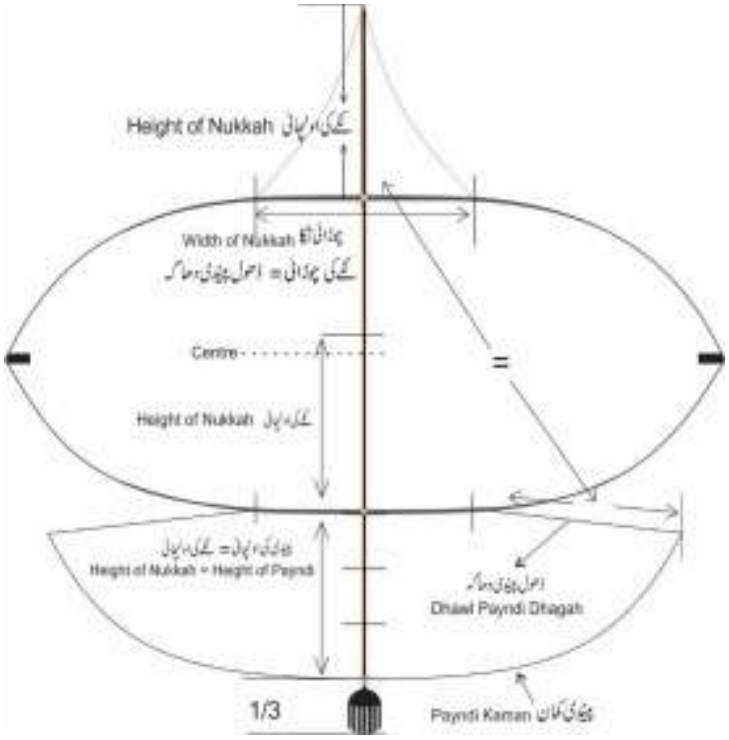

Figure 12. *The shape and structure of patang with measurements shown.*

If we translate the conventions and knowledge of kite makers into scientific terms, the following explanation can be inferred. The first consideration is the surface area of the kite along with the surface quality. The greater the surface area, the more air pressure will be exerted. The friction of air on the texture of surface is also very important. If the surface used is not smooth, it may result into a greater exertion of pressure. Due to this usually a kite paper with smooth surface is used. In case, where a series of surfaces is used, their joinery becomes another factor that responds to air pressure. The pieces of cloth used at the joinery can also be included in the surfaces. The wooden framework with all the sticks, ties, and braces also responds to air

pressure. The wooden framework also holds the kite paper stretched and is therefore under constant pressure, the air pressure due to striking wind or the pull of line affects the wooden framework. The thickness of the stick is responsible for handling air pressure but at the same time the thickness adds more weight to the kite. It also determines the force by which the kite paper is stretched. The kite makers therefore had to have an equation between the size and shape of kite at one hand and the weight of paper, thickness of sticks on the other. Another very important component in the structure of kite that responds to multi-directional air pressure is the glue used in the joinery. The glue is specially prepared and has ingredients that stand the test of time, weight and pressure. Given the complexity of laws involved, kite making becomes a serious business.

Conclusion

The art of kite making in Pakistan is a tradition that has survived through oral transmission of knowledge. The selection of materials, the treatment of materials, the cutting process, the peeling of bamboo sticks, the measurements and joinery all contribute to make a perfect kite for kite makers. The formulas used in kite making are known to the kite makers by heart. They do not understand the laws of physics involved but they have an experienced based practical knowledge fund. Each and every step of kite making can be related to the aerodynamic performance of a kite. The kite prepare by an expert kite maker is the most sought after for kite fighters, who are the connoisseurs of excellent work. Kite making would have been a process that developed through a process of trial and error and in the absence of theory, the practical conventions got fixed in a manner that today the we find a compatibility in

the oral repertoire of experienced based practical knowledge and the science of aerodynamics.

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