# BUILDING A PACKAGE TO RESCUE EGGS

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ABSTRACT

The purpose of this paper is to design an effective structure that protects an egg when drops from 2.5 meters height. To build an effective structure all natural involved mechanisms such as air resistance, gravity, and physical properties of the egg should be taken into account. The effort is to calculate and minimize all the forces against the egg when it crashes the floor combining physics and mathematics. So we are going to invent a passive device that will provide safe landing for an uncooked hen's egg . The device must fall together with the egg.

***Key Words :*** *Egg , invention a device, safe landing*

## 1. Introduction

Egg is a spherical shape material with a thin and vulnerable crust. Thus, it must be carried in such a safe boxes during loading to reduce the risk of being cracked in potential falls. This will economically help both producers and sellers. The height of trucks is usually between 2 to 2.5 meters which makes it necessary to save the eggs when it falls (Fig. 1). As seen in figure (2) the egg has a spherical structure . Egg contains different layers and parts shown in figure (2). The layers and components of the egg are: eggshell, air cell, internal and external membrane, thin and thick egg white (albumen), germinal disk, vitellina membrane, chalaza, yolk covered with a soft egg shell (crust) .


**Fig. 1:** Egg's car transportation

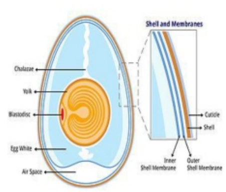

**Fig. 2:** The different layers of eggs [3]

Considering the shape of egg different type of containers have been built (Fig. 3).

**Fig. 3:** Box of eggs

Spherical shape of the eggs make it resistance to the chicken (hen) body weight when the chicken lay down on it. Also, this structure makes the egg to move along a curve path when leave it on a flat surface instead of a straight path. When the egg is being carried in a vertical state it can bear the maximum pressure compared to horizontal, therefore care must be taken to hold the egg vertical in the container during transportation. Due to the arch-shaped design the applied pressures will evenly be distributed and because of that eggs are most resistance when the pressure applies to their ends. Experiments show that egg can stand up to 15 kg.

## 2. Materials and Methods

We want to design an instrument that will enhance the strength of eggs in falling. This could help efficient and more secure transport of eggs by trucks, as we know the height of normal trucks are 2.5 m so it can protect the eggs against the falling and reduce the financial damage.
Velocity and time are two important factors that could help to reduce the hit impact.

## 3. Theory

Force distribution on an arc-shape structure is shown in figure (4) .Gravity is the force that attract a body with smaller mass toward the earth which has bigger mass.

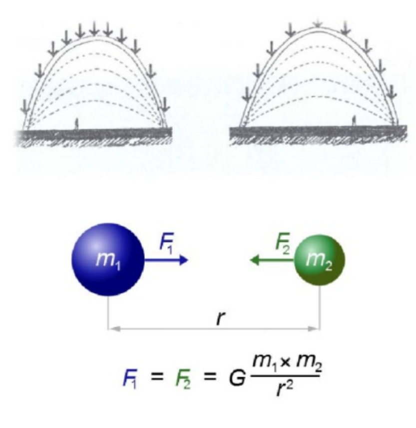


**Fig. 4:** Forces are applied on eggs

All bodies will fall with the same acceleration, unless air friction or other forces affect them. Acceleration is the velocity changes per unit of time. If two different body masses fall from the same height they will land on the earth at the same time. If a body with the mass of “m” falls the force affecting that is equal to F=m.g, in which, g is the gravitational acceleration; and is 9.81 square meter per second . If a net force of “F” affects an object, that object will gain an acceleration that has a reverse relation to the mass of the object (the second law of Newton) and also the velocity from falling a height (Eqs. 1 and 2).

$$F=ma\,,\ F=\frac{dp}{dt} \quad (1)$$

$$v=\sqrt{2gh} \quad (2)$$

According to the equation by reducing the velocity or increasing the impact time one can decrease the force and also one can use a protection as a guard for example: spongy and …

Important factors to decreasing the force:

- Reducing the velocity,
- Increasing the time of impact,
- Height, local gravity, the area and the cross section of the falling object is important.
- Gravity, the word "gravity" refers to the force that pulls an object to another object. More specifically, it is the force that the Earth or another heavenly body exerts on people or objects, pulling them toward it. The gravitational acceleration of Earth is 9.807 m/s^2.

The kinetic energy of an object is the one that it possesses because of its motion ($K=1/2.m.v^2$) and the potential energy is the energy stored in an object because of its position relative to a reference position. Depending on the amount of object mass and gravitational acceleration the potential energy is calculated (U=m.g.h).

In fact when the egg is falling the potential energy is continuously converting to kinetic energy. The more the eggs getting close to surface the less the potential energy and the more the kinetic energy become. Therefore, we need to design a structure that not only acts as a buffer but also increase the air friction force e.g., parachute.

Friction is the force resisting the relative motion of two solid surfaces against each other. The lower the friction the faster two surface will move against each other. The air resistance against the falling objects is a friction force. Therefore, the air friction should be taken into account in the calculations .

Impulse is the product of the force acting on an object during a time interval. Therefore, during the egg fall we need to reduce the impulse from the surface. The designed structure should have a good buffer against the impulse. The bufferingmaterial used to reduce the impulse force can be an umbrella, spring, foamy stuff, air cushions, or even hanging the eggs, or suspending it in a gelatin .

## 4. Structures

Structure and its strength play a main role in the distribution of the forces and reduce the impulse. Structures are like cubical, pyramids, unsymmetrical shapes.

As mentioned earlier due to arch-shaped nature of egg is better to let the egg to hit the ground on it either end in order to increase its strength against the impulsion force.

### 4.1. The First Idea

Idea taken from the nature is very useful in solving every day's life problems. We took our structural idea by looking at the honey bee hexagonal nest architecture. The hexagonal architecture is the most effective shape of the nesting compared to square or triangular shaped structures. Since the bees body is spherical shaped, in order to reduce the ineffective spaces, it will be ideal to make the hexagonal cells (Fig. 5). In a hexagonal structure each cell each has at least three connections with neighboring cells (cell number 2 to 7 with the central cell and adjacent cells). This fact makes the cell stronger and also makes it less time consuming to build the nest. In reality when we put six cells next to each other we have built an extra bonus cell (cell number 7) for free. In a mathematics expression using 30 matches we build seven hexagonal cells; in other word we should have 42 matches to be able to make seven hexagonal cells but we were able to save 12 matches.

If we are going to save only one egg, we need one hexagonal cell which has less cost. Compared to one egg with the mass of m, when a box containing 7 eggs hits the ground the impulse force is seven times greater than the prior case with one egg. Because in this case the F=ma has changed to F=7×m.a. thus, we need to have a stronger structure that can tolerate the bigger impulse forces.

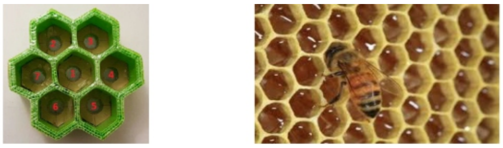

**Fig. 5:** Structural design according to the nest of bees

As seen in figure (6) when the egg hit the ground from the sides it will be cracked, however when it hits the ground on either of the ends, the impulsion effect would be much less. We would be able to save the egg, if we could protect the sides of the egg and try to distribute the forces evenly on both ends. We did this by placing a hexagonal paper with a hole in the center to fit the ends inside the hexagonal cell (Fig.7). The central hole caused the equal force distribution as the cell hit the ground and also protected the sides of the egg. Additionally, the walls of the cell will consume the impulsion effect and thus less pressure on the egg (Fig.8). Forces exerted on the entire structure is plotted in figure (9).

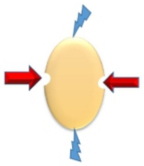

**Fig. 6 :** the effect of trauma to the body and head and bottom of the egg

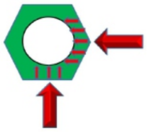

**Fig. 7:** bumpers hex

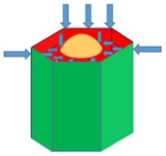

**Fig. 8:** forces exerted on the cell division

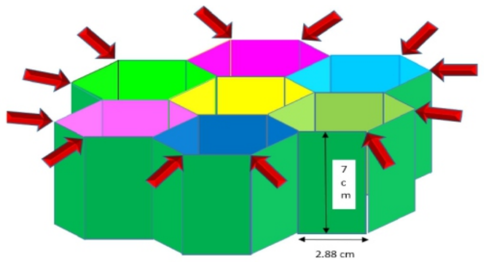


**Fig. 9:** The structure of the hexagonal single-cell

## 5. Experiment by First Structure

The purpose of this project is first to design a structure containing 20 to 30 eggs that not only can protect the eggs during falling from a height nearly 5.2 meters, but also economically feasible. The perimeter of a hexagonal cell is less than triangular and cubical cells. Therefore, hexagonal cell box is more efficient than the triangular or cubical cells in terms of strength and cost (Fig. 10).

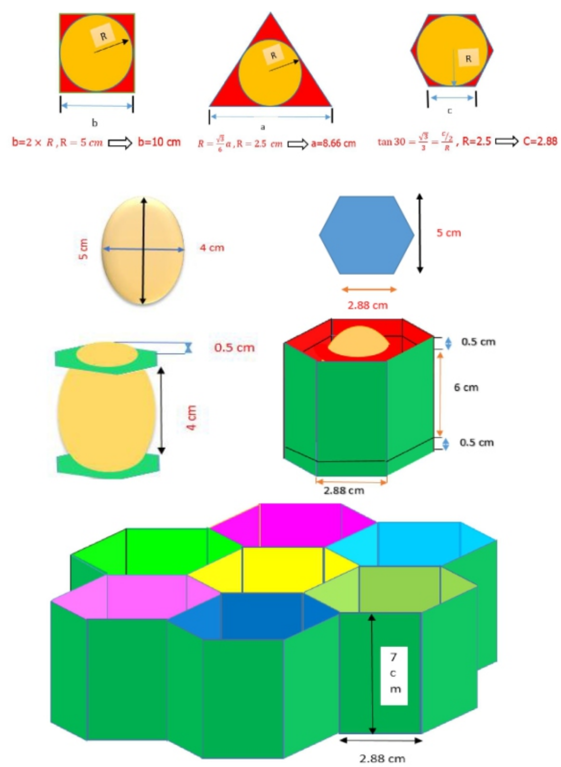


**Fig. 10:** Different shapes with 40 cm circumstance in square, 25.9 cm in triangular and 17.28 cm in hexagonal and the dimensions in hexagonal structure

The weight of the structure with and without the egg is calculated (Table 1).

**Table 1:** Weight of the structure

| | |
|---|---|
| Structure weight without the egg | 140 gr. |
| The weight of an egg | 62 gr. |
| Structure weight with the egg | 1000 gr. |

## 6. The Second Structure

Materials were used in this structure are:

- cardboard
-a box of eggs
-rubber band
-Nylon bubble

This is one of the lowest cost structures because of using the cardboard in the most parts. We used the rubber band due to its elasticity. The circular instruction is used so when it hits the ground it is starting to roll and the potential energy convert to kinetic energy and the speed gradually reduced to zero. This will protect eggs against damage.

In the other hand, two poles of the eggs are stronger than the other side.This design can withstand more weight than the initial state (between 16kg -19kg) and the pressure doesn't concentrate at one point to harm eggs.

Rubber band are used in this structure creates resilience so they reduce the energy of impact. The rubber bands act as spring and can save energy . During this motion the potential energy is converting to kinetic energy.

Hooke's law, $F=K\Delta L$, for total possible deformation and the potential energy U (L) stored in a spring , $U= 1/2\, k\, x^2$, which comes from adding up the energy it takes to incrementally compress the spring. That is, the integral of the force over displacement so (Eq. 1):

$$k=\frac{2mgh}{L^2}\Rightarrow k=\frac{2\times0.08\times9.8\times2.5}{(0.04)^2}=2450\,{}^{N}\!/_{m}. \quad (1)$$

The maximum value of K is 17400 N/m and in our experiment it is about 2450 N/m. So if we let the rubber bands extended or compressed about 2~3 cm (0.02~0.03m) the constant factor will be about 9800 to 4355 N/m.
we repeated this experiment 19 times and it takes about 0.7 seconds to hit the land (Fig. 11) (Eq. 2).

**Fig. 11:** the second structure

$$h=\frac{1}{2}gt^2\Rightarrow t=\sqrt{\frac{2h}{g}}=\sqrt{\frac{5}{9.8}}=0.71\mathbf{s}. \quad (2)$$

Kinetic and rotational energy can be as (Eq. 3):

$$mgh=\frac{1}{2}mv^2+\frac{1}{2}I\omega^2+\alpha \quad (3)$$

Witch m is the mass, g is gravity acceleration, v is liniere speed, I is rotational momentum, ω is rotational speed and α is lost energy in hitting. So Rotational speed and energy is as (Eqs. 4-6):

$$\omega=2\pi f=2\times5\times\pi=10\pi\ \ rad/s. \quad (4)$$

$$gh=\frac{1}{2}v^2+\frac{1}{5}r^2\omega^2+\alpha\Rightarrow\frac{1}{2}v^2=gh-\frac{1}{5}r^2\omega^2-\alpha \quad (5)$$

$$\frac{1}{2}v^2=24.5-302.5\pi-\alpha \quad (6)$$

## 7. Results and Conclusions

In the first structure as corrugated plastic sheets are two outside flat plastic sheets made of high density polypropylene separated by small plastic beams placed

perpendicular to them. These sheets are strong against the pressure, durable in temperature between -15 to 60 degrees of centigrade, light, flexible, smell less, non-poisonous, reusable, electric and thermal proof.
The second design with cardboard and covering with nylon bubble makes it safe for landing.

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