

## Equilibrium Analysis of the Structures in “Angry Birds”

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### Abstract

“Angry Birds” is one of the hottest games in 2010 which features challenging physics-based structure demolition [1]. To achieve the goal of destroying the castles of green pigs which stole the birds’ eggs, the birds would be put into the sling-shot (Fig. 1) and be shot towards the structure to demolish it (Fig. 2 & 3). Before shooting the birds, structural equilibrium analysis is vital due to the limitation of available birds and the aim to get high marks.

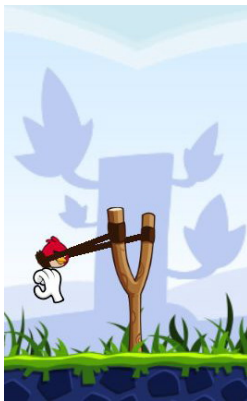


Fig. 1



Fig. 2



Fig. 3

### Equilibrium Analysis

Considering the structure (Fig. 2) in level 1-1 in Angry Birds, it is in a state of unstable equilibrium. The structure can be destroyed easily when a bird is shot towards the weak spots of the structure such as the top point and the middle point of the left wooden column just above the foundation. However, if a bird is shot towards the point close to the base of the left wooden column just above the foundation, the bumped column will slightly slide to the right hand side but the structure will not fall down (Fig. 4). The structure keeps its equilibrium because the moment induced by the impulsive force is smaller than the moment induced by the weight of column and its axial load, whereas the left wooden column slightly slides because the impulsive force is larger than shear resistance on the base of the column.

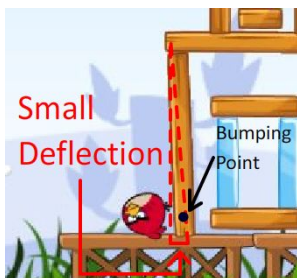


Fig. 4

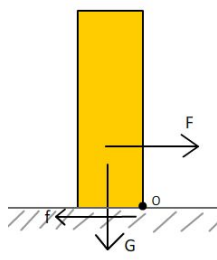


Fig. 5

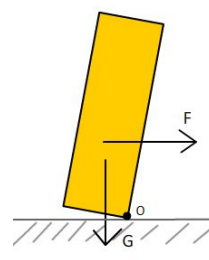


Fig. 6

Taken into account the left wooden column, the structural equilibrium analysis would be made as shown in Fig. 5 & 6, where  $F$  denotes imposed force on the object,  $G$  denotes the gravity of the object, and  $f$  denotes the shear force on the base of the object. There are 3 situations of the structural equilibrium:

(1)  $M_F < M_G, F < f$  :

( $M_F$  means the moment induced by the imposed force about point O, and  $M_G$  means the moment induced by the gravity about point O)

In this situation, the object does not move because the rotation about point O cannot happen and the imposed force does not exceed the shear resistance.

(2)  $M_F < M_G, F > f$  :

In this situation, the object just slide and does not fall down because the imposed force exceeds the shear resistance which in turn results in the slide, and the moment induced by the imposed force is not large enough to rotate the object.

(3)  $M_F > M_G$  :

In this situation, the object falls down directly without slide because the moment induced by the imposed force exceeds the moment induced by the gravity, resulting in the rotation about point O.

From these situations discussed above, it is easy to know that the object is more prone to fall down if there is a larger imposed force or a longer distance between the imposed point and the base of the object. Therefore the optimal strategy for the game “Angry Birds” is to shoot a bird towards the top of the column which in turn demolishes the whole structure completely (Fig. 3). As the YouTube video “Angry Birds Played in Real Life” [2] shows, shooting towards the top of the column is really an effective method to destroy the structure (Fig. 7 to 9).



Fig. 7



Fig. 8



Fig. 9

### Model experiments

To prove the three situations discussed above, the relevant experiments were carried out. What we need were very simple tools, including the keys, small and large scissors, a box of playing cards (green box), a string and a white box which is fixed on the desk. The fixed white box was used to ensure that the string which ties to the green box keeps horizontal and to stop the movement of the green box. The keys and two pairs of scissors were used to change the value of the imposed force on the green box. The detailed operational procedures were mentioned in the video clip.

Fig. 11 (Experiment 1) shows situation (1) where the green box didn't move when the small scissors were tied to the green box.

Fig. 12 (Experiment 2) shows situation (2) where the green box just slid without falling down when the small scissors and the keys were tied to the green box.

Fig. 13 (Experiment 3) shows situation (3) where the green box fell down directly instead of sliding when the small scissors, the keys and the large scissors were tied to the green box.



Fig. 10



Fig. 11



Fig. 12



Fig. 13

To sum up, the results of the three experiments shown above are consistent with the three situations discussed in the “Equilibrium Analysis” part. (The record of experiments is collected in the video clip below.)

### Video presentation

The video clip is a 4min24s video clip edited by myself, including the structural analysis about “Angry Birds” and the record of experiments. The website link is:

<http://www.youtube.com/watch?v=9pNokQe2-z8>

### Conclusion

Structural equilibrium analysis is very important in daily life as well as in the games like “Angry Birds”. The keys include understanding the physics-based principles and knowing how to simplify the complicated structures. In this paper, only simple structures are mentioned. However, what we see in our daily lives may be much more complex structures. Even in the game “Angry Birds”, there are many complicated structures that we need to analyse with our wisdom and structural knowledge, and the optimal strategy of shooting birds is to be gained after analysing the structures. Wish everyone to have fun of structural equilibrium analysis while playing “Angry Birds”!

### References

- [1] <http://www.rovio.com/index.php?page=angry-birds>
- [2] <http://www.youtube.com/watch?v=vKBZo-lmQuo>