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Would the Demolition Man become the Demolished Man?

Jacob Cox, Cassie Obee, Jon Cogle, Jimmy Pierce
The Centre for Interdisciplinary Science, University of Leicester
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Abstract
In the 1993 film Demolition Man, starring Sylvester Stallone, the main character falls from a helicopter suspended by a wire of steel. The fall would generate a G-force of 14.03G and since the wire is attached to his waist it would most likely be terminal but a further, more in depth look into the problem is required.

Introduction
Falling from great heights attached to a wire is a common thrill seeking adventure in this day and age, in the form of bungee jumping. This activity uses the elastic properties of a material to slow a person's velocity over a greater period of time to reduce the damage caused. However, in the film Demolition Man, the wire used does not seem to be elastic enough to actually reduce the damage that would be caused by falling from a great height.

Calculations
To calculate the impulse, first the final velocity Stallone was falling at before coming to an abrupt end due to the length of the wire was needed to be calculated. He fell for 4.1s (timed by watching the film) and he would have been accelerating toward the ground at $9.81ms^{-1}$, therefore using the SUVAT equations the final velocity can be found:

$$v = u + at$$
$$v = 0 + (9.81)(4.1)$$
$$v = 40.22ms^{-1}$$

(Equation 1)[4]

Impulse can be equated as:

$$I = m\Delta v$$

(Equation 2)[4]

The change in velocity is equal to the final velocity before coming to the abrupt end and *m* is the mass of Stallone himself 104.15kg. Therefore:

$$I = (104.15)(40.22)$$

$$I = 4189.02Ns$$

With the impulse now calculated, the peak G-force that Stallone would be under during the impact would be:

$$Peak\ G = \frac{v^2}{gs}$$

(Equation 3)[2]

Where *v* is velocity change during impact, *g* is the acceleration due to gravity and *s* is the stopping distance. The stopping distance, *e,* can be calculated by using the Young's modulus of the wire:

$$E = \frac{FL}{Ae}$$

(Equation 4)[4]

Where *F* is the force of the impact:

$$F = ma$$
$$F = (104.15)(9.81)$$
$$F = 1021.71\text{N}$$

(Equation 5)[4]

A is the cross-sectional area of the wire, which has been estimated to be $0.002m^2$, *E,* the Young's modulus of the wire at room temperature, is 29.5×10^6 [3], *L* is the length of the wire, which can be found using SUVAT:

$$L = ut + \frac{at^2}{2}$$

$$L = \frac{(9.81)(4.1^2)}{2}$$
$$L = 82.45m$$

(Equation 6)[4]

Therefore the stopping distance can be calculated using a rearranged equation 4:

$$e = \frac{(1021.71)(82.45)}{(0.002)(29.5 \times 10^6)}$$
$$e = 1.43m$$

Therefore the Peak G is:

$$Peak\ G = \frac{40.22^2}{(9.81)(1.43)}$$
$$Peak\ G = 14.03$$

Discussion

According to the Eiband curves which state the human tolerances to G-forces, the limit is around 15 G [2]. Comparing this value with the calculated value, it can be suggested that Stallone would survive. However, this is unlikely due to several reasons. The values given by the Eiband curves are assumed to be equally spread over the whole body and so is the value that has been calculated. However, the force exerted on Stallone will be localised to his waist and would therefore have a much greater effect. To model this more accurately would require a more in depth look into the problem that would include creating a physiological model of Stallone so that the true effect of the force could be determined [2].

Conclusion

So it is still unclear whether the Demolition Man would become demolished or if he would survive. The value calculated is below the tolerance limit and does not truly depict the real outcome.

References

[1] http://csel.eng.ohio-state.edu/voshell/gforce.pdf

[2] ftp://ftp.rta.nato.int/PubFullText/RTO/EN/RTO-EN-HFM-113/EN-HFM-113-06.pdf

[3] http://www.engineeringtoolbox.com/young-modulus-d_773.html

[4] Tipler, P.A., & Mosca, G., (2008). Physics for Scientists and Engineers. W.H. Freeman.