

Point Loads and Impulse

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The questions probed in this tech note is how to determine the safety of scenery that is receiving heavy point loading or impulse forces. An example of just such a situation would be a platform on which one or more actors are jumping around. The first solution to this issue would be to just grossly overbuild the platform, like the proverbial ‘brick shithouse.’ Of course, this is not a very elegant solution — rather, it would be nice to have a way to actually calculate the effect of impulse forces and point loads on a platform. This tech note will deal with each of these issues.

1 Point Loads

Most structural standards and rules of thumb are built on the assumption that loads will be evenly distributed. The issue with which we should be most concerned when dealing with structural elements is the maximum stress which they undergo. If you work out the math, the maximum stress caused by a static point load will be twice the maximum stress caused by a uniformly distributed load of the same total amount. An extremely good explanation of beam loading is given at this website, so I will direct you there rather than trying to echo their derivations:

<http://physics.uwstout.edu/StatStr/statics/Beams/beam41.htm#Topic>

As stated before, if we only look at the maximum stress, the issue of ‘converting’ a point load to a uniform load is simple. The yield stress, which for wood is basically the point at which it snaps, is a material property. It should be noted that in the case of wood, the orientation of the grain drastically changes the value for σ_y , the yield stress. As suspected, the wood will yield at a much lower stress value across its grain than along it. In general, wood has a maximum shear stress value of 70-100 psi, and a maximum axial stress value of over 1000 psi. Anyway, these issues are identical in uniform and point loading problems, so they’re beyond the scope of this tech note.

2 Impulses

Impulse forces are the big issue when it comes to platforms that are going to be jumped on. If the platform fails, it is going to fail due to impulse forces. An impulse is defined as a change in momentum, and it is equivalent to an application of force for a duration of time. Mathematically, it looks like this:

$$m\Delta v = F\Delta t$$

Since we are concerned with determining the amount of force that we have to bear, the useful form of this equation is

$$F = \frac{m\Delta v}{\Delta t}$$

In other words, we can estimate the force applied to the platform by estimating the change in momentum and the change in time. It takes a person about 0.5 seconds to land,

bend, and jump again. In that time, their velocity is essentially reversing, so $\Delta v = 2v$. Again using a person as an example, a typical adult weighs about 70kg, and a person is traveling about 0.5 m/s when they leave the ground. Plugging in to the above equation, the resulting force on the platform is about 140N, or 30.8 pounds in addition to the person's weight; a total of about 180 pounds. Since this is a point load, it's equivalent to having a uniform weight of 360 pounds spread across the platform.

When using this technique to get an estimate, remember that shock loads also have the effect of causing vibrations in the joints and connections of your system. This effect can cause the platform to be 'jarred' loose and come unglued or unattached, so watch out for this as well.

A good explanation of impulse force can be found at

<http://users.mstar2.net/garyalan592/My>

and an excellent website on loading of stress skin platforms is at

<http://www.timberframe.org/technotes/sipsandssps.html>