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Tech Note: Structural Design
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Note: The following assumes a familiarity with basic concepts of structural mechanics, including beams and internal shear and moment forces. For anyone unfamiliar with these ideas I recommend Alys Holden and Ben Sammler's *Structural Design For The Stage*. For applications of double overhanging beams without the explanation, skip to the later sections of this article.

Unsung Heroes of Structural Mechanics: The Double Overhanging Beam

One important step in optimizing structural design is often neglected. Before member selection, before connection details, and possibly even before estimating magnitudes of loads (though after gaining a qualitative idea of loading conditions) a structural designer can select basic shapes and structural systems.

In theater we use efficient structures like continuous beams over multiple supports (flying battens) and sway-braced frames (tall platform legging with diagonal supports), and through convenience use very inefficient structures (simply supported beams and non-moment supporting frames pretending to be moment supporting frames in short platform legs). One specific structure that can be very efficient is the double overhanging beam.

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ADOUBLEOVERHANGINGBEAM LOOKS
    L                T
    I                H
    K                I
    E                S
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Note: For the purposes of this version of this article, I have chosen simply ASCII diagrams over hand drawn diagrams or time intensive, well drafted diagrams. Clearly, this could benefit from quality, custom made diagrams to illustrate important points.

Anatomy of a double overhanging beam:

Simple (non-moment supporting) supports are "Like" and "This". They are also the points of reaction forces, R1 and R2.

The length of the overhanging sections, "Adou" and "ooks" is length A.

The length of the primary span "Bleoverhangingbeaml" is length B.

The EVENLY DISTRIBUTED load across the beam is w (which has units of force/length).

Structural Design For The Stage features an excellent example of analyzing a specific double overhanging beam, and comparing it to a simply supported beam or similar total length or length similar to the primary span (finding in both cases that the double overhanging beam generates smaller internal moments and shear forces, and therefore can use a smaller structural member for a given load). I won't attempt to recreate that discussion here.

Structural Design fails to include case formulas to find shear and internal moment in double overhanging beams. They can be looked up in other sources, or derived directly (as I did), but are included here for convenience. Note that because the equations describe a generic double overhanging beam, without restriction on the respective magnitudes of A and B, the equations can be reduced to those describing a simply supported beam by setting A = 0. At the same time, the location of maximum shear and moment can not be found without A and B, so each of the listed possible sites of maximum shear and moment must be checked.

Maximum shear will occur either:
At the OUTside of each support, equal to: w X A
Or at the INside of each support, equal to: w X B/2

Maximum internal moment will occur either:
At each support, equal to: w X A^2
Or at the center of the beam, equal to: w X ([B^2]/8 – [A^2]/2)

Note that the equations for shear give an answer in units of force and the internal moment equations give an answer in units of force X length. In any mathematical analysis, "dimensional analysis" or "checking units" is a simple and effective way of checking that your answer is, if not right, at least not wrong.

With more knowledge, these case formulas can be used to select appropriate members for specific loading conditions. With no more information, they can be used to compare relative shear forces and internal moments in different designs.

The most important caveat in understanding use of double overhanging beams is that the analysis above relies on an evenly distributed load. Applying a constant load to the primary span, while removing the overhanging load, or applying a constant load to the overhanging span while removing load from the primary span, will in each case *increase* the maximum internal moment in the beam.

It is because of this caveat that the advantages of a double overhanging beam in the simplest application, platform design, is not of particularly great value. A double overhanging beam may be used, but structural analysis must be based on reasonable worst case scenarios, which for any theatrical platform can not rely on an evenly distributed load (consider telling an actor "you can stand in the middle… only if John and Jim are standing at the outside ends.").

Efficient uses of double overhanging beams occur frequently in rigging. A standard pipe batten, extending past it's outer pick points by several feet, is an excellent example. As long as the batten has some semblance of even loading, this overhang will be more structurally efficient than the same batten with pick points spread at greater intervals to evenly cover the entire length.

One specific use of double overhanging beams in my experience is in rigging and support of large traveling objects (typically walls or other flats). In this case it is generally reasonable to expect an evenly distributed load without fear of worst case loading scenarios.

Beyond the simple structural efficiency of a double overhanging beam for supporting a traveling wall, there can be other practical advantages. Track only has to run as far as a carrier needs to travel, the edge of a set piece may travel significantly farther. This can be useful because track is expensive and in limited supply, and in cases where constraints of a specific theatre create a need to send traveling set pieces slightly farther than track can go (such as in MIT's Kresge Little Theatre). The structural efficiency of a double overhanging beam can also reduce the number of pick points (and hence carriers) necessary to support a wall. Reducing carriers, even if each carrier takes on a larger load, can significantly decrease unwanted noise, because noise scales much more closely with number of carriers than with weight supported per carrier (that is, ten unloaded carriers whizzing around will make much more noise than one heavily loaded carrier).

The double overhanging beam is just one example of how a qualitative, not quantitative, understanding of structural mechanics (which does *not* necessarily most designers' intuitive understanding) can lead to superior structural design. Give a man rectangular lumber, and he can build things out of thick and deep rectangular lumber. Give a man understanding of tubes, triangles, moment of inertia and diaphragm walls, and he can do much, much more.