# Infiltrator Chambers and Tanks - The Mechanics of Corrugated Thermoplastic Structures

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Corrugated shapes are commonplace in a variety of materials today including but not limited to corrugated cardboard, plastic sheet, metal siding and roofing, and metal and thermoplastic pipe. The undulating shapes of corrugations provide greater strength to products than what they would have using just a flat sheet of the same material. For example, corrugated metal roofing is better able to support a heavy snow load than a flat sheet of the same metal. The advantage corrugated shapes provide is the creation of many small interconnected "beams" that collectively serve as reinforcing structures, leading to improved load-resisting capability. Infiltrator's molded thermoplastic Quick4 and Arc chambers and IM-Series tanks employ corrugated designs.

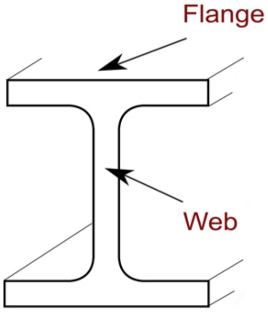
**Corrugated cardboard**

**Corrugated metal roofing**

**Corrugated polyethylene pipe**

Beams support bridges and buildings all around us. The beams supporting a bridge or roof system for a building are visible from below and can help gain an understanding for how the structure supports itself. Beams come in many sizes and shapes, from the traditional "I" shape, or "I-beam," to square and rectangular configurations, referred to as "box girders." The traditional I-beam includes three components, the web, which is the vertical portion of the "I" shape, and two flanges, which are the horizontal sections connected to the top and bottom ends of the web. A typical I-beam is shown below, along with an example of I-beams on a bridge under construction.

**I-beam components, including the web and flanges**



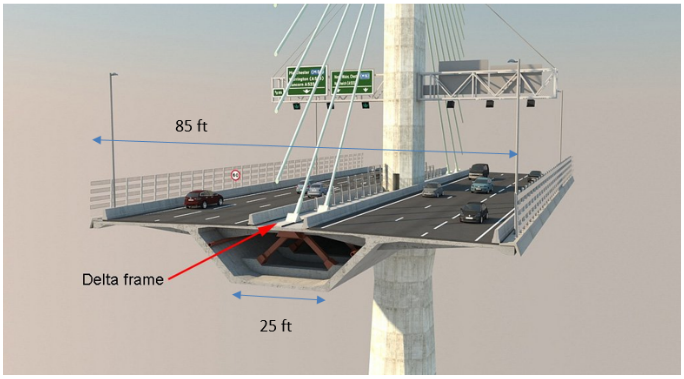
**Image**[i]

**Steel I-beams in bridge construction showing the vertical web sandwiched between top and bottom horizontal flanges**

**Image**[ii]

Box girders, shaped differently than I-beams, are commonly designed with a rectangular cross-section and hollow center area. Flanges on the top and bottom of these structures are connected with two webs located on the outsides of the box. When used in bridge construction, a box girder may include the roadway surface on its top side, integrating the beam and road.

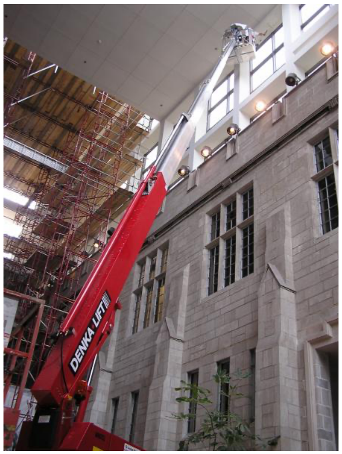
**Concrete box girder bridge with integrated bridge deck showing two angled webs sandwiched between a wide top flange and shorter bottom flange**



**Image[iii]**

Equipment booms frequently employ box girder designs and may include boom cranes, overhead cranes, and lifting equipment. These applications are typified by a rectangular box girder, where two webs connect the two flanges on the top and bottom edge of the rectangular box shape.

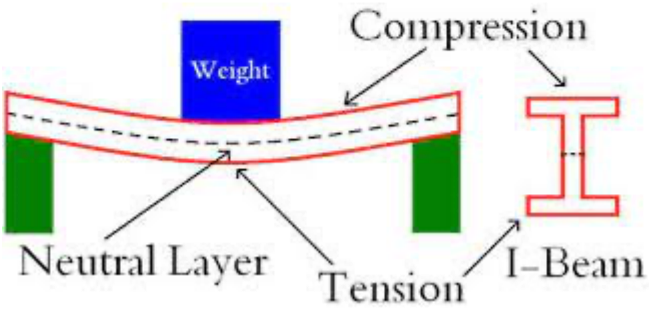
**Equipment boom utilizing a telescoping rectangular box girder design**



**Image[iv]**

A simple beam bending under the force of a weight is shown below. This is referred to as a beam "in bending." All beams in bending have a neutral axis, the location of which depends upon how the beam is geometrically configured. The neutral axis is neither being compressed nor placed in tension, but the material above and below the neutral axis is subjected to these conditions. In the example below, portions of the web and flange above the dashed line are being compressed or pushed together, while portions of the web and flange below the dashed line are being placed in tension or pulled apart. The combination of compressive and tensile forces in the beam around the neutral axis is what allows I-beams and box girders to resist an applied load. The neutral axis could be in the vertical center position or offset from this position if the beam is asymmetrically designed, such as the bridge box girder shown on the previous page. The quantity of beam material (e.g., steel, concrete, wood, plastic) and distance it is positioned above or below the neutral axis contributes to the load-carrying capacity of the beam. More materials positioned farther away from the neutral axis translate to increase load-carrying capacity.

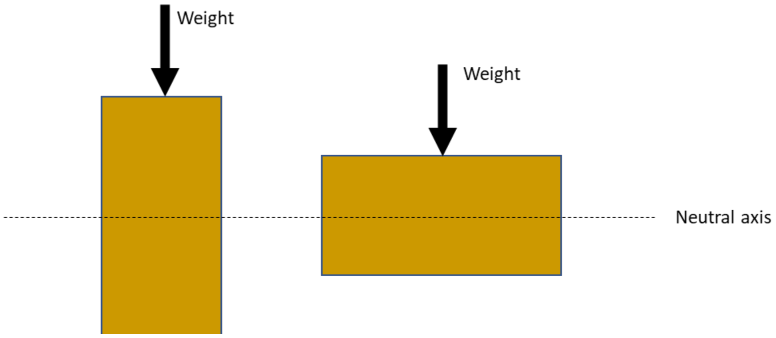
**Model of a beam under load showing the top of beam in compression and bottom in tension**



**Image**[v]

A simple wood 2x4 can be used as a beam. The neutral axis on a 2x4 is located at mid-height, whether the longer side of the 2x4 is oriented vertically (shown at left below) or horizontally (shown at right below). While the volume of wood above and below the neutral axis is the same in either orientation shown, a 2x4 with its long axis oriented vertically (left image) can support a greater load than when the long axis is oriented horizontally. The reason is that the wood of the 2x4 is positioned farther from the neutral axis in the vertical orientation, producing greater load-carrying capacity. This is the reason that a long bridge span is constructed using tall I-beams having a substantial quantity of steel in both the web and flanges. Shorter spans are characterized by shorter beams with a lower quantity of steel in the web and flanges.

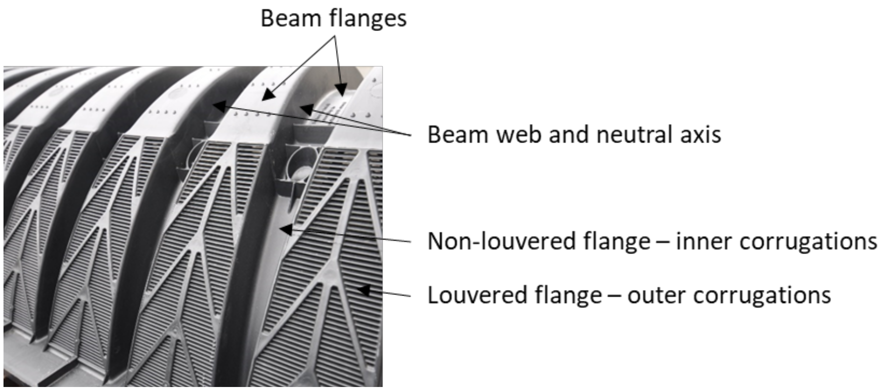
**When a 2x4 is oriented vertically, it achieves greater load-carrying capacity by increasing the distance that the wood is offset from the neutral axis.**



Beams are designed to have an optimal quantity of material in the web and within the flanges at a certain distance from the neutral axis, such that design loads can be supported. The design must take the height of the beam into account as excessive height can result in lateral instability. This aspect of beam design maximizes the effectiveness of the material used to construct the beam.

At this point, you may be wondering how bridge beams and 2x4s are related to Infiltrator chambers and tanks. Knowing that beams can come in a variety of configurations and sizes, examining the corrugated design of a chamber or tank shows that the corrugations are a system of interconnected beams arranged sequentially along the axis of the chamber or tank to support external loads. Like a bridge beam, corrugations allow the thermoplastic used to mold these structures to be offset from the neutral axis of the beam, thereby increasing beam strength. This increases the ability of the interconnected system of beams to collectively resist the loads applied by soil and other external sources. The photo below shows the locations of the beam flanges and webs on a Quick4 Plus Standard chamber. The neutral axis is at roughly mid-height on the web.

**Quick4 Plus Standard chamber corrugation pattern showing side-by-side beam design with thermoplastic being separated from the center of the beam**



For a Quick4 chamber, the corrugations are beams. They are rectangular in cross-section and arch shaped, spanning from chamber foot to chamber foot. The corrugation pattern interconnects the beams, with inner and outer beams forming a continuous, undulating pattern along the long axis of the chamber. The shape of the corrugation varies along the arch, with increased or decreased width at the connection with the chamber foot and narrower on the chamber dome, depending on whether it is an inner or outer corrugation.

Chamber corrugations are similar in cross-sectional shape to a box girder, having one flange interconnected by two webs. In the chamber shown above, offsetting the beam flanges from the neutral axis achieves a design where the polypropylene used to manufacture the chamber is positioned in manner that increases strength as compared to the strength of a flat, curved polypropylene sheet. Using the example of a bridge beam from above, where the height of the beam is designed to account for the span of the bridge, the height of the chamber corrugation contributes to the strength of the chamber. Polypropylene being offset from the neutral axis contributes to the strength of the beam. For chambers, the corrugations are designed to develop strength even when the flange component of the beam contains holes, which are purposefully incorporated into the product design in the form

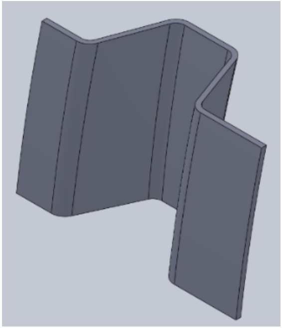
**Quick4 Equalizer 36 chamber**

of sidewall louvers. Collectively, the individual beams that are the corrugations allow chambers to support an AAHSTO H-10 load with 12-inch soil cover over the chamber dome.

Corrugations on IM-Series tanks are shaped differently than chamber corrugations. Rather than a series of arches, tank corrugations are generally linear segments connected by curved segments along the sides of the tank. On the tank ends, the corrugations are gently curved. Like a chamber, tank corrugations represent a series of interconnected structures, with inner and outer beams forming a continuous, undulating pattern along the sides and ends of the tank. The open box girder design applies with one flange interconnected by two webs per corrugation period (see image of one tank corrugation period below). The beam-based design of the thermoplastic structure maximizes the effectiveness of the polypropylene used to mold the tank body by offsetting thermoplastic a certain distance from the neutral axis of the corrugation. The system of corrugations is interconnected with a variety of other structural reinforcing features that collectively develop the load-resisting capability of the assembled IM-Series tank. IM-Series tanks can be installed up to four feet below ground surface.

**IM-1530 tank showing interconnected straight and curved box girder-type beams**

**IM-1530 tank corrugation profile showing an open-ended box girder-type design**



Corrugated structural designs are a key component of many construction products, including molded onsite wastewater system components. The next time you see a Quick4 or Arc chamber or IM-Series tank, take a moment to consider how the interconnected system or corrugations creates a structure capable of supporting applied loads.

Please contact Infiltrator's Technical Services Department with product design questions at (800) 221-4436 or by sending an email to info@infiltratorwater.com.

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[i] **Image 1 Source**: https://build.com.au/universal-beams-i-or-h-beams

[ii] **Image 2 Source:** https://erkrishneelram.wordpress.com/2015/01/21/what-is-a-girder-bridge/

[iii] **Image 3 Source:** https://www.chegg.com/homework-help/questions-and-answers/bridge-deck-shown-design-wind-speed-200-mph-box-girder-15ft-deep-1-1-sides-bridge-2500ft-l-q47261568

[iv] **Image 4 Source:** https://www.alumitecltd.com/services/atrium-lifts/

[v] **Image 5 Source:** http://www.learncivilengineering.com/wp-content/themes/thesis/images/structural-engineering/PE-reviewStructure-Mechanics-of-Materials-Tension-and-compression.pdf