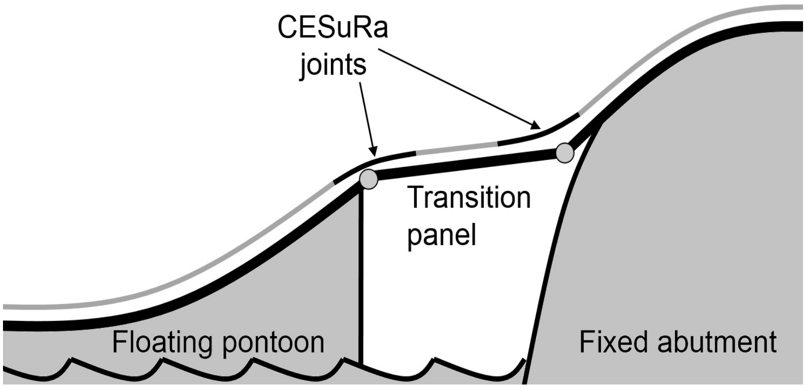
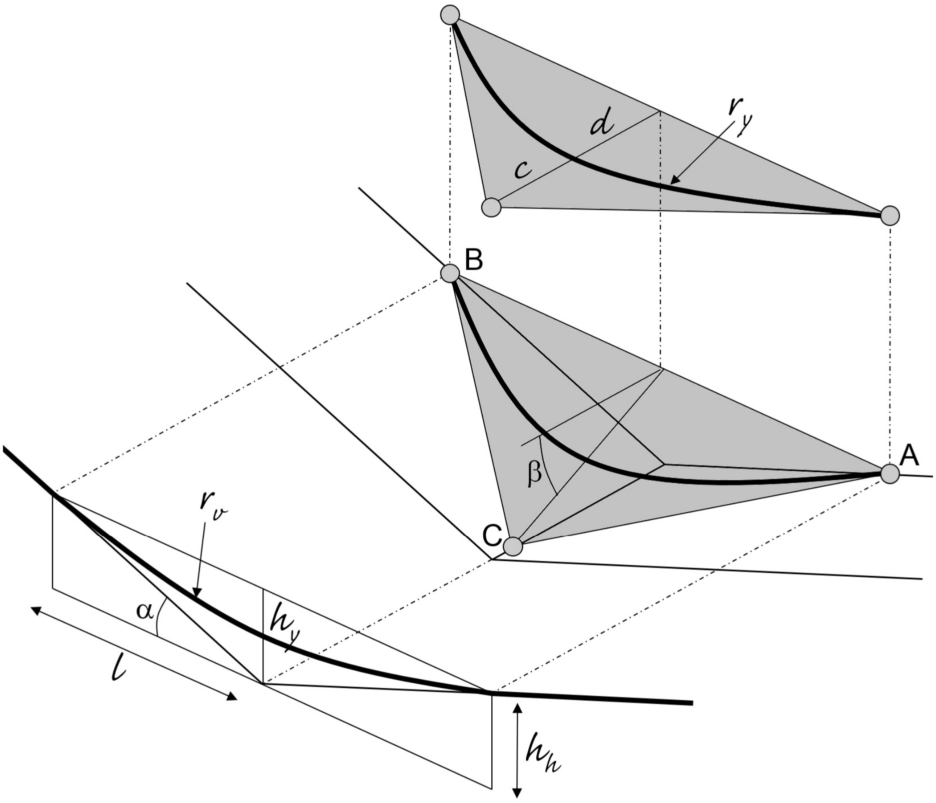
Continuously Variable Radius Track Panel

A pair of continuously variable radius track panels, called CESuRa joints, is being used to generate a smooth ride across a floating bridge under varying conditions of water level and weather. The arrangement is used at each end of the pontoon, which is approximately one mile wide.



Principles

A simple thin CESuRa joint of length *2l* is first considered lying flat in a symmetrical position relative to a hinge between two planes. A curve or yoke is drawn in the surface with radius r_y. As the hinge folds to an angle 2α the wing spine AB is forced up the sloping planes while the vertex C remains at the hinge. Sliding movement along the x-axis is assumed at vertices A and B, and along the hinge axis at vertex C.



The wing rotates through an angle β and then the projection of the radius of the yoke on the vertical plane takes up a radius r_v. It is this radius that determines the permissible speed.

Of all the possible yoke radii, one has the property that the track curve remains tangential at both ends. We need to find the yoke radius and its relationship to the wing ABC that has this property.

Provided the hinge angle is small, the height difference between the axis AB and the vertex *C* is given by:

$$h_h = l.\tan\alpha$$

The width of the wing *w* (altitude of the triangle ABC with AB as the base) is measured as the perpendicular distance from the axis AB to the vertex C. The height difference h_h when the hinge articulates is the same as that seen as the wing rotates an angle β about the axis AB, so:

$$h_h = w.\tan\beta$$

For tangency at the ends the vertical height difference h_y at the peak of the yoke is given by:

$$r_v = \frac{L}{\sin a} \quad \text{and} \quad h_y = r_v.(1 - \cos a)$$

The versine *d* of the yoke radius is the perpendicular distance from the curve to the line AB. The wing width or altitude is composed of the versine of the curve and a remainder *c*, that is:

$$w = c + d \quad \text{and} \quad d = \frac{h_v}{\sin\beta}$$

The yoke radius is related to the length *l* and the versine *d* in the plane of the wing by the equation:

$$r_y = \frac{\left(l^2 + d^2\right)}{2.d}$$

The end tangency of the CESuRa curve can be shown to be a simple property of the triangle ABC formed by the wing bearings. The angle θ subtended by the half the yoke is given by:

$$w = l.\tan\theta, \quad \text{and also} \quad l = r_y.\sin\theta \quad \text{and} \quad d = r_y.(1-\cos\theta)$$

rearranging, we find:

$$w_f = \frac{d}{w} = \frac{d}{c+d} = \frac{r_y.(1-\cos\theta)}{L.\tan\theta} = \frac{r_y}{r_y.sin\theta}.\frac{(1-\cos\theta)}{tan\theta} = \frac{\cos\theta.(1-\cos\theta)}{\sin^2\theta}$$

which can be simplified to:

$$w_f = \frac{\cos\theta}{(1+\cos\theta)}$$

As θ approaches zero:

$$w_f = \frac{1}{(1+1)} = 0.5$$

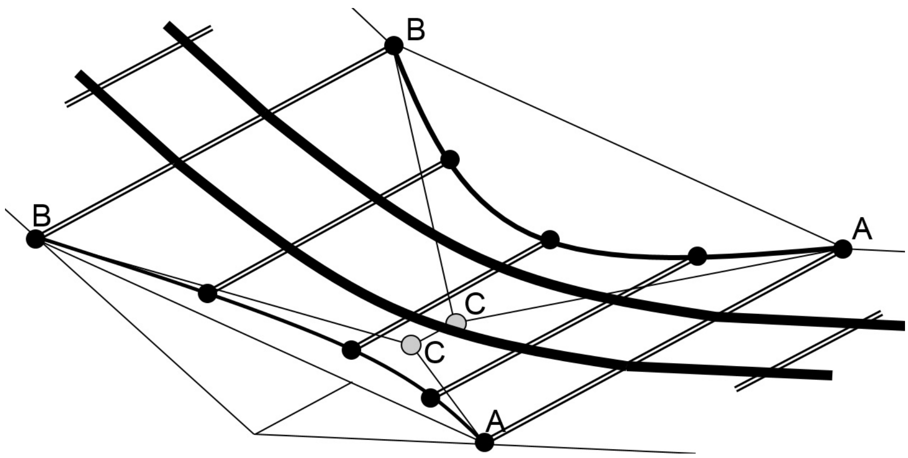
which means that, for small hinge angles, the yoke should have the simple property that its versine is half the altitude in order that the track curve remains tangential at both ends.

There is a constant relationship w_r between the hinge angle *2a* and the wing rotation β. This is a useful characteristic of the joint configuration and is called the wing ratio.

$$w_r = \frac{\beta}{2\alpha} = \frac{l}{2w}$$

Application Guide

Any application of the CESuRa joint can be approximated very quickly using these equations. For example, if *2L*=10m and the pitch angle 2α=4°, the vertical track radius r_v=143.3m. For *c*=*d*=0.5m the yoke radius *r*=25.25m, and for this pitch angle the hinge dip h_h=174.6mm and the wing rotation β=9.9°. In this example equals the wing ratio is 2.47.



Real applications introduce complicating factors, for example the height of bearings and the wings and bearer bars causes rail dilation. Also the central bearings C may have to sit on one side or the other of the hinge, however provided they are reasonably distant from the spine AB and located along the lines AC or BC the above relationships hold.

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