the difference of these two forces by experiments. Several persons pursued researches on this subject; especially Mr. Barlow, of the Royal Military Academy,[4] who investigated the subject with great labor and skill, so far as wood is concerned. But the difference between the resistance to tension and to compression requires more special study in the case of iron; and has been especially attended to in recent times, in consequence of the vast increase in the number of iron structures, and in particular, railways. It appears that wrought iron yields to compressive somewhat more easily than to tensile force, while cast iron yields far more easily to tensile than to compressive strains. In all cases the power of a beam to resist fracture resides mainly in the upper and the under side, for there the tenacity of the material acts at the greatest leverage round the hinge of fracture. Hence the practice was introduced of making iron beams with a broad *flange* at the upper and another flange at the under side, connected by a vertical plate or *web*, of which the office was to keep the two flanges asunder. Mr. Hodgkinson made many valuable experiments on a large scale, to determine the forms and properties of such beams.

But though engineers were, by such experiments and reasonings, enabled to calculate the strength of a given iron beam, and the dimensions of a beam which should bear a given load, it would hardly have occurred to the boldest speculator, a few years ago, to predict that there might be constructed beams nearly 500 feet long, resting merely on their two extremities, of which it could be known beforehand, that they would sustain, without bending or yielding in any perceptible degree, the weight of a railroad train, and the jar of its unchecked motion. Yet of such beams, constructed beforehand with the most perfect confidence, crowned with the most complete success, is composed the great tubular bridge which that consummate engineer, Mr. Robert Stephenson, has thrown across the Menai Strait, joining Wales with the Island of Anglesey. The upper and under surfaces of this quadrangular tube are the flanges of the beam, and the two sides are the webs which connect them. In planning this wonderful structure, the point which required especial care was to make the upper surface strong enough to resist the compressive force which it has to sustain; and this was done by constructing the upper part of the beam of a series of cells, made of iron plate. The application of the arch, of the dome, and of groined vaulting, to the widest space over which they have ever been thrown,

[4] *An Essay on the Strength and Shape of Timber.* 3d edition, 1826.