CONCERNING WEB STIFFENERS.

It is easy to say that the function of a stiffener is to prevent buckling of a plate girder web, and that it must be designed to accomplish this purpose. But when one attempts to summarize one's ideas as to how this shall be done one finds that the fund of accurate information concerning stiffeners is meagre. The actual design is accompanied by so many assumptions as to make one who inclines to theory rather than experiment somewhat sceptical of the results obtained. Notwithstanding the indeterminate character of the action of stiffeners of loaded plate girders, it is satisfying to know that failures of web stiffeners are very rare, and that those that have been known to occur are of such a nature as to cause no other serious consequence than slight inconvenience and expense of repairs. But many tons of steel are used annually in stiffeners, and the subject is therefore one that merits more study than has been given it, says the "Engineering Record."

Web stiffeners are used at concentrated loads for the double purpose of transferring these loads from the flanges into the web and to prevent the web from buckling under the compression, and they are also used at intermediate points between concentrated loads solely to prevent buckling of the web. The sizes of these intermediate stiffeners are nearly always assumed, but their spacing—that is, the horizontal distance from one set to the next—is now quite generally determined by a formula based upon compression in the web. resulting from the shearing forces acting upon it. Some important specifications still use the arbitrary method of spacing intermediate stiffeners at horizontal distances not exceeding the depth of the girder, even though this rule has practically no reason for its existence. Since the tendency of a web to buckle must be due to the compression acting within it, and since this compression is a direct function of the shearing force on the web, it seems perfectly clear that the method used for spacing intermediate stiffeners should bear some relation to that shear; that, other things remaining the same, the greater the shear the closer together should be the stiffeners.

There seems to be a deep-seated conviction that intermediate stiffeners must be fitted accurately at both top and bottom flanges, for by being so arranged they add strength to the girder in some mysterious way. It is readily seen that if fitted to a compression flange, stiffeners might act to a limited extent as braces to this flange, and hence the expense of fitting them might be justifiable; but when one looks for a reason for fitting them to a tension flange it is not forthcoming, except it be in the desire to secure a tight fit for the sake of appearance, or to eliminate small openings wherein painting is difficult. Of course, it is perfectly right to insist on close fitting at flanges for either of these two reasons, but let us not deceive ourselves into thinking that intermediate stiffeners must be fitted to both flanges to add strength in some unknown manner.

Stiffeners at such concentrated loads as bearings and columns should be, and usually are, designed as columns, and sufficient rivets should be placed in them to transmit the proper forces between stiffeners and webs. Determining the cross-sectional area of a set of stiffeners under a column load or over an end bearing by applying the ordinary column formula is on the side of safety, for this process assumes the stiffeners to have their maximum compression throughout their entire length, whereas the stress diminishes from the maximum at one end to zero at the other. In this respect, therefore, the ordinary stiffener at a concentrated load differs from a column, because in the latter the loads are applied at the ends, and column formulæ as generally used apply to this case only.

Consider the stiffeners under a column which rests upon the top flange of a plate girder. The entire column load is transmitted first to the top flange, then to the outstanding legs of the stiffeners under the column. The outstanding legs must be carefully fitted, and must be of sufficient area to give proper bearing against the horizontal legs of the top flange angles. The stiffener legs lying against the web transmit very little or no stress from the top flange, because they are sheared or ground to fit the curved fillet of the flange angles, and should be neglected in determining the required area for bearing at the top flange, and it is for this reason that only the outstanding legs of stiffeners should be relied upon to transmit the column load from the inside of the top flange angles. When the stress has thus entered the outstanding legs, these legs are thrown into compression, and until a portion of this stress is transferred to the legs lying against the web, the comparatively thin projecting legs must be able to sustain this comparative stress without buckling.

It is just here that a link in the chain is usually overlooked, for this buckling tendency is ordinarily not considered, even though the bearing against the flange may be carefully provided for. As the stress becomes distributed over both legs of the angle stiffener, column action is approached, and for this reason a column formula is applied to determine the gross cross-sectional area of the two legs of the stiffener. In the case here supposed—that is, the case of a stiffener under a column,—the maximum stress exists only for a short distance down from the top, for the uppermost rivet in the stiffener transmits its quota of stress from the stiffener into the web, and each succeeding rivet further diminishes the stress until at the bottom the stiffener has no stress at all. Consequently, when stiffeners are designed as columns having the full stress through a length equal to the girder depth, they are on the side of safety.

It is apparent, then, that if the bearing of the outstanding legs be sufficient to transfer the column load from the top flange, that if the cross-sectional area of the stiffener angles be large enough to satisfy the column formula, and that if the rivets be the correct number, there still may be a weak link in the design if the buckling of the outstanding leg at the top be overlooked. An interesting case of this buckling occurred a few years ago at the Union Street drawbridge in Salem, Mass., U.S.A., This was a deck plate girder highway swing bridge, with a centre bearing having the entire revolving weight suspended from the centre casting by means of a series of round rods which were attached at their ends to the top of the centre casting. The rods passed through holes in the distributing girder flanges, and their lower ends engaged in nuts bearing against the bottom flanges of the distributing girders. This arrangement resulted in a series of large concentrated upward forces on these flanges, and a set of angle stiffeners were used for reinforcement at each rod. The outstanding legs of these stiffeners were too thin. and they buckled, the buckling being confined to the lower 8in. of each stiffener. As a consequence of the failure of these stiffeners, the drawbridge settled vertically to such an extent that its operation was almost impossible because of frictional resistances at the abutments. The Salem case made an everlasting impression on the engineers who had anything to do with it, for local column action of the outstanding legs had been manifestly overlooked in the design.

The brief analysis here given indicates that the designers should investigate four things in connection with stiffeners at a concentrated load:—