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HIGHLIGHTS OF CRANE GIRDER INVESTIGATION

In this talk, I am going to explain briefly what we have done and propose to do in our crane girder study.

The study of crane girders has been divided into two parts. The first part consisted of an analysis of existing specifications and design procedure. The second part consists of the actual research program which is being carried out this year.

The analysis indicated that although the design of cranes for vertical static loads is straightforward enough, the effect of acceleration, braking, and impact is differently handled. As a result, cranes have been designed on a conservative basis due to a lack of data on the exact magnitude and action of these dynamic forces.

Secondly, most crane specifications have evolved from the older I-beam bridge specifications. Thus in most cases, full advantage of the superior characteristics of box girders has not usually been taken. The most important effect of this shows up in the clauses for allowable stresses of the top flange. Failure in long, narrow I-beams usually takes place when the compression flange buckles sidewise. Consequently the compression design stresses are reduced in a manner which depends on the ratio of width to unsupported length of the girder. However, for the compression flange to buckle, the girder must necessarily twist. Since a box girder is much stronger in twisting than the equivalent I-beam girder, its top flange does not buckle sidewise. Thus there is no necessity for reducing the compression design stress of a box girder for this reason. Bending tests, made in the laboratory, on models whose length was such that the compression design stress by usual formulae was zero, resulted in local buckling at the yield-point stress with no signs of lateral buckling.

This demonstrates in a striking manner the over-conservatism of the design formula. In the present program, five welded girders and two riveted girders with various $l/b$ ratios will be tested. It is expected that they will fail at about the same stress.

However, in order to depend on the torsional strength of the box girder to resist lateral buckling, exact knowledge of the torsional strength is necessary. Therefore torsion pilot tests were made on small welded and bolted boxes, with and without diaphragms. The results on the welded box checked the theoretical, but the bolted box twisted twenty times as much as the equivalent welded box, since slippage occurred along the seams. This is a factor not considered in the theory. To determined the effect of rivet slip, seven girders have been fabricated for torsion tests. Of these, three are riveted box girders with various diaphragmsspacings, two are riveted I-beams, and two are welded I-beams. The torsion tests already completed indicate that rivet slip reduces torsional strength by two-thirds.

To raise compressive design stresses, careful consideration must be given to allowable width-thickness ratios of the flange and web plates in order to insure against buckling. Eight girders varying these ratios have been fabricated for tests to determine if the allowable ratios can be increased. Lighter cranes would result, and the field for the economical use of hi-tensile steels would be extended.

The effect of longitudinal stiffeners is also being investigated. Such stiffeners greatly increase the stability of the plate, and their use offers good possibilities for saving weight. The diaphragm stresses are also being measured in the girders previously mentioned to formulate a basis of design.

The tests already mentioned, are primarily laboratory tests and will show how the girders behave under laboratory loads. The value of these tests depends on how close the laboratory loads approximate the actual service loads. To determine the actual service loads, tests are being made on steel mill cranes to measure the dynamic forces. This is done by means of a scratch gage which tives a record on a polished metal surface of the strains in a crane.

The tests are of two types, lateral load tests and impact tests. In the lateral load tests, stresses due to acceleration and deceleration are measured, and they have been found to be quite appreciable.

The impact tests are being made to determine the stresses from rough handling, and bad rail joints. The tests already made indicate that impact is not as great as usually assumed in design. Cranes run over 3/4-in. wedges on the runway rail showed impact stresses in the bridge of about fifty per cent which is much less than theory indicates. The reason is obvious, the spring in the girder and the stretch in the cables cushion the shock, and although some vibration may occur, the vibratory stresses are small.

Since it is impossible to get all the necessary stress readings on a crane in service, tests are being made on cranes under construction in the fabricating shope. Two such tests have already been made, one on a 10-ton riveted crane, the other on a 30-ton all-welded crane. Similar tests are planned on two more cranes. These tests are made primarily to determine what portion of a bridge girder resists the lateral loads. In these tests, one girder was pulled against the other by means of a turnbuckle attached to the trolley rail, and the stresses, deflection, and twist were measured. The tests show that the whole section of a box girder resists the lateral forces, and also that the girder acts as a partially fixed beam. Both moment and shear are developed at the end of a girder instead of pure shear as is usually assumed. The lateral stresses in the girder are thus less than usually computed. There is also a second effect. Failures in the structural elements of a crane are very rare. Yet it is not too uncommon to find cranes in which there is play between the girder and end ties, consequent loose bolts and rivets, and one end truck out of line with the other. Proper consideration of these moments in the design of the end ties should largely eliminate these difficulties and the resultant mechanical wear.

When these tests are completed, it is believed that enough information will be available to write a set of specifications which will be in accordance with the forces and stresses acting in the structure. The increased knowledge of what is actually happening in a crane should enable the specification writer to increase the design stresses without reducing the safety factor. Thus future cranes should be lighter, more dependable, and possibly cheaper. Finally, in these days of expanding operations, a review of existing cranes in the light of a more exact knowledge of their behavior, may result in additional capacity with little or no change in the design.