HIGHWAY RESEARCH CIRCULAR

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Bridge Design
Construction
Traffic Control and Operations
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INFORMATION AND RECOMMENDATIONS FOR IMPROVED QUALITY ALUMINUM SIGN STRUCTURES

THE PROBLEM AND ITS CAUSE:

The Special Committee on Safety Activities of the Highway Research Board issued a questionnaire which ultimately revealed a problem of weld failures in aluminum overhead sign trusses. A subsequent survey determined that slightly over half of the states permitting the use of aluminum have experienced failures of varying degrees.

It was surprising to learn that most states experiencing failures did not consider this a new problem and a few were aware of the problem in the early sixties. Each state seems to have diagnosed its own problem, made the necessary changes, and is now receiving good service from their structures.

There is almost unanimous agreement that the primary cause of the failures is due to accelerated fatigue resulting from the aeolian effect. Moderate or low velocity winds passing around the tubes create harmonic vibrations which may cause fatigue weld failures. Other factors contributing to weld failures are: forcing camber into the trusses, misalignment of flanges, poor fabrication techniques and practices, undersize tube sections, improper slenderness ratios, methods of shipment, and faulty handling and erection procedures.

SURVEY DATA

Forty-six states responded to the survey. Thirty -three either specify the use of aluminum or allow it as an option while the remaining states require galvanized steel. Seventeen states using aluminum have encountered failures in their sign structures with a few reporting similar problems with aluminum light standards also.

SOLUTIONS:

Since harmonic vibrations must be eliminated or held to a minimum, the simplest and most effective method is to mount the signs prior to erecting the trusses.

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Many states require that all signs and miscellaneous attachments be installed within the same eight hour period that the trusses are erected. This accomplishes three important functions: first, the weight of the signs, luminaires, cat walks, etc. act as truss dampers; second (and probably more significant) is that the signs block the flow of wind through the truss, reducing the aeolian effect, and third, the shedding frequencies of the signs tend to counteract those of the truss. Frequently, trusses are erected for long periods of time with only a minimum of temporary signing installed, or with only one sign in place when the truss was designed and will at some future time, carry three large signs. This practice should be discontinued. Blank signs or other dampers should be installed until all permanent signs are in place. Some states use sand bags as temporary dampers; however, this is not as effective since the tubes remain exposed to the winds.

A few Southeast and Gulf Coast states, subject to hurricane winds, are using truss dampers (Stockbridge Type) with good success. This device not only continually helps dampen the trusses but also provides a built-in safeguard system in case the signs become separated from the support structures. Figure 1 illustrates the damper. Considerable thought and study should be given to the method and location of attachment of these dampers when used.

Although many states now require camber to be built into the truss sections or have developed other unstressed methods of achieving it, forcing of camber still remains quite common. This practice increases the probability of failures in a metal that was conditioned and designed (reduced allowables) to meet the strength requirements of a (T6) material but is considerably less after welding, especially in the heat affected zone of the weld area.

As anyone familiar with the fabrication of steel can attest, there are certain basic rules that must be followed if quality production is to be achieved. Adherence to similar basic rules is much more critical when fabricating and welding aluminum. There is no room for short cuts in this industry and all specifications must be strictly followed:

1. Tubes should be milled to the required radii with the maximum gap at any point not greater than 1/16".

2. All areas of welding must be brushed with stainless steel brushes immediately prior to making the welds. (Aluminum oxide is one of the harder substances known to man with an extremely high melting point. Trying to weld through films of this oxide is like trying to weld two boulders together - it cannot be done with any degree of success or lasting effect.)

3. Only microscopically clean welding wires (those which have been shaved after drawing) should be used and spools of wire remaining at the end of the day's production should be sealed in polyethylene bags. Wire not so protected should be discarded. This includes wire in the drive rolls and gun.

4. Forced fits must be avoided and only downhand welding is recommended.

5. All weld craters must be eliminated and welds should carry through tight areas without stopping when possible.

Past design practices should be reviewed and modified in some instances. Slenderness ratios of 120 for compression members and 150 for tension members, or making the ratio of tube thickness to diameter (t/d) greater than a limiting value of 0.12 is recommended by one state now having good success with aluminum structures. These figures are based on a critical wind velocity of 20 mph (See Figure 2).

False economy should be considered in design also. Often, it is less expensive to require the thicker and larger tube sections since they are more readily available than the many odd sections now required by some present designs. The use of either forged or machined plate flanges is also recommended because experience has determined them to be more sound and superior than cast aluminum flanges.

The method of shipping can play an important role in the elimination of cracked welds. All sections should be transported in as unstressed a manner as possible. The practice of bolting sections together and shipping them by pickup truck and rear dolly wheels is especially detrimental. Such sections usually arrive at the project site with numerous cracked welds which often remain undetected through erection and service, until they propagate to failure.

Erection crews, who should know better, often mishandle and overstress members to the point of failure. Misaligned flanges should not be forced into full contact by torquing but should be shimmed as necessary prior to final tightening. Only nylon slings providing at least a two point pick up and wrapping the entire cross section should be used for handling purposes. Lifting by chains or by a single cross member should be prohibited. It is recommended that a well qualified inspector should be present during all phases of fabrication and erection; he should also approve the method of shipping the structure.

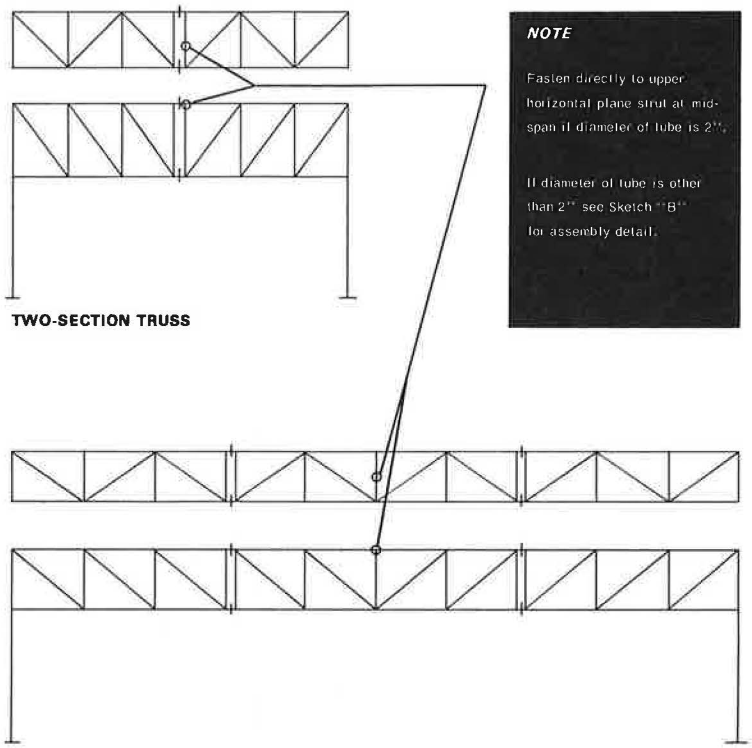
CONCLUSIONS:

Aluminum sign structures can provide the intended years of trouble free service if mandatory design, fabrication, and erection procedures are meticulously followed. This is an area which has been grossly neglected in the past and will need much closer attention if improvement is to be achieved. Periodic inspections should be made of all sign structures similar to the current bridge inspections now being performed by most states.

Because the nature of aluminum fabrication is so demanding in the many respects, strict adherence to specification requirements cannot be over emphasized.

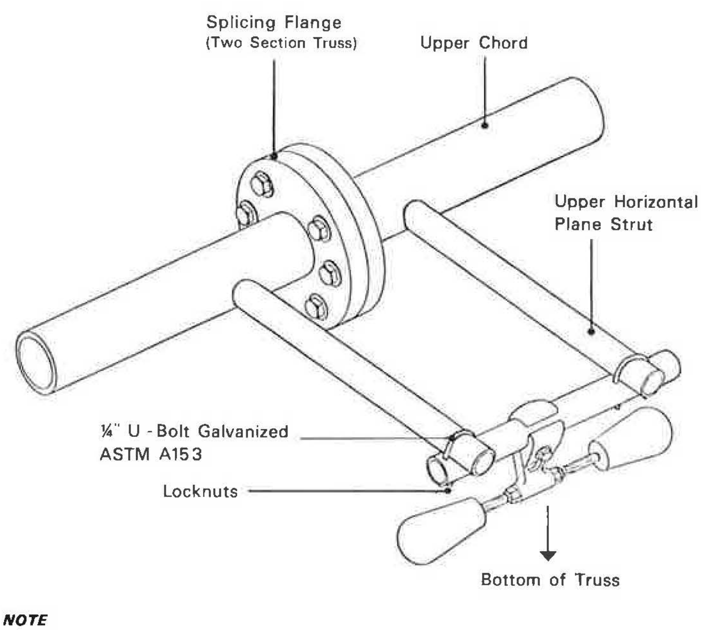
Recommended Installation of
Alcoa Highway Truss Dampers
(Stockbridge-Type)
On Bridge-Span Sign Trusses

SKETCH A



THREE-SECTION TRUSS

SKETCH B



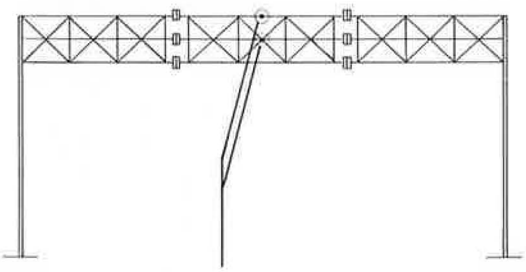
NOTE

Damper must be located at mid-span and horizontal, however, may be assembled in any horizontal direction in relation to the truss.

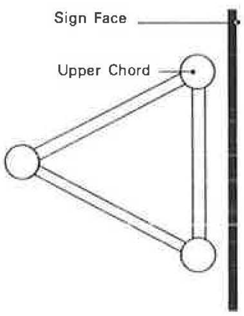
Figure 1.

Suggested Method of Assembling Damper on
Tri-Lon Type Bridge-Span Sign Trusses

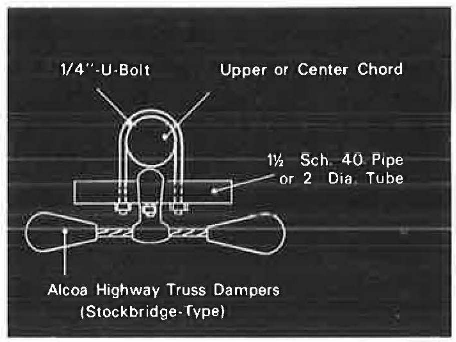
SKETCH C



Damper to be assembled to upper or center chord member



SIDE VIEW OF TRUSS



DETAIL OF ASSEMBLY TO CHORD

Figure 1 (continued).

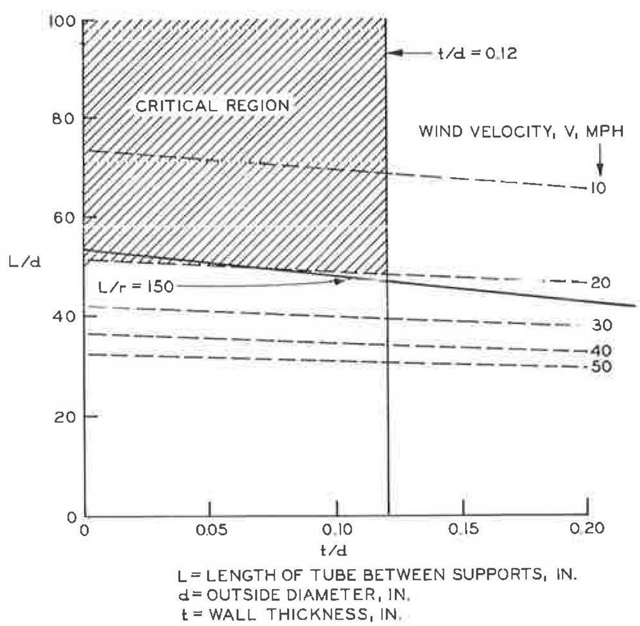


Figure 2. Aeolian vibration of round tubes.

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