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ADVANTAGES OF WELDING IN CONTINUOUS STRUCTURES

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INTRODUCTION

In structural design we have in general two major problems to consider, that is, the use of free or of continuous connections. By continuous connections is meant all connections capable of carrying a certain amount of bending moment. The question of continuous structures versus simple connections has recently been brought forcefully to the fore by the reinforced concrete industry. In discussing this question before the 1935 annual convention of the American Concrete Institute, Mr. Mehren, President of the Portland Cement Association, stated**: "Almost to this day, in the United States at least, the assembly (that is of the structural members) has followed designs traditional in timber and steel. Each element is considered independent of others, - the post and lintel system merely applied to a new material. The great inherent advantage of concrete, that which makes it different from all other structural materials, which enables it to be adapted to any architectural form, which gives to it tremendous advantages in economy - that characteristic, continuity, has been neglected". This statement applies equally well to welded structures. We have the same opportunities for adopting welded structural steel to any architectural form, we have the same advantages of rigidity and continuity. Have we fully

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** CONCRETE-YESTERDAY, TODAY AND TOMORROW, by Edward J. Mehren
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realized these facts? Have we departed from the conventional types of joints which were specially adapted to riveting and developed the types of connections in which the full advantage of welding is utilized? Unfortunately, we have not as yet realized the full advantage of structural welding. In meeting the challenge of the reinforced concrete construction the structural steel industry should and must give closer attention to the advantage of welding individual members into a rigid unit. It is with the purpose of stimulating the interest in all welded connections in structural design that this paper is being presented.

RIGIDITY OF WELDED AND RIVETED CONNECTIONS

Although we generally consider riveted connections as being free or unrestrained, this is actually not so. A considerable amount of rigidity may be produced by the rivets, but because of the many uncertainties which enter any riveted connection it would probably be inadvisable for designers to take rigidity of riveted connections much into account. With welded connections, however, we have comparatively little difficulty in producing an appreciable amount of rigidkty, and we can readily carry the welded connection toward a fully rigid joint. In order to review some of the fundamental relationships between free and rigid connections I will present a diametrical sketch of the effect of restraint on the bending moments. Fig. 1 is taken directly from the valuable paper, THE RELATIVE RIGIDITY OF WELDED AND RIVETED CONNECTIONS by C. R. Young and K. B. Jackson of the University of Toronto, and it illustrates very clearly how even a relatively small coefficient of restraint reduces the bending moment appreciably. Making use of this restraint in design will result in a considerable economy in the final structure. The problem facing the structural steel engineer is therefore that of ascertaining how much restraint or rigidity may be counted upon in welded connections. Although we have some information available on the amount of rigidity in certain types of connections, the field is far from explored and much experimental work has to be done before we can take the full advantage of the rigidity in welded structures. I am not going to discuss the relative rigidities of welded and riveted connections. However, I will give you a picture of the general conditions as revealed by the load-deformation behavior. In Fig. 2, which is taken from the paper, ÜBER DAS ZUSAMMENWIRKEN VON NIETVERBINDUNG UND SCHWEISSNAHT by H. Kayer and A. Herzog of the Technical Institute of Darmstaft (Der Stahlbau, July 20, 1934, page 113), the diagram to the left represents a riveted connection and that to the right a welded connection. The greater deformation in the riveted connection is so apparent and the effect of the slip between plate and rivet so well illustrated that further comments are superfluous.

RECENT DEVELOPMENTS IN FOREIGN COUNTRIES

It seems that European engineers are more aware of the economic advantages in welded structures than we are. I will therefore present some typical foreign ddsigns.

Fig. 3 and 4 show respectively a former rivetdd rigid frame as used by the German Government Railroad and the new welded frames which replaced the former. The simplicity of construction and the pleasing appearance of the welded construction make it apparent why the change was made. Furthermore a 25 per cent reduction in material and a similar reduction in cost present an excellent illustration of what economies welding may give to structural design. Another type of welded frames used by the German Railroad is shown in Fig.5. This frame had a span of 72 feet. The forthcoming government work on grade crossing elimination may be an excellent field for the use of all welded rigid frame bridge construction.

An illustration of the type of welded frames which replaces riveted connections in industrial building is shown in Fig. 6. The simplicity of the welded frame to the right as compared to the riveted frame at the left is apparent and the economies obtained by changing to the welded construction was as much as 25 per cent also for this case. The span was about 39 feet. The renewed interest in the Vierendeel type of bridges created by the introduction of all welded connection is especially significant. A number of welded Vierendeel bridges have been constructed in Europe during recent years because of their economical advantage. Fig. 7 and 8 show a bridge which was constructed last year in Holland.

Another type of bridge in which welding is being used extensively is two-hinged arch bridges. Because they are closely related to the more apparent continuous types of bridges I will mention a few of them.

An all welded arch bridge of 166 feet span is shown in Fig.9. A detail of the hinge is shown in Fig. 10. This is a German construction and the reduction in weight over a riveted construction was 32 per cent. Another all welded arch bridge is shown in Fig. 11. This bridge was constructed in Sweden and has an arch span of 184 feet. It was originally designed for riveted connections, but redesign for welding showed that a 40 per cent reduction in weight and about 25 per cent reduction is cost would result. A unique type of rolled flange sections which is used extensively in Swedish bridge construction is shown in Fig. 12. This type is very convenient for the welding of girders of all kinds.

These few illustrations show that the field for structural welding is as yet far from fully developed.

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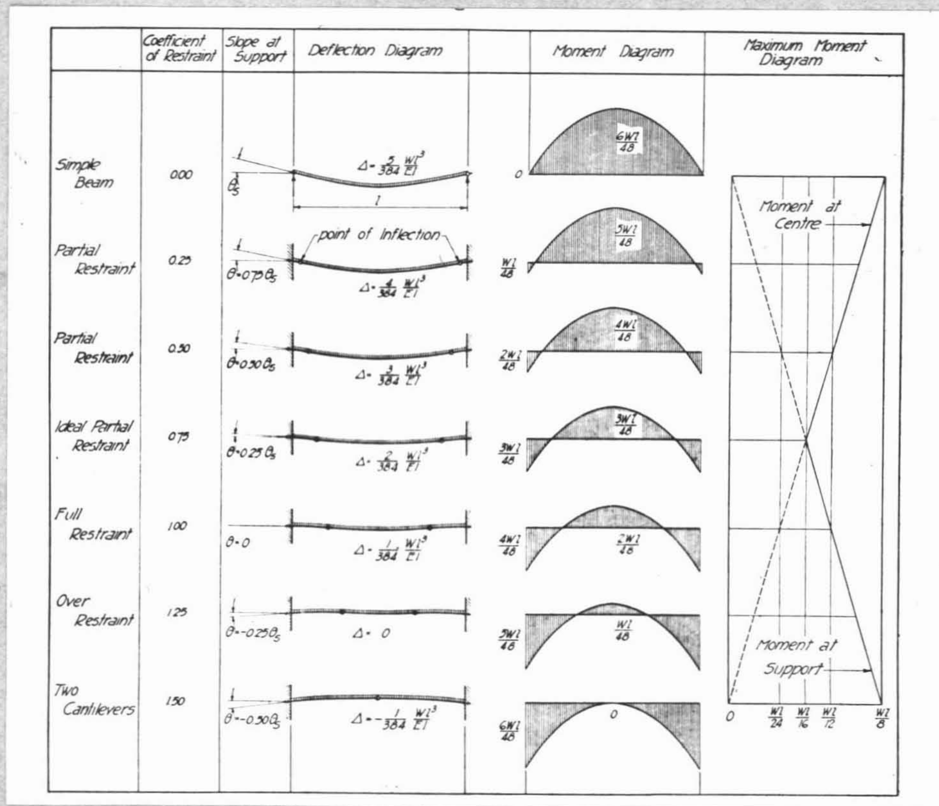


Fig. 1 - Effect of Restraint on Bending Moments

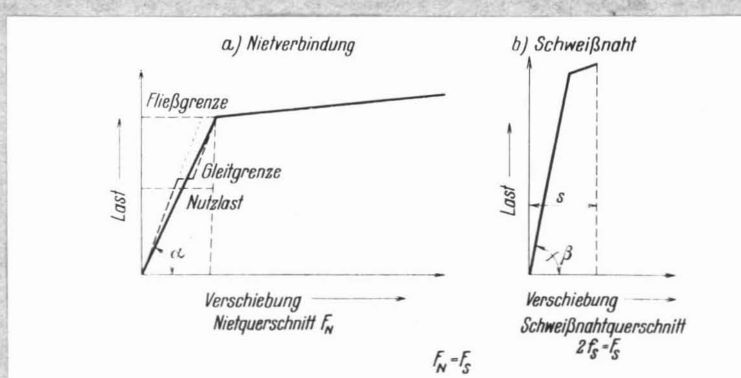


Fig. 2 - Typical Load-Deformation Curves for Riveted and Welded Joints

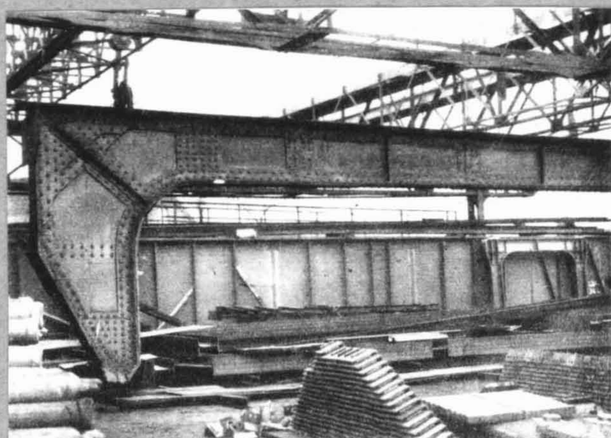


Fig. 3 - Riveted Frame Used In The Past

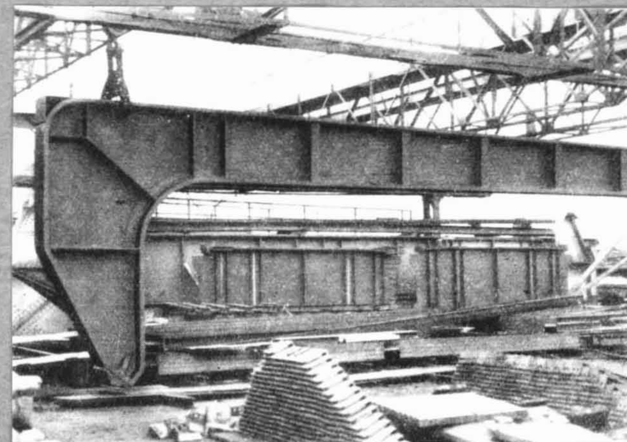


Fig. 4 - Welded Frame Used At Present

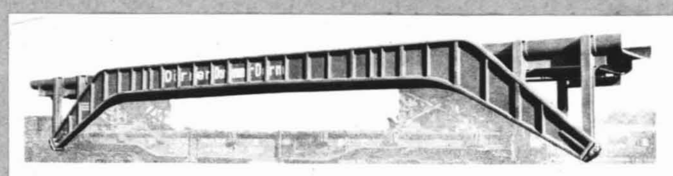


Fig. 5 - Welded Frame of 72-Ft.Span

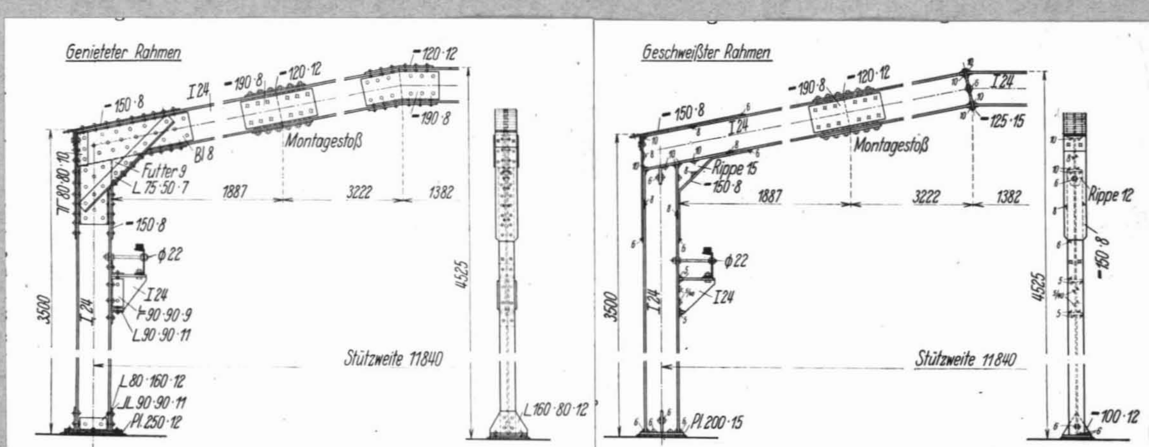
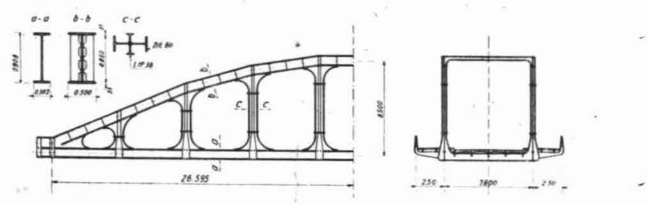


Fig. 6 - Riveted and Welded Frames For Industrial Buildings



1) Niederländische Eisenbahnen.
2) Niederländische Eisenbahnen in Verbindung mit N.V. Electrolasch Mij. in Leiden.
3) N.V. Electrolasch Mij. in Leiden.

Fig. 7 - All Welded Vierendeel Bridge

Fig. 8 - Photograph of the Vierendeel Bridge

Fig. 9 - German All Welded Two-Hinged Arch Bridge

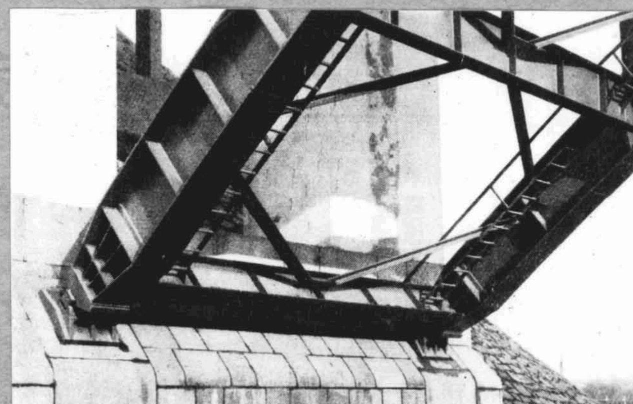


Fig. 10 - Details Of
Welded Hinge

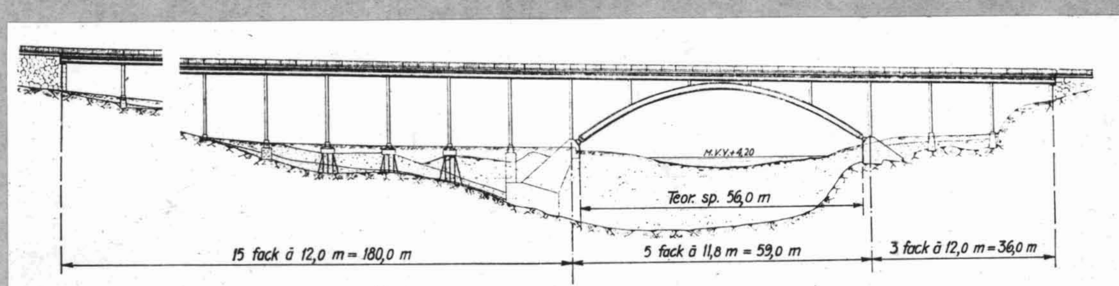


Fig. 11 - Swedish All Welded Arch Bridge

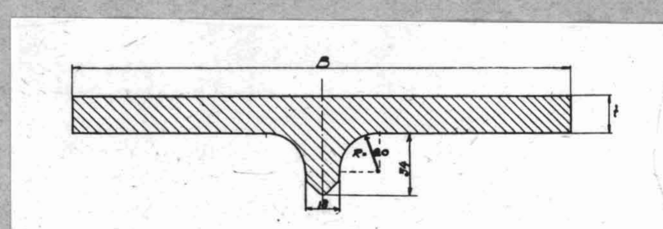


Fig. 12 - Rolled Flange Section For
Welded Girders Used In Sweden