討　　議

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THEORIE DER ROSTE UND IHRE ANWENDUNGEN.

（第十七卷第五號，第十號及第十八卷第六號，第九號所載）

By Tadafumi Mikuriya, Assoc. Member.

It was great pleasure to have had an opportunity of reading Mr. Fukuda's thesis and to express an opinion on his works.

To my estimation Mr. Fukuda's extensive work on this subject is a good contribution to our engineering field and at the same time it is a stimulas to consiencious engineers. I believe that any improvement in any work can be done step by step. And his work brings forward this particular engineering problem.

I agree with Mr. Shigematsu to some extent; in September number of the Society Proceedings he gave an opinion that Mr. Fukuda's equations can be simplified, and perhaps can be shortened eliminating repetional explanations. But on the other hand we have to expect many conditional equations when many unknown factors are taken into cosideration. Yet even such cases for practical problem it is desirable to have as simple expression as possible.

To us, engineers, it is very important to have definite considerations concerning any principle we use.

The principle must be theoretical and practical. Theoretical treaties should lead to practical applications. A good harmony between theory and practice is the ideal state.

Therefore I would like to evaluate Mr. Fukuda's thesis from the standpoint of practical application. It would be a priviledge to me if I could make any suggestion that would add to the value and usefulness of Mr. Fukuda's constructive piece of engineering research.

His thesis is valuable when we have indeterminate structures with perfect rigidity at any joint such as well built reinforced concrete structures.

For the solution of indeterminate structures we usually assume that all joints are perfectly rigid. But actually vary according to the materials used and the method of construction.

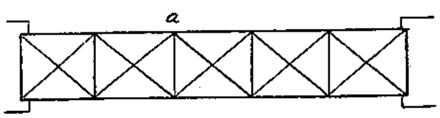

Fig. 1.

For example, as shown on **Fig. 1** at point *a* the girder may have good rigidity if it is made of reinforced concrete. But if it is made of steel plates and angles then it is not as rigid at joint *a* as we would anticipate.

Suppose this joint is riveted then we have two possible main causes of weakening the perfect rigidity:

First : Buckling effect of main girder web.

Second : Effect due to slip of rivets.

Suppose the joint is welded then we may avoid second possibility but still we have first. The rigidity of riveted joints will be discussed later.

I am afraid that we cannot get good results from the theory when actually in an imperfect rigid joint the tortional moment and other forces will not be transmitted from one to the other as theoretically expected. Then for practical purposes the laborious calculations may have little value.

Take a tall building frame as an example from the practical side for the discussion of rigidity of riveted joints.

In Mar. 1930 Mr. Elwyn E. Seelye (Wind on tall buildings: Engineering News-Record Mar. 1930) made a study on this subject taking the tortional moment of beams into consideration.

Yet he did not take the condition of rigidity of a joint into consideration.

Concerning the joint of building frame we made rapid progress with growth of tall buildings. For the analysis of tall building frames rapid progress has been made within the last ten years, especially in the last five years. In this article the percentage of rigidity of joints only will be discussed.

The joint of members especially at the intersection of main beams and columns is the most important one. Because the main beams and columns take care of vertical and horizontal wind or other load. For vertical load only a complicated connection may not be required but the joint must bear the vertical and horizontal load effects at the same time.

In 1917 Experimental Station of University of Illinois made tests which were

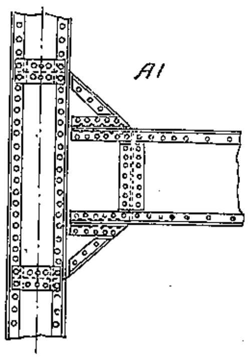

Fig. 2.

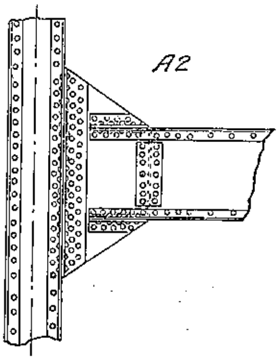

Fig. 3.

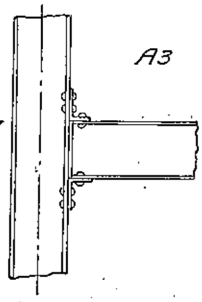

Fig. 4.

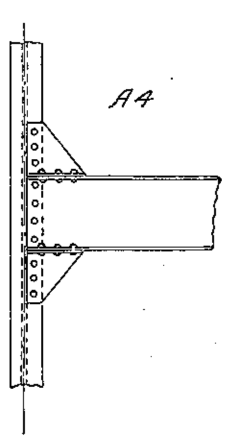

Fig. 5.

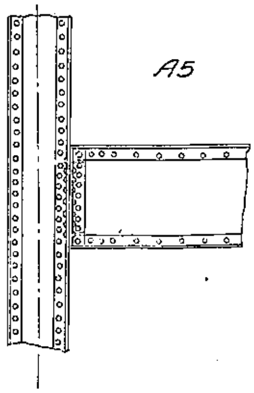

Fig. 6.

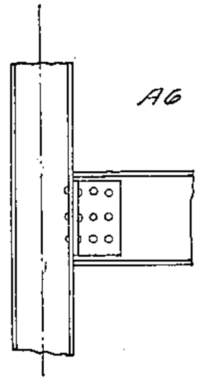

Fig 7.

published in Bulletin No. 104 for the following six different types, as shown in sketches.

The results of the tests are as follows: Connections of the type used for specimen $A\,1$ and $A\,2$ are so rigid that for the purpose of analyzing stresses in rectangular frames the connections can be considered as perfectly rigid without introducing serious errors into the results.

Connections of the type used for specimen $A\,3$, $A\,4$, $A\,5$ and $A\,6$ for the purpose of analyzing stresses cannot be considered perfectly rigid.

But from the standpoint of the architect types $A\,1$ and $A\,2$ are not desirable because the gusset plate interferes with the floor line except for wall beams. In present day practice in America the connection. column and beam of tall buildings are so designed that the top and bottom angles or lugs of the beam take care of the moment

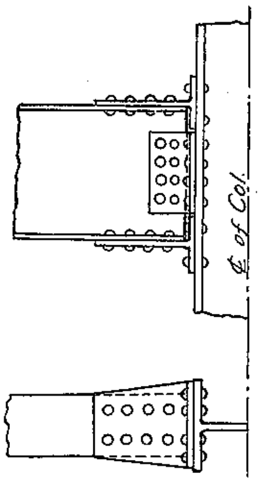

Fig. 8.

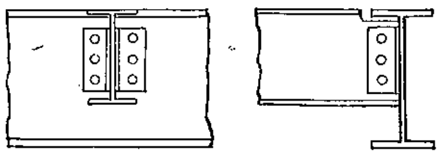

Fig. 9.

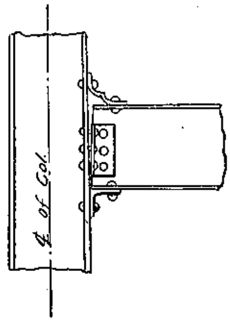

Fig. 10.

at the joint, and the web connection take care of the vertical load. **Fig. 8** is the typical connection used in the Empire Building, Hotel New Yoker, Manhattan Bank Building and others. Top and bottom lugs were cut out of a beam.

This type of connection may be able to have 90 to 98 percent rigidity, but for the connection between beams as shown in **Fig. 9** the percentage of rigidity may be 40 to 75 percent.

A careless design of connections brings disasterous results to the entire structure. For example the Kaiser Building having about twenty stories in Maiami Florida, U. S. A. suffered terribly from the hurricane five years ago and required repairing. Certainly the connections of that building were poor. They had only thin top and bottom and web angles. Therefore the angles bent and opened the connections and the columns also bent. This is rather an extreme case but shows that an assumption of rigidity of joint does not make it so.

With the improvement in the welding process we may bring the percentage of rigidity of joint to almost the desired point.

For reinforced concrete structures it is necessary to consider how to arrange the reinforcement to make the joint rigid.

A consideration of the percentage of rigidity of joints must be kept in mind in the solution of this kind of problem before the application of the theory. But on the other hand we have to keep in mind the fact of the connections so as to harmonize with the theoretical result in order to complete the theory.

In short, my opinion is: That the theory must harmonize with the practice.

Mr. Fukuda's theory certainly suggests to us that more careful study must be made for problems from different angle such as indeterminate structures and in designing main members and connections at joints.