Zeitschrift: IABSE reports of the working commissions = Rapports des commissions de travail AIPC = IVBH Berichte der Arbeitskommissionen

Band: 9 (1971)

Artikel: Some problems of mass production of steel bridges in Japan

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DOI: https://doi.org/10.5169/seals-10372

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Some Problems of Mass Production of Steel Bridges in Japan

Quelques problèmes de la production en série de ponts d'acier au Japon

Einige Probleme bei der Massenfertigung von Stahlbrücken in Japan

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1. Foreword

Recently the national economy of Japan has shown remarkable growth, which has affected also civil engineering, and as a result a number of epochmaking projects have been put into practice.

In urban district, tall buildings went up and 2- or 3-storied expressways were built. Also networks of expressways connecting major cities were coordinated, and consequently numerous bridges, small and large alike, are constructed at each key points.

The representative expressway networks operating today in Japan are Tokyo Metropolitan Expressway, Tomei (Tokyo-Nagoya) Expressway, and Meishin (Nagoya-Kobe) Expressway. Japan World Exposition Expressway is added as a new comer.

With construction of expressways as well as numemous plans to build long-span suspension bridges across Setonaikai (Seto Inland Sea) and major city ports, domestic demand for bridges is ever in creasing in last ten years.

On the other hand, this fast-pacing economical growth gives a rise to concentration of population to cities, shortage of young men's labor power, and inflow of population to the third industry, inviting a serious labor power shortage in heavy industry such as shipbuilding and bridge construction.

Under these social environments, in making of steel bridges, rationalization of production continues. And as a way of cost-down, labor saving and standardization of works are promoted. Furthermore, as a final image, prefabrication and mass production of structures should be developed. However, at the present, bridge production in Japan has not reached this stage generally.

2. Problems Arise from Mass Production of Steel Structures in Japan

Products precessed from the plank roll materials are steel structure products ——— such as bridge, steel frame, steel tower, underground tunnel, steel pipe, etc. and ships ——— tanker and container ship. A characteristic of any one of these products is up-to-now small-scale production of various items. That is, it is always a dishes a la carte. Now let us take a look to see how the makers of these products think about the problems of labor saving, standardization, and mass production as means for final solution to production rationalization of each product.

(1) Bridge : Centered around urban area, elevated bridges for expressways are built, and bridges of same dimensions or similar structure are existing. However, because topography of Japan is complex, there are extremely little cases of actual examples of same dimensional bridges built over long lengths.

The shape is overwhelmingly the simple supported composite girder. Although recently in Japan, long-span suspension bridges are planned, problems of mass production can be spotted in component members for such super-structure, such as suspension bridge's stiffening truss, floor beam and prefabricated slab.

(2) Steel Tower : Due to the complex topography in Japan there are only a few cases that the same steel towers are constructed in large quantities. However, the upper structures of steel towers are often similar in design. In comparison, for the works ordered from foreign countries, there are numerous cases of planning that the steel towers having the same dimensions are planned in quantity, to be built on the vast wildernesses.

(3) Steel Frame : Individual building iron frames are similar; but there is a remarkable tendency for dishes a la carte. On the other hand, as for a large-scale structure as a super-mulfistoried building, the component members such as column and beam are often same dimensional : thus they may be considered to be subject to mass production.

(4) Steel Pipe : For penstocks installed in mountainous region, there are fairly variations in material quality, plate thickness and shape. However in case of water service steel pipes used in leveled city area, products of same form are numerous, and thus, they are subject to mass production in many cases.

(5) Underground Tunnel : For use in a relatively flat sea bottom, ther is a possibility of mass production of same dimensional products.

(6) Ship : Although ordered production is dominating, in recent years there appeared some projects of producing several ships of same dimensions and structure prior to receiving of an order and selling them as the ready-make product. This is a new attempt.

(7) In General : Although mass production of steel constructions is possible partially, only for the members having the same dimensions and design, when viewed for entire Japan, there are many problems to be solved before stepping into the ready-made product production such as the automobile industry.

3. Merits from Mass Production of Steel Bridges

For Japan's bridge construction, many difficulties lie in way in applying the mass production method to same dimensional products. Below is shown the degree of cost down to be attained by producting several units of same size bridges at one time (Figure 1).

Figure 1. Cost Down Attainable by Mass Production of Steel Bridges

Item		Cost Down
Cost of material		Not expected
Designing cost		Drastic
Erection cost		Some
Production cost	Full size marking	Drastic
	Gas cutting	Not expected
	Plate butt welding	"
	Assembling	Some
	Welding	Not expected
	Test erection	Some
	Painting	Not expected
	Material handling	Some
	Transportation	Not expected
	Inspection	"
General administrative cost		Some
Total		Approx. 20%

4. Problems Related to Standardization of Steel Bridge, Simple Composite Girder, in Particular

For Steel bridges, the simple composite girders are most frequently designed and produced. And this type occupies a remarkable share in Japanese high way bridges. Therefore, let us consider the standardization of simple composite girder in particular.

It is regarded that in Japan the problems related to stardardization of design and produetion of similar products are centers of consideration rather than the problems related to mass production of same dimensional bridges. The problems concerning the standardization of composite girder members are enumerated in Figure 2.

Figure 2. Problems Related to Standardization of Composite Girder

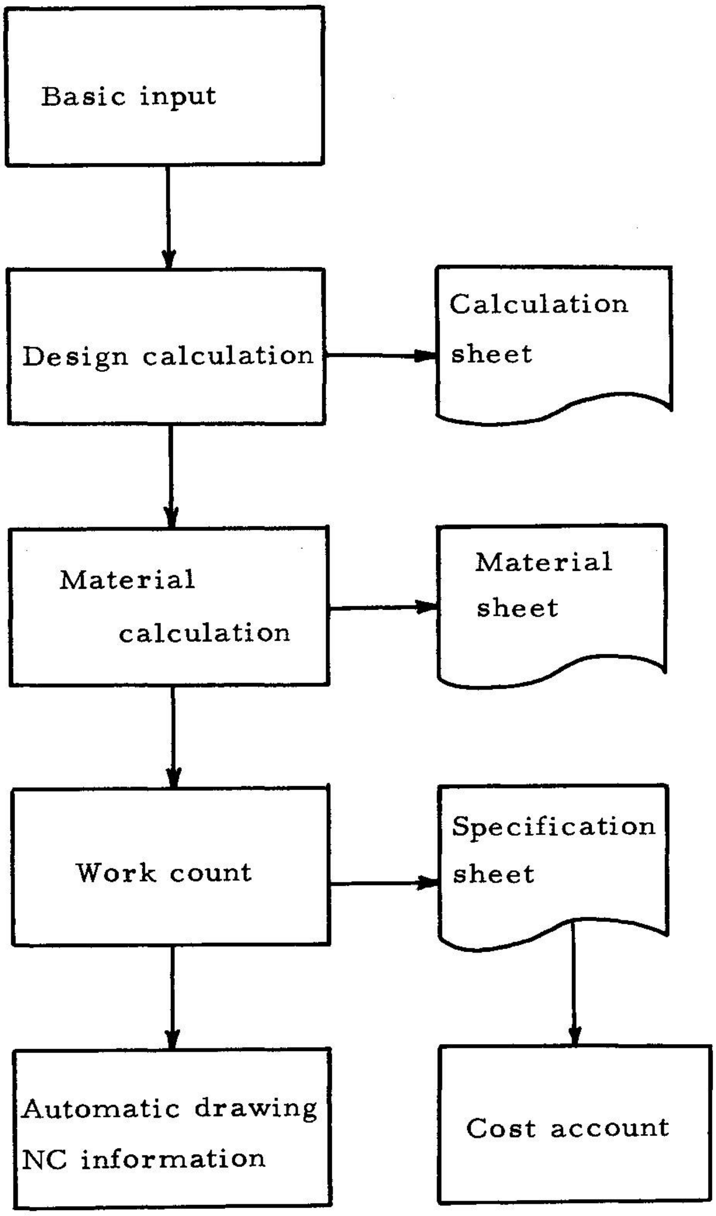
Structure	Problems for Standardization
Flange	Establishment of rule for cross section change
	Clear indication of material quality, plate thickness and plate width according to application
	Establishment of minimum and maximum sizes
Web	Standardization of material quality and plate thickness
	Establishment of rule for most suitable height of web
	Standardization of cambers
Cross beam	Standardization of coupled structure with main girder
	Standardization of corss beam material
Lateral truss	Standardization of major material used
	Standardization of gusset plate fitting condition
Splice	Standardization of arrangement for rivet and HT bolt holes
	Standardization of splice material size

If standardization of the composite girder is executed, automatic designing and automatic drawing can be done on basis of a relatively simple input data.

The automatic designing program "SLAM" developed by the authors carries out the design calculation, material calculation and cost calculation. Figure 3 shows the outline of the flow chart.

Automatic drawing is an important technique having a relation to NC technique of manufacture at plant besides labor saving in drawing work. Figure 4 is a sample of automatic drawing developed by us.

Figure 3. Flow Chart of "SLAM"



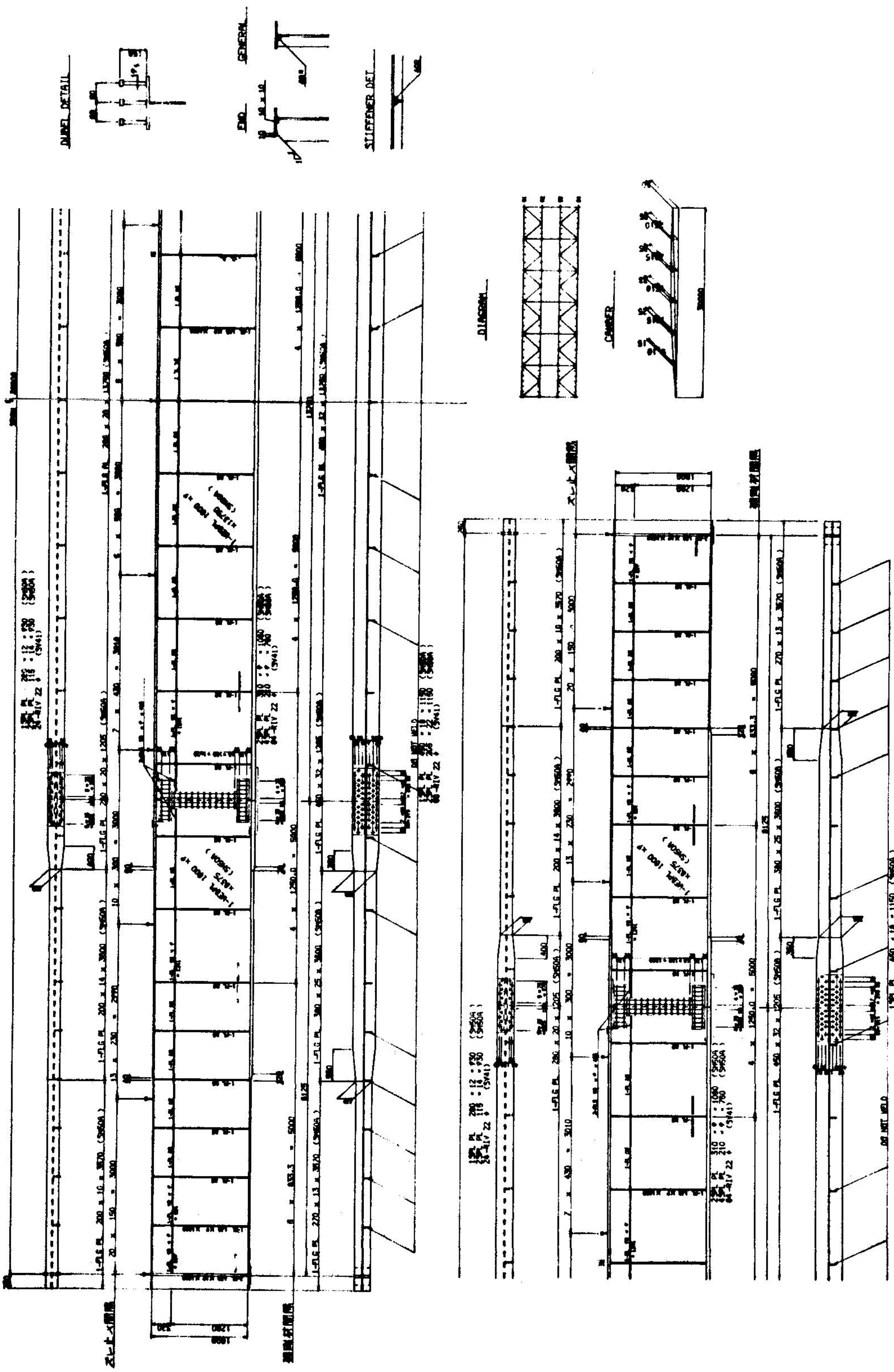


Fig. 4 Sample of Auto Drawing

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5. Similarity of Steel Bridge Members & NC Technique

If component members of steel bridge are classified according to their processings, thus being divided into the following four groups.

(1) Relatively large items with numerous markings

(2) Slender rectangular items with few markings

(3) Small parts of irregular shape

(4) Shaped steel, etc.

The relations between the features of each group with NC technique are as shown in Figure 5.

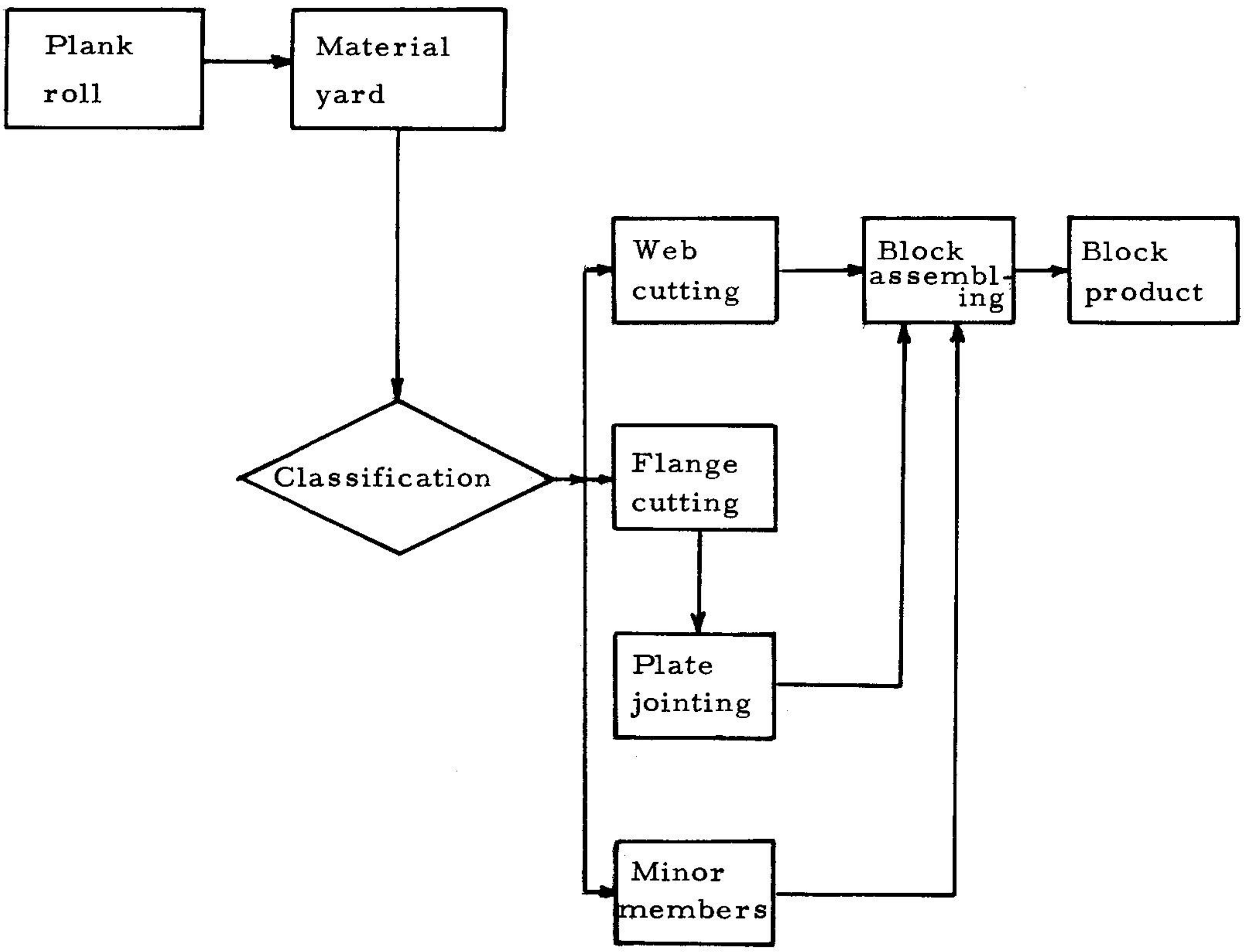
Figure 5. Bridgemembers and N/C technique

Members	Characteristics of members	N/C technique
I girder Web Box flange	One member is taken from one material. Volume of marking is much.	Suitable for automatic marking and automatic gas cutting by means of N/C.
I girder flange, small section box main member	Member is of long and slender rectangular shape and thickness is large. Volum of marking is less.	Cutting plan and groove detail for welding by automatic drawing.
Stiffener gusset Splice	There are many small members of irregular shapes.	Full size model is made out by automatic drawing.
Shaped Steel	No welding work linear nesting.	Working sketch

6. Production Line of Steel Bridge

When steel bridges are produced, it is necessary to grasp the features of component members and to regulate the traffic inside the factory for smooth flow of bridge members. Because there is a limit to mass production of steel bridges, it is necessary to give flexibility to the factory layout. . An example the layout is shown by Figure 6.

Figure 6. An Example of Production Line for Steel Bridge



7. Conclusion

When considered from a point of view of actual circumstance in Japn, time is not riped for steel bridge and other steel structure products to enter a stage of mass production. However, each product has similar members, it is necessary to grasp their features and to promote labor saving and standardization of designing and manufacturing in order to secure a cost down.

In labor saving of works, application of a digital computer becomes a focal point.

It is important to seak a better layout of works according to the items to be produced.

SUMMARY

Due to the topographical conditions in Japan it is impossible to introduce a large-scale mass production of steel bridges, but it is practicable to standardize designing and each engineering process as well as to rationalize processes by introducing, for example, NC process, since each component member composing the steel bridge has a similarity on basis of which the standardization can be realized. However, the production line requires flexible layout.

RESUME

En raison des conditions topographiques du Japon, il est impossible d'introduire la production en grande série des ponts en acier. On peut, par contre, en unifier la conception et les calculs et en rationaliser tous les procédés, en utilisant par exemple le procédé NC, où tous les éléments du pont ont une similitude sur la base de laquelle on peut réaliser la standardisation. La ligne de production exigera pourtant une disposition flexible.

ZUSAMMENFASSUNG

Aufgrund der topographischen Bedingungen in Japan ist es unmöglich, Stahlbrücken in grossen Mengen herzustellen; es ist jedoch durchführbar, die Durchbildung sowie die technischen Prozesse zu normieren und gleichzeitig zu rationalisieren, zum Beispiel durch Einführung des NC-Verfahrens, indem alle Einzelteile, welche die Stahlbrücke zusammensetzen, eine Grundähnlichkeit aufweisen, gestützt auf welche eine Normierung möglich ist. Die Fertigungsstrasse erfordert indes eine flexible Auslegung.

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