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AUTOMATIC PREASSEMBLING SYSTEM FOR REINFORCEMENT OF UNDERGROUND LNG TANK

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ABSTRACT

A new automatic reinforcement preassembling system introduced in a underground LNG tank construction project at the Sodegaura Plant of Tokyo Gas is discussed in this paper.

The system incorporates a curved bar setting apparetus and a straight bar setting apparatus for arrangement of reinforcing bars, a bar arrangement support base for holding reinforcing bars, an automatic binding apparatus, and a control apparatus, and is constructed in a manner for assembly of reinforcing bar meshes through certain procedures. Each bar setting apparatus (one unit for straight reinforcing bars, the other for curved reinforcing bars) moves sequentially to designated locations to arrange reinforcing bars on a frame. After arranging reinforcing bars, the bar binding machine moves to the specified places and ties the intersecting point of the reinforcing bars. The binding machine uses No.10 (3.2 mm) annealed wire of general type.

The system is capable of handling 60 each of straight D41 bars, length 10.5m, and curved bars of length 10m. The maximum dimensions for preassembled units are 12.7 × 12.4m. The procedure for preassembly can be changed simply by programmable controller in accordance with pitch and size of arranged bars.

As a result of application in the field, a reduction of manpower by approximately one-sixth of conventional requirements was achieved and contributions were made to improvement of the work environment.

1. INTRODUCTION

In side-wall reinforcement work of a large scale underground tank, the method used is for bars curved in the circumferential direction to mutch the tank shape, and straight bars crossing perpendicularly with the curved bars to be assembled beforehand in mesh form for setting at the inside wall of the tank. The assembly operataion for reinforcing bars is considered as difficult-to-handle, hazardous work since the reinforcing bars handled are long and of large diameter, and moreover, curved to fit the shape of the tank.

In tying of reinforcing bars, since the bars are of large diameter, No.10 (3.2 mm) annealed wires are used, and compared with using normal binding wires, the work is arduous, and requires much skill and labor. In addition to these work conditions, there have been changes in the environment of the construction industry such as a shortage of skilled laborers, and the need for mechanization and automation of reinforcement assembly work has becom intense.

This report describes a system which combines an apparatus for dealing with curved reinforcing bars and an automatic binding apparatus newly developed based on the concept of the prefabricated reinforcement unit automatic arrangement apparatus already in practical use in the authors' company.

2. CONVENTIONAL REINFORCEMENT ASSEMBLING WORK

A view of conventional reinforcement unit assembly operations is shown in Photo.1.

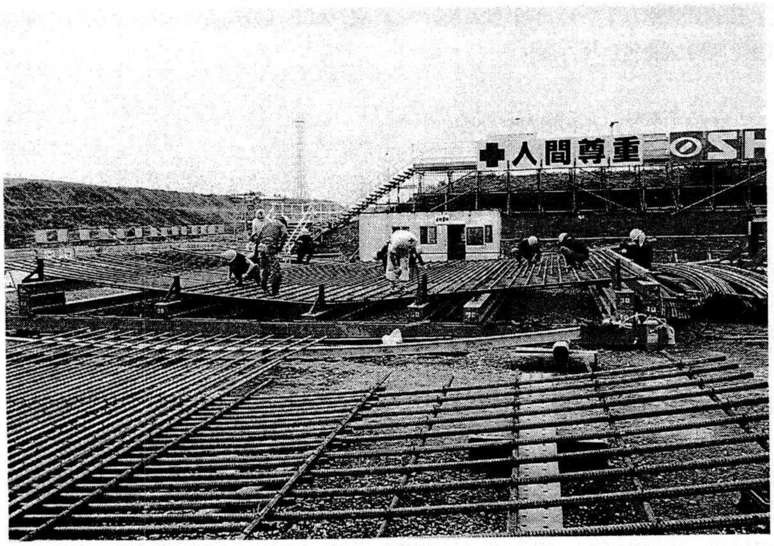

Photo.1 A VIEW OF CONVENTIONAL REINFORCMENT UNIT ASSEMBLY OPERATION

The conventional reinforcement unit assembly operation is carried out with the procedure of arranging at prescribed locations reinforcing bars which had been tentatively put on the bar arrangement support base provided at a part of the jobsite yard by crane or other equipment, and then tying.

The tying work is done with wire thicker than used in ordinary building construction. This is because a unit of reinforcement mesh is heavy, having a large weight of 12 t or more, while moreover, there are the operations of tilting up the reinforcement mesh unit and lowering it into place at the jobsite, and the mesh unit being deformed or breakage at ties occurring and reinforcing bars falling at such time must be prevented. Practically all of the work relies on manual labor and 10 to 12 skilled workers are required.

3. OUTLINE OF SYSTEM

3.1 Automatic Bar Setting Apparatus

The automatic bar setting apparatus automates making prefabricated units of reinforcing bars, the kind of unit consisting of a combination of curved bars (reinforcing bars in horizontal direction) and straight bars (reinforcing bars in vertical direction).

The principal specifications of this apparatus are shown in Table 1 and a general view of the apparatus is shown in Photo.2.

The system is composed of a curved bar setting apparatus and a straight bar setting apparatus for arrangement of reinforching bars, a bar arrangement support base for resting reinforcing bars, and the automatic bar binding apparatus described later.

Fig.1 shows the side elevation of the curved bar setting apparatus and Fig.2 the side elevation of the straight bar setting apparatus.

Table.1 SPECIFICATIONS

Bar sizes	D19, D25, D32, D35, D38, D41
Bar configuration	straight and curved bar
Bar length	straight bar:7000 ~10500mm curved bar :9500 ~10000mm
Binding wire size	No. 10(3. 2mm)
Maximum units size	12.7m ×12.4m

The method of reinforcing bar arrangement consists of the straight bar setting apparatus moving forward to the specified location, and then, while retreating, placing one bar at a time on the bar arrangement support base at specified intervals. Since the straight bars are set following the shapes of curved bars, the bar placing section of the straight bar setting apparatus is of a structure allowing raising and lowering to be done in accordance with the curved shape of the reinforcing bar arrangement support base. After completing the setting of straight reinforcing bars, curved bars are set in similar manner. The position of an individual reinforcing bar is determined by a sensor provided on the bar setting apparatus which detects dogs for detecting bar setting locations provided at the side of a rail on the bar arrangement support base. The straight bar setting apparatus is equipped with a bar arrangement support base configuration detecting mechanism to detect the curved shape of the bar arrangement support base, which detects the height of the plate for detecting the height of the bar arrangement support base provided on the stand, to control the vertical positions of the reinforcing bar placing mechanism.

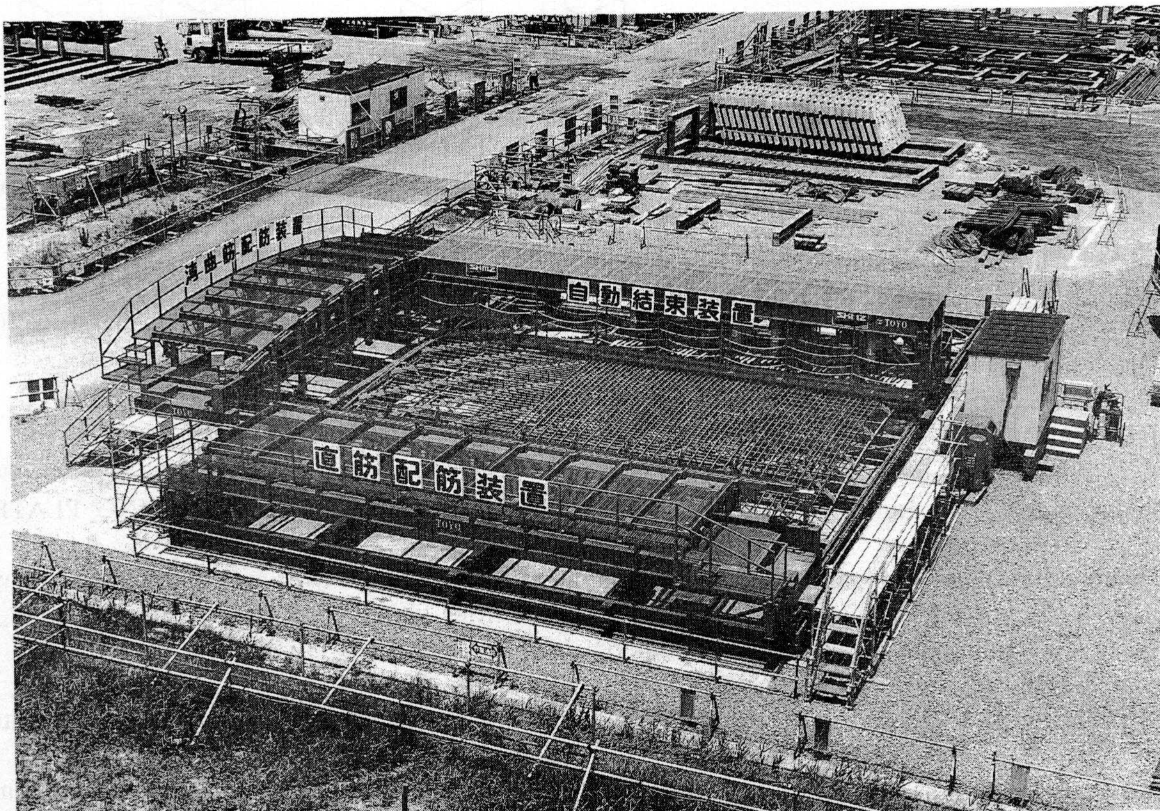

Photo.2 GENERAL VIEW OF THE APPARATUS

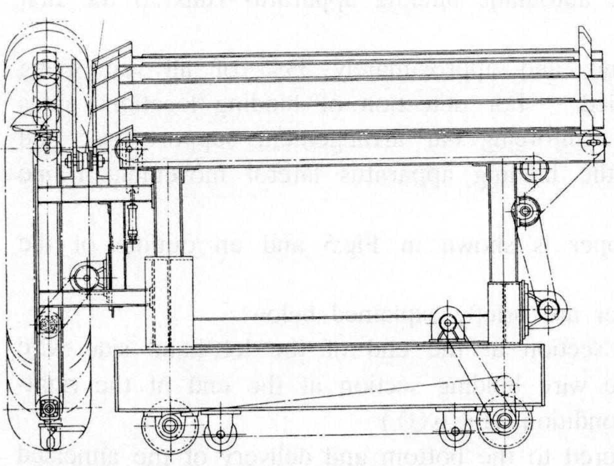

Fig.1 THE SIDE ELEVATION OF THE CURVED BAR SETTING APPARATUS

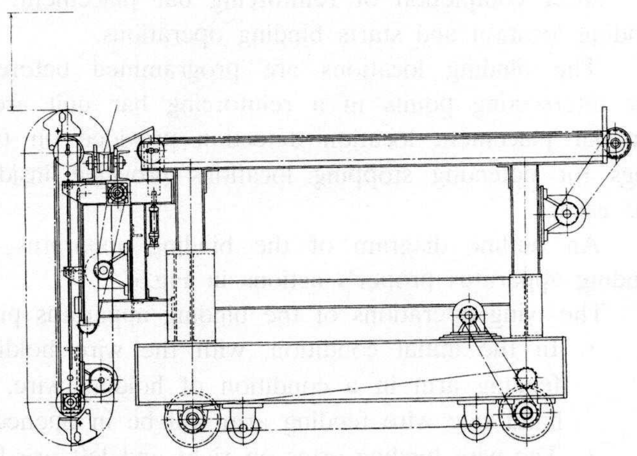

Fig.2 THE SIDE ELEVATION OF THE STRAIGHT BAR SETTING APPARATUS

The bar arrangement support base is provided with the reinforcing bar holding plate shown in Fig.3 at a 45-deg angle to the reinforcing bars to be placed and the bars placed by the bar arrangement platform car are accomodated in these V-shaped grooves.

The angle of bar placement by the reinforcing bar holding plate is of a degree to avoid interfering with wire feeding arms of the automatic binding apparatus. This bar holding plate, as shown in Fig.3, has two kinds of grooves which are provided alternately, with deep V-shaped grooves holding straight bars and shallow V-shaped grooves holding curved bars. Because of the V-shapes, it is possible for locations to be determined accurately even when bar diameters are changed. Fig.3 shows the condition of the reinforcing bars to be handled in the current project as arranged on the bar holding plate.

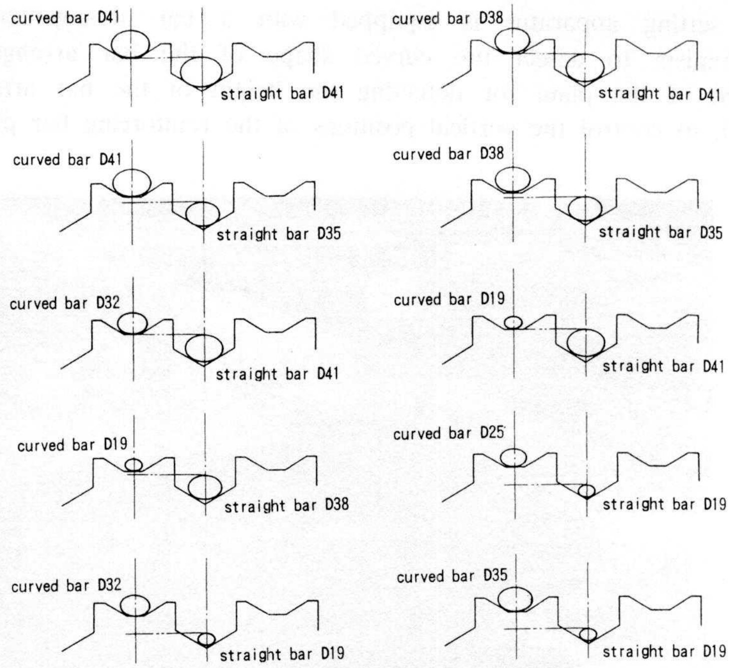

Fig.3 THE REINFORCING BAR HOLDING PLATE

3.2 Automatic Binding Apparatus

The automatic binding apparatus fully automates reinforcing bar tying operation which have conventionally been performed manually. Wires are feed from above reinforcing bars and tying is achieved by twisting the wires together. The material used for binding is No.10 wire. A conceptual drawing of the automatic binding apparatus is shown in Fig.4.

This apparatus is composed of a binding apparatus propulsion platform car, binding apparatus lateral movement frame, binding apparatus proper, and wire feeding apparatus. Four units each of binding apparatus proper and wire feeding apparatus are provided at specified intervals. One unit each of binding apparatus proper and wire feeding apparatus are paired together and they travel laterally within a specified range inside the binding apparatus lateral movement frame.

After completion of reinforcing bar placement, the automatic binding apparatus runs to the first binding location and starts binding operations.

The binding locations are programmed beforehand, and approximately 33% of all reinforcing bar intersecting points in a reinforcing bar unit are tied. For detection of binding locations, dogs for bar placement location detection provided on the reinforcing bar arrangement support base and dogs for detecting stopping locations provided inside the binding apparatus lateral movement frame are used.

An outline diagram of the binding apparatus proper is shown in Fig.5 and an outline of the binding apparatus proper's actions in Fig.6.

The tying operations of the binding apparatus proper are briefly explained below.

- In the initial condition, with the wire holding section at the end of the left-hand side wire feeding arm in a condition of holding wire, the wire holding section at the end of the right-hand side wire feeding arm will be in opened condition. (Fig.6 ①)
- The wire feeding arms on right and left are lowered to the bottom and delivery of the annealed wire is done. (Fig.6 ②)
- After completion of delivery of the annealed wire, the wire feeding arms on right and left are raised to the specified positions. By doing so, annealed wire is passed through the reinforcing bar intersection. (Fig.6 ③-④)
- The annealed wire twisting arm is closed, annealed wire passed through the reinforcing bar intersection is held and the wire is cut. Next, the wire twisting arm is raised, and while applying tensile force to the wire, the wire twisting arm is rotated to twist the wire. Upon completing

the specified number of times of twisting, the wire twisting arm is opened, and the ends of the binding wire are bent by the binding wire twisted portion bending apparatus. (Fig.6 ⑤–⑥)

The condition of binding performed with the automatic binding apparatus is shown in Photo.3. Binding by this apparatus differs somewhat from the binding method conventionally performed manually.

In conventional binding operations, binding wires of U-shape are used so that the twisted part of wires consists of four wires. With the automatic binding apparatus, a single wire is passed through the intersection of reinforcing bars and the two ends of the wire are grasped and twisting is done. Therefore, at the twisted portion of wire, it will be as if two wires are being twisted. With this method, there are only two binding wires at the twisted part, but the annealed wire used for binding is made one size larger than in case of binding manually, while further, a mechanism is provided for the tensile force to be applied to the binding wire to be maintained at the optimum level, and therefore, ample binding force is obtained.

Binding of combinations of reinforcing bars from D19 to D41 is possible with this apparatus.

The annealed wire is carried in coiled form on the turntable of the wire feeding apparatus at the back of the binding apparatus proper. Feed-out of annealed wire is done by rotating the turntable while detecting the tension of the wire. The turntable is automatically operated depending on whether or not there is tension of the binding wire.

Annealed wire commercially available is used without modification as the binding material.

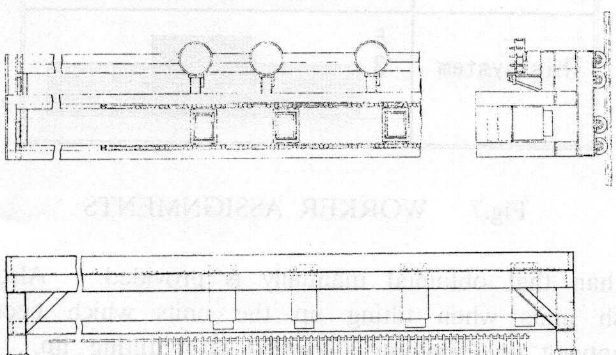

Fig.4 A CONCEPTUAL DRAWING OF THE AUTOMATIC BINDING APPARATUS

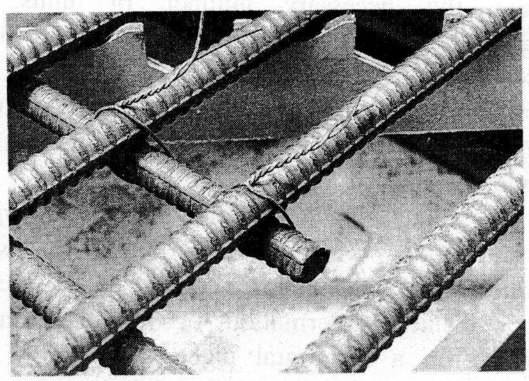

Photo.3 CONDITION OF BINDING PERFORMED

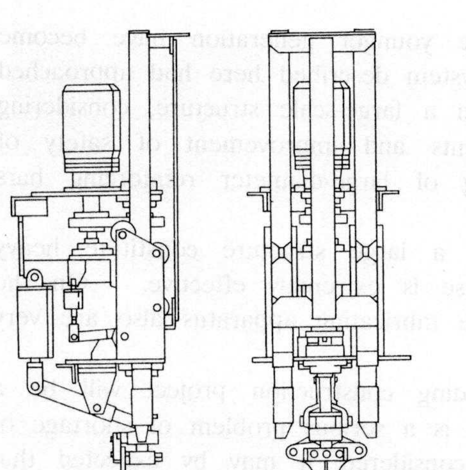

Fig.5 THE OUTLINE DIAGRAM OF THE BINDING APPARATUS PROPER

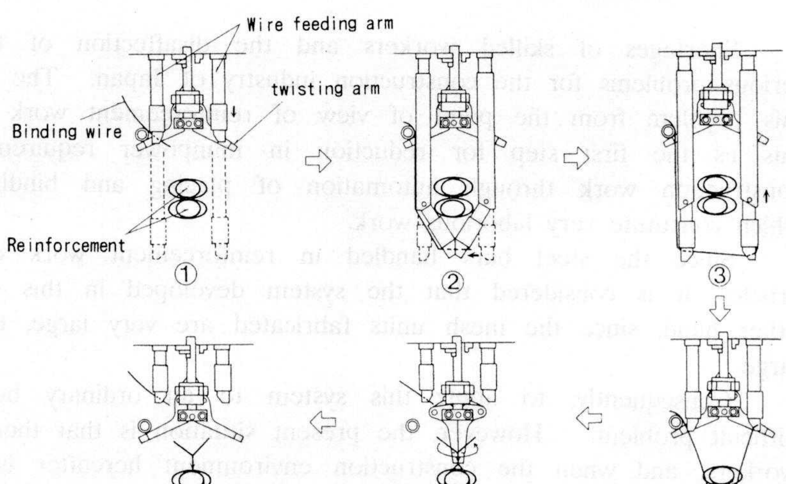

Fig.6 THE OUTLINE OF THE BINDING APPARATUS PROPER'S ACTIONS

4. EFFECT OF ADOPTION

The system was used at the construction site of an underground LNG tank in Chiba from May to August 1991.

To compare this system with manual operations, in case of the latter, reinforcement mesh units are mede with two crews of 10 to 12 workers per crew. The number of reinforcement mesh units which can be made in one day is approximately six, while the weight of reinforcing bars per unit is approximately 12t. This means consequently that one worker assembles approximately 3t of reinforcing bars.

In the case of this system, approximately three reinforcement mesh units are made per day by two workers. Therefore, one worker will have assembled approximately 18t of reinforcing bars.

From this result, according to simple arithmetic, the amount of reinforcing bars handled by a single worker is increased by approximately 6 times.

Fig.7 shows worker assignments for the conventional method and for this automatic system. When using this system, since it is unnecessary to concentrate a large number of workers for a certain period as previously, two workers can take say a whole month to fabricate the necessary number of units. Although the number of mesh units made per day with this system is about one-half that of manual work, it was ascertained that requirements can be met adequately with the allotement shown in Fig.7.

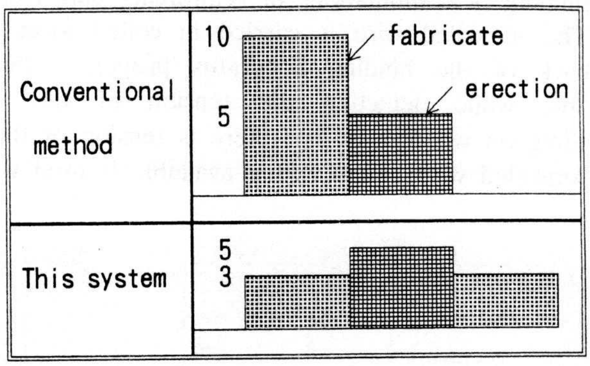

Fig.7 WORKER ASSIGNMENTS

Regarding binding force obtained with the automatic binding apparatus, it was confirmed that binding force equal to or greater than that obtained manually is provided. Also, there was little deformation of reinforcement mesh units when tilting up the units which been assembled on a horizontal plane, and hardly any untying or loosening occurred after tilting up. Therefore, it was ascertained that is adequate reliability of binding performed with this system.

5. CONCLUSION

Shortages of skilled workers and the disaffection of the younger generation have become serious problems for the construction industry of Japan. The system described here had approached this problem from the point of view of reinforcement work in a large-scale structure, considering this as the first step for reduction in manpower requirements and improvement of safety of construction work through automation of placing and binding of large-diameter reinforcing bars which constitute very laborious work.

Since the steel bars handled in reinforcement work of a large structure constitute heavy articles, it is considered that the system developed in this case is extremely effective. On the other hand, since the mesh units fabricated are very large, the fabricating apparatus also are very large.

Consequently, to apply this system to an ordinary building construction project will be a difficult problem. However, the present situation is that there is a serious problem of shortage of workers, and when the construction environment hereafter is considered, it may by expected that this system can be fully established as an effective means for solution, and it is the intent of the authors to make added efforts in research and development in this regard.