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Development of the Automatic Screeding Machine Mounted on a Girder for Concrete Placing Work

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ABSTRACT

Takenaka has developed a girder-mounted automatic screeding machine (SCREED ROBO) to improve concrete screeding work, and to solve problems such as the shortage of skilled workers and variations of accuracy.

This machine makes it possible to screed concrete on the large span automatically with high quality, by traversing the screeding part on a girder which runs independently on rails.

Takenaka has two of these machine. The machines operated on about 78,000m2 of floors at 19 sites as of the end of December 1991, contributing to manpower reductions, and improved working accuracy at sites.

This paper describes the outline of the automatic screeding machine with self rail shifting and working results, etc.

1. INTRODUCTION:

Research and Development for routinizations in the recent contruction work are being studied and developed with the aim to improve accuracy, reduce heavy lavor, avoid dengerous work, and overcome the labor shortage. Above all, concrete work which labor condition and work environment are especially bad and has so many aspects relying on manual labor highly requires both labor saving and automation of concrete work.

This concrete work is executed in the order of concrete placing-screeding -direct finish work. So far, a " Horizontal Distributor" for concrete placing work and "Surf-Robo" for direct finishing work have been developed and put in practical use. This report describes the outline of the girder type concrete automatic screeding machines No. 1 and No. 2 which have many past records of positive achievements and about the target of development of No.3 machine, which is being added with new functions.

2. PRESENT SITUATION OF FLOOR SCREEDING WORK:

Concrete floor screeding work is to roughly screed placed concrete with a hoe or a shovel to some extent, and proceeding to levelling work to get the crest level with a ruler, etc. The level accuracy of the floor is mostly determined at this stage and although correction of a small unevennes can be done with a trowel in the next step, correction of level cannot be accomplished. Floor screeding work has the following problems:

(1) Dispersion of floor level is created by the difference in skill of the workers.
(2) Big variation of work load due to concrete workability.
(3) Most work is done by hand.
(4) Sortage of skilled workers.

3. PROCESS OF DEVELOPMENT:

We commenced reserch of actual situation for automatic concrete screeding machine in 1984 and decided the basic concept in 1985. And for the elemental technology such as screeding function, we performed various experiments up to 1986 to confirm its function. In 1987, the No. 1 self-advancing machine and in 1988, the No. 2 self-advancing machine were manufactured and acknowleged for their performance.

On the other hand, we started development of the "Girder Type", which is suitable for large span, and then, manufactured the No .1 machine running on temporarity installed rails in 1989 and went on to the site running step having added self rail shifting function to the No. 1 machine and manufactured an "improved No. 2 machine" in 1990.

Since 1991, we have started making a new No. 3 machine with improved function which is now under test and adjustment.

4. OUTLINE OF GIRDER TYPE CONCRETE AUTOMATIC SCREEDING MACHINE.

The girder mounted automatic screeding machine has an automatically controlled screeding part mounted on a girder, having a truss construction which performs screeding sequentially line by line along the girder running over a self shifting rail. When reaching the edge of the rail, the rail is shifted forwordautomatically (or self rail shifting function). Outline of system being shown in figure 1 and the specification in list 1, respectively.

The system consists of a screeding machine which automatically controls horizon and height, girder being traversed by the screeding section, self-advancing rail section and control section, having automatic shifting function. Total weight is about 885kg (girder, 19m long), however, the weight is reduced and the machine modularized so that it can be manually assembled. Therfore, assembling and disassembling can be accomplished by 2 or 3workers x 0.5 day.

4.1 Screeding part:

This part is constructed with a screw to perform levelling by transporting surplus concrete to the side direction, vibration board making screeding phase flat, traversing saddle on the girder and a surbo cylinder which always controls screw and vibration board to be horizontal and to a specified height without being influenced by bending of the girder, or depression of concrete surface, etc. (figure 2).

The screeding width when tranversing is 1.6m. However, in the actual execution, the screeding area will be somewhat overlapped. Maximum divided weight is about 130kg.

4.2 Girder:

The girder is modularized and edge part of girder can be divided into 3m, and the intermediate part into 1m and 2m, the length of the girder can be selected from 6m. min(screeding width: 4.5m) to 19m max (screeding width: 17.5m) at option (with 1m pitch).

A Travelling saddle is located under both edge parts, and the control board is mounted on the girder and operating board can be installed optionally at either the right and left edge parts. Also, to make it light in weight, alumi-alloy is used and the maximum divided weight has been decided to be less than 50kg.

List 1 Specification of Girder-mounted Automatic Screeding Machine

Nomenclature	Automatic Screeding Machine
T y p e	CFR-350G
Size (L × W × H)	6.4-19.4 x 4.3 x 2.3 m
W e i g h t	about 885kg (Girder length, 19m)
Girder length	6.0 - 19.0m (1m pitch)
Screeding width	4.5 - 17.5m
Screeding part	2 lines screw type 1.6m length
Traversing speed	maximum 0.8m/sec
Travelling speed	maximum 0.3m/sec
Operation mode	full automatic, level automatic, manual
Power Source	3 phase 200/220v 4KVA

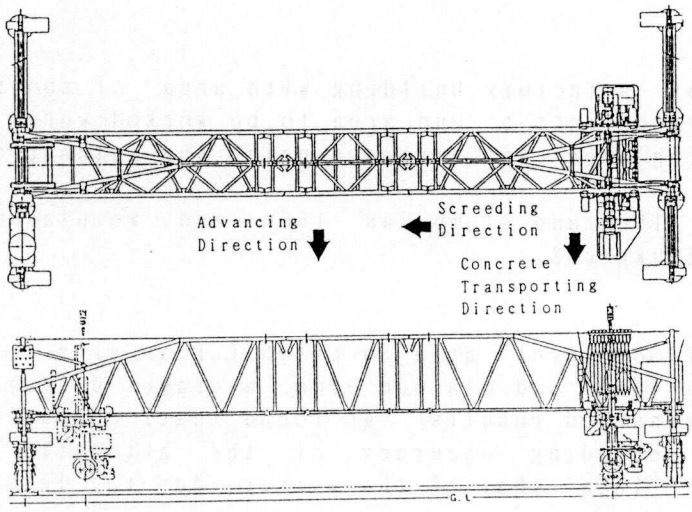

Figure 1 Outline Drawing of Automatic Screeding Machine(No .2)

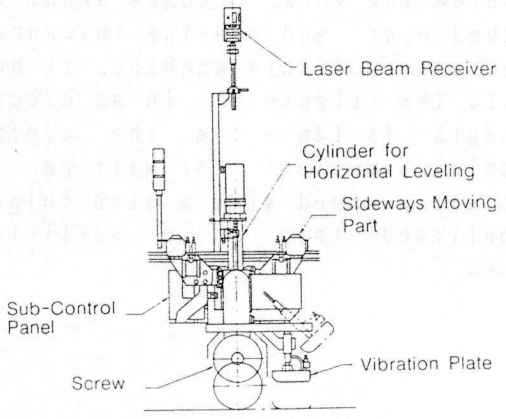

Figure 2 Screeding Part

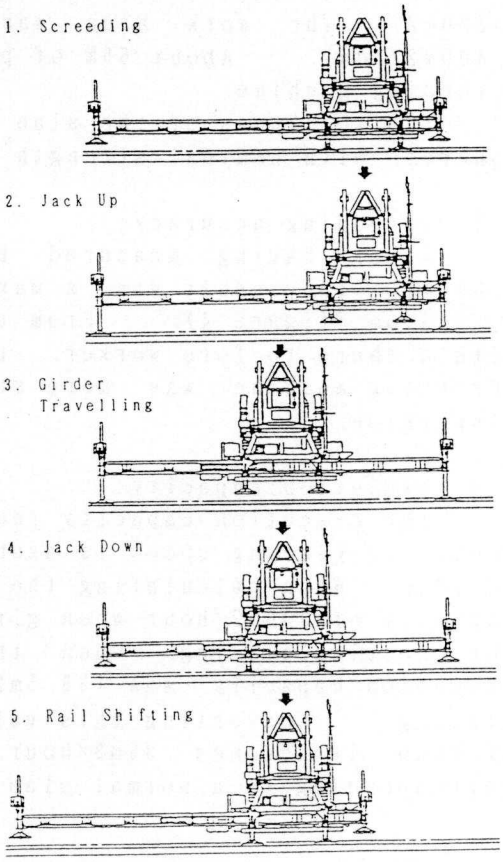

Figure 3 Seif Rail Shifting Function

4.3 Travelling saddle / Self Shifting rail:

Girder movement stretches the jack at both edge of the rail, assembled inside the travelling saddle, and moves the travelling saddle on the rail lifted. When reaching the edge of the rail, the jack is retracted and the leg part of travelling saddle is grounded under the condition of being floated up and the rail is sent forward, using the travelling drive (figure 3).

4.4 Control part:

The control part consists of the main control section mounted on the girder and sub control board mounted on the screeding part. The main control board is constructed with a programmable controller and various I/F, and controls actuator of each part by precessing information from the external sensors (clinometer, laser level and rotary encoder, etc.).

5 WORK EXECUTION RESULTS:

The machine had been used in 19 sites, for the total area of about 72,000m2, as of December 1991. Among the above execution results, the H-3 job will be explained.

5.1 Outline of work:

The site was the earth foor of a factory building with area of about 7,220m2. The work area was divided into 5 and area to be worked were 1,400m2/ day. About 65% of placing area was screeded using the automatic screeding machine.

The thickness of the slab was 18cm and slump was 16cm and we placed concrete with nominal strength of 270kg/cm2.

5.2 Screeding accuracy:

After having measured the floor level at a 5m pitch for an area of 2,800m2, the result was a maximum +4mm and minimum -7mm, average -0.54mm, σ =2.34mm (figure 4). From the measured results, we found that, compared with a there to fore worker, the screeding accuracy of the automatic screeding machine was more stable than that of the worker due to less dispersion.

5.3 Execution capacity:

The execution capacity required for screeding work, becomes about 220m2 /hour, if placing speed is assumed to be 40m3/hour, and placing thickness to be 18cm. When calculating the execution capacity of this machine, it has a capacity of 350m2/hour when girder length is 18m (figure 5). In an execution for one time placing, when the girder length is 13m - 15m, the average execution capacity was 196.5m2/hour including time lost for waiting the placing. Converting this value into a placing speed with a slab thickness of 18cm, it becomes 35m3/hour. We confirmed this to be sufficiently corresponding to a normal slab placing speed.

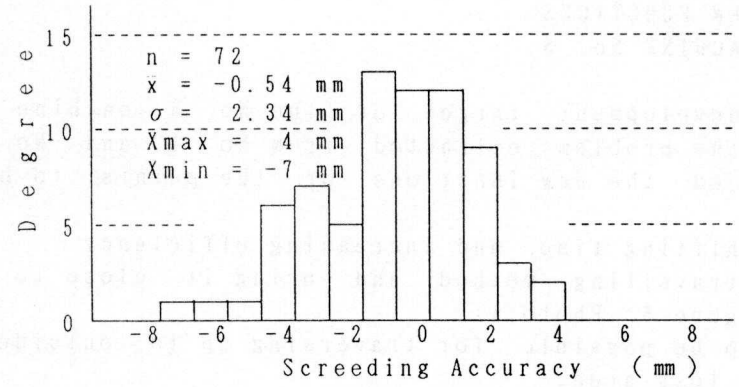

Figure 4 Screeding Accuracy

[Conditions] · Traversing speed 0.1m/sec
· Overlapping width 0.3m
· Travelling speed 0.3m/sec

Figure 5 Execution Capacity

6. ANALYSIS OF PROBLEM:

After completing the No. 1 machine, of a girder-mounted screeding machine, which has been used at the site for 3 years, we could confirm it to have sufficient accuracy and capacity, however, we further studied the problem of screeding machine with further improved function which may come to stay as a various purpose machine.

(1) Screeding work will be stopped, during rail shifting (about 100 seconds).
(2) 1,250mm inside from the rail core left and right totaled, and 1,600mm from external dimension of the system will be impossible to excute. As the girder length is decided in accordance with the narrowest span, inside the column at both edges of building, executive area by screeding robot may be around 70% of the placing area.
(3) The operator will not able to operate unless he has experience to some extent with the switch and LED display method. The operator must have expert knowledge in case of failure and emergency stop.
(4) Power feeder and signal cable are cabtyre cord lifted by a messenger wire, therefore, there is a danger of hitching other body, and the maintenance and unit assembling and disassembling are not easy.

7. DEVELOPMENT TARGET AND NEW FUNCTIONS OF AUTOMATIC SCREEDING MACHINE No. 3:

We have established a development target of the No. 3 machine taking into consideration the problem extracted from No. 1 and No. 2 screeding machine, and decided the new functions or the points to be improved.

(1) Shortening present rail shifting time, and increasing efficiency
→ Adopt "Sledge Type Edge" travelling method and bring it close to a continuous screeding work. (Figure 6, Photo 1)

(2) Making screeding part to be possible for traversing up to outside of travelling part to reduce the loss area:
→ By making the travelling part in arch type and changing the girder to a suspended type the screeding part can execute up to outside the travelling part without contacting travelling part (coming close to 400mm from external wall surface of the building). The girder-swing mechanism should be added to send the body of the girder out to the right and the left so that execution can be done up to the back side of the column. With the girder-swing, it will be able to avoid odstacles such as the mast of tower crane. By taking this action, lost screeding area will be reduced, and area to be executed will be promoted to around 85%. (Figure 7)

(3) Operation procedure is to be simplified so that the machine can be operated even by a worker:
→ Use plasma graphic display and touch panel, inputting with a menu or guide message, to make it easy to understand so that a handling manual becomes unessary. If a failure or emergency stop occurs, to make the position of failure will be known instantly with error message.

(4) Stop supporting power feeder and control signal cable with wire, and for clearing the area around the girder:
→ Use trolley duct and multi-transmitting method to make unit-assembling, disassembling and maintenance easy. And we expect no protection around the girder.

Other than the above, above 10 new functions and points to be improved are contained. Outline of system is shown in figure 8 and Photo 2.

List 2 Specification of Automatic Screeding Machine(No .3)

Nomenclature	Automatic Screeding Machine
T y p e	CFR-320G
Size (L × W × H)	6.4-18.4 x 5 x 2 m
W e i g h t	about 1220kg (Girder length, 18 m)
Girder length	6-18m (1m pitch)
Screeding width	5.2-17.2m
Screeding part	2 lines screw type 1.6m length
Traversing speed	maximum 0.8m/sec
Travelling speed	maximum 0.1m/sec
Operation mode	full automatic, level automatic, manual
Power Source	3 phase 200/220v 6KVA

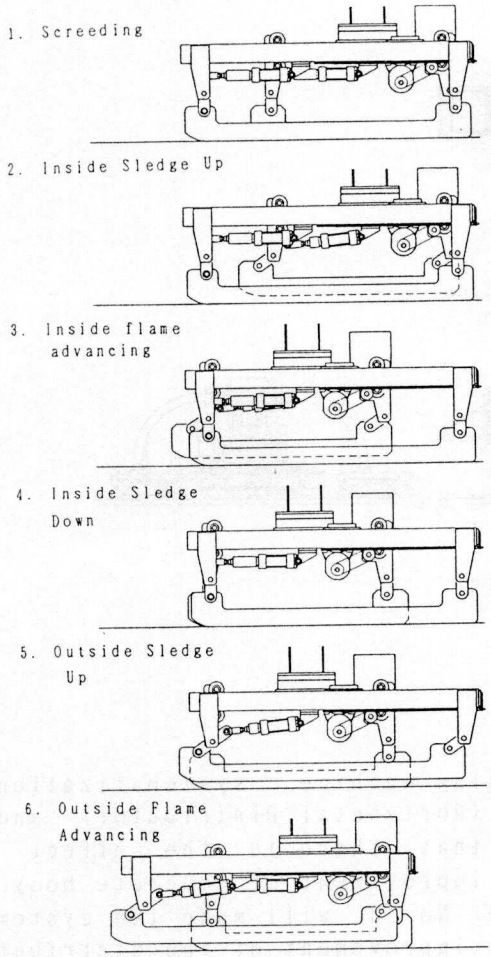

Figure 6 Travelling Mechanism

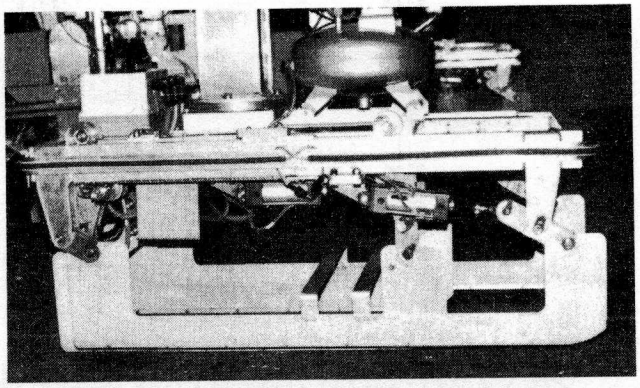

Photo 1 "Sledge Type" Travelling Part

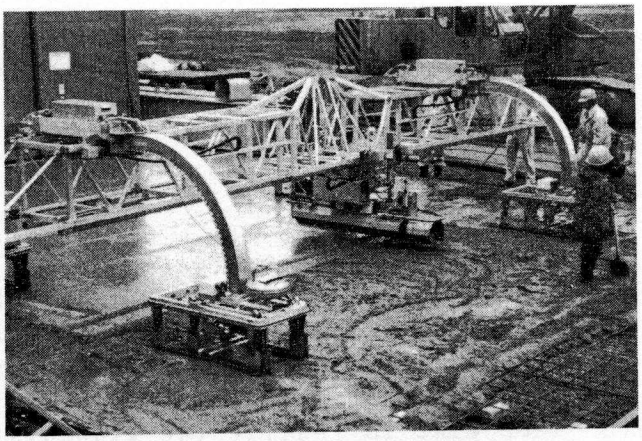

Photo 2 Experimental Execution

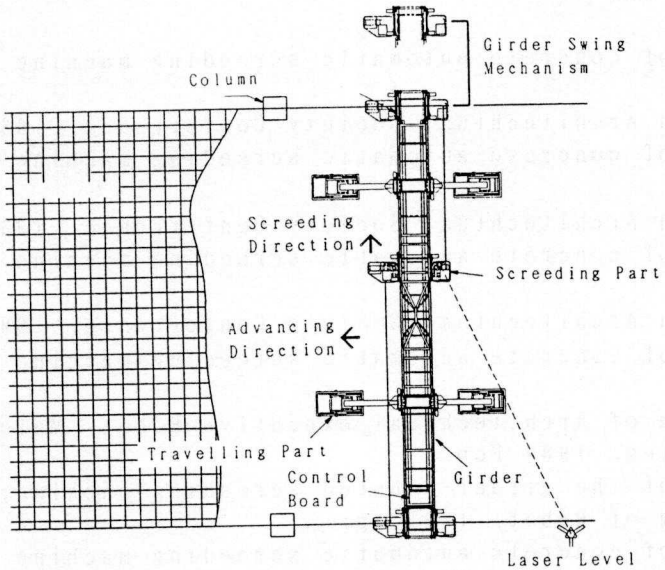

Figure 7 Execution Scheme Drawing

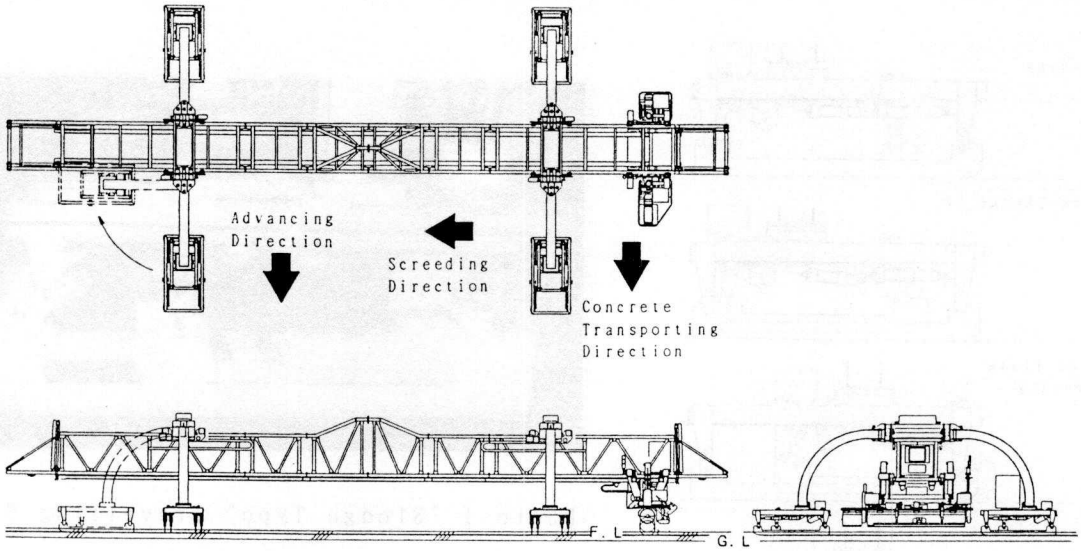

Figure 8 Outline Drawing of Automatic Screeding Machine(No .3)

8. CLOSING:

With the development of a concrete screeding machine, systematization becomes possible, ranging between placing work (Horizontal Distributor) and direct finish work (Surf Robo), we knew that there is the effect on improvement of concrete work and quality improvement of concrete body.

From now on, concrete screeding machine No. 3 will make the system easier to be incorporated at the site with the improvement of the distribut or etc. We want to realize the wide distribution of the concrete screeding machine.

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