AN AUTOMATIC CONCRETE TRANSIT SYSTEM

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1. Summary

In general, the gravity concrete dam construction site requires a combination of a transfer car, a cable crane and a concrete bucket.

The transfer car operation bears some element of risk resulting from a possible, simple error of the operator as it is repetitious, monotonous work in the confines of the operator's cab over a long period.

Traditionally, the worker opens and closes the bucket gate at the concrete deposit place by attaching or detaching a hose to and from the bucket, thereby permitting the concrete to be deposited. This procedure, however, entails various problems such as ① dangerous working directry underneath the suspended load, ② the possibility of a collision between the bucket and a worker or an object, and ③ irregular air injection blamed for unclear sign.

In order to deal with these problems, Fujita Corporation has recently developed an "Automatic Concrete Transit System" for use at dam construction sites.

This system has undergone a series of modifications ranging from "unattended operation of the transfer car", "remote-controlled opening/closing of the concrete bucket" and "centralized management".

Fig. 1 shows the flow of concrete transit and placing work at the dam construction site, where the target area is enclosed with a dotted line.

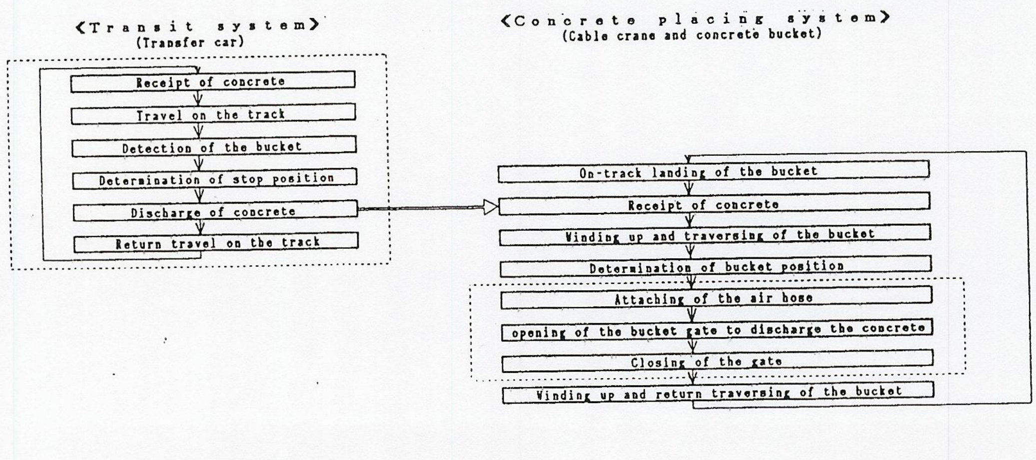

Fig. 1 Flow of concrete transit and placing

Fig. 2 shows the rough configuration of automatic concrete transit system.

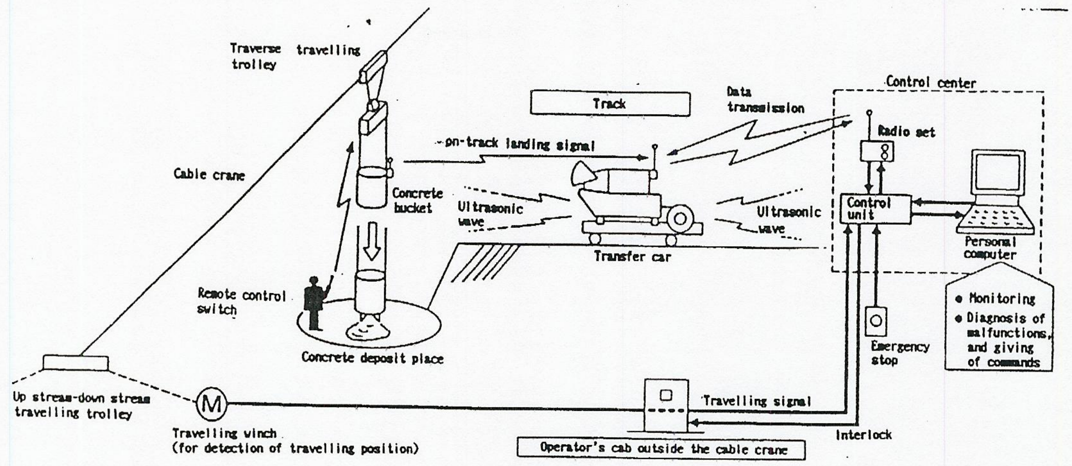

Fig.2 Rough configuration of automatic concrete transit system

2. Unattended transfer car operation system

2-1 System overview

This system is designed to automatically detect the on-track landing position of the bucket, and allow the unattended performance of all work by the computer mounted on the transfer car (Photo 1).

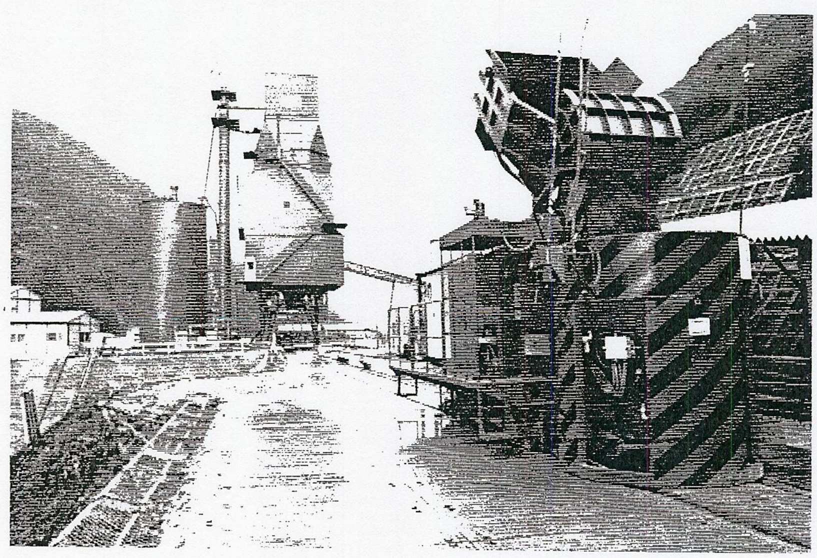

Photo 1 State of unattended operation

2-2 System configuration

Fig. 3 shows the system configuration.

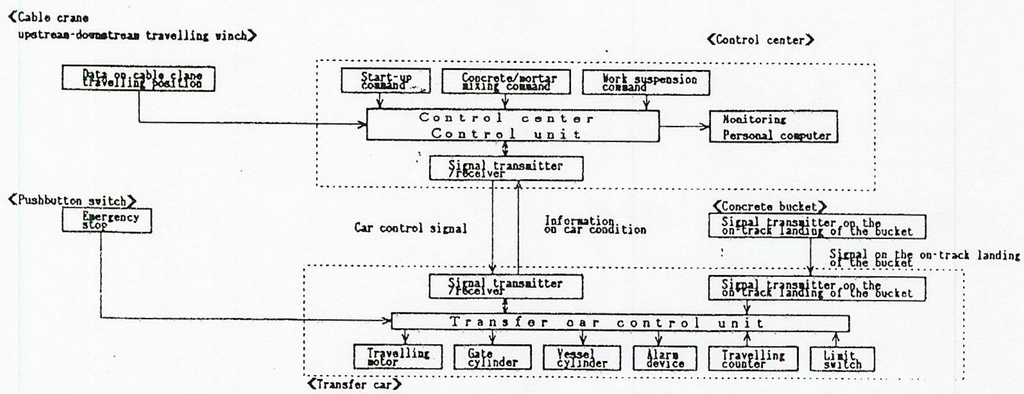

Fig.3 Configuration of unattended transfer car operation system

(1) Detection unit for the on-track landing position of the bucket

The upstream-downstream travelling winch of the cable crane rotates to generate the on-track landing position of the bucket on the track, and then transmits a wired signal to the control center located in the batching plant operation room.

(2) Control center control panel

Based on the information of the on-track landing position of the bucket, this control panel calculates the travelling distance of the transfer car on the track. The control panel also generates as car control signals the various commands from the control center and those from the operator's cab located outside the cable crane, and then transmits these signals to the transfer car by radio.

(3) Transfer car control panel

Based on the command signals received by radio and the information from the sensor mounted on the transfer car body, an unattended operation can be carried out. The operating state of the transfer car is transmitted by radio to the control center.

2-3 Functions

(1) Selection of concrete discharge mode

The dumping speed of the transfer car vessel is designed so that it varies depending on the load (concrete or mortar), and that can be changed over at any time with the transfer car vessel being at the control center.

(2) Work suspension

When the operation is to be suspended during unattended operation, the system can be stopped or resumed at any time from the control center, or from the operator's cab outside the cable crane.

(3) Emergency stop

While operating automatically, the transfer car can be stopped in an emergency by the following procedure:

① Detection of any foreign object entering the track when the transfer car is travelling on the track.
② Detection of abnormalities by the various types of sensors mounted on the transfer car body.
③ Pressing the EMERGENCY STOP switch mounted on the control center, the operator's cab outside the cable crane and the track.
④ Pressing the EMERGENCY STOP switch mounted on the transfer car body.

3. Concrete bucket remote opening/closing system

3-1 System overview

This system is provided with a cage at the hook block of the cable crane. Inside the cage there are a computer, a radio set, etc. The system is so designed that the remote-controlled discharge of concrete at the deposit place is carried out from a remote control switch (Photo 2).

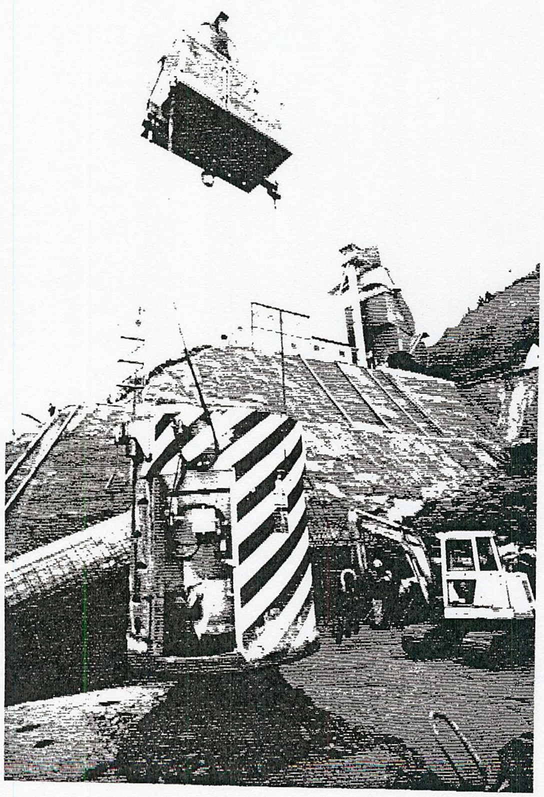

Photo 2 State of concrete deposit

3-2 System configuration

Fig. 4 shows the system configuration.

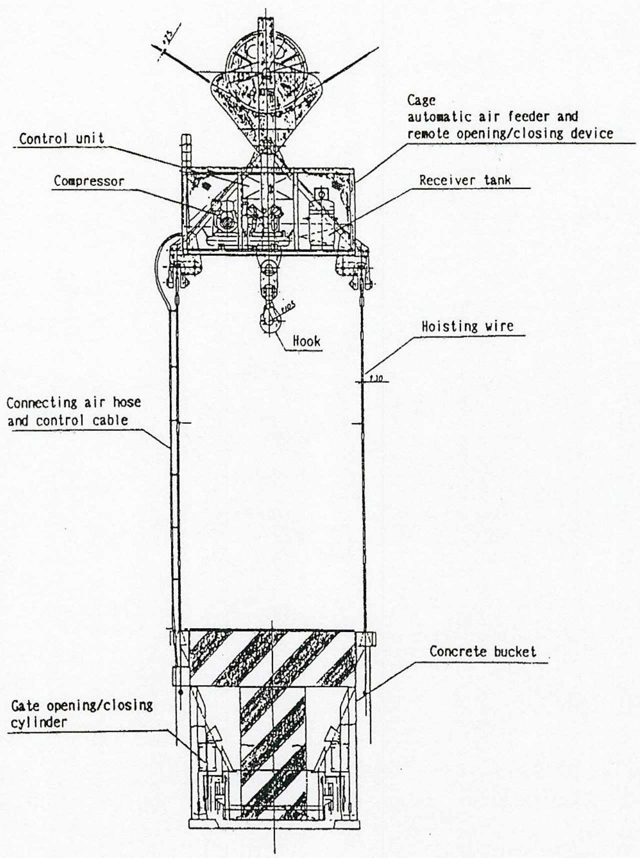

Fig.4 Configuration of concrete bucket remote opening/closing system

(1) Air feeder

The air compressor located in the cage is started up when work is commenced, and connected through an air hose to the gate opening/closing cylinder.

(2) Control unit

This control unit is also located in the cage. It is designed to receive a gate opening/closing signal to manipulate the opening/closing of the bucket by the remote control switch at the concrete deposit place.

3-3 Functions

(1) Safety measure

A safety measure is provided so that the control panel is operated by the remote control switch only when the bucket at the concrete deposit place has approached within the predetermined distance. When the control panel is not in operation, it does not receive the opening/closing signal. This measure prevents the opening or closing of the gate by erroneous manipulation resulting from the falling of the remote control switch or other mishandling.

(2) Openig/closing modes

The opening or closing of the gate is carried out by transmitting the opening/closing signal following selection of the appropriate Opening/Closing Mode.

With Mode 1 selected, the gate is kept open as long as the opening/closing switch button is being pressed, and with the mode released,the gate closes. This mode is for ordinary concrete depositting.

With Mode 2 selected, the gate repeats jogging as long as the opening/closing switch button is being pressed. This mode is for placing mortar, or concrete around the form work or structure.

As above, the opening or closing of the gate can be conducted by only one worker at a point away from the bucket. Attaching or detaching the air hose is also be unnecessary.

4. Centralized management system

4-1 System overview

This system is designed so that the control center located in the batching plant operation room gives control commands, performs operation monitoring, the diagnosis of abnormalities throughout the system, and gives necessary commands.

4-2 System configuration

The programmable controller performs the input/output and calculation of operation related control signals. A personal computer is provided as a machine interface for pictures and displays.

4-3 Functions

(1) Monitoring of operating conditions

This system determines the real-time operating conditions of both the transfer car and the concrete bucket.

(2) Diagnosis of abnormalities

The diagnosis function for system faults shows malfunctioning areas, and displays appropriate pictures.

(3) Remote monitoring

By providing an extended communication cable, the progress of concrete depositing work can be monitored at offices etc., thereby facilitating control of operations from a distant place.

5. The System's concrete construction achievements

5-1 Place of the system actually used

Dam name : Tonami Yamada River Dam (at Jyohana-cho, Higashi Tonami-gun, Toyama prefecture)
Dam type : Gravity concrete dam
Dam height : 59.0 m
Crest length : 216.5 m
Volume of dam: 137,400 m^3

5-2 History of concrete placing and system operation (as of December 1989)

First concrete placed : August 2, 1988
Accumulated volume of concrete placed : Approx. 110,000 m^3 (unoperative for 2.5 months in winter)
Total operation time : Approx. 2,700 hours

5-3 Maintenance

Periodical maintenance and servicing is required, although limited to extremely general practice. This advantage is attributable to the personal computer which diagnoses faults and provides proper, responsive countermeasures, thereby eliminating the need for technicians on staff and minimizing the influence of system malfunctions on the concrete placing operation.

5-4 Safety

The introduction of this system achieved ① unattended work around the track, ② the elimination of working directly under the suspended load and ③ the elimination of worker error, hence improving by far the safety of the concrete transit and placing operation.

6. Conclusion

The construction industry will face increasing, more acute problems such as the aging of workers, the improvement of working conditions, and the improvement of the working environment. As one of the methods of solving these problems, expectations held for "construction robots" are considerable, and greater safety and more labor-saving are demanded. Based on the abovementioned construction achievements, we will aim at an integrated automation of entire dam construction plants.

7. Reference

T. Mori, Oct. 1989, 'Automatic Concrete Transit System at the Tonami Yamada River Dam Construction Site', the Mechanization of Construction, pp 41-45