

Automation and Robotics in Construction:
State of the Art in Finland

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ABSTRACT

The thrust area of Finnish construction automation is concrete technology and the related construction business. Also heavy duty manipulators and mobile on site robotics are developed. National projects aiming at better productivity in construction business are underway.

1. INTRODUCTION

Decreasing demand in construction has reduced construction R&D activities in Finland. However the active governmental technology policy and the concrete component prefabrication have contributed automation and robotics in the construction business.

The degree of prefabrication in Finland is one of the highest in the world, therefore the main emphasis is focused on automation of component manufacturing and on the information transfer. In short series the flexible production automation and information systems are key elements for profitable construction business.

The governmental technology policy has been activated during the 1980's, and several national programmes have been started. These programmes have an important enabling role.

2. MECHANISATION, AUTOMATION AND ROBOTIZATION IN CONSTRUCTION

2.1 Construction Materials Industry

Large construction material component firms have been rather active in product and process development.

Partek Concrete Ltd has started an "Automated Factory Concept (AFC) Development Program" where the goal is to develop through material and technology innovations new techniques, where large building components made of concrete or like material can be profitably manufactured in short series with flexible production automation and information technology observing a Total Quality Management (TQM). This project will take several years and over fifty million Finnish marks to be completed.

Earlier they have developed a system for designing and constructing prefabricated concrete facades with detailed decorations or sophisticated three dimensional shapes.

Partek Concrete Ltd has also taken into use an Acman-System in production of precast concrete. The planning of elements is performed in a CAD-system. The data for preparing the moulds of precast elements is then transferred to the Acman-System. Before casting the Acmeter Prog. 3D-measuring device, is used to guide the part fabrication and mould assembly, and after casting for quality control. By using the Acmeter hand computer the operator can rapidly show the points for part fabrication and mould assembly. The aim is to increase measure accuracy and throughput of precast concrete elements.

Lohja Corporation is the leading partner in the EUREKA project "Mechanisation of brick laying technology on the building site", where the aim is to improve competitiveness of the brick laying occurring on the building site. A new brick laying system including on a track moving brick laying platform, hoisting equipment and conveyors as well as different auxiliary tools has been developed. All the equipment the bricklayer needs in his work are on the deck which is also a transport container for all the equipment. The system is based on contemporary scaffolding solutions and simple mechatronic components. A prototype of this new system has been tested on a building site, and experiments are encouraging; productivity is increasing and ergonomics improving.

2.2 Research Organisations

The Technical Research Centre of Finland (VTT) has done research on construction robotics and automation for years. The mobile tiling robot and its platform are described in references 8, 9. The automation in the concrete component factory has also been studied 10. The research was focused on the development of flexible manufacturing automation for prefabricated concrete facades in short series production. The themes include examination on the data transfer system in the production of prefabricated concrete facades, production line solutions for prefabricated concrete facades, and as a practical application a robotized tiling of outsides of the prefabricated concrete facades in short series production. In the applied research the tiling of the prefabricated concrete facades was started as a simulation study, and in the experimental part a

domestic NSR-10 robot was used. Experimental cases include the laying of tiles on the bottom of the mould by using clinker or brick tiles, on the surface of the concrete cast and on the surface of the hardened wall in upright position. Results are basic in their nature, but rather promising both technically and economically.

The applicability of 3D measurements in construction has been investigated in Ref. 5. On the bases of this and earlier crane automation studies⁴ a project on robotization of frame erection is now been launched by VTT. In this experimental research CAD data is used in the erection of pillars with an automated crane. Positions of pillars are measured with an advanced 3D measuring unit. The exact position of the erected pillars are transferred back to the CAD system which automatically calculates new dimensions for the wall elements according to the erection. Facades are manufactured according to the advises given by the CAD system. In the erection of wall elements the 3D measuring unit is again utilised. In future the Acman-System of Partek Concrete Ltd can take the advantage of this research in their production.

Materials handling in unstructured or dynamic environment requires more intelligent behaviour from the manipulators than current robots can provide. Intelligence is needed in adapting to continuously changing situations. Information on such changes during task execution is obtained by sensors. VTT together with the Oulu University is carrying out a project where the main goal is to develop an integrated control method for intelligent autonomous machines and verify its suitability with a proper loading manipulator. The control scheme is based on a hierarchically organised set of Planning-Executing-monitoring (PEM) cycles. Every PEM cycle is a goal-oriented module, which consists of three generic activities - planning, executing, and monitoring - and a separate meta control mechanism, which takes care of the control of generic activities inside a PEM cycle⁶. The project is currently in its pilot stage. Results of this "Machine of the Future" -project can be applied in machines working on construction sites.

A six legged walking machine for research purposes in outdoor environment is been performed by VTT and Helsinki University of Technology. Legged locomotion provides certain clear advantages when considering vehicle movement in uneven natural terrain. When compared to more classical wheeled or tracked locomotion the legged machines can step over minor obstacles and thus obtain a much smoother movement. The project aims to develop and test the fundamental properties needed for a six legged work machine capable to move in typical forest environments including steep hills. In the project a test bed, called MECANT I, has been designed and constructed³. In future walking machines have advantages over wheeled ones also in the construction site.

3 ENABLING PRACTICES AND TECHNOLOGIES

3.1 National Research Programmes

During the 1980's, a bunch of development projects with wide participation have been initiated in Finland in order to create the necessary basis for a second wave of industrialisation of construction. The projects have been realised in the national research programme "Industrialised Building Technology", initiated and co-ordinated by the Technology Development Centre (TEKES)¹.

The national RATAS project aims at defining the basic structure of the computing environment of the construction industry. The long term goal of the RATAS project is computer integrated construction based on a building product model. This development is seen as a necessary complement to the changes in the construction process and in the building system¹.

The project for construction quality system has been launched by TEKES. A quality infrastructure will be developed so that it will meet the requirements of ISO 9000 and so that the quality system of individual companies will work as a part of the whole system.

3.2 Co-operative Research by Construction Companies

The Federation of Finnish Building Industry, where practically all construction firms are members, has established a system of co-operative R&D. This has been motivated by the big number of small and medium sized companies, which cannot easily start their own R&D activities.

A number of research committees, nominated by the Federation, initiate and fund contract research projects, carried out by VTT, universities and consultants. The major research themes are codes and information files, construction management systems, production technology, product development and personnel development.

One such a programme is the "Logistics of Construction Production". Since construction industry has been developed towards the direction, where the work on construction site is decreasing and that of prefabricated parts and components is increasing. As a result of this the industrialisation of construction has increased logistics costs. Therefore "Logistics of Construction Production"- programme has been launched. This programme is divided into four parts: Supervision of the design of construction project from the logistics viewpoint, development of the logistics on the construction site, purchasing business and product group related logistics. The programme is co-ordinated by the Finnish Federation of Building Industry. The research work is carried out by VTT, universities, consultants and trade.

4 CONCLUSIONS

Activities related to automation and robotization of the Finnish construction industry have been underway for several years. Still construction robotics is in its infancy, and practical applications are scarce and the number slowly increasing. Anyway, it has been recognised the need of advanced automation and robotics in construction.

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