# The Development of a Robot for Paving Floors with Ceramic Tiles

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**ABSTRACT:** In 1997 a development project was started aiming on mechanisation of the process of paving floors with ceramic tiles. Together with a number of companies from The Netherlands, Germany and Belgium and with additional funding from the European Commission the project was carried out by A+ innovations in co-operation with the Eindhoven University of Technology, Department of Architecture, Building and Planning. The development was based on an analysis of the traditional tiling process and includes a range of devices for several stages of the tiling process.
This paper includes a short overview of the total development. More particular it focuses on the core development: the tiling robot. Several concepts are discussed. This holds for the robot device but also for the carriage, the software and the control. A special aspect was the necessity of 'forward tiling'. As a consequence the robot has to move over the tiles that have been laid just a minute ago. It is evident that this approach is critical for the mortar bed. Also the development of a mortar bed was part of the development.
Finally conclusions are drawn:
Apart from the deliverables of the project, which implies a.o. a working robot also conclusions have been drawn regarding the main success factors.

- The development is based on a market problem;
- The development is structured by experience with product development;
- The market (tiler) was involved in the development, especially during the definition phase and in testing situations;
- The commitment and drive of the participants

**KEYWORDS**: Automation, Ceramic tiles, Development, Robot, Success factors.

## 1. INTRODUCTION

On basis of market needs a development project was set up in order to achieve a degree of automation and robotizing in the field of paving floors with ceramic tiles. The project was funded by a number of companies and the European Community under the industrial & Materials Technologies Programme (Brite-EuRam III). The development was carried out by A+ innovations in co-operation with the Eindhoven University of Technology, Department of Architecture, Building and Planning and a key contribution of Kranendonk Production Systems and Hilhorst Tegelwerken.
This paper presents the present achievements of the development, as well as the status quo and future developments.

## 2.TRADITIONAL TILING MARKET

Floor covering with ceramic tiles has been applied since about 3,000 years before Christ.
Naturally an evolution took place for the ceramic tile as well as for the mortar bed and the processing. The present market however is changing so much that in fact one can regard the traditional paving technology as out of date:

- the technology is labour intensive;
- the market for tile floors is under pressure by the high prices, a.o. because of the dependency of labour ;
- tile floors are ousted from the market by floor coverings from a minor quality, which affects the quality of building;
- labour circumstances for the tiler are very bad (about 10% of the tilers is disabled before they are 52 years old);

- because of the bad labour circumstances the attraction of the tiler-profession is decreasing and the problem of finding professional tilers is increasing.

For the above mentioned reasons it is obvious that structural changes have to take place to supply the market in the future with tile floors, as no alternative exists for tiles with the same performance.

Analysing the labour in tiling activities the work can be divided into three main activities:
a. Spreading and levelling the mortar;
b. Placing the tiles;
c. Finishing (levelling, tightening, joint filling).

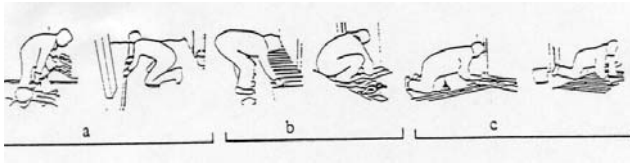


*Figure 1. Tiling labour*

It is obvious, that this development is also very important for the future of the ceramic industry.
All over Europe tiling is a very well accepted technology and tiled pavements are beyond any alternative. Europe is a typical ceramic area (world leader). Countries like Italy, Spain and Portugal do have a strongly developed ceramic industry, which is still very prominent all over the world. Also countries like Germany, France, UK and The Netherlands have industries with an international reputation.
The total production of ceramic tiles in the European Community is about 780 million $m^2$ (which is more than 50% of the total output in the world. From this production about 21% is exported, whilst about (strongly increasing) 13.5 million $m^2$ (= about 2%) is imported.
Yet the industry is threatened by a strong competition from countries outside Europe, the market for ceramic pavements is under pressure, not only by the negative health-reputation of the tilers, but also by the decreasing competition possibilities in comparison to pavements from countries with low wages like Brazil, Taiwan and China and other materials for floor covering (coatings, PVC, laminates, et cetera).
The participants in the project were interested to extend the applications of new technologies in view of better working circumstances and better competition possibilities. This on a co-operative basis with the tile industry and the machine builders.

## 3. DEVELOPMENT PROGRAMME

The development programme was aiming at a total solution for the tiling profession and consisted of work packages.

**WP 1 Preparatory arrangements.**
In this work package an analysis was made of the tiling practice and the requirements in different building projects, especially the projects suitable for automation. These are mainly projects with large surfaces such as railway stations, commercial buildings, garages, industrial buildings, warehouses, etc.
Especially requirements concerning the strength, the flatness, the slope, the integration of gutters, flexible joints, studs, etc. ware subjects of this analysis.

**WP 2 Development of a device to transport and rule the mortar bed**
The work in this work package originally concentrated on modifying an existing machine of Drion Constructie BVBA for on site producing of concrete cycle-paths.
Under pressure of WP 3 however it was decided to focus on the tiling robot and postpone the development of this device.
Nevertheless the work in this work package regarding the development of a suitable mortar bed was quite essential for the success of WP 3. As can be seen hereafter de design was based on a device moving on top of the floor shortly after being placed. This was considered to be a very critical factor for the quality of the mortar bed. The University Eindhoven performed a research programme in order to develop a suitable mortar bed.
As a spin off in the frame of this WP a device to rule and level the mortar bed was developed and adapted.

**WP 3 Development of an expedient to pick and place tiles**
In the frame of this WP it was foreseen, that possible adaptations of tiles had to be realised. These adaptations refer mainly to control the tolerances of ceramic tiles.
The main part of this work package however was the pick and place device, which during the development process was developed as a robot. (see here under).

**WP 4 Finishing device**

This work package was focussing on the development of a vibrating plate in order to compress the mortar bed, to suture the tiles and to level the floor. This device was developed as a stand alone tool.

**Robot**

This paper focus on the development of the tiling Robot. WP 3 however was originally not aiming on a robot design. The first conceptual design for a device for picking and placing tiles was based on a hand controlled device. This device should have been able to pick up about 1 $m^2$ of tiles in one movement. However manipulating with this weight turned out to be difficult. It should be kept in mind, that the pallets with tiles had to be carefully prepared in the right pattern and no disturbance could be allowed.

Another problem was, that the device had to be installed on a fork-lift truck. Due to the weight this concept was to work according to the withdrawing principle and therefore to drive over the unfinished floor. This was causing inaccuracy but also a logistical problem, since the mortar bed had to be realised inbetween.

These problems prevented the possibility of a substantial reduction of labour.

On the moment that it was clear, that the device had to move over the tiled surface and a special carriage had to be developed it became attractive to reconsider the total concept.

After about one year of development the first two designs for a robot based concept were made.

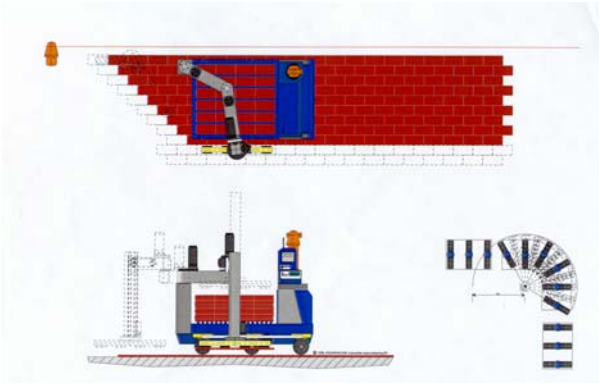

*Figure 2. Original Robot design*

The total concept is based on a robot which is positioned on a carriage which is able to move forward and backward and also is able to turn without causing frictions on the tiled floor.

The robot is able to pick and place one to four tiles in one movement.

On the carriage there is also space for a limited stock of tiles. An additional satellite shuttle carriage will provide the robot with sufficient tiles.

On the back of the carriage also the power unit has been installed.

The device can be semi hand controlled or completely be automated. Finally the project is aiming at a sensor controlled configuration. By laser technology the robot holds contact with reference points installed in the hall in order to continuously calibrating the position of the robot.

Part of the concept is also a preparation station with a robot that will be able to sort tiles and to prepare pallets with certain patterns of tiles. In the preparation station also the satellite shuttles will be supplied.

This part of the concept is not developed yet. Meanwhile Röben Tonbaustoffe GmbH is prepared to supply the tiles pre-sorted on suitable pallets.

Critical factors in the development were the software development in relation to the necessary accuracy and velocity and the development of the carriage.

For the carriage for example, three prototypes were developed.

## 4. RESULTS

After a development period of about five years most of the aimed developments are established.

- A device for ruling and levelling the mortar bed;
- A device for tightening the mortar bed, to suture the tiles and to level the floor;
- A mortar design which is characterized by a high stability short after producing;
- An improvement of the accuracy of industrial tiles was established;
- A suitable method for palletising and transporting tiles was developed;
- The tiling robot was developed.

Apart from the deliverables of this project, the author was also interested in the project as a case study in the frame of an analysis of success and failure agents in product development.

The main success factors in this project are:

- The development is based on a market problem;

- The development is structured by experience with product development;
- The market (tiler) was involved in the development, especially during the definition phase and in testing situations;
- The commitment and drive of the participants;

*Figure 3: Tiling robot (1)*

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*Figure 4. Tiling robot (2)*

## 5. FUTURE DEVELOPMENT

The co funding of the European Commission came to an end achieving the robot in the status as shown on figure 3 and 4. Due to the European policy the Commission do not wish to participate until the end of development (only pre competitive development).
This was the situation in 2001.
Ever since a lot of effort has been made to improve the velocity of the system.
At this very moment the system is able to realize 20 $m^2$ of floors per hour.

The original purpose was to develop a robot exclusively for the Hilhorst company. Meanwhile plans have been made to bring the concept to the market as a product. Under the name IKASK the product will probably be introduced in 2004.
By a market introduction in view, the development again is accelerating right now. In the next year the sensor control and the satellite shuttle will be developed. The development of the preparation robot will follow short after introduction. Especially this development and the market introduction approach will depend on the availability of venture capital and partners and agents for other market areas.

The benefits for the participants are that they will maintain their existing market and extend this and that they will enlarge their working area by cost savings per m² (competition possibilities). By mechanisation of the labour and the cohesive costs, participants will have the possibility of extending their working area and also improve the quality and lighten the working circumstances.
In the working area an extra potential market of at least more than 1 million m² can be achieved.
With a share of 10% this means an extra turnover of about € 3,500,000.- every year for the SME participants.
For the ceramic industry it is to be expected that they will enlarge their market with at least 20-30% (150-200 million $m^2$; turnover € 3,000-4,000 x $10^6$. The increase can be achieved by new special products that are suitable for export and that can compete with other floor coverings.

## 6. CONCLUSIONS

Apart from the deliverables of the project as been discussed, some conclusions can be drawn regarding the success factors in the development process.

- The development is based on a market problem;
- The development is structured by experience with product development;
- The market (tiler) was involved in the development, especially during the definition phase and in testing situations;
- The commitment and drive of the participants;

## 7. REFERENCES

Lichtenberg, J., Segers, S., 2000, *Mechanisation of Ceramic Tiling*, End report EC Contract no BRST-CT98-5238, Project no: BES2-2676