

DETERMINANTS OF VISUAL CONTROL IN THE PRODUCTION OF PAVING STONES

Abstract: The chapter presents the characteristics of the research company, which produces paving stones and concrete gallerie. The subject of research - paving stones and the manufacturing process in technological aspect and types of visual control during the production process of paving stones was presented. In the research part an analysis of one set of factors of BOST questionnaire was presented. This set of factors is connected with 7th Toyota management principle and concerns the most important factors in visual control. It also presents the characteristics of respondents, indicated in BOST questionnaire as an area E12. The results were shown in the form of histograms.

Key words: paving stone, manufacturing process in technological aspect, BOST questionnaire, 7th Toyota management principle, visual control, respondents characteristics

10.1. Characteristics of the subject and the object of study

The subject of research is the company, which produces paving stones and concrete gallerie. Products, manufactured by the company, are compatible with Polish standards and are characterized by high strength, resistance to frost and fire resistance.

Paving stone is a structural element, which is made of non-reinforced concrete by method of pressing. It is intended for road pavements, parking lots, driveways, yards or roads in recreational or sports objects. The advantage of paving stone is the multiplicity of its forms and shapes, as well as high durability, the ability to re-be built after the demolition and lower cost comparing it with natural stone or fired clinker road.

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Paving stones can be produced (depending on the technology) from one or two layers of concrete. Paving stones with one layer of concrete due to the one used type of concrete are produced faster than paving stones with two layers, however, their production should be used concrete mixes with a higher point sand (result is an increase in the consumption of cement) and should be stained the entire mass of the concrete (increased consumption of dye). Paving stones consisting of one layer of concrete have also less esthetic appearance. Two layers paving stone is a paving stone, where the top layer should have a thickness minimum 5 mm and should be connected with the bottom layer – structural.

Paving stones can be square, rectangular or hexagonal, there are also other forms as well as the copular and cover paving stones. The surface of paving stone is profiled and dyed. The basic color is gray, which results from the color of cement, but paving stone may be dyed different colors and shades.

For the production of paving blocks are needed:

- portland, siliceous and slag cements,
- fine aggregates sand and fractionated, gravel-capsular and broken aggregates,
- chemical additives,
- mineral supplements,
- pigments,
- water.

10.2. Manufacturing process of the paving stones in technological aspect

Manufacturing process of the paving stones in technological aspect (BORKOWSKI S., ULEWICZ R. 2008, BURCHART-KOROL D., FURMAN J. 2007, DURLIK I. 1993) is presented on the Figure 10.1.

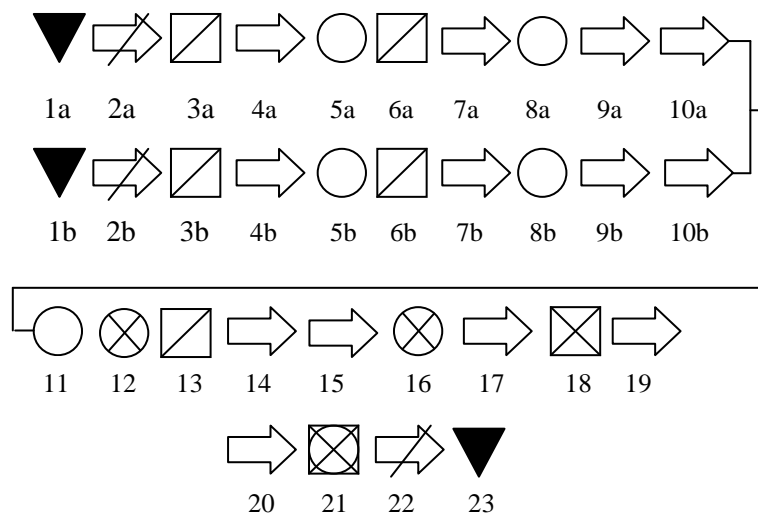


Fig. 10.1. The scheme of manufacturing process of the paving stones in the technological aspect

Source: own study

Characteristics of manufacturing process of the paving stones (BORKOWSKI S., ULEWICZ R. 2008, DURLIK I.1998, BURCHART-KOROL D., FURMAN J. 2007):

- 1a.Storage of sand and gravel needed for the production of structural layer of paving stones.
- 1b.Storage of sand, basalt and fine aggregates needed for the production of top layer of paving stones.
- 2a.Sand and gravel transport to aggregates tanks.
- 2b.Sand, basalt and fine aggregates transport to aggregates tanks.
- 3a.Control weight of sand and gravel (using weights that are in a wheelchair), using a microwave probe (this allows for correction of the recipe, to the amount of added water, raw materials).

- 3b. Control weight of sand, basalt and fine aggregates (using weights that are in a wheelchair), using a microwave probe (this allows for correction of the recipe, to the amount of added water, raw materials).
- 4a. Transport of raw materials (sand and gravel) charging car into a pan mixer.
- 4b. Transport of raw materials (sand, basalt and fine aggregates) charging car into a pan mixer.
- 5a. Mixing sand and gravel in a mixer.
- 5b. Mixing sand, basalt and fine aggregates in a mixer.
- 6a. Humidity control of concrete mix (using a line probe, which is located in the pan mixer).
- 6b. Humidity control of concrete mix (using a line probe, which is located in the pan mixer).
- 7a. Cement transport from a silo using a screw conveyor, chemicals, pigments and water to the mixer.
- 7b. Cement transport from a silo using a screw conveyor, chemicals, pigments and water to the mixer.
- 8a. Production of concrete mix.
- 8b. Production of concrete mix.
- 9a. Concrete mix transport the structural layer from pan mixer to the bucket with lid.
- 9b. Concrete mix transport the top layer from pan mixer to the bucket with lid.
- 10a. Transport of bucket with concrete to the molding machine (concrete block machine).
- 10b. Transport of bucket with concrete to the molding machine (concrete block machine).
- 11. Connecting the structural layer and top layer using a molding machine.
- 12. Production of paving stones in concrete block machine.
- 13. Current initial control on the position.

14. Transport of production plates with manufactured paving stones, using the feeder chain to the stacking machine.
15. Transport of production plates with manufactured paving stones from stacking machine to the ripening.
16. Ripening of the finished product in the dryer, duration 24 hours.
17. Transport of production plates with manufactured paving stones from ripening to the destacking machine.
18. Final control on the position.
19. Transport with manufactured paving stones using feeder chain on the production plates to the paletizer.
20. Transport of paving stones with paletizer on the packing position.
21. Visual control of the compatibility number of layers and packaging of paving stones on transport pallets.
22. Transport paving stones with using forklift to the store.
23. Storing of final products.

10.3. Control in the manufacturing process of paving stones

After connecting structural layer with a top layer using a molding machine and production of paving stones in concrete block machine, the current control is made, by checking:

- height of paving stones (using caliper),
- humidity of paving stones (if paving stones don't absorb water),
- if paving stone has closed, sealed with cement grout exterior surfaces,
- if paving stone has specific slides on the side surfaces and the "goose pimples" on surface finishes,
- if paving stone hasn't jagged edges of the upper surface,
- if paving stone has adequate density - after break you can see fragments of irregular aggregates cubes, it means that the product will be a little tough and brittle; a product of good density should break together with the aggregate contained therein.

Final inspection of paving stones instead, is made, by checking:

- if paving stone hasn't cracks and surface cracks,
- if paving stone hasn't stains and dirt, which cannot be washed off with water,
- if paving stone hasn't jagged edges of the upper surface,
- uniformity of the surface texture of paving stones,
- color unevenness of paving stones,
- concavity and convexity of paving stones,
- tensile strength at splitting of paving stones,
- absorption of paving stones,
- frost resistance of paving stones - tests for freeze/thaw with the participation of de-icing salts,
- abrasion resistance of paving stones - measuring the wear on the disc or by Boehme wide abrasive wheel, depending on the type of surface.

10.4. Presentation of the results of the selected set of factors in the BOST questionnaire

In the company, which produces paving stones and concrete gellanry among 33 production workers, BOST questionnaire was conducted (BORKOWSKI S. 2012a, BORKOWSKI S. 2012b, BORKOWSKI S. 2012c). For the detailed analysis set of factors (BORKOWSKI S., JAGUSIAK-KOCIK M. 2011, BORKOWSKI S., JAGUSIAK-KOCIK M. 2013, BORKOWSKI S., KRYNKE M., INGALDI M. 2012, JAGUSIAK M., ULEWICZ R., ŚWIDER A. 2009, ULEWICZ R., MAZUR M., KNOP K. 2012) related to the 7th Toyota management principle (LIKER J. K. 2005) was selected. Respondents were asked to answer the question: What is the most important element in a visual control? In the box, enter 1; 2; 3; 4; 5; 6 (6 most important factor).

CS		Cleanliness, order
EP		Flow
TI		Information boards
UP		Participation in production
ME		Monitoring
GW		Graphical presentation of results

In addition, the analysis of the respondents features, indicated in the BOST questionnaire as an area E12 was made. Figure X.2 shows the percentage characteristics of the respondents features of the company producing paving stones and concrete gallerie, due to:

- gender (MK) - 1- man, 2- woman,
- education (WE) – 1 - basic, professional, 2 - secondary, 3 - higher I (first degree), 4 - higher II (second degree and higher),
- age (WI) – 1 - below 30 years, 2 - 31÷40 years, 3 - 41÷50 years, 4 - 51÷55 years, 5 - 56÷60 years, 6 - 61÷65 years, 7 - over 66 years,
- job seniority (SC) – 1 - to 5 years, 2 - 6÷10 years, 3 - 11÷15 years, 4 - 16÷20 years, 5 - 21÷25 years, 6 - 26÷30 years, 7 - 31÷35 years, 8 - 36 years and more,
- mobility (MZ) – current employment is a place of work: 1 - first, 2 - second, 3 - third, 4 - fourth, 5 - fifth, 6 - sixth,
- mode of employment (TR) – 1 - regular, 2 - transfer, 3 - finance.

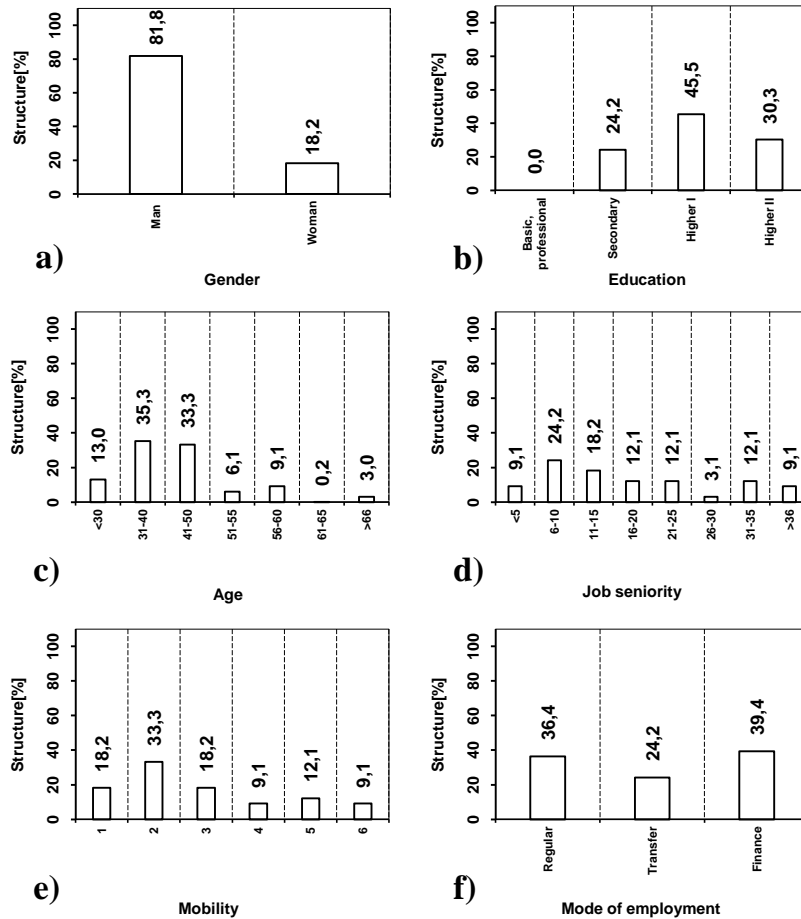


Fig. 10.2. Histograms. Characteristics of respondents with consideration of: a) gender, b) education, c) age d) job seniority, e) mobility f) mode of employment. It concerns the production of paving blocks and concrete gallyntry

Source: own study

In the research company, by gender (Fig. 10.2a) dominated men (81.8%). By analyzing the characteristics of the respondents including

education (Fig. 10.2b), you will notice that the largest group are the employees with higher education I (45.5%), and the second and third group of the cardinality group are workers with higher education II (30.3%) and secondary education (24.2%). The next histogram shown in Figure X.2c shows that the largest group are workers in age 31 to 40 years (35.3%) and 41-50 years (33.3%). Employees under the age of 30 years account for 13% of respondents. Under the terms of job seniority (Fig. X.2d) the largest group of employees are the employees with job seniority from 6 to 10 years (24.2%) and from 11 to 15 years (18.2%). For 33.3% of the respondents research company is the second workplace, and for 18.2% of the respondents is the first or third job (Fig. 10.2e). Due to the mode of employment (Fig. 10.2f) majority of respondents (39.4%) was adopted to work due to better financial conditions.

10.5. Conclusion

Next figure 10.3 presents an analysis of distribution of evaluations for the set of factors, which describe the 7th Toyota management principle.

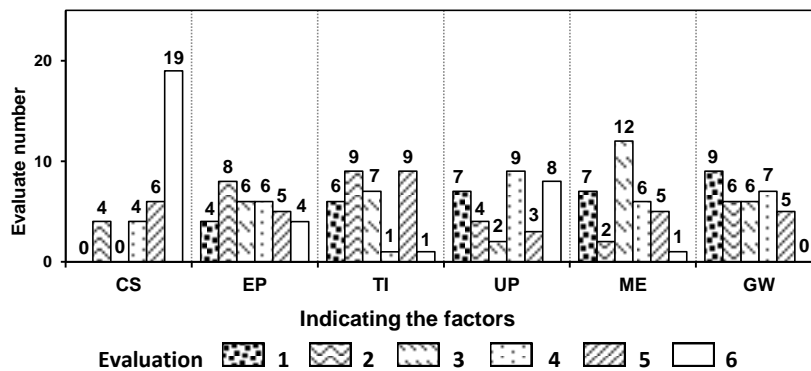


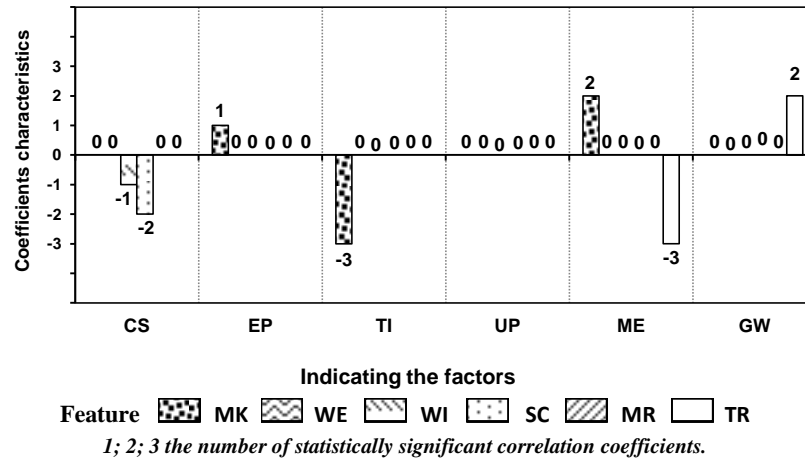
Fig. 10.3. 7th principle. Analysis of distribution of the evaluation of the factors from E7 area. It concerns the production of paving blocks and concrete gallyntry

Source: own study

The figure 10.3 shows that for the respondents from the company produces paving stones and concrete gellantry, a factor *cleanliness, order* (CS) is the most important type of visual control. It demonstrated by the large number of votes cast for the highest “6” evaluation and the lack of votes on the “1” evaluation. On the figure 10.3 we can see also that 8 respondents rated the factor *participation in production* (UP) as important type of visual control, but in this case the lowest “1” evaluations admitted until 7 respondents. On the other hand, the factor that respondents assessed as the least important type of visual control is *graphical presentation of results* (GW). Respondents did not admit to this factor the highest evaluation “7”, and as many as 9 respondents considered this factor as the least important type of visual control, giving an “1” evaluation.

The next figure 10.4 presents a summary of the results of correlation analysis to determine the impact of the characteristics of respondents on the importance of factors describing the 7th Toyota management principle.

Between evaluations of *flow* (EP), *information board* (TI) and *monitoring* (ME) factors and feature gender exists a relationship. In case of *flow* (EP) and *monitoring* (ME) factors this relationship is positive respectively at $\alpha = 0.2$ and $\alpha = 0.2$ and $\alpha = 0.1$ level, while in case of *information board* (TI) factor this relationship is negative on the level of $\alpha = 0.2$, $\alpha = 0.1$ and $\alpha = 0.05$. Between the evaluations of *cleanliness, order* (CS) factor and an age feature exists a negative correlation on the $\alpha = 0.2$ level. Between the evaluations of this factor a negative correlation on the level of $\alpha = 0.2$, $\alpha = 0.1$ and $\alpha = 0.05$ and a job seniority feature was also found.



(+) positive correlation, (-) negative correlation

Fig. 10.4. 7th principle. Summary results of correlation analysis to determine the impact of the characteristics of the respondents on the importance of factors E7 area. It concerns the production of paving blocks and concrete gallertry

Source: own study

The figure also shows that there is a negative correlation on the level of $\alpha = 0.2$, $\alpha = 0.1$ and $\alpha = 0.05$ and positive correlation on the level of $\alpha = 0.2$ between a feature of mode of employment and an evaluations of factors: respectively *monitoring* (ME) and *graphical presentation of results* (GW).

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