A STUDY TO COMPARE THE MOST FREQUENTLY USED PAVING TECHNIQUES IN THE NETHERLANDS

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SUMMARY

On. behalf of the Centre for Research and Contract Standardization in Civil and Traffic Engineering in The Netherlands (C.R.O.W), a workinggroup is working on a report concerning pavingtechniques. Out of a great number of possibilities eight most frequently occurring situations were chosen for a study in order to compare them.
In spite of the limited character of these studies, two materials were taken into account (concrete and burnt clay) and two different blocksizes were used.
Besides that the paving of new work and repaving of existing pavements were compared.
Paving by hand was done from two different attitudes: standing up and on the knees.
Also three pavingtechniques were studied:

paving by hand
laying by hand
mechanically laying.

The comparisons are based on several criteria:

1. The costs of laying expressed in objective data like manhours/m^2
2. The effects of a specific method on the physics of the pavior
3. The quality obtained by each specific method
4. The suitability of a method in connection with the local circumstances and the special demands of the desired pavement.

The results will have their effect on municipal and other authorities, contractors, designers, consulting agencies and educational institutes.

1. INTRODUCTION

In 1990 a study was carried out on eight paving projects (blocks and kerbs). This study was backed up by a workinggroup of the Centre for Research and Contract Standardization in Civil and Traffic Engineering in The Netherlands (C.R.O.W). In these eight projects, six different ways of paving one type of concrete block were chosen and two other projects were related to the paving of smaller concrete blocks and blocks of burnt clay.
These eight projects are very representative for the daily practice in The Netherlands. The aim was to investigate three subjects:

* The labour conditions of the pavior
* The quality of the results achieved in each case
* The production and the costs of each observed technique.

Each pavement has its own characteristics in length, width, connections, details and laying pattern. Each pavement in blocks can be executed on several ways and methods. Besides laying or paving by hand and mechanical laying, each crew of paviors has its own way of doing, depending on the local circumstances. The difference in labour conditions is very substantial for the different methods. Since long time it is known, that paving by hand and especially laying by hand is extremely demanding work. Mechanical laying is much less demanding and therefore must be promoted.

Timestudies during the eight projects have produced a lot of data. The times that were clocked up for all the actions that were observed are produced in detailed calculations for the whole process of paving.
All aspects related to the costs of paving are recorded. Yet it has been rejected to give data about the money and prices involved. This can differ so easy per region, in time and per contractor that this is omitted. The basic data for calculation are given to enable each one to fill in his own appropriate prices. The eight projects have produced very interesting knowledge so far, but there is more to come.

Due to unexpected circumstances the final report is still in progress and under discussion by the workinggroup when this contribution was written. Especially the subject of costs and productivity was not yet ready for publication.
This paper deals with the labourconditions and gives the main conclusions.

2. LABOUR CONDITIONS AND PAVING TECHNIQUES.

2.1 General data

Paving pavers in the field of building is one of the heaviest occupations there is. In The Netherlands about 40% of the paviors is younger than 25 years, 25% is aged between 35 and 55 and a pavior elder than 55 years can hardly be found.
Yearly 15% of the paviors changes their occupation and leaves the building industry. It is estimated, that for the production of one man-year one and a half pavior is needed. Compared to other building workers young paviors are not in proportion suffering from illnesses. Every pavior aged between 45 and 65 years has an average of 70 days of benefit a year. In 60% of the cases backinjuries are the reason for becoming unfit for work permanently.
These figures are at least indicating that the occupation of a pavior has its drawbacks in connection with health and physical condition.
In this chapter attention is paid to the process of paving elements and the human factor in it.

2.2 The process of applying pavingblocks

Before a pavement can be applied the existing toplayer of the subsoil has to be removed and replaced by a layer of sand or a roadbase. In common the material for these layers is brought in with a lorry and roughly spread out and shaped by hand (small sites) or a machine. After compaction of these layers the surface is trimmed to the desired profile by a thin layer (50 mm) of bedding sand. So far the labourconditions are not to demanding for the workers involved in the process.
Then the elements of the pavement to be applied are moved into place at the site by the big lorries of the supplyer of the elements. The moving of the elements within reach of the pavior is done by an assistant In this part of the process the bodily strain of handling the pavers becomes a nuisance, because in most cases it is done by hand.
It is recommended to use tools for this (like a barrow) in order to ease the labour, but in spite of all the measures that can be taken, the work of this assistant is still very demanding when the blocks have to be placed in reach of the pavior by hand.
When the elements are applied with a machine this assistant is not necessary any more while the blocks

can be moved into place by the supplyer-lorry, using prearranged packages of blocks.
Putting the kerbs into place is another very heavy activity during the pavingprocess. In The Netherlands it is now forbidden to carry weights more than 35 kg. So the mechanically placing of kerbs is obligatory. For this purpose excellent machinery is already available and in the near future the handling of these heavy elements by hand will only be restricted to small works where a machine cannot work economically.

Putting the pavers into place by hand can be done on the knees, standing up and sitting on a little stool. None of these attitudes is worse than the other, all three of them are bad for the human body. If the paving is done by hand, which can be the case if complicated patterns are used or on smallscale works, it is recommended to change this paving or laying with other activities during the day in order to achieve some variation in attitude and to prevent physical overloading.
From the ergonomic point of view the mechanically laying of pavers is always in favour of handwork. For technical reasons there are practically no restrictions on using paverlaying machines.
In the case of relaying, a lot can be improved in the process of cleaning the pavers to be reused.

2.3 Weights of daily productions

The total weight of the blocks that is displaced by one man during a day can differ quite remarkably depending on the pavingtechnique that is used. Figure 1 shows the maximum values that can be obtained in theory. These figures are calculated on the basis of the labourstudies mentioned before during the eight works that were chosen.

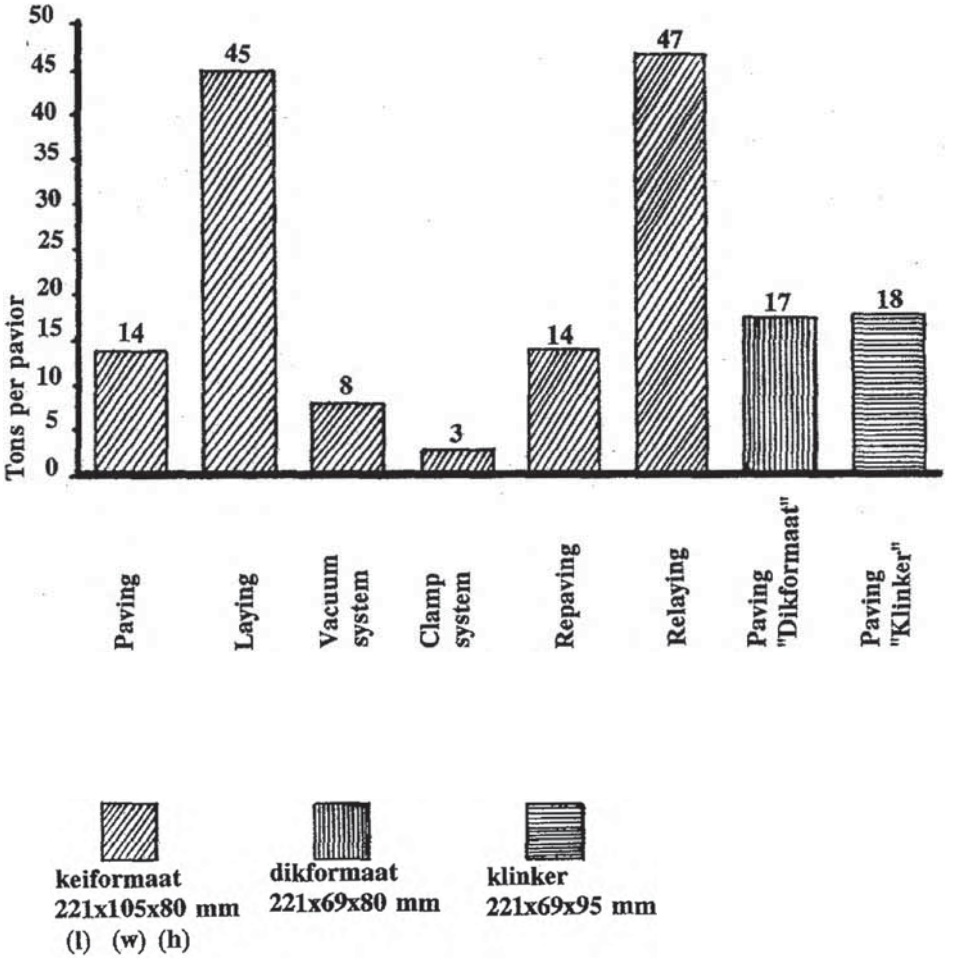

Figure 1: Calculated maximum theoretical weights carried by a pavior in a full day production

On an arbitrary moment of the day a certain activity in the process of laying was observed during a limited time (for instance one hour). This activity can be: cleaning the old pavers to be reused, trimming the sandlayer, compacting the sand, supplying the pavers, laying the pavers, paving the blocks, etc.
As a result of these measurements the daily production can be calculated for each of the eight situations observed by extrapolating the results to the total of the whole day. This means, that if the pavior keeps on working during the whole day with the velocity that was measured in this limited time, the data of figure 1 become reality.
Experienced people know, that this cannot be true and therefore a different approach is chosen.

It is known from practical experience over a long period that the production of a pavior, paving pavers of "keiformaat" by hand estimates about 80 m^2 a day. The dimensions of the "keiformaat'-paver are 211(l) x 105(w) x 80(h)mm, weighing about 4 kg a piece. One square meter counts 44 blocks. The weight of a daily production can be calculated as follows: 80 x 44 x 4 = 14000 kg = 14 tons. This figure corresponds with what is reasonable in practice. A comparison with the amount in figure 1 learns that the theoretical and practical value for this way of paving this kind of block are pretty close the same. The reason is, that the working velocity for paving by hand can be kept up for practically the whole daily working period of 7-8 hours.

Laying by hand is a quite different story.
Again from practical experience it is known, that a fair daily production stops at 125 m^2. For the same type of block this means that the weight of this daily production will be: 125 x 44 x 4 = 22000 kg = 22 tons. This is about 50% of the theoretical value calculated in figure 1 and it shows how dangerous it can be to extrapolate an observed workingvelocity that can only be maintained for a limited time.
The production of square meters of pavement is almost identical for paving and repaving as well as for laying and relaying, estimating approximately 80 m^2 and 125 m^2. These figures are also learnt from practical experience.
This daily production changes when the size of the blocks differs like is shown for "dikformaat" and "klinkerformaat" in the two last columns of figure 1. It is learnt from practice, that a daily production of approximately 60 m^2 in this case is normal for both types of blocks. One square meter counts 66 pavers weighing about 2.8 kg for the "dikformaat", respectively 2.65 kg for the "klinkerformaat".
The weight of the daily production in the case of "dikformaat" is 60 x 66 x 2.8 = 11088 kg = 11 tons.
In the case of "klinkerformaat" this amounts: 60 x 66 x 2.65 = 10494 kg = 10.5 tons. Here also a slight reduction of the theoretical value has to be taken into account, although these calculations arr accurate enough to consider this to be of any significance

Lackcalculating from practice for the mechanical ways of laying is more complicated, but based on experience the results indicate, that there is almost no difference between the theoretical and the practical values. This is true for the vacuumsystem and the clampsystem and causes no surprise. Both types of machine have a steady velocity of working and this is practically maintained during the whole day. The workers that are involved in this way of laying can compete with this velocity while the additional work finishing the paving by these machines is easy to perform.

Taking all this into account, a new diagram can be drawn like is shown in figure 2.
It still must be concluded, that for laying and relaying by hand a pavior is moving about 22 tons of concrete blocks per day. Despite the reductions learnt from practice this still is an awful lot of weight and physically almost unacceptable for human labour. Special tools and machines have to take over.

The development of tools and machines for applying this kind of pavement has been growing very strongly during the last years and it will continue. In 1988 several reports were presented on this subject.

Experiments have now been successful in paving burnt clay pavers mechanically. The reuse of blocks of concrete or burnt clay and flags can be stimulated by the use of machines and special equipment. This has already been demonstrated on a large scale project.

It's for sure that the old fashioned skill of paving always will be needed for special jobs and the laying of special patterns. The machines are there to do the heavy work and to make large productions.

It is very essential that the contractors and purchasers have an open eye for these developments and will stimulate this process.

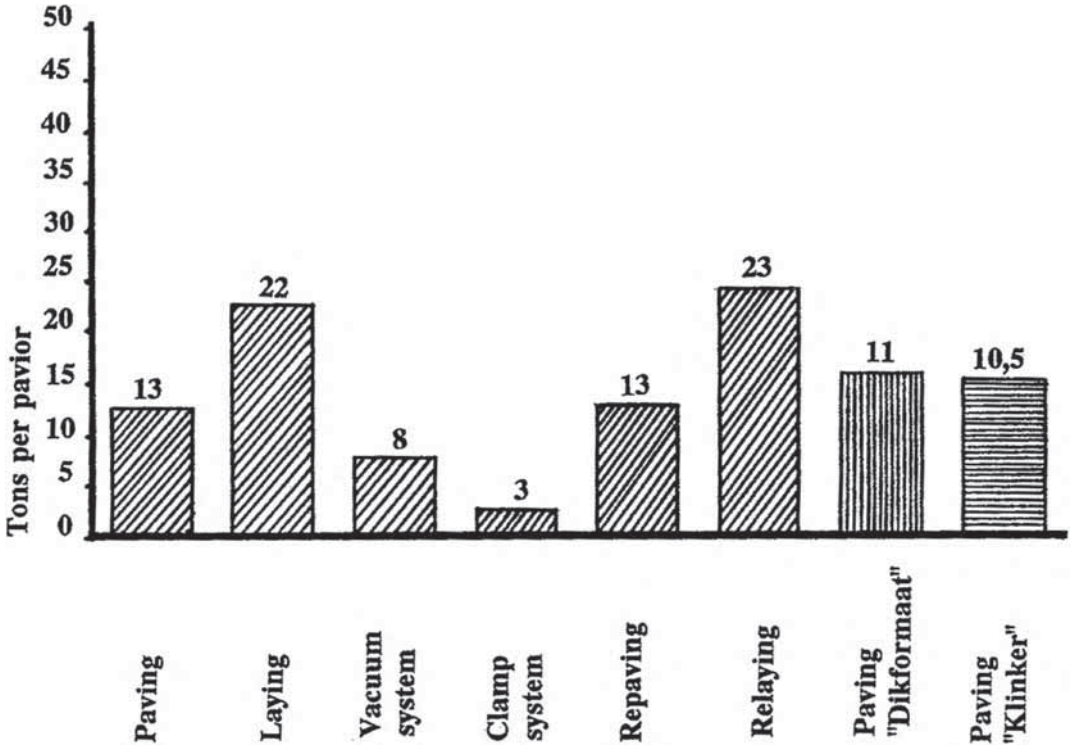

Figure 2: Carried weights in practice by a pavior in a day production

3. GENERAL CONCLUSIONS

Comparing the different paving techniques indicates that if sufficient skill and effort is involved each method can produce a good piece of pavement which can meet the common quality standards. Either with paving or laying by hand or with laying mechanically it is possible to produce an uniform quality.

Every paving technique has its own pro's and contra's. This causes, that each paving technique has a special practise and field of application.

Ergonomical studies have indicated, that there is no preference for the three attitudes for paving: standing up, sitting and on the knees. All three attitudes are a significant overload for the human body.

If for one reason or the other this way of paving has to be carried out during a long time, it is very strongly recommended, that the paving or laying is alternated with other work of the paving process.

In many cases mechanical laying can be a solution to lighten the work of the pavior. From a technical point of view there are hardly limitations on using machines for laying pavers.

Not only the paving of the pavers is a demanding work. Also trimming the sandbed can be a heavy task. This can also be done very easy by using machines. The problem of today is, that machines for this purpose work to fast for the pavingmachine and so they are only economical in very special cases.

It deserves special attention to do the repaving of existing pavements that have to be reconstructed on a big scale. This makes the use of machines economical. For instance in the case of mechanical repaving and with a crew of 5 to 7 workers a daily production of 400 to 600 m^2 can be achieved. This has already become a real experience.

The cleaning of the blocks and flags needs better techniques like rolling caves and pneumatical treatment. Also the carried weight by the operating personnel on the cleaning-equipment is too high and in this aspect the techniques have to be improved.

All these new developments have to be taken into account in the education of the pavior.