Importance, Demands and Possibilities of a Rationalized Laying of Concrete Paving Blocks

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1. Concrete block paving on the up-and-up

In order to prevent the sinking-in of pedestrians and vehicles into the ground and in order to use the corresponding surface easily in good condition the paving of roads and squares with concrete blocks developed from the original way of building by laying stones and stone pieces Approx 90 years ago concrete paving blocks have been used for the first time. Since then new knowledge in the field of concrete technology and the steady development of prefabrication and machine techniques reached a quality standard that makes the use of concrete paving blocks possible for many building project. Within the last 10 years (1972-1982) the annual production of concrete paving concrete blocks increased from 6.007 to 7.857 mio tons [1].

A high degree of exact measuring and an extremely high quality of the concrete (B 55), the resistance against petrol, oil and lubrication material as well as the effects of frost and thawing salts give a long design life to concrete paving blocks. Multiple shapings are offered by means of different colours, the way of bond, the surface divisions and the different concrete blocks. A group outline covers systemaically the 11 different shapes of the concrete blocks [2]. Compared with bituminous construction systems not only the maintenance of the concrete paving blocks but already their production is more economical [3].

According to design civil engineering and economical reasons concrete paving blocks play an important role for the future of hydraulic and road engineering. It has already today become irreplaceable. In order to make its use oven more efficient it is necessary to economize its paving as this procedure Is still too time consuming and highly waged. In 1960 the cost for the paving made 20-25% of the concrete paving block price ex works; in 1980 this price increased to about 120-130%. Important results for the paving have been already obtained.

2. Rationalization of the paving

The paving procedure consists of the concrete blocks transport to the paving place followed by their laying.

For the paving of concrete paving blocks it is very helpful that the concrete blocks due to their high degree of exact measurements do not have to be layed from the bed but from the surface. For this reason the surface already layed serves as transport way for concrete blocks to be layed next.

One point of the rationalization procedure is to diminish the distances of the concrete blocks transport in order to realize a more rapid exact paving.

In the 50' this theoretical solution was realized as the following: at the concrete factory, the concrete blocks were loaded on a lorry, unloaded at the building site, transported to the paving place by means of a wheelbarrow and layed in piecework. The unloading of the lorry near the paving place did not cause any problems and shortened the distance. Emphasis was then put on the solution of the basic problem caused by four hardcores: loading and unloading of the lorry and wheelbarrow which resulted in damages of the concrete blocks. As the pusher of the wheelbarrow was a temporarily worker, the paver, doing already piecework, had to lay the concrete blocks himself. That meant that his paving capacity was limited.

In the 1960ties problem was solved by means of concrete block packages. At the factory the concrete blocks were made up to packages of a $7m^2$ size and held together by means of steel bands or shrinkage foils.

As not each building site was equipped with a crane, a lorry loading lorry crane was at least necessary for the unloading of the concrete blocks packages. This method is still applied today. On page 201 BFT 3/84 some plants for concrete paving blocks are introduced.

in order to transport the concrete block, to its paving place a special transport plant, the so-called concrete block transport cart was developpod. With its help the unloaded concrete block packages were carried to the paving place [4], The paver now could fully use his paving capacity which also resulted in an increase of the paving capacity. This increase stood in contrast to the cost for the lorry crane or discharging equipment respectively, the packaging of concrete blocks (machine and packing material), the transport security of the lorries, the concrete block transport cart as well as to the time of unloading the lorries. On the other hand these cost were diminished because of the larger loading capacity of the lorries and the exclusion of concrete bock damages.

The paving place has at that time not been subject to a rationalization. The concrete blocks were still layed by hand (Fig. 1).



Fig. 1

A first cost reduction at the laying place itself was the employment of temporarily workers. They layed the concrete blocks against each another without any interspace as the existing row served as stop. When shaking the laid touching concrete blocks, the edges could splinter away. In case of breaking ups, the disappeared joint caused a major problem. The opening and closing of the concrete block surfaces is more dificult without joints; when closing, the original bond and the joints can be detracted (Fig. 2) [6]. Regardless of whether the justified demand could also be conditioned to planning and repair, the problem of expert workers was solved. As the profession of qualified pavers was no longer attractive due to physical demands and the dependance on the weather, the rate of experts has diminished enormously. Contrary to "nature concrete block pavers" temporarily workers instructed corespondingly can be employed for paving [2]. [6].



Fig. 2

A first real rationalization at the paving place was the building-in of paving units by means of pliers carried by two workers. The concrete blocks of the paving unit were connected through fixed concrete webs. First the use of the pliers was inefficient because of the breaking of the concrete blocks. But their development was continued.

In the 70ties the paving cart was brought on the market followed by paving clamps, vacuum-lift-slab and machines. These were the first rationalizations at the paving place; the new era of paving by machine started. A mechanization, representing an enormous contribution to the humanization of the working place and opening of new markets to the industry of concrete paving blocks.

Neither the argument that joints could not be held when pressing the concrete blocks nor the argument of insufficient alinements

are specific to machinery; concerning the joints a loose bond can also be obtained through the attachment ot the paving unit. In the second case mechanical paving facilitates a better holding of the alinements than paving by hand. A revision without overestimation of this argmentation is necessary, the efficiency of distence holders has to be taken into account.

3. The present situation of paving technology

At present the mechanical paving only covers 4-5% of the whole concrete paving bock production [8] A large field of activity is open to the concrete paving block and paving industry, firms offering mechantical paving as service, already exist. Different paving systems and corresponding plants or machines respectively are introduced in the following

3.1 The operation of the paving cart

The one-axle machines are operated by one worker. The front jib can be moved vertically and stopped in each position. It carries the heavy weight clamp. The procedure: the well laid concrete blocks are positioned in paving units of 0.3 to 0.5 m^2. With the jib being rised the clamp is mounted on top of the paving unit and then fixed On its way to the paving place the jib is already lowered slowly. After the adjustment of the unit the clamp opens automatically. The paving capacity runs to 165m^2 per day (Simms). The paving carts are dependant on different concrete blocks and only available In connection with this.

3.1.1 Paving cart of the SF-Compound Block Cooperation (Fig 3)

This device is used oil-hydraulically. Taking up the load, the weight of the paving unit pulls the grappingg plier down; this power is transmitted to a spring. The laying down of the paving unit releases the spring and the power now serves to lift the emptied paving plier. The plier is put on top of the upper layer of the block palette and then pressed on. The procedure can be repeated. An assistant worker operating two machines, surveys the streamlined insertion of the concrete blocks and in case of need moves the blocks up.



Fig. 3

3.1.2 Paving carts of the UNI-License-group (Fig. 4)

Compared with the above described machine, the device of the UNI-license-group in D-7550 Rastatt only differs in as much as the effect of the power accumulator is reached by an additional weight. When discharged, the plier is guided upwards on a track. The machine has been developed for UNI-Coloc-blocks. If necessary the set down block-unit can be corrected in its position with a rubber hammer. One assistant worker is needed for two to three paving carts.

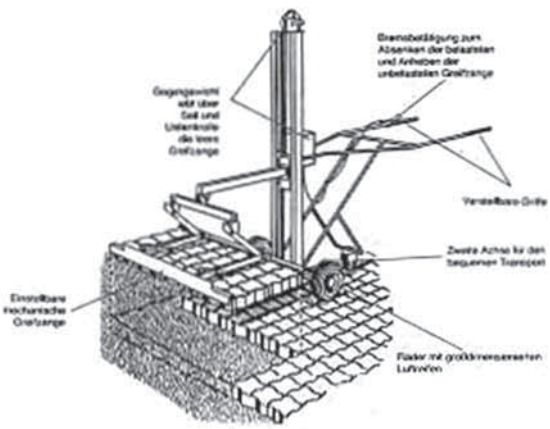


Fig. 4

3.2 Functions and demands of combined paving machines

Combined paving machines are paving machines and their transport vehicle (excavator, loading crane and fork truck). Paving machines are the mechanical and hydraulc paving clamps, as well **as the vacuum lift**ng device

Paving clamp and vacuum liftng device differ in the way of transport of each paving unit. Using two paving clamps the blocks are pressed in sidewise, whereas the vacuum lifting device transports the blocks by sucking them up. As the generation of the vacuum depends on an additional aggregate, the vacuum lifting device as combined paving machine did not have much success. It is offered on the market as a united paving machine and applicable for combined methods (sea Section 3.3).

The mechanical and hydraulic clamp differ In their operation method insofar that one is operated mechanical and the other hydraulically.

The paving clamps usually do not depened on block systems. They are put over the paving unit (either mechanically or hydraulically) pressed to the block and transported to the paving place. Paving surfaces can cover a size of 0.4 to 1.1 m^2. The clamps are fitted-in at the already paved surface, opened automatically which means that the paving unit is lowered and inserted. The paving capacity per day covers a surface of 260 m^2.

Demands to paving devices are: a possible large and good paving capacity, muiltiple applitcation of the base equipment concerning the different stone shapes, a wide range of varieties for the paving arrangement, the easy operation, the non-failure of the machines, the possibility of repair and a long service life.

1. Quality of paving is given if the stones are appropriate to the alinement, the joints equal in height in a regular bond with an efficient width given by the raster measurements and paved on the paving bed [9]. In particular cases additional paving instructions of the producer have to be taken into account.

2. The quantity of paving - as many as possible - is limited by paving quality and economic reasons. It is necessary to define and aim at the optimation point of quantly, quality and economy. The planner has to consider standard measurements.

3. A wide ranged application of the base equipment means that it can be used without any enormous changements for all 11 concrete paving brick systems.

4 Varieties of paving arrangements The planning teams aim at a loosened, aesthetic paving in order to improve the quality of service life. Paving devices being able to combine different paving patterns face good chances in the future and this mainly for their use in cities.

5. Easy operation means that the devices can be operated and serviced by an instructed assistant worker.

5 Parts being object of regular failure have to be excluded; repairs to be carried out quickly and easily. Parts should be normed in order to keep the replacement of spare parts at low prices and to make them available everywhere. A long service life means that the paving devices can be used even after the expiration of the depreciation time.



Fig. 5

3.2.1 The Kinshofer's paving clamp (Fig 5)

The hydraulic paving damp of *Kinshofer Greiftechnik*. In D-8160 Miesbach impresses through a simple, striking and handy construction form.

One of the two clamping gibs is controlled by a hydraulic operated press with the help of which the corresponding paving unit is pressed to the rigid clamping gib. The range of grapping runs between 420 and 1020 mm; setting-out bolts of the short lifting grapping machine allow a changing of the package width. The paving units range between 0.4 and 1.1m^2.

The clamp is lead in the paving place with a bail (see right side of the photo). The clamping gib of the bail side points at the already paved surface and for a better putting down of the concrete blocks, specially equipped. The hanging of the clamp is adjustable and by means of a lightly inclined position, allows a good setting down of the concrete blocks. A hydraulic rotary engine with telescopic hanging can be interconnected to the basic equipment of paving clamps. This improves the control of the device and furthermore eliminates one worker.

3.2.2 The Probst's paving clamp (Fig. 6)

With its basic equipment the hydraulic paving pliers HVZ of Probst Geratebau in D-7141 Erdrrannhausen can pick up and lay the marketable compound concrete paving block units. Small screw–able adapter additionals make almost all paving formations pos–sible. Two side swing angles attract attention beside the two clamping gibs; they guarantee a regular paving formation and can move concrete block rows in their length. Depending on the adjusting measurements they push the rows, the clamping gibs close and only open after the transport to the paving place. Steel lamellas fixed and spring-mounted to the clamping gibs regulate the width of the block layer and grab them at soft pressure firmly and safely from both sides. The clamping gibs are quickly adjust–able in a range of 480 and 1060 mm by means of screws and setting-out bolts. Paving units of 1.1 m^2 are possible with a good quality of the paving. The device is attached to the carrying vehicle by means of a four extrusioned excentric chain hanging and connected with it through a hydraulic control circle. The chain leading is simple and does not transmit any pressures, enables and independant lifting of the pliers from the paving units and prevents the clamping gibs from penetrating in the planum.

The side-wise relocated arrangement of the handles enable the worker to insert the new paving unit from the surface exactly into the existing bond. An oil trap prevents from a possible oil pollution of the paving blocks

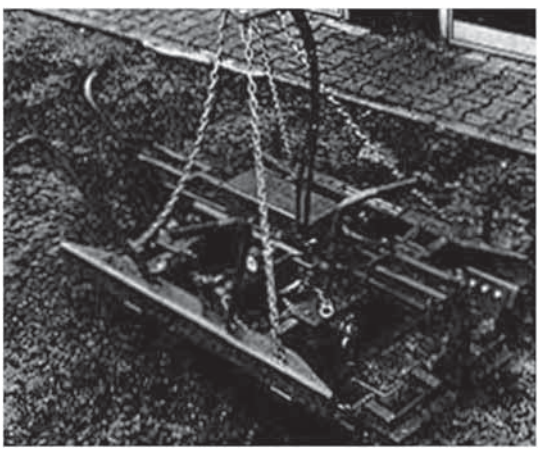


Fig. 6

3.2.3 The UNI-License-goup's paving clamp (Fig 7)

Similar to the paving cart of this group, the clamp is offered depending on the shape of the concrete block. It was developed for the UNI-Coloc-paving block and could be rent from the con-crete block suppler until the building project with these blocks was finished.

Striking is that the clamping gib facing the paved surface consists of two parts divided in their length. The hydraulic clamping device with its two clamping pistons is built-in at the middle between the two clamping parts. In the axle of the clamping piston each of them is moveable to the top so that they almost touch separated front-sides.

The clamping parts are lifted by a distance holder as soon as they touch the paved surface enabling a firm bond of the concrete blocks. The hanging of the device to the transport implement is fixed. The paving unit approx. 0.9 m^2.

3.3 Function and demaads of paving machines

Paving machines consist of the paving device and its transport vehicle. They complete the system idea of the paving device. Device and transport vehicle now form a unit as paving machine. Paving machines are devided into two groups, machines with paving clamps and machines with vacuum lifting device.

Operation method of the machines with clamps:

Again the distinction is made between mechanical and hydraulic clamps.

At a concrete block palette a paving unit - a surface of 0.8 to 1.2 m^2 - is picked up mechanically, transported to the paving

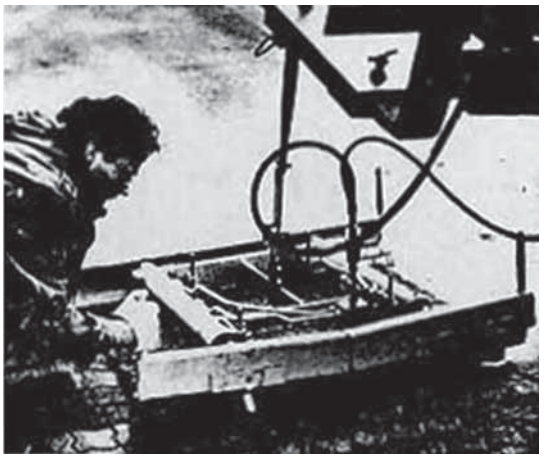


Fig. 7

place, put down again by mechanical control end checked by a worker. It only takes 35 secs. to perform one procedure, the day capacity covers a surface of 400-500 m^2. The existing machines differ in their vehicle and clamping technics.

Operation method of the machine with vacuum lifting device:

Usually this machine depends on blocksystems snd sizes; the suction cups must be positioned in the middle of the blocks. By means of an vacuum the blocks are lifted from the pile, trans-ported to their paving place and inserted; after the laying of the blocks the pressure is released. The surface covered by the paving units runs between 0. 8 and 1. 2 m^2. One procedure takes between 30 and 45 sec. An average day capacity is a surface of 450 and 500 m^2.

The demands concerning paving devices (s. a. Section 3.2 Pos. 1-6) are also applicable for the paving machine.

Additionals:

7. A favourable coordination of paving device and vehicle in the technical and economical but also optical field.

In the technical field the following points are valid: unity which means that there is a firm and secure connection between device and vehicle but also a rapid and simple separation. A good sight at the picking up of the stones (high device) and paving procedure (tow device) an easy operations necessary. The vehicle should be near the last paving row front and sidewise; whereas the wheel axle shouldn't, in order not to run danger to effect a movement of the non paved concrete blocks. Simple operation is necessary as vehicle as well as device are controlled. A swinging of the charged device is only possible it the machine is stable.

For the economic coordination, an irregular use has to be excluded. From the optical point of view the machine should be a unit, the device strike through a signal colour.

8 Various application possibilities, not only for large but also for small surfaces which are not accessible tor heavy machines.

9 Control and moveability at the smallest place without damag-ing the paving. A rationalization aim is a short way of transport which means that the vehicle has to be moveable in itself, short braking distances are required, the control has to react easily but shouldn't be too sensitive. Braking and turning manoeuvers should not cause any pulling apart or settings of the paving.

10. General requirements the machine, already listed in Sec-tion 6. paving clamp: these are general demands with specifically orientated characteristics to the paving machines. The important criteria are fulfilled by all machines offered at present. In particular cases the individual compromize is necessary.

11. Additional requirements for a vacuum lifting device are: sim-ple generation of a vacuum with little energy; exclusion of sucked stones, sand and dust in the machine: a rapid change of the suction cups

3.3.1 Paving machineswith clamps

3.3.1.1 Hydromak's paving machine (Fig. 8)

The firm group Lehnen in D-4100 Duisburg 17, has favourable preconditions for its Hydromak, as it can look back on concrete block technological experience through its Wardenburger con-crete factory group to connection with its machine production. Hydromak has already layed 1 000 000 m^2 of paving surface.

Besides the original form of the machine, the paving clamp is striking because it is equipped with various technical refinements. The fully hydraulic clamp is equipped with 14 own cylinders and works by means of a four-side pressure which can be controlled and adjusted individually by electromagnetic impulses. As stones are often not delivered conform to paving but to production, the clamp can arrange the concrete blocks correctly. Within the

particular layers the concrete paving blocks can be formated, moved and even brought in a distance. Packages of concrete blocks being out of line, can be moved to a bond. The clamp is constructed for all forms of concrete blocks; units of a surface from 0.6 to 1.2 m^2 can be paved.

A specially developed sliding track guarantees by a hydraulic effect a “fitting-in” of the paving unit in the surface. The clamp revolving attached makes paving formations, length and cross–wise possible.

Vehicle and clamp form one operation unit, the drivers sits near to the paving place.

The vehicle is driven by a sound absorbed diesel engine with 9 HP. Two tooth controlled hydraulic valves make an exact control for the fitting in of the paving unit in the surface possible. The machine can also be delivered with a weather protection equip–ment.

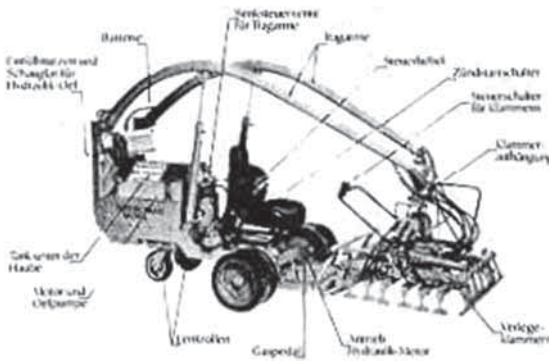


Fig. 8

3.3.1.2 Kruger's paving machine (Fig. 9)

The constructors of this machine - Maschinefabrik *Krüger* in D-8951 Rieden and *Goeskon* Maschinen GmbH in D-8949 Min-delheim - specialized in the application of hydraulic machines

Their paving machine is clearly arranged and equipped with a fully hydraulic clamp which finds itself in the fifth developing genera-tion. A lift cylinder leads the necessary pressure to the two clamping gibs. The two side swing-angles press moved concrete blocks on and bring them back into their place. The paving clamp can lay units of 0.6 to 1.1 m^2. Screw connections allow a quick adjustment of the clamping gib according to the paving units. For the different concrete paving blocks shapes the clamping gib can be exchanged easily at the building site.

The machine is controlled by a moving hydromate; a pedal effects that the machine is moved for- and backwards, releasing the pedal stops the machine. The rear wheel-buckling steer results in a moveabiity of the machine. The rear axle is not fixed rigidly but on a turning bolt. With the buckling steer, paving conditional side powers can be absorbed through a counteraction of the axle position. Different axles widths prevent from a driving in the track in order not to cause any damages.



Fig. 9

3.3.1.3 Optimas' paving machine (Fig. 10)

The "PAVER-FIX" of *Optimas*, Baulemente und Bagugeräle GmbH in D-2915 Saterland 1, can be called the best known paving machine (10). Clamp and vehicle become one optical and technical unit. The clamp is constructed mechanically. It adjusts itself elastically to the package layer to be paved as it is composed of various single elements These clamping elements are con-nected by springs and it is operated through a beam scale system, so that the clamping pressure is distributed regularly to the concrete blocks. Another speciality was taken into account when fitting-in the paving units; after the exact positioning of the surface the driver lowers me damping device. When the paving row, facing the planum, touches the ground the clamping power is released. Therefore the still swinging surface bends downwards followed by the rest (see Fig. 10). The concrete paving blocks are laid and not dropped. The clamp can be used for all existing concrete paving blocks shapes.

As the arm largely overhangs, even difficult situations as a building site can be mastered. The steering of the vehicle is constructed so that the freshly paved concrete blocks are not turned. It is a combination of buckling and pivoted bogie steel with four wheels participate in the steering. The steering deflection is distributed steadily to all four wheels and therefore the deflection, is held at a minimum for each particular wheel. The operation of the machine is easy; by means of a steering movement overhead arm the clamp can be directed exactly.

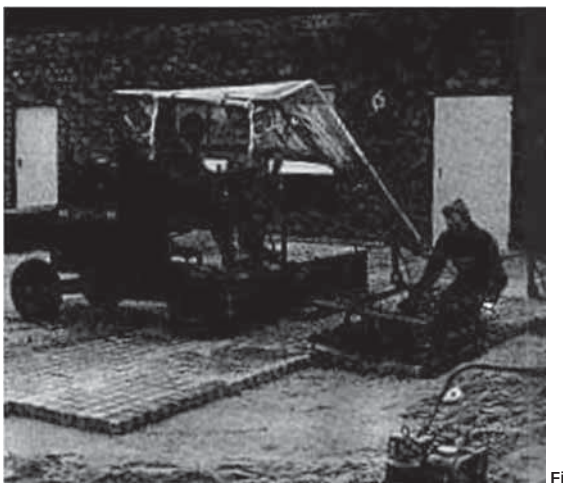


Fig. 10

3.3.2 Paving machine with vacuum lifting device

3.3.2.1 The Schaeff's paving machine (Fig. 11)

This machine has been constructed by Reinhard *Göpfert* D-3070 Nienburg, in cooperation with Maschinenfabrik Schaefr D-7183 Langenburg.

The machine attracts attention by the size. Model for the construc-tion was the small mobile hydraulic excavator of Schaeff. The excavator is additionally equipped with an aggregate which is 11 HP hydromotor delivering the neccessary energy for the vac-uum. According to the block material it produces a vacuum 70-90%. It is connected with the machine through hoses being fixed at the leads of the excavator by means of pull down coupl-ings.



Fig. 11

The vacuum finally reaches the suction cups (Fig. 12) these are fixed on a magazin board and easily as well as quickly exchange–able. A cyclone separator in the membrane bellows serves as a dust trap.



Fig. 12

The 4 side swing-angles (see Fig.) are moved each by a hydraulic cylinder; they can rearrange crocked and loosened paving units. Then the suction cups are lowered on the blocks. The vacuum valve opens so that the vacuum can effect the lifting of the blocks. They are transported to the paving place and inserted without any other help. Another interesting effect due to rationalization is the limitation of the transport times. The revolving moveability of the upper cart and the arm make the paving of a whole palette possible.

After the paving procedure the excavator digging device can be connected instead of the vacuum lifter.

4. Future developments

The rationalization aim is to keep the transport distances short and to realize a quick professional exchange of particular parts.

Some impressing results have already been obtained. A surprising innovation in the field of mechanical paving is not expected within the near future. Theoretically shorter distances of transport exist already in case the machine carried a stone package with it. Concerning the damps the range of sizes will settle down at 1.0 m^2 as this surface can be regarded as planning measurement.

The clamps can be subject of further development in order to make their use possible in operation areas with special construction forms i.e. in towns. So it might be interesting to pave curves and roundings.

For larger building projects the paving machine will make its way the use of machines requires a special consideration of the organization at the building-site. The concrete block paving can draw on a large market part.