Automated Block-Laying, using the master mason

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ABSTRACT: Over the years, the art of block laying has been an important factor in building construction. Different cultures and construction experts have developed various styles, giving values to block laying.

The major problem in block laying has been traced to the poor productivity of the masons. This has really hindered the construction time of most buildings. This project is an investigation into the use of automatic block laying machine or Robot known as "The Master Mason". Each "Master Mason" is a triple-axis drive system with productivity of 100 (one hundred) blocks per hour and could be powered with a generator (solar or conventional) or direct electricity and has a rather low energy consumption and high serviceability of spare parts/components. It is easily affordable, considering the cost of each unit. One interesting aspect of this "Master Mason" is its ability to communicate with the Building or Project supervisor, using remote sensing and decoding techniques. The "Master Mason" is equipped with block haulage, placement, alignment and chucking tools. It is an essential equipment for the construction industry in the new millennium.

KEYWORDS: Axis; Chucking; Console; Drive; Sensing; Stroke

1.0 INTRODUCTION

1.1 An Overview Of Robots And Robotics

The word "Robotics" is synonymous with "Cybernetics". According to Taylor (1978) Cybernetics is the study of control and communication mechanisms in machines and animals, covering all automatic control devices, selectors, relays, robots and computers and also the corresponding body mechanisms such as those of automatic balance, reflex action and cerebral association. When cybernetics is applied to electronic computers, more light is thrown on the function of the brain. "Mechanized or electronic brains" control the activities of Robots in the engineering industry. In Engineering, Robots are electro-mechanical devices that carry out the normal production processes or services of human beings. For instance, there are Robots that make, clear tables, serve people and wash dishes/pots. There are others applied in the production industries to increase productivity and reduce wastes.

Generally, according to DRO (1979) Robots are seen as variable – speed systems, controlled by programmable microprocessors, via remote control consoles. Robots use different power drive systems in their mechanisms. While some use Ball screws and servo motors, others use air pressure or hydraulic pressure etc. These drive systems depend on the demands of the proposed function of the Robot. Again, Robots are fashioned to carry out the exact functions of workers or human beings in their natural order. Their features must therefore have some degrees of freedom e.g the arms or legs or heads must be able to rotate about some specified degrees or radians. The Robots should also be able to move around, if necessary, about some defined axes (x, y or z). The various, designed and specified distances along all these axes, are called "work strokes". The x-axis work stroke may be different from the y-axis work stroke etc. Also, different motors control different axial work strokes.
Also, different motors control different axial work strokes. These motors have different speed ranges, depending on the function & timing.

At the end of the production of any Robot, certain standard recommended tests are administered to the Robot. A good time is necessary to prepare test procedures, observe the tests, collect data and prepare test report data and test reports. Robots are usually tested by a team (see fig.1)

Companies with challenging ingenuity (and experience in microprocessors, lasers, fibre optics, exotic material) have demonstrated engineering, scientific, and manufacturing capabilities in the development design, manufacture, and operation of industrial Robots, automating some sensitive activities in the industry.

The art of block laying is one of the sensitive activities in the building industry. This is done, using concrete blocks. There are many types of concrete or sandcrete blocks but these come under any of the following families;

(a) Solid tongued and grooved
(b) Cellular, plain ends.
(c) Keyed common
(d) Cellular, tongued and grooved
(e) Cellular, plain ends.

(see table 1)

1.2 Manual Block laying

1.2.1 Work Procedure

The normal work procedure for block laying is as follows;

(a) Define your building profiles, during and after earth (foundation) excavation and concrete blinding.
(b) Put the end blocks (i.e 1st and last blocks) without chucking them in place.
(c) Align the end blocks using a taut rope or line (one by the side and the other on the top)This ensures a straight line.(N/B. leave the rope or line until all other blocks are put in place.
(d) Plum the end blocks to make sure that they are in line with one another and have their tops at the same level.
(e) Put other blocks in place, in between these two end blocks and plum them together as before.
(f) Remove the alignment ropes and chuck the blocks together, using a pre-mixed mortar.
(g) Rub the joints to smoothen them.
(h) Start the laying process/cycle again.

1.2. 2 Limitations Of This Practice

(a) The mason easily gets weak.
(b) His productivity is low, because his activated time is low.
(c) His accuracy is low.
(d) Much material (mortar) is wasted.
(e) Production is not economical because of the dynamic increase in labour costs.

2.0 METHODOLOGY

2.1 Field Studies

Various workstudies were carried out on experienced, professional brick layers (Masons) at standard construction companies. Idle times were matched with activated times of these masons and their work methods and productivities were noted over a period of 12 (twelve) months. These results from different companies were put together, stochastically and averages were worked out.

2.2 Robot Design

Different designs of Robots were made initially to meet the construction process requirements of block laying.

2.3 Computer Simulation

Simulations were made using the computer and the “master mason” was adopted as the best Robot that could achieve economy and productivity.

2.4 Automated Block laying Procedure

Every “master mason” has a “servant”. The servant hauls the blocks, lifts and puts them in place, while the Master Mason aligns, chucks the blocks and makes another mortar bed for the next block course. This cycle continues until it is stopped by the Building Supervisor on the control console.

3.0 DESIGN ANALYSIS OF MASTER MASON

Generally, this Robot is operated by a programmable microprocessor with a 32k Ram.

3.1 The Auto- arm

Every master mason has two automatic arms, each fitted with a gripper. Every auto-arm is designed to rotate 90 degrees(1.5 radians) around the base (the shoulder). This degree of freedom enables the master mason to pick up blocks from the floor, put them in place and work on them. Within a 50.80 cm radius, from the block wall. The auto-arm conforms with the specified maximum length of the x-and z- axes work strokes. Each auto-arm is operated by four stepping motors, with well calculated work speeds. Again, calculations were made to determine the gripping pressure of the wrist claw of this master Robot on the block units. It was found out that enough pressure could be exerted on the blocks to lift and work on them with minimal damage. This pressure was observed to be directly proportional to the unit weights of the blocks.

3.2 The Auto-legs

These are legs that are operated on the y- axis, with a stepping motor and Ball Screw Drive. In each run, the motor reverses direction in one quarter of a second. The torque is designed to fall within acceptable specifications. The work strokes, speeds and overshoot are also within limits. Manual scaffolding is no more necessary. The Auto-legs allow the Robot to stoop and pick up blocks and hoist them at desired heights or levels.

3.3 The Head

Each master mason's head is equipped with a voltmeter, an ammeter, and a thermometer to give readings of voltage, current and temperatures of the system, respectively. It also has a compact mouth or speaker that alerts the Supervisor in case of any internal danger.

3.4 The Working Trunk

The Trunk is designed to have complex meshing gears to facilitate movements of the mechanical parts and to automatically lubricate internal parts so as to reduce high- noise levels/frictions and consequently internal temperatures.

3.5 The Mortar Feeder.

This chute has an automatic control/gate valve, which admits or shuts off mortar supply to the Robot. It is fed directly by a mobile mortar mixer, with pre-mixed materials.

4.6 Operation Sequence.

Operations set up a work for the Robots, positioning them within acceptable axial work strokes. The operators move outside this work post to a remote control console. At the console, they dial in the desired x- (horizontal) axis data, the z-(transverse) axis data, the number of stroke, and the speed of the drive motor.
They also input the y-(vertical) axis fall and arise distances and the distance the transverse motor moves the blocks to position. The system now starts and completes cycles accordingly until further instructions are give.

4.7 Productivity

the "Master Mason" increases productivity by 800%, and cuts mortar waste by 97%, block waste by 85%.

5.0 CONCLUSION

The "Master Mason" is a wonderful worker. All the components of its system, are readily available and affordable. It is so cheap that every construction company can afford to have one. It is highly serviceable and could be maintained or repaired if need be. It is also of a high productivity and precision.

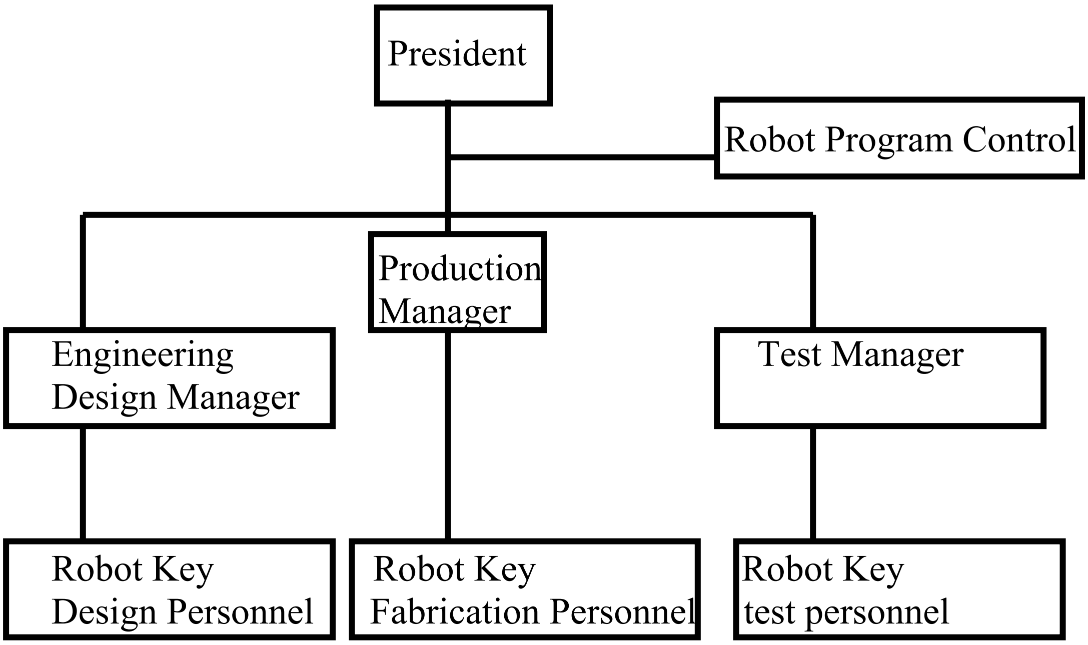

Figure1 Program Organization for Robot.

Table 1: Concrete blocks Specifications

Thickness & type of block	Dimensions of face (length x width) (in mm)	Block weight (in kg)
75 mm solid, tongued and grooved	400 x 200	6.3
100 mm cellular, plain ends	450x225	9.5
140mm cellular, tongued and grooved	450x225	10.9

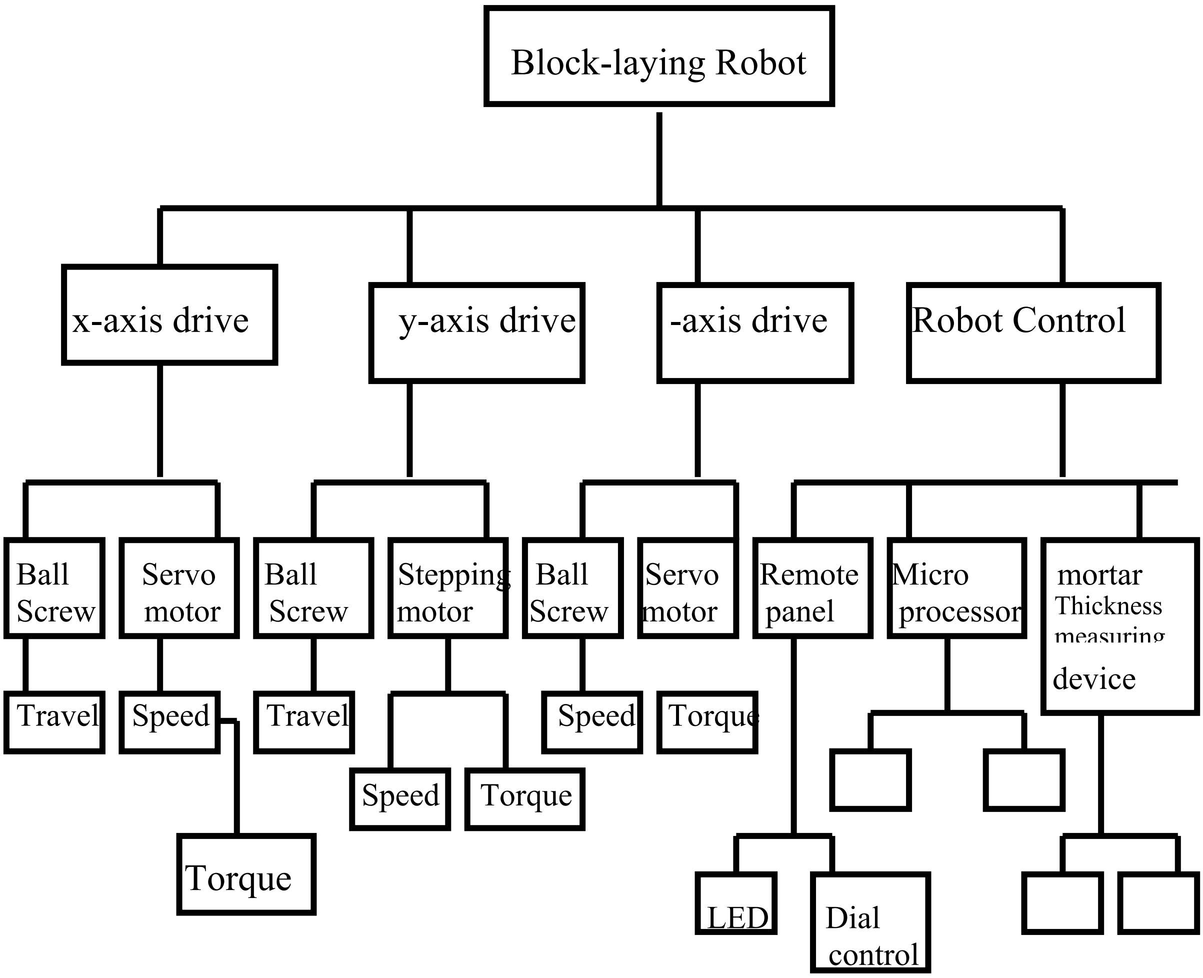

Figure 2. Typical Hardware Breakdown Structure Of Robot.

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