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Essay: A Macro Machine For Large Scale Construction

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ABSTRACT

The KCMM (Khawand Construction Mega Machine) concept is a large, multi-functional and robotized, one hundred and fifty foot long construction machine. It is envisaged as the offspring of the technologies of the last quarter of the twentieth century. At a global level, the human population explosion has created the need for massive construction projects. Macro machines of unprecedented sizes, sophistication and power are seen as the most effective means for constructing the housing and essential infrastructure as part of this. The substantial progress that has been achieved in the enabling technology make it feasible, for the first time, to build, control, and successfully operate such machines. It is envisaged that the impetus for this development will be derived from space exploration programs, with plans for large bases on the moon, mars and outer planets, also need powerful and sophisticated equipment to perform large, complex and diversified construction activities with minimum reliance on human labour.

INTRODUCTION

In this essay, 'macro construction machine' is the term used to define a mobile factory for large scale construction. The term 'micro construction machine' refers to single function construction plant of the conventional type or that being developed through construction automation and robotics research.

The authors views and research on the macro construction machine concept have developed as the result of his interest in the very large construction projects in Saudi Arabia during an unprecedented historic boom of building cities and industrial complexes between 1976 and 1991. During this era modern construction management sciences and available technologies were put to a straining test by competing companies and nations facing a combination of short time and large scope of construction objectives.

The conception and design of the macro construction machine were the direct results of those events. But the ensuing studies on an international scale soon revealed that such machines, were needed far beyond those events. It became apparent that beyond one nations boom needs, the

world's population explosion will be the first beneficiary of such machines. Many of the objectives of the Saudi boom may have been met but at the cost of huge losses due to the ineffectiveness of conventional techniques and machinery for such large scale projects. A civilized response to the world's population explosion imposes even greater constraints of time and magnitude than already encountered in that particular boom. But it cannot afford, on a global scale, the inadequacies incurred during a local, though national undertaking.

KCMM, a scaled down demonstrator of the macro machine principal has been built for evaluation. It is the product of direct site experience supported by feasibilities studies covering the underlying technology, design and economics. This work was undertaken with the co-operation of major institutions in the USA, the Middle East and Japan. All studies confirmed its revolutionary capabilities and economics.

MACRO CONSTRUCTION

On site automation with micro machinery (existing types) has, to date, lacked technical and commercial success. A partial explanation is that essential to any automation is the necessary presence of some fixed frames of reference in space and time which can be continuously checked by machines and operators at work. Conventional or micro machinery with individual operators cannot perform efficiently if they have to keep continuously re-establishing accurate position in time and space. A macro machine would overcome this problem by providing a continuos, non redundant, 'Real Time' reference base for all operating systems and workers. It also represents a opportunity to concentrate research and development activity into a limited number of well co-ordinated and comprehensive solutions rather than ad hoc and development of incompatible micro machines. The path, from an increasing number of micro machines to one macro machine is not a linear progression of advantages. At one point, there occurs a great jump in the advantages and new possibilities.

Macro machines promote decentralization with and 'ON SITE' automation. Large scale construction is thus no longer dependent on the vicinity of the factory. Automation can go wherever the components of the macro machine can be transported and assembled. This could have significant urban and social consequences.

KCMM PROTOTYPE SYSTEM

The KCMM concept is a one hundred and fifty foot long, highly automated, multifunctional machine for large scale construction of housing and industrial buildings. The experimental prototype, twenty feet long, was built in Boston in 1983. It has served to demonstrated the revolutionary technical and economical premises of the macro machine principal. It comprises a main bridge structure moving on crawler tracks. It is capable of high precision movements in three directions: Forward and Reverse (X direction), Right and Left (Y direction), and Up and Down (Z direction). It is equipped with sophisticated surveying and distance measuring equipment using state-of-the-art computer and laser technology. A sliding computer control room provides the machine, and each operating equipment, with automatic and precise

performance and self locating capabilities at all times. As such, the machine can be operated by a crew of no more than five.

Various tools, instruments, and machinery needed for any construction function are attachable to powerful 'Operating Modules' which can slide along the main beams. The 'Operating Modules' carry heavy tools with precision and handle them with all axes of motion needed: Linear movements and Rotary ones such as Roll, Pitch, and Yaw; as processed by the computer. Each tool, or machine, performs a specific construction function. It is detachable and replaceable as needed during the progress of various construction phases. The machine, with its assortment of interchangeable tools, can carry out automatically all construction activities. such as surveying, earth moving, ground preparations, road construction, installation of underground utilities, slab construction, and finally house building up to two or three stories high.

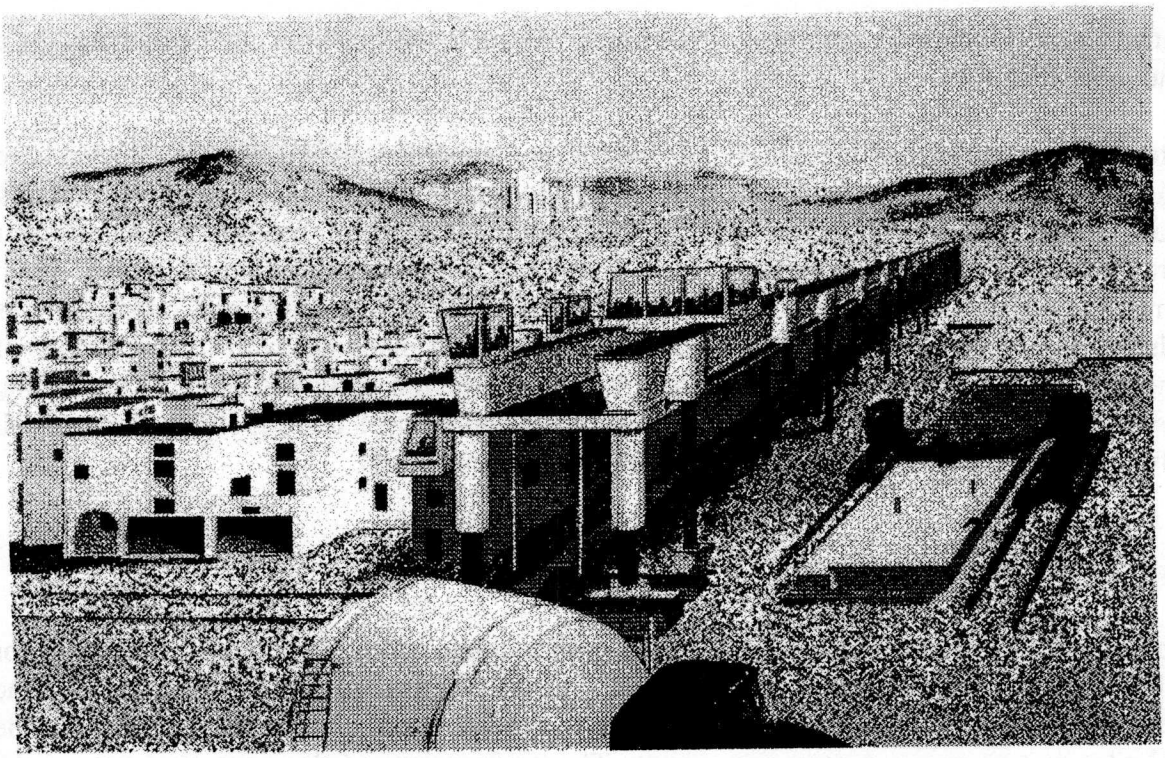
PROTOTYPE EXPERIMENTS

An experimental model was produced and fitted with a single house construction function for testing: Tile laying (ceramic tiles 3/8"x 10" x 10"', as is widely used around the world). The model was equipped to spread the sand and mortar to precise level, and to place the tiles at the rate of 32 tiles or two square meters per minute. The performance of this prototype proved the concept valid with the observations that (i) despite the inherent flexibility in the large structures it is possible, by electronic control, to compensate for this, (ii) the machine can performed with acceptable speed, reliability and precision, (iii) rough terrain conditions need not be a significant handicap to successful operation, (iv) a full scale macro machine should be capable of performing complex tasks with a crew of a few persons only and (v) deviations in its performance can be easily detected and corrected.

CONCLUSIONS

So far, construction automation has been generally confined to the factory, because of inherent difficulties in automating a multitude of independent plant items. Macro machines like the KCMM can provide a single large structure common to all operations. This step from individual 'micro automation' to collective 'macro automation' is a most necessary step to effective site automation.

One or several KCMM's could operate on a site remote from a central headquarters. A large radius of activity could be achieved by making the dismantling in several sections which are delivered to the site by conventional transport. Once on site it can be largely self-assembling with the help of it's crew of three to five people within two to three days.



Macro Machine Concept