Mechanised production of prefabricated cored and channel units

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The paper describes the very simple equipment designed to produce mechanised prefabricated cored and channel units. Designed to take into account the labour-intensive conditions prevailing in the country, the equipment has been succesfully field tested at Delhi and Bhopal. The equipment and process now await commercial development.

Industrialisation in building construction which is a recent development compared to other industries has rather come late, because the obstacles to be overcome in the building trade are greater. Industrialisation in building calls for a change of attitude and fresh thinking on the part of building experts. The unbroken traditions of the art of building, stretching back thousands of years have given rise to rules, customs and norms which have, practically acquired the status of 'laws'. It is easier to create an entirely new system than to make radical changes in traditional ones. Most branches of industry have made great progress in the last few decades. Some are already well advanced towards automation in their production. The building industry has, it is true, also made progress, it uses cranes and other machinery, but broadly speaking, it has lagged behind other industries with regard to industrialisation. As compared to other industries, building is an established trade with its own traditions. The building industry makes use of the production of some fifty other branches of industry whose production possibilities and peculiarities have to be taken into consideration to introduce industrialisation in building construction.

After the second world war prefabricated construction with precast concrete components attained the status of construction method in its own right. Mass production is possible only if large series of units of any particular type are required. In addition, the components must be capable of being manufactured by mechanised methods and be reasonably convenient to handle and transport. The design and determination of units for serial prefabrication is called 'type standardisation'. This is comparable to the compilation of tables of rolled steel sections. Next step is detailing individual parts from which a building can be assembled. Finally, the whole building can be constructed on the basis of standard type design.

The major part of the labour involved in the prefabricated building component is in its production. The possibilities of further development of prefabrication are more likely to be found in the rationalisation of manufacture rather than in improved structural solutions. On the other hand there is a close inter-relation between production methods and construction, so that it is not possible to design prefabricated components without, at the same time, determining their method of manufacture. Therefore, the principle of manufacture should be the speediest possible production, improved quality, with least amount of labour. In comparison with traditional methods these aims can be accomplished only by using mechanised manufacture. The primary object of using machinery is to get rid of the human elements to ensure consistent better quality. The savings in labour achieved, if any, is secondary.

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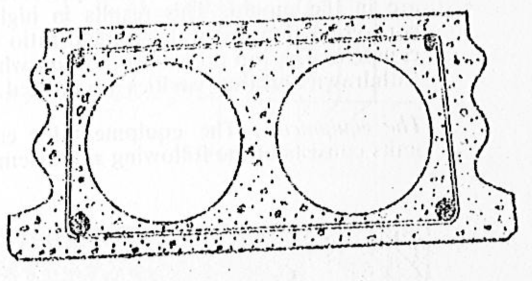
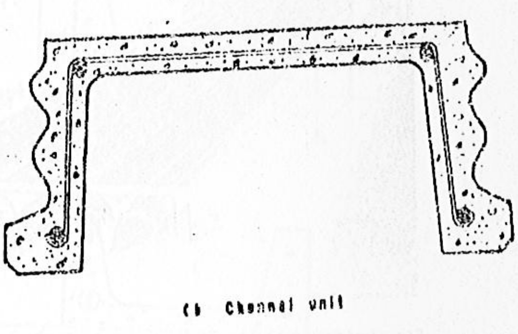
Present status

An important construction aspect that must be considered in design is the increased capability offered, and the limitations imposed by, available construction equipment. Availability of equipment means that the equipment is not only available in time for use on the job, but also the site conditions are such that they make the equipment usable at all required locations; that there are no government ordinances prohibiting or limiting the use of equipment, and finally, the ease of maintenance and the availability of spare parts. The arsenal of construction equipment is daily increasing in variety, capacity and reliability. There are also great possibilities for designing and fabricating equipment for special operations. This potential should certainly be considered in the design concept since it is now possible to produce structures which were economically impossible to produce a few years ago.

In developed countries like USA, USSR and elsewhere, highly sophisticated equipment is available for precast construction of the building components. In India, the machine building industry has considerably developed and has necessary potential and capability of fulfilling the need of equipment required for precast construction work. But as there is lack of demand for the precast construction work, special equipment for precasting is not being produced. The basic equipment required are concrete batchers, mixers, vibrators, etc., all of which are



(a) Cored unit



(b) Channel unit

Fig 1 Cross sections of cored and channel units already available in market. This equipment alongwith some special type can be used for precasting work. The development of special type of equipment cannot progress because the building industry in India is essentially labour oriented and traditional in nature. Only recently some manufacturers are starting to produce precast components, but they have not been able to succeed completely in their efforts. In countries abroad, the production of structural building components such as roofing and walling elements is undertaken in highly mechanised factories. The plants work either with the extrusion, multilayer or individual mould techniques. In all these countries highly sophisticated machines are being used for the preparation and feeding of concrete with accelerated methods of curing, making use of steam, hot water, etc. In India, the infrastructure of the building and its allied industries is not in a position to adopt such techniques and the machinery that goes with it in its present form. The technique to be adopted and the plant involved has to be simple, requiring low capital investment and high labour component to make it readily acceptable.

The Central Building Research Institute, Roorkee is one of the institutes engaged in the development of various types of prefabricated components in India. Two such components were taken for manufacture by mechanised methods. These precast components were the concrete cored unit and the channel unit. For this project, the complete process and the related equipment for casting these units has been developed.

Cored units

The cored unit is a box type structure with two circular hollows in the centre of the unit, *Fig* 1(*a*). The reinforcement is provided according to the design requirements. Generally, mild steel bars or deformed bars are used, but for large spans the use of high-strength, prestressed steel wire is also undertaken.

The process: The process developed for casting the cored units is based on the 'pressure vibration technique'. The concrete is vibrated under pressure when the cores are in the mould. This results in highly consolidated concrete with a less water-cement ratio than the normal concrete. The top pressure is still on when the cores are withdrawn and thus cavities are created.

The equipment : The equipment for casting the cored units consists of the following sub-assemblies:

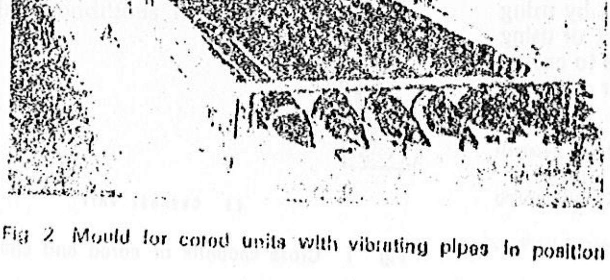


Fig 2 Mould for cored units with vibrating pipes in position

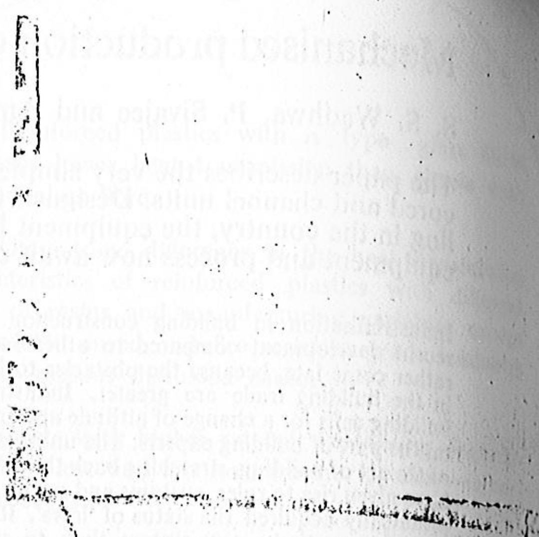


Fig 3 Filling concrete in mould of cored unit

(*i*) the mould

(*ii*) the vibrating cavity forming cores

(*iii*) mechanical winch for pulling the cores

(*iv*) fixed gantry to handle the dead weight and unit transfer system.

The mould consists of four detachable sides fixed with pins and wedges to the bottom pallet, *Figs* 2 and 3. The sides are made out of pressed steel sheets with steel channel backing. The bottom pallets are made with mild steel sheets of 3-mm thickness and stiffened with mild steel angles at appropriate places.

The vibrating cavity forming cores, consist of needle vibrators fitted inside the steel pipes, *Fig* 4. The needle vibrators are run by flexible shafts. These vibrating cores are attached to a trolley moving on rails. An electric motor to drive the vibrators and a winch set-up to pull and push the vibrating cores into the moulds are mounted over the trolley.

The vibrating cavity forming cores are positioned inside the mould to vibrate the concrete around them and to create hollows in the units. The cores vibrate with a frequency of 120Hz and with an amplitude of 0.4 to 0.6mm. A rectangular reinforced concrete beam is used as a dead weight, to impart pressure to the concrete. The dead weight and the mould are handled with the help of an electric hoist attached to a fixed gantry.

Method of production: The sequence of operation for production by the above process is as follows: The mould alongwith the reinforcement cage is placed on the casting platform under the fixed gantry. The cores which are attached to the trolley are introduced into the mould and vibrated, thus making the charge of the concrete to flow around the pipes to the soffit of the unit. An additional charge of concrete is then added and the dead weight is placed on top, to act as pressure on the concrete. The vibration of the cores at this stage makes for thorough compaction, thereby producing a denser mass of concrete. The cores are withdrawn by winch operation, immediately after which the vibration is stopped leaving behind the dead weight on the top of the unit. With the help of electric hoist hung from the fixed gantry, the dead weight is removed and the cast unit is loaded on to the trolley for onward transmission to the curing yard. The sides of the moulds are stripped off after two to three hours and brought back, near the production platform for re-use. The bottom pallets are recovered the next day.

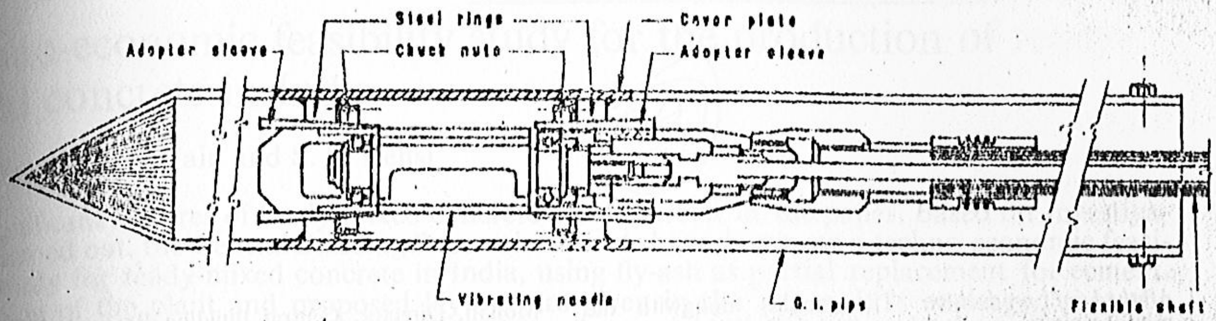


Fig 4 Section of vibrating core pipe

Channel units

A channel unit is a precast reinforced concrete trough shaped unit having longitudinal corrugations with vertical grooves at the ends, *Fig 1(b)*. Here, again the reinforcement is provided according to design requirements. Generally mild steel bars or deformed bars are used for this purpose.

The process: The process for the manufacture of channel units is based on a technique known as 'vibro-stamping', *Fig 5*. Here, in this process, the mass of concrete lying inside the mould is stamped down by the vibrating trough. This action creates the impression inside the concrete mass depending upon the shape of the vibrating trough.

The equipment: The equipment for casting channel units by the above said process consists of the following sub-assemblies:

(*i*) the mould
(*ii*) the trolley with the vibrating trough
(*iii*) the unit transfer system.

In this case also, the mould consists of four detachable sides made out of pressed steel sheet, with steel channel backing. In this case, there is no provision for the bottom pallet as the mould, consisting of side frame, is directly laid onto the well finished floor. Four sides of the mould are assembled with the help of nuts and bolts.

The trolley with vibrating trough is mounted on four wheels, and moves on the rails, *Fig 6*. The trolley is equipped with (*i*) a hand operated driving arrangement; (*ii*) a hand operated arrangement for lowering and raising the vibrating trough; (*iii*) and, shutter vibrators for vibrating the trough. The trolley is made with two trapizoidal frames connected with structural members. The driving system consists of a circular shaft with two sprockets inter-connected with the wheels fixed to the sprockets by a chain. The trolley can be moved to and fro on rails by a handle provided on one end of the driving shaft. The trough is made out 3-mm steel and stiffened with steel angles and pipes. The trough contour is similar to the inside shape of the unit. The trough is hung from the trolley through two power screws and bevel gears. A circular shaft mounted in two bearings with two bevel gears drives the power screws. A handle is provided at one end of the shaft to drive the power screws. Two shutter vibrators with a frequency of 50 to 100Hz and an amplitude of 0.4 to 0.6mm are fixed inside the trough for providing vibration. Four guiding pins are fixed to the trough which engage the pipes attached to the mould sides. This ensures correct positioning of trough vis-a-vis the mould.

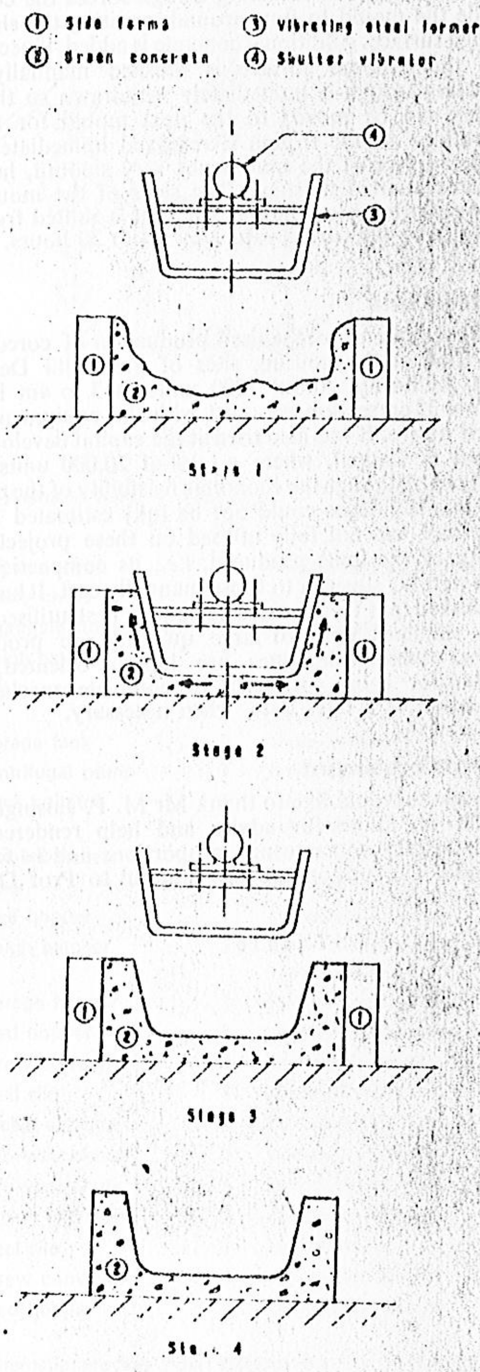


Fig 5 Vibro-stamping technique of casting channel unit

Method of production: The moulds alongwith the reinforcement are placed on the platform in a parallel direction to the trolley. Concrete is charged in the mould and the vibrating trough is lowered in with the help of power screws. The vibrating trough forces the concrete inside the mould to flow around, creating the shape of trough surface. Additional concrete is added, if necessary, and the exposed surface is finished manually. The vibrating trough is immediately withdrawn so that the trolley can be moved to the next mould for further operation. As the trough is removed immediately, the inside surface of the unit is not very smooth, hence it requires manual finishing. The sides of the mould are removed after 2 to 3 hours. The unit is shifted from the platform to the curing yard after 24 to 30 hours.

Conclusions

The technique of mechanised production of cored units was tried at the housing sites of the Delhi Development Authority. About 7000 units of 3 to 4m length, 13 cm × 30 cm section were cast with the equipments described above. It was also tried at the capital development project in Bhopal, where a total of 20,000 units were produced. Although the economic feasibility of the project with this technique could not be fully estimated as the equipment was not fully utilised on these projects, the quality of the units produced, *i.e.*, its compaction and finish were far superior to those manually cast. It has been established that these processes can be best utilised only when standard units of large quantity are produced. Further these techniques are labour oriented, but suitable for being converted to complete mechanised production at a later date, when necessary.

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