Machine finishing of concrete floors

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The uniformity of floor finishes and the resistance of floors to wear depend to a great extent on the way in which the finishing operation is carried out. Manual finishing of concrete floors using steel float is the only method that has been followed in the country up to now. Apart from being slow and time-consuming, the method does not always ensure a satisfactory finish. The Central Building Research Institute has been studying this problem, and has developed a machine which finishes concrete floors more efficiently and economically at greater speed. The paper describes the salient features of the machine, and discusses its use and relative performance as compared with finishing by hand.

Large areas of concrete surface are involved for floors in any building project. The production of such surfaces entails concrete laying, screeding and finishing. After the concrete has been laid, compacted and screeded, it is finished by a steel float. The object of finishing is to produce as hard and close-knit a surface as possible. The performance of the floor depends largely on its finishing. At present, the finishing operation is carried out manually by means of steel floats. The process is very slow and strenuous, and takes up considerable labour. For finishing large areas of concrete in particular, it proves uneconomical and inefficient. The manual finishing of horizontally cast prefabricated large floor or wall panels also poses many problems. Besides, manual finishing operation is becoming costlier with the rising cost of labour. Abroad, the finishing of floors is accomplished by means of machines which are available under various proprietary names and patented designs. These machines are claimed to be not only faster and economical in operation but also to ensure a uniform finish with a harder top for the concrete floor. Since floor-finishing machines are not being indigenously manufactured, and as their import from other countries will involve the expenditure of scarce foreign exchange, the development of a floor-finishing machine was taken up at the Central Building Research Institute. The development work has now been successfully completed, and the machine has been tried out extensively for finishing large floor areas in the Institute premises.

The power-trowel

The machine developed at the Institute has been designated the power-trowel, *Fig* 1. It consists of a worm-gear speed reducer which affords base for a petrol engine. The power from the engine is transmitted to the worm of the speed-reducer through a multiplate friction clutch, the control of which is provided on the handle of the machine for the easy reach of the operator. The worm-gear speed-reducer rotates a power-head which has four radial arms projecting horizontally outwards. A trowel blade is attached with each radial arm in such a way that the entire power-trowel assembly rests on the floor on four trowel blades. Rotation of the power-head will start the trowel blades revolving on the floor. Since the machine is not fitted with wheels and it rests on the floor with the help of its trowel blades alone, during the operation, it can be made to work over a particular area by just giving the handle a gentle push in the required direction. The machine can be easily transported over short distances manually; two persons can easily do the job. An eye-bolt has been fitted at the top of the engine for hoisting the machine by crane.

Two types of trowel blades can be employed with the machine: the floating trowel blades and the finishing trowel blades. The former type is used in the initial stages of finishing, while the latter is employed for the final finishing operation. For obtaining the desired type of finish with the power-trowel, the finishing trowel blades should be tilted to a suitable angle with respect to the floor being finished. The tilting of trowel blades effects change in the area of contact between the blades and the floor thereby varying the intensity of the weight coming upon the floor. The operation of tilting the trowel blades is controlled by rotating a knob on the machine handle. A stationary guard-ring attached to the worm-gear speed-reducer surrounds the rotating trowel blades, and ensures the safe working of the power-trowel near obstacles. The speed-reducer is fitted with a handle which is held firmly by the operator thus preventing the speed-reducer from revolving during the rotation of the trowel blades.

The salient features of the power-trowel are given below:

petrol engine 3 hp, or electric motor 2 hp	
area trowelled per revolution	0·5 m²
no of trowel blades	4
diameter of blade guard-ring	890 mm

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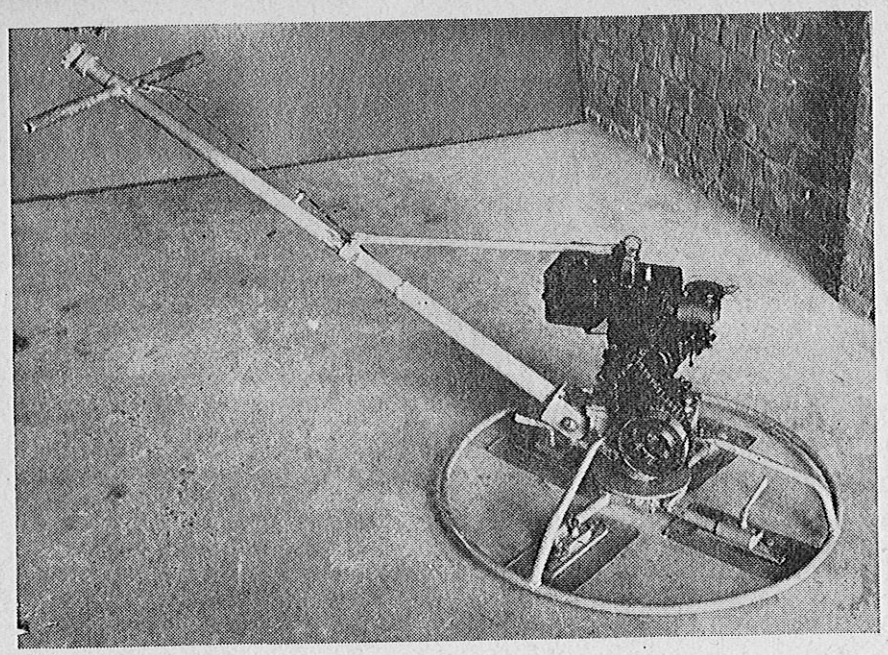

Fig 1 Prototype of the power-trowel

weight	70 kg
output	120 m²/hour
fuel consumption	1·5 litres of petrol per hour
manufacturing cost	Rs 3,000 approximately

Laying of the floor

A number of floor panels were laid and finished with the power-trowel. The floors were laid in the usual manner and no special precautions were required to be observed except that the floor panels were laid in long stretches in order to ensure the efficient use of the power-trowel. As regards the mix, normally a nominal mix of 1 : 2 : 4 proportions can be used. However, for the present trials a 1 : 2·5 : 3·5 concrete mix with a water cement ratio of 0·5 was used as recommended in Indian Standard Code of Practice for Laying In Situ Cement Concrete Flooring, IS : 2571–1963. The floor was divided into suitable panels so as to reduce the risk of cracking. For efficient working of the machine, the panel length was kept between 5 and 6 m, and width from 3 m to 4 m.

Finishing

After the concrete has been properly laid and screeded, it is finished by means of the power-trowel, *Fig* 2. It may be noted that no extra mortar or cement slurry is to be laid on the panels, because while finishing the machine itself brings to the top a sufficient amount of cream to provide a good finish. The finishing is carried out in three successive trowelling operations as laid down in the IS code cited earlier. The time interval allowed between successive trowelling operations is very important from the point of view of imparting the required type of finish to the concrete.

The finishing operation should start soon after the laying and screeding of the concrete. A time lag is required between the screeding and the first trowelling operation to make sure that the concrete has become stiff enough to prevent the machine from sinking into it while working. This time interval has been observed to vary considerably according to the weather conditions, the water-cement ratio of the mix, and the type and condition of the base on which the concrete has been laid. For a 1 : 2·5 : 3·5 concrete laid to 40-mm thickness, it is found to be about two hours in winter and forty-five minutes in summer. The first trowelling operation is carried out just to consolidate and give a level surface to the concrete. For this the floating trowel blades should be used and the machine made to sweep over the concrete top very quickly, thereby avoiding excess of trowelling in any one particular spot. About two such runs of the machine will be generally sufficient. Excessive trowelling in the earlier stages unnecessarily induces extra matrix to come to the top leading to formation of a thick layer of cement mortar which develops cracks in service and gets chipped off. Similarly, machine trowelling of dry cement or mortar spread separately on the concrete surface should not be permitted. As the concrete will not be hard enough at the time of the first trowelling, special care has to be taken for starting and stopping the power-trowel while being used on the green concrete floor. If the machine is allowed to rest idle on such a floor even for a few seconds, it will sink into the concrete leaving its impress on the surface which will require re-touching for its removal. To avoid this, the power-trowel with the power cut off from the trowel-blades and only the engine running is placed on the fresh concrete surface manually. Immediately after placing the machine on the concrete, the clutch is released to set the trowel-blades in motion. The machine is then made to sweep over the floor quickly as stated earlier. When the trowelling operation is over, the trowel-blades are declutched from power, and the machine immediately lifted off from the floor, and its engine stopped. The machine can be placed on some suitable hard surface near the green floor. Sometimes when there is a hard and properly levelled floor adjoining the green one, the machine is started on the hard floor and is brought on to the green one with the blades in motion. At the end of the trowelling, the machine is taken back to the existing hard floor while it is still running. A floor that is finished one day can be considered to provide a hard surface on the next day for the placing and starting of the power-trowel.

The purpose of the second trowelling is to make the floor further dense and hard. This eliminates also the trowel marks left in the first trowelling operation. The second trowelling is performed after such time when the machine will leave no imprint on the concrete if it is run

in a particular spot continuously for three to five seconds. The time lag between the first and second trowelling operations varies mainly according to the weather conditions. However, an interval of 1 to 1½ hours gives fairly good result. Three or four runs of the trowelling machine on a particular panel will prove quite effective. The second trowelling is also done using floating trowel blades.

The final trowelling is carried out well before the concrete has hardened, when it requires considerable pressure to make any impression on the concrete surface. In the final trowelling, various grades of finish can be obtained by tilting the trowel blades of the machine to different angles with respect to the concrete surface and also by extending the finishing operation for a longer duration. The use of the finishing blades is recommended for the final trowelling since they are made from abrasion-resistant steel and are so shaped that they can be easily tilted to produce various grades of finish. Normally three to four trowelling operations will impart a fairly good finish, and a harder top to the floor. Subsequently, the floor can be cured in the normal way. The power-trowel should not be allowed to remain on the green floor immediately after the final trowelling is over.

The use of the machine entails a certain amount of training for the machine operator since the output of the machine, uniformity of the finish and correctness of level of the concrete top depend mainly upon the skill of the operator. With the sturdy guard-ring provided with the power-trowel, the operator can make it work close to the wall within 25-mm distance quite safely.

Fig 2 Floor finishing with the power-trowel; in the background is floor, already finished by the machine, being cured

Performance

Floors finished by the power-trowel and hand-operated floats were compared. The finish obtained by using the machine was more uniform and free of trowel marks. As regards the speed of finishing, the power-trowel took barely twelve minutes for complete finishing of a bay, 5m × 3m in size, whereas two mason hours were required for finishing a bay of similar dimensions.

As far as the abrasion resistance of machine-trowelled, floor panels is concerned, it is yet too early to draw any definite conclusion in this regard because it is hardly four months since the machine trowelled-floor panels were laid. However, during this period, the floor showed no signs of cracking, pitting or any other defect in spite of the fact that it is being used under severe working conditions.

Advantages

The following are the main advantages of power-trowel :

(*i*) it imparts to the concrete a dense, uniform surface, free from spots, ripples and trowel marks

(*ii*) it is much faster, economical and efficient in use

(*iii*) it enables the handling and finishing of concrete surfaces using coarse, dry, economical mixes with low slumps which otherwise are difficult to be manipulated by hand-trowelling

(*iv*) because of the high speed of trowelling, the machine can be used effectively and economically wherever large concrete surfaces have to be finished

(*v*) power-trowel is ideally suited for laying industrial floors since it imparts a denser floor finish

(*vi*) for finishing horizontally cast large panels for prefabricated construction, the power-trowel can be used effectively and with ease.

The power-trowel is simple in construction and can be easily fabricated from indigenously manufactured or locally available standard parts and materials. It requires very little attention for its maintenance. An application for a patent for the machine has already been filed, and licences for its production are soon to be given to interested manufacturers.

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