A primer on vibration
Part 1

Placing low slump concrete is greatly simplified by the correct use of the proper vibratory tools. This is the first installment of a two part article dealing with the fundamentals of vibrating concrete.

The high strength concretes, which are called for in most modern structural designs are mainly attainable through the use of low slump mixes. One important consequence of this is that in today's practice stiff mixes are the rule rather than the exception.

The use of structural concrete has grown by leaps and bounds in recent years, and this expansion has inevitably focused increased attention on problems related to the proper handling and placement of stiff mixes. The advent of prestressing and ultimate strength design has further emphasized these problems since greater demands are being placed on the concrete.

Then, too, exposed concrete is gaining popularity with the development of many new surface textures and treatments. This necessitates concrete that is free from honeycombing and other surface defects caused by faulty placement practices.

Out of these needs arose the concept of vibration. It was found that vibration, applied internally, simplified the placing of stiff mixes which would otherwise contain voids and have poor bond with the reinforcement. Low slump concrete that would have confounded contractors three decades or so ago can now be placed and consolidated with thoroughness and speed.

An important element in vibration that largely determines the ease and economy of such work is the choice of equipment. This decision will almost always be governed by the nature and scope of the work involved.

power

Vibrators are commonly powered by one of three types of motors—gasoline, pneumatic or electric. Power option costs do not vary materially, and since units of a wide range of sizes and capabilities are manufactured for all three power sources, selection will probably often depend on the type of power that will be available.

Imagine a machine delivering over 10,000 one ton blows in a minute! Vibrators are called upon to perform this work as a matter of daily routine. Such rough service naturally means that vibrators must be carefully constructed of high quality materials. Workmanship and performance records mean a lot when comparing vibrators. It's necessary for contractors to look beyond the price and operating specifications.

‡Revolutions per minute in this context indicates one complete cycle of vibration per minute, and is used here to avoid the ambiguity of the term "vibrations per minute."
of a unit to determine its true value. Often two vibrators will appear to be alike physically but will differ markedly in cost. Upon closer inspection the two items will often reveal sharp differences in terms of quality of manufacture. A savings in original cost can be offset in short order when maintenance starts rising and breakdowns increase.

**Efficiency**

Frequency, amplitude and force are the main functional characteristics of vibrators to consider when selecting such equipment. Their resultant centrifugal force determines the effectiveness of the vibrator in concrete.

As you know, concrete is a mixture of aggregates of widely varying sizes bound together by a cement paste. Aggregate particles due to their unlike mass or size, have different inertias (resistance to movement). In a stiff, plastic mix it is necessary to vibrate at a rate sufficient to set up movement of the larger aggregate particles. This will cause aggregate movement of greatly varied direction and speed. Such movement results because the particles of lesser size will move at different rates and in several directions. The variety of aggregate shapes will also add to this differential movement. It is this diversity of action in vibrated concrete that works free air in the mix to the surface.

In considering the effectiveness of a particular vibrator its frequency cannot be considered alone, but must be properly related to the amplitude (the amount of movement). For example, a very high frequency vibrator with a very low amplitude has a tendency merely to cream the material immediately adjacent to it without causing appreciable movement a short distance away. In the United States today the generally accepted frequency for vibrating concrete is in the 9,000 to 10,000 rpm** range.

Thus, a vibrator must be chosen that operates at a high enough frequency to consolidate the concrete thoroughly with a minimum of labor; but care must be exercised to avoid the high upkeep expense of an underpowered machine.

Amplitude (the side-to-side distance that the head travels in its vibration cycle) is of equal importance in frequency in gauging a machine’s effectiveness. Most concerns making vibrators adopt an amplitude for each of their models that best complements the frequency range of the machine; that is, one that will be most effective in consolidating the concrete and yet put the least amount of strain on the workman and the vibrator.

**Types**

Four general types of concrete vibrators are in use today: (1) internal; (2) form; (3) surface; and (4) table. The latter type is not covered in this article since it is largely limited to use by laboratories and manufacturers of small precast products.

Where practical, it is advisable to use internal vibrators. They offer highest efficiency since their output is transmitted directly to the concrete. In addition, internal vibrators place the least amount of strain on formwork. Many models still contain the bulky power source on a base intended for semi-fixed positioning with the power transmitted through a flexible shaft to the head, which is inserted in the concrete. But today there is also a wide choice of ultra-compact machines that contain the motor in the head assembly.

Form vibrators are invaluable for sections that are too deep and narrow or that contain too much reinforcement to vibrate effectively with internal units. Extra care must be exercised in choosing this type since a high force is needed to penetrate through the forms to the concrete. Amplitudes should be minimal to prevent form damage.

Surface vibrators have extended the advantages of vibration to thin, horizontal sections such as roads, floors, driveways and sidewalks. This type is available in a wide variety of models including units to attach to screeds and complete screed units that roll on their own wheels. A complete unit should be heavy and rigid enough to maintain a straight bottom edge and yet be easily portable. It should also be readily adjustable in terms of length and height.

Contractors today have a magnificent array of general purpose and special purpose vibrators from which to choose. General purpose units have the widest field of application and are probably the most practical choice for small contractors who may not wish to invest in several types. Special purpose vibrators can save time, money and headaches for the contractor who has special, recurring problems.

In figuring the number of vibrators for a job, it should be remembered that vibrators are often subjected to rough handling, and by their very nature they are prone to require periodic repair and maintenance. Skimping on the number of
Vibrators ordered for a job can be false economy since their role in the construction routine is so vital. The picture of a crew standing idle and a lineup of ready mix trucks waiting while the job foreman works frantically to repair an ailing vibrator can be very disheartening.

Importance of Slump

Vibration makes possible some notable economies in mix design. To achieve the higher strengths now commonly being specified, it has been necessary to reduce the amount of mix water. It becomes necessary, therefore, to choose between a rich stiff mix or a lean stiff mix.

Rich mixes require an increase in the quantity of sand for handling purposes and consequently an increase in the surface area which the cement paste must cover. This is expensive. If a greater amount of coarse aggregate is used, an increase in strength can be effected without a commensurate rise in concrete cost. Naturally, the resulting mix is harsher but vibration makes it possible to place and consolidate such mixes easily and quickly. Contractors should keep this in mind when ordering ready mix. When a rich high slump concrete is ordered, not only is economy sacrificed but the vibration of such concrete results in segregation and poor wearability of horizontal concrete surfaces.

Selecting the right slump for any given job will depend on several factors, including vibratory equipment efficiency, depth and width of the section, amount of reinforcement and available handling equipment. Low frequency vibrators and form vibrators often require higher slump concrete than is needed with high frequency internal vibrators. Some manufacturers offer external vibrators with sufficient speeds to be adequate for concrete placement. Heavily reinforced sections make it difficult to penetrate with an internal vibrator and also limit the size of the coarse aggregate. This means a relatively unstable mix and the obligatory use of a less efficient form vibrator. Unusually deep or narrow sections often render vibration uneconomical or impossible except with form vibrators, although some manufacturers offer special internal vibrators for this purpose.

High quality handling equipment should be used for transporting and placing low slump mixes. Chutes should be steeply inclined to minimize the need for pushing the concrete along by hand.

Vibration thus makes it possible to reduce the amount of cement in a mix without lowering its strength. Compensation for this reduction in cement content is made by using less water. In this manner cement requirements can often be lowered from five to four sacks in a typical mix.

To be concluded in the April issue.