Vacuum dewatering experts answer questions

The questions answered here were collected by the editors and submitted to Harald Wenander, Technical Director, Tremix AB, Skarholmen, Sweden. Mr. Wenander has answered most of them himself but reports that some replies were written in cooperation with Professor Roman Malinowski, of Chalmers University of Technology, Gothenburg, Sweden.

Operation of equipment

Q. *How many men are there to a crew for vacuum dewatering of concrete?*

A. The system requires two men to place the suction mats or pads; but once this is done and the vacuum valve to the pump is opened, the vacuum treatment continues on its own for the 15 to 20 minutes of operation. The pump needs no supervision. Should the tank become overfilled with water the pump stops automatically. In fact, in Scandinavia the work cycle is planned to start up a new vacuum treatment cycle just before a work break and the vacuum is left on during the break so that the treated part of the slab is ready for finishing immediately afterward.

Q. *What is the productivity of such a crew in square feet per day?*

A. With the type of equipment in most general use in Europe at present, about 700 square feet[1]* can be vacuum treated at a time. If the vacuum is left on for 20 minutes and another 10 minutes are required to move the suction mats to the next location (while the water collecting tank of the pump is being emptied), the resulting cycle is ½ hour. This means 1,400 square feet are treated per hour.[2] Without overtime, concrete placing and dewatering can continue for 5 or 6 hours depending on working conditions. This gives a total area of 7,000 to 8,400 square feet per day,[3] achieved with one vacuum pump running two suction mats and using two men for the entire vacuum treatment. These two men are not occupied full time and can also be used for other jobs such as floating and troweling while each vacuum cycle proceeds. In Scandinavia the whole job of placing, vibrating, screeding, vacuum treatment, floating and troweling of the slab is done by a crew of 4 to 5 men.

Q. *Who operates the pump?*

A. If this question means "Is a special mechanic required to run the pump?" the answer is no. The pumps sold in the United States generally are driven by internal combustion engines with electric starters. Once the engine is started it can be left on its own during the whole vacuum dewatering operation. When the vacuum mat is to be moved to the next location the pump is stopped and the water discharge valve is opened so that the water collecting tank is emptied. The pump is again started and nothing else need be done. Should the water collecting tank for any reason become full, the pump stops automatically. Some models have two collecting tanks which can be emptied independently while the pump is running.

Q. *How do you decide when it is time to shut off the vacuum dewatering equipment?*

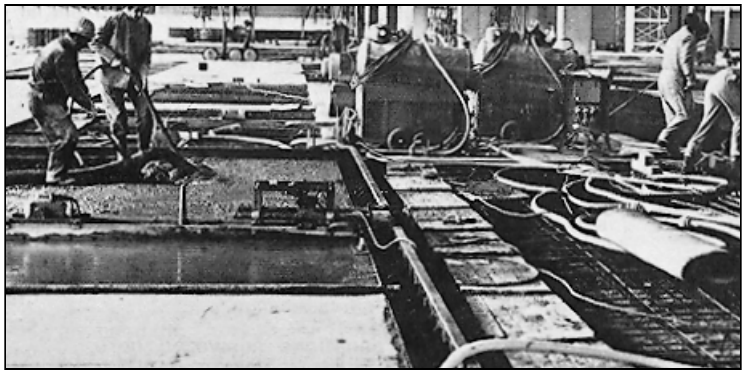
A. The vacuum is left on for about 2 ½ to 4 minutes per inch[4] of slab thickness. Different types of concrete vary in the rate at which they release their water. For this reason a simple test is required: Place one foot on the suction mat and feel whether the concrete gives way to your weight. If it feels somewhat soggy, continue dewatering for some additional time; if it feels hard the vacuum can be shut off.

Q. *What is the maximum thickness of floors to which vacuum dewatering can be applied?*

A. The generally accepted maximum penetration depth is about 12 inches.[5] Processing time for this depth is about 45 minutes. Experiments made at the Lund Technical University in Sweden have shown that it is possible to remove some water from concrete to a depth of about 31 inches[6] but the vacuum time was 1½ hours and this is too long to be practical except for very special circumstances. A very thick slab can be treated successfully, however, because generally the main objective is to remove excess water near the surface so the slab can be walked upon and finished within a short time. The top part of the slab is usually the more important portion and dewatering here provides increased compressive strength and wear resistance, greatly reduced water permeability, lower shrinkage and higher modulus of elasticity.

Q. *When concrete slabs are to be treated by vacuum is it necessary to screed a little bit high in order to compensate for the loss in thickness due to water removal?*

A. Since water is removed, some concrete volume is lost. The resulting compaction is about 2 percent, which means that a slab of 6-inch[7] thickness will settle by .02 x 6 or about ⅛ inch.[8]



Five pumps used on this large job assured that there was always a pump available and maintained rapid progress.

Q. *What can be done if there is a power failure during the vacuum dewatering cycle and the slab is only partially dewatered when it is time to finish the surface?*

A. If there is a failure in the prime mover of the vacuum pump, you would be no worse off than if you had placed concrete without vacuum treatment in the first place. If for strength, wear qualities or other reasons it is imperative to use vacuum treatment, then the use of a standby vacuum pump or a standby electric generator must be considered. The vacuum pump today is a very well developed piece of equipment and chances of failures are very small.

Q. *What can be done if it rains while the vacuum is being applied and it continues to rain afterward? Is there any way to finish the slab without working water into the surface?*

A. Obviously dewatering can take place while it rains because the surface being treated is covered by a vacuum mat during the process. If a heavy downpour occurs when the process is finished there is no way of finishing the concrete but if the rain is only a light drizzle the concrete can be floated immediately, using the troweling machine with planing disc. If the surface is to be troweled, plastic covers can be used immediately after disc planing and, when the surface has set to a certain degree, it can again be exposed and troweled. Immediately after this operation it should be covered again.

Q. *Is there ever any trouble with plastic shrinkage cracking when vacuum dewatering is used? If so, is it any more difficult to beat the cracks closed than it would be with ordinary concrete ? (This is sometimes done by hammering the surface with wood floats.)*

A. There is no trouble with plastic shrinkage cracking during vacuum dewatering. The cracks which may appear along the perimeter of the mat because of the reduction of concrete volume due to the vacuum process are closed efficiently and completely during use of the planing disc immediately after vacuum treatment. Because of the reduced water-cement ratio, subsequent plastic shrinkage and likelihood of plastic shrinkage cracking are less than with non-vacuumed concrete.

Q. *Are there any specifications available on recommended practices for vacuum dewatering?*

A. Handbooks and instructions are available for recommended practices based on experience from thousands of work sites in Europe. The best recommended practices yet published are from the Cement & Concrete Association in England, which has published three booklets on concrete floor placing: "Concrete Ground Floors, Their Design, Construction and Finish," by R. Colin Deacon; "Concrete Ground Floor Construction for the Man on Site, Part 1—For the Site Supervisor and Manager"; and "Part 2—For the Floorlayer," by G. Barnbrook. These can be obtained from the Cement & Concrete Association, 52 Grosvenor Gardens, London SW1W OAQ, England. A two-page summary of these booklets is given in "Vacuum Dewatering Procedures," Concrete Construction, July 1975, page 280

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EQUIPMENT

Q. *What is the largest size mat in use?*

A. Our company's largest standard mat is about 400 square feet[9] (17 by 23 feet[10]), though larger sizes have been used successfully for special jobs. The largest one we know of is about 550 square feet.[11]

Q. *Has the vacuum process been used with 45-foot[12] screeds such as are in commercial use in the States?*

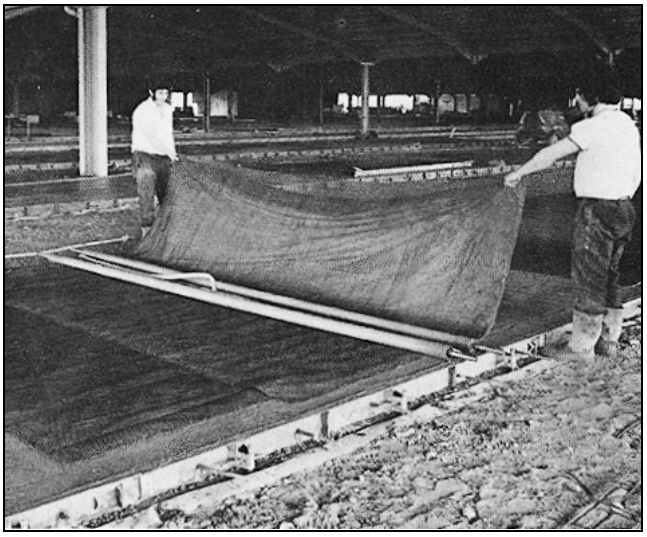
A. The longest standard screed we use is 40 feet[13] For special applications 45-foot[12] screeds have been used and are entirely practical. A gasoline engine or electric motor distributes the vibrations evenly along the entire length of the screed.

Q. *How much pressure per square foot can be created in vacuum dewatering?*

A. At full vacuum the pressure is about 2,000 pounds per square foot.[14] In practice the vacuum developed is 80 to 90 percent of the theoretical maximum: 1,600 to 1,800 pounds per square foot.[15]

Q. *How often must vacuum mats be replaced?*

A. When using soft vacuum mats which come in two parts (filter pads and top covers) the filter pads which are placed directly on the concrete are the more vulnerable parts. If properly cared for they will last for 100,000 square feet or more of use; if not cleaned after each day's work, they may become clogged with hydrated concrete and will then have a much shorter life.



Two men are needed to place suction mats. The same men start and stop the pump.

Vacuum mats protect the slab during a sudden rain and permit dewatering to be done during a storm; finishing operations require a period virtually free of precipitation.

The top cover, made of a durable reinforced plastic, has a very long life, perhaps as much as several years.

Where vacuum plates are used the filter cloths of the plates have to be cared for in the same way as the filter pads of soft mats. The filter cloths must be replaced at regular intervals but as a rule this is a fairly simple operation.

Q. *Is there any problem with ripping or tearing of mats through ordinary job handling? If so, what measures are taken to prevent it?*

A. Mats may of course be torn on sharp ends of rebars or other projections but this does not occur very often. A small rip in a filter pad does not make it useless. Rips in the top cover can very easily be repaired by gluing on a patch.

Q. *What kind of servicing of parts and repairs can be expected on equipment made in Sweden?*

A. I can answer only for our own company, which never sells anywhere without also providing service. We now have dealers in Indiana, Minnesota, Ohio and Connecticut; each provides service facilities. Our dealer network is gradually expanding. If a certain spare part is not on hand with a dealer, it will be flown in at once.

Q. *What happens to the minus-50 mesh[16] material that accompanies the water removed by vacuum?*

A. A very small amount of fines in the concrete, mostly cement and filler, accompanies the extracted water to the water collecting tank of the vacuum pump. The actual amount is very small—less than 1 percent by volume of the collected water. The amount of cement lost is thus a very small fraction of 1 percent of the cement content of the mix and is of no practical importance whatsoever.

Q. *If you must avoid dumping water in the immediate vicinity, what is the usual procedure for disposing of water from the vacuum tanks? Also, how much water does one unit produce in a day?*

A. In all our experience there always seems to be some place fairly close to the pump where water can be dumped. If there is none, perhaps the only solution is to move it away in tank trucks.

One pump unit can treat up to about 8,000 square feet in a day.[17] If the slab has a thickness of 6 inches,[18] this means about 150 cubic yards[19] of concrete and if 5 to 7 gallons of water are extracted from each cubic yard[20] there would be about 750 to 1,050 gallons[21] of water per day.

Q. *Are vapor barriers needed when building a floor with vacuum dewatered concrete?*

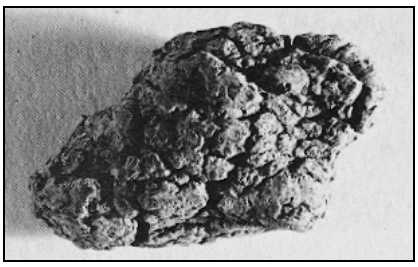
A. If you are thinking of a vapor barrier as a means of sealing the vacuum system, there is no need for it. The concrete itself seals around the vacuum mat edges and no air is sucked in through the bottom of the slab until the vacuum has penetrated all the way from surface to bottom. By that time the vacuum treatment is finished anyway. Only for very thin slabs may a vapor barrier be required.

If a vapor barrier is needed for the more common purpose of blocking moisture from entering the building through the slab, then a vapor barrier may be needed although the permeability of vacuum treated concrete is ordinarily lower than that of untreated concrete.

ECONOMICS OF USE

Q. *What is the smallest size job on which vacuum dewatering is practical?*

A. There really is no lower limit; almost any size job can be tackled.



Lightweight aggregate such as this highly porous ¾-inch particle (shown enlarged) retains some water for curing after vacuum is released.

Q. *What is the cost per square foot of vacuum dewatering?*

A. There is no ready answer to this question since the total time taken to place and finish a slab when vacuum dewatering is used is generally less than that required to place and finish one by usual methods. This is because vacuum dewatering permits the concrete to be stepped on immediately after treatment; machine floating also can be started immediately. There may have to be a certain waiting time before final troweling can be started but generally the time before the slab can be completely finished is greatly reduced. This time gain is very pronounced, especially in cold and damp weather. So in actual fact, the total cost per slab is less when using vacuum dewatering than when not.

Q. *Does anyone rent vacuum dewatering equipment?*

A. Not to our knowledge but dealers will certainly do so when they get properly started.

Q. *Has anyone gone into the specialized contracting business of vacuum dewatering as a service to floor contractors?*

A. We do not know of any such firms yet in the United States but it is likely there will be such specialists in the future.

MIX DESIGNS AND TESTING

Q. *Can admixtures be used in concrete to be vacuum dewatered?*

A. Yes, but they are often unnecessary. The only admixtures with which special care must be taken are air entraining agents. The fine air bubbles they produce tend to slow the rate at which water can be extracted. No more air entraining agent should be used than the amount needed for a total air content of about 4 percent in the original mix. Slump should not be more than 3 inches[22] and preferably only 2 inches[23] since higher slump may lead to segregation. The suction time should be lengthened by about 50 percent.

Air content in concrete after vacuum treatment is slightly more than before treatment. In view of the greatly reduced water permeability of the surface of vacuum treated concrete—especially if it has been thoroughly machine floated and troweled —the use of air entraining agents for prevention of frost damage is sometimes reduced in amount or completely omitted.

Q. *Is shrinkage compensating cement ever used in combination with vacuum dewatering?*

A. There has been no experience yet with the use of shrinkage compensating cement in combination with vacuum dewatering. There is probably no reason why this type of cement could not be used.

Q. *Is a vacuum dewatered slab equal in wear resistance to a concrete slab treated with a dry shake hardener?*

A. Several recent official tests have shown that a vacuum dewatered slab which has been properly machine floated and troweled has a wear resistance 2 to 3 times that of ordinary or treated concrete.

Q. *Can vacuum dewatering be used with lightweight aggregate concrete?*

A. Yes, and to great advantage. Since the water and fluid phase of the concrete is subject to vacuum, air in the pores of lightweight aggregate expands and presses water out of the aggregate, some of which is extracted. When the vacuum is shut off, atmospheric pressure presses some of the water back into the aggregate as its air content again contracts. This means that the concrete after vacuum treatment gets fairly hard and dry and can quickly be finished. The short waiting time before finishing can be completed reduces the risk of plastic shrinkage.

Q. *Lightweight aggregate is said to hold water which is available for curing the cement paste. Is there any likelihood that this so-called curing water will be removed by vacuuming, thus losing the advantage?*

A. When some of the water returns to the aggregate after the vacuum is shut off the surface gets fairly hard, and floating as well as troweling can take place immediately. If properly done, there is no danger of too little water being left for hydration of the concrete.

In ordinary circumstances there is no risk that too much water will be extracted from the concrete. The water is extracted through capillaries of the concrete. The diameter of these capillaries is proportional to the water-cement ratio of the concrete and by the time the water-cement ratio gets down to 0.35 the capillary diameters are so small that no more water can be extracted. There is no possibility of extracting so much water that there will not be enough left in the concrete to hydrate the cement.

Q. *How long does it take to vacuum dewater structural lightweight aggregate concrete?*

A. For this type of concrete it is advantageous to use a slightly lower vacuum than normal—60 to 70 percent of maximum vacuum—and extend the timing by 30 to 50 percent. This is to ensure that the top part of the slab is not dewatered more rapidly than deeper portions. Because of the porous nature of the aggregate, rapid dewatering of the top might lead to too dry a surface.

Q. *Is there any difference in the handling of test cylinders for vacuum dewatered concrete? If not, how does one estimate the actual strength of the concrete at any given age?*

A. As yet there is no proper way to make vacuum treated test cylinders correspond exactly to conditions on the actual slab. The only way to find out precisely the strength of the vacuum treated slab is to drill out test cores. The Schmidt rebound hammer will give fair readings if calibrated against the actual concrete. Our company is developing a method to vacuum-treat test cylinders but the equipment needed is not yet on the market.

Metric equivalents

1. 65 square metres
2. 130 square metres per hour
3. 650 to 780 square metres per day
4. 1 to 1.6 minutes per 10 millimetres
5. 300 millimetres
6. 800 millimetres
7. 150-millimetre
8. 3-millimetre
9. 35 square metres
10. 5 by 7 metres
11. 50 square metres
12. 14 metres
13. 12 metres
14. 9750 kilograms per square metre
15. 7,800 to 8,800 kilograms per square metre
16. minus 0.300-millimetre
17. 740 square metres per day
18. 150 millimetres
19. 115 cubic metres
20. 24.8 to 34.7 litres per cubic metre
21. 2,840 to 3,975 litres
22. 75 millimetres
23. 50 millimetres

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