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Review on Strength Parameters of Vacuum Concrete

Karthik Prasanna.U[1], Mohamed Althaf.I[2], Tamilarasan.G[3], Bharathikumar.D[4], Perarasan.M[5]
U.G. Scholar, Department of Civil Engineering, Adithya Institute of Technology, Coimbatore, India[1,2,3,4]
Assistant professor, Department of Civil Engineering, Adithya Institute of Technology, Coimbatore, India[5]

Abstract: This project presents the review on the study of mechanical properties of vacuum concrete. It increases the strength of concrete in a short period fora smaller volume/area. Water-cement ratio is determined for concrete. We have always tried to restrict the water-cement ratio in order to achieve higher strength. The chemical reaction of cement with water requires a water-cement ratio of less than 0.38, whereas the adopted water-cement ratio is much more than that mainly because of the requirement of workability. Workability is also important for concrete, so that it can be placed in the formwork easily without honeycombing. After the requirement of workability is over, this excess water will eventually evaporate leaving capillary pores in the concrete. These pores result into high permeability and less strength in the concrete. Therefore, workability and high strength don't go together as their requirements are contradictory to each other. Vacuum concrete is the effective technique used to overcome this contradiction of opposite requirements of workability and high strength. With this technique both these are possible at the same time.

I. INTRODUCTION

Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance known as an aggregate (usually made from different types of sand and gravel), that is bonded together by cement and water. Vacuum concrete is concrete which includes high water content during the mixing to facility the mixing process and to improve the workability to enable it to be handled, placed into complicated molds or around extensive reinforcement. After moulded, the concrete is subject to a vacuum dewatering process when water for workability no longer needed to removes the excessive quantities of water. Vacuum processed concrete which is widely used in some countries, especially for slabs and floors was first invented by Billner in the United States in 1935. In this technique (hereinafter termed the conventional technique), a filter pad is first applied on surface of freshly cast, vibrated and leveled concrete. This filter pad used to prevent cement particles from going through it. Then, an airtight covering made of flexible mat is laid over the filter pads. In center of covering mat connected the vacuum pump with hose and since fresh concrete contains a continuous system of water-filled channels, the application of vacuum to the surface will result in a large amount of water being extracted from a certain depth of concrete (Neville, 2011). In general, the amount of water is two to four times as much as the amount required for hydration of the cement, it is advantageous to remove water not needed for hydration. The removal of excess water from concrete causes compaction due to mobilization of atmospheric pressure on concrete surface. Vacuum dewatered concrete has been stressed time and again that adaptation of low water cement ratio will give around improvement in the quality of concrete, but satisfactory workability is the essential requirement of placing concrete. Vacuum dewatering techniques is fairly widely used in the construction of factory floors. The techniques have been adopted in a big way for the construction of DCM Daewoo Motors at Delhi, Whirlpool factory construction near Pune, Tata Cummins at Jamshedpur etc.

Harald S. Wenander has published paper on May 24, 1976.This invention relates to apparatus for vacuum processing concrete for removing surplus water from the concrete by exposing the concrete to vacuum. Accordingto the invention solid particles are prevented from being sucked away from the concrete by applying the vacuum to the concrete surface through a sheet perforated with a great number of holes. The holes are sized to substantially exceed the smallest particles to be prevented from being sucked away by filtering within the concrete.

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Bror Dyrander has published research paper on July 11, 1969.For draining cast concrete a filter gauze is spread over the concrete surface and covered by a mat of flexible rubber or plastics. Draining passages are formed between the gauze and the mat and connected to collecting spaces provided at the outside of the mat. Outlet ports from said collecting spaces cooperate with a nozzle connected to a movable suction conduit and dimensioned to cover all said outlet ports when applied manually in correct position against the exterior of the mat.

Jacob J. Creskoff has published research paper on Jan. 30, 1968. An improved method and apparatus for treating concrete. An apparatus is provided which comprises a cover, a first member which is provided about the periphery of the cover to form an outer compartment under the cover and a second member which is provided within he first member to provide an inner compartment within the member. Means defining a port are provided for connecting the inner compartment to a Source of reduced pressure. Means defining fluid passages between the inner compartment and the outer compartment are also provided which are smaller in area than the port. This apparatus is used for vacuum treating concrete having excess water. The improved results from the fact that the smaller inner compartment is easier sealed to the concrete than the outer compartment and once sealed it causes the outer compartment to Seal.

Morsel Erdalhas published paper on 28 August, 2009.Concrete which is a composite material is one of the most important construction materials. For the improvement of concrete quality some advanced technologies are used for curing and placement of concrete. Vacuum processing is one of these technologies. With the vacuum application, water content of the mixture is decreased and by this way a better water/cement ratio is obtained. Since most of the empirical equations which use nondestructive test results are developed for normal concretes, their prediction performance for vacuum processed concrete is unclear. In this study regression equations and an Artificial Neural Network (ANN) were developed for the estimation of compressive strength of vacuum processed concrete. For the experimental set up, three different concretes were prepared by applying variable vacuum application duration. On these concrete samples, Windsor probe penetration tests, Schmidt hammer tests, pulse velocity determination tests, were performed. In addition to these; densities, void ratios, water absorption values and capillary water absorption values of extracted core samples were determined. Several equations using single independent variables for the estimation of compressive strength were developed, a multi linear regression equation which uses Windsor probe exposed length, pulse velocity, density and water absorption ratio as predictor variables was developed.

A neural network was developed for the estimation of compressive strength. Finally prediction performances of previously published empirical equations, single and multiple variable regression equations developed during this study and ANN were compared. According to this comparison, best prediction performance belongs to ANN.

Hakan Bolat,has published research paper on Dec. 5, 1998. Mustafa Çulluhas published paper on Polypropylene fibers are manufactured as an alternative to steel fibers. When steel fibers are exposed to adverse environmental conditions, they can lose their properties by time. Therefore, the physical and mechanical properties of the concrete expected from them are weaken. Polypropylene fibers have superior properties compared with steel fibers in terms of chemical and physical properties. There are two types of polypropylene fibers as an admixture in concrete; macro and micro. This study investigated the effects of macro and micro fibers of polypropylene on compressive strengths of normal and vacuum applied concrete. Parameters of the study were as follows: fiber diameter, 3-different fiber ratios, different fiber length, 3-different concrete strength class (C16/20-C25/30-C35/37 according to EN) and two different application methods (normal and vacuum).

Compressive strength tests were performed at the end of 1, 3, 7 and 28 days. Consequently, all the parameters affected the compressive strengths and other properties of the macro and micro polypropylene fiber-reinforced concretes.

VAKUUMBEHANDLING AV BETONG Mar has published research paper on 26 1975.The literature was surveyed and tests were carried out in an effort to find what improvements in quality occur in the concrete at varying depths below the surface. A method was also devised to confirm these improvements, primarily the increase in strength. The literature review indicated that it is the redistributions of pressure in the concrete during the vacuum treatment which squeeze water out of the concrete and thereby increase its strength. Details are given of the determination of the changes in concrete properties due to vacuum treatment. During vacuum treatment the quantity of water removed from the concrete was measured by

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collecting the water extracted and also by recording the loss in weight of the slab. Vacuum in the concrete was measured using water-filled sleeves cast into the concrete and connected to a pressure gauge. The strengths of the slabs were determined on cores taken from the slabs. It was possible to detect a relationship between strength and suction period, quantity of water extracted, compression and vacuum in the concrete. The effect of vacuum treatment on shrinkage was determined by drilling cores horizontally from the sides of the slabs at different levels. Details are outlined of a method of estimating the final strength on the basis of behavior during vacuum treatment, and it is shown how a graphical relationship may be used to determine the water-cement ratio which is equivalent to a stipulated strength, and to calculate in advance how much water may be extracted from a certain level in the concrete. It is also shown how it is possible to determine continuously how much water has been extracted from a certain level and thus the strength which is to be expected.

Simsek, O has published research paper on 12 October 2004. In this experimental study, the effects of vacuum process on mechanical and physical properties of concrete were investigated by comparing mechanical properties of vacuum processed and half vacuum processed concrete specimens with those of control specimens. Vacuum equipment was used to apply vacuum to fresh concrete in order to extract water from floor concrete. Compressive strength and some other test results obtained from both vacuum processed and plain concrete core specimens were evaluated and then compared. Test results have shown that the compressive strength of vacuum processed concrete specimens increased substantially due to the decrease in water/cement ratio by dewatering process. The effects of the process on compressive strength at early ages and on surface placement are much more pronounced. Some of the other properties such as dry density, unit weight, surface hardness, and surface porosity are also improved by vacuum dewatering process.

Theodore O. Mandish has published paper on 1996-09-27. A vacuum molding process includes selecting a flexible polymer cover for covering a selected cement container and at least partially filling the container with a cement mixture. The polymer cover is removable attached to the partially filled cement container and a vacuum is applied to the cement mixture in the container. The process may also include connecting a vibrator to the container for simultaneously vibrating the container and the placing of a hollow mold core member having a plurality of apertures therein in the middle of the container for the gas bubbles to escape as a result of the vibration of the cement mixture in a vacuum.

Latham, J has published research paper on 1979-8.The article reviews the constructional reasons for the introduction of wetter mix concrete such as ease of handling and faster construction. The use of vacuum treatment of concrete as a means of extracting surplus water from concrete mixes was first introduced before 1939. Equipment used for this treatment was improved in the 1960s and now consists of a compact portable vacuum pump coupled by means of non-collapsible flexible pipes to a system of pliable vacuum mats that can be used on a range of slab sizes. Immediately following removal of the vacuum mats the concrete surface can be machine finished. Vacuum-treated concrete is stronger than untreated because the water/cement ratio is considerably lower. The shrinkage risk is also reduced with vacuum treated concrete and so cracking is reduced.

Robert G. Harfst has published paper on 1978-10-26. A car wash vacuum cleaner and the method of making same is disclosed. The car wash vacuum cleaner comprises an inner shell means. A plurality of vacuum motors are secured within the inner shell means and adapted to provide a suction means therein. A monolithic concrete outer housing surrounds the inner shell means and encloses the top and bottom thereon. A plurality of door means disposed on the concrete housing provides an opening within the housing and inner shell means to both provide a vent means for the vacuum motor and a means for removing dirt particles or the like from within the inner shell. A suction tube fitting extends through the concrete housing and inner shell and is adapted to attach to a suction tube. Dirt particles or the like are drawn through the tube and tube opening into the inner shell when the motors are energized.

K. Audenaert, G. De Schutter has published research paper on 2009-06-16. Self-compacting concrete (SCC) was developed in Japan in the 1980's. The aim was to develop a concrete with a high flow ability and a high resistance to segregation, so that it could be placed without vibration. In this way, durability problems related with badly vibrated concrete would be reduced.

The high flow ability is obtained by the use of super plasticizers and a high amount of fine particles. Due to the presence of a high amount of fine particles, the pore

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structure is differing from the pore structure of traditional concrete.

In this paper vacuum water absorption tests, carried out on 16 SCC and 4 traditional concrete mixtures (TC), will be discussed. Four types of cement (Portland cement and blast furnace slag cement), three types of filler (fly ash and two types of limestone filler with a different grading curve) and two types of coarse aggregate are used and the influence of the amount of powder and the amount of water is studied. The drying temperature was 40°C or 105°C, corresponding respectively with the temperature of evaporation of the free capillary water and the gel water. These test results are compared with the calculated capillary porosity and gel porosity, leading to the conclusion that a good estimation is obtained.

Shigemitsu Hatanakahas published researchpaper on26 Oct 2007. The strength and hardness of concrete slab surface is considered significantly affected by bleeding of concrete. It has been reported that dewatering by vacuum processing is quite effective to obtain high density of concrete. The method, however, has not been successfully used for the concrete work in the field of building construction, compared with that of civil engineering works in Japan. In the present study, firstly the state of the art concerning vacuum dewatering method is reviewed and the newly improved vacuum dewatering method is introduced. Then the effect of the proposed method on concrete properties of slab is examined by a series of experiments in order to find more reasonable and effective way in the application of the proposed method.

Haitham Hazim Saeed --- Anas Amjed Ezzulddin has published paper on2015. In this work a new technique is used to produce vacuum dewatered concrete. In this technique perforated PVC pipes encased in cotton cloth are used to dewater concrete from inside of concrete volume, rather than from the surface, as is the case in the conventional vacuum dewatering method. These pipes are laid in position inside concrete forms, and a vacuum pump is connected to the dewatering pipes, which is operated after casting of fresh concrete to remove the excessive water from internal portion. Properties of vacuum dewatered concrete using the new technique are investigated by a series of tests such as compressive and flexural strength tests. Based on test results, the new technique improves concrete strength and other mechanical properties particularly at early ages. The new dewatering technique is a good alternative to the conventional vacuum dewatering technique and can have a wider range of practical applications than the conventional method.

Scott S. Pickard has published paper on 11/1/1981. Vacuum dewatering in effect produces a zero-slump concrete from fresh concrete with a high water-cement ratio. The process involves three basic steps: (1) filter pads are placed over the fresh concrete; (2) a suction mat is placed over the filter pad, with a hose connecting the suction mat to a vacuum pump; (3) the vacuum pump is operated for several minutes, depending upon the thickness of the concrete slab. Vacuum dewatering lowers the water content of a freshly placed concrete slab by 15-25 percent, increases the density, strength, and frost resistance of the slab, and decreases the slab's absorption, abrasion, and shrinkage. This article discusses the mechanics of the process, the steps in the procedure, and conclusions as to vacuum dewatering's cost effectiveness as a construction technique for certain applications.

Haitham H.Saeed1,Anas A. Ezzulddin has published paper on 10, October-2014. In this work, investigate a new technique for producing vacuum-dewatered concrete. Perforated PVC pipes incased in cotton cloth are used in this technique to dewater concrete from inside of concrete volume, rather than from the surface, as is the case in the conventional vacuum dewatering method. These pipes are laid in position inside concrete forms, and a vacuum pump is connected to the dewatering pipes, which is operated after casting of fresh concrete to remove the excessive water from which. Properties of vacuum dewatered concrete using the new technique are investigated by a series of tests. Based on test results, the new technique improves concrete strength and other mechanical properties particularly at early ages. The new dewatering technique is a good alternative to the conventional vacuum dewatering technique and can have a wider range of practical applications than the conventional method

Emre Sancakhas publishedresearch paper on 2008. In this study, reference concrete slab, which its height is 15 cm and size is 200x600 cm, a concrete slab to be exposed to vacuum for 35 min (full vacuumed) with size of 300x400 cm and a concrete slab vacuum-processed for 18 min (semi-vacuumed) with size of 300x400 cm were produced. Compressive strength tests were performed on core specimens taken from these three concrete slabs on 7th, 28th and 1080th (36th month) days and tensile strength test was performed on 1080th (36th month) day. Carbonation depth test was performed on the core specimens produced was

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investigated. Carbonation depth and Cl^- ion determination were tested on powder samples from these core specimens. Test results have shown that vacuum dewatering to concrete increased its resistance to long term chemical corrosion and also improved its mechanical properties.

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